Royal Australian Navy Apprentice Training Establishment

TIMBER

BOAT BUILDING

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REFERENCE LIST

1. "Timber in Boat Building" J.H. Heath and W. J. Read
Revised By K.R. Bootle

Forestry Commission of New South Wales.

2. "Building a Plywood Boat" New South Wales Timber Advisorty Council

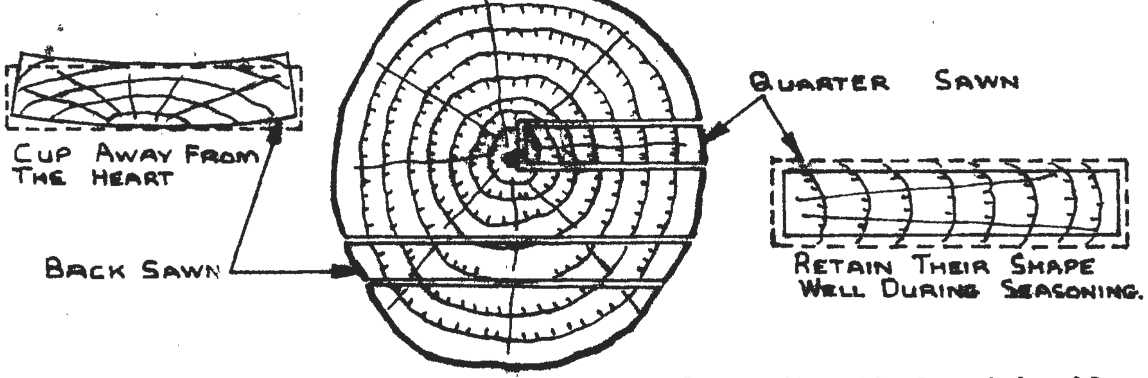
3. "Australian Fisheries" (January 1977)

INTRODUCTION

Wood has always been a favourite building material for small craft, and despite the advent of new materials and the increasing difficulty of obtaining suitable timber, it is maintaining its popularity. The advent of new timber products, new adhesives and new techniques has made boat-building by the amateur much more popular. In order to provide guidelines for timber selection the Standards Association of Australia prepared a Standard, AS 1738-1975: "Timber for Marine Craft". Copies are available from that Association.

Timber for planking, stringers, chines and ribs should be selected for straightness of grain, low shrinkage and freedom from defects. If the boat is to be seaworthy very few defects can tolerated in these particular parts, so knots, shakes, sapwood, incipient decay, compression failures, and brittle heart must be rigorously excluded. Tight gum veins borer holes, and surface checks will not cause trouble unless they are concentrated in a relatively small area. They can usually be satisfactorily caulked.

Unless the boat is to be glued construction, or will be out of the water for considerable periods, there is no necessity to use timber dried 12 per cent moisture content, except for interior fittings. Because it shrinks while drying, however, timber for the upper parts and interior framing should have a moisture content of less than 20 percent, while for these parts, which are customarily submerged the moisture content should not be less than 20 per cent. Of course such requirements are much easier to specify than to observe because of the time usually required to build the boat. To minimise shrinkage during contruction or when the boat is out of the water, all boards should be quarter sawn.

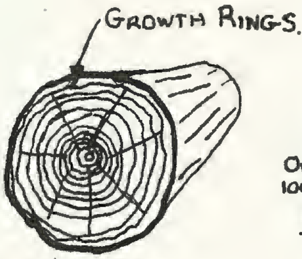


It is not always possible to build small craft entirely of durable timbers, and since the decay hazard in a boat kept at moorings is high, it is wise to take precautions. Some preservative-treated plywood and timber is available. Where such material is not obtainable either from stock on order, non-durable timber should be liberally treated with a recognised preservative. Australian Standard 1604-1974: "Preservative Treated Sawn Timber, Veneers and Plywood," should be consulted for types of preservative and appropriate loadings.

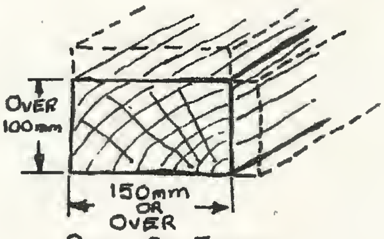
The chief advantages of timber and plywood are:-

1) Positive buoyancy
2) High strength in relation to weight
3) Resilience and thus ability to withstand suddenly applied shock loads
4) Ease of shaping, bending and finishing without the need for special equipment.
5) Good appearance
6) High durability when properly selected, installed and ventilated.
7) Ability, in many cases, to accept treatment with preservatives to give long-term durability under severe conditions and where ventilation is inadequate.
9) Ease of working without requiring closely controlled factory conditions in respect of temperature and humidity.
10) Resistance of abrasion.
11) Ability to be altered at relatively low cost.

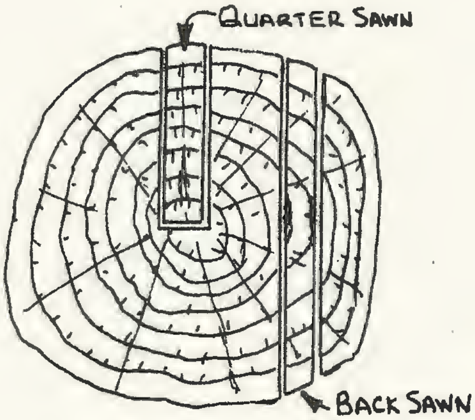
Improvements in plywood and adhesives have opened up a new field for constructing craft. The main advantage of plywood is that it is flexible and obtainable in large sheets. Providing a marine grade plywood is used plywood chine system is very successful. New methods, new materials and new forms of construction have been tried and adopted and there is still scope for progress in these fields of construction.

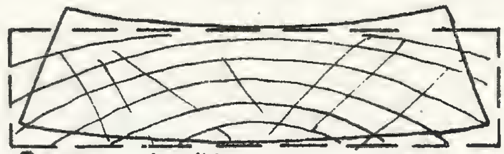


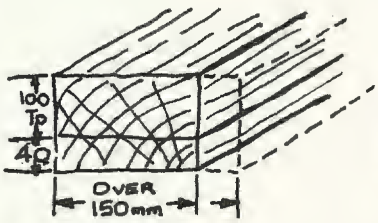
LOG



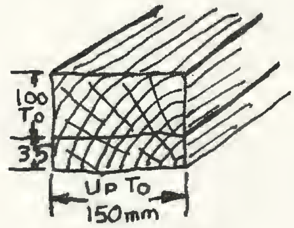
BAU. OR FLITCH



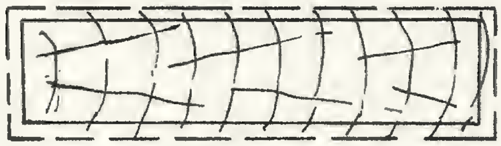

BACK SAWN BOARDS TEND TO CUP AWAY FROM THE HEART.

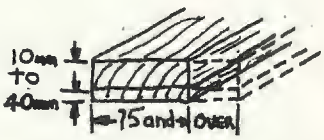


PLANK

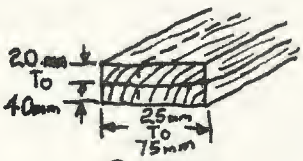


SCANTLING

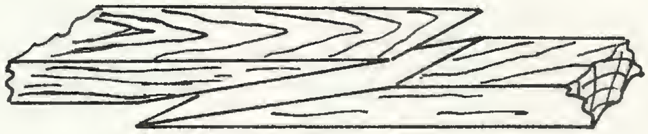

QUARTER SAWN BOARDS RETAIN THEIR SHAPE WELL DURING SEASONING.

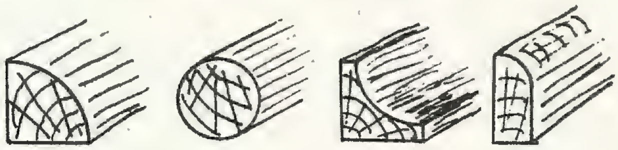


BOARD

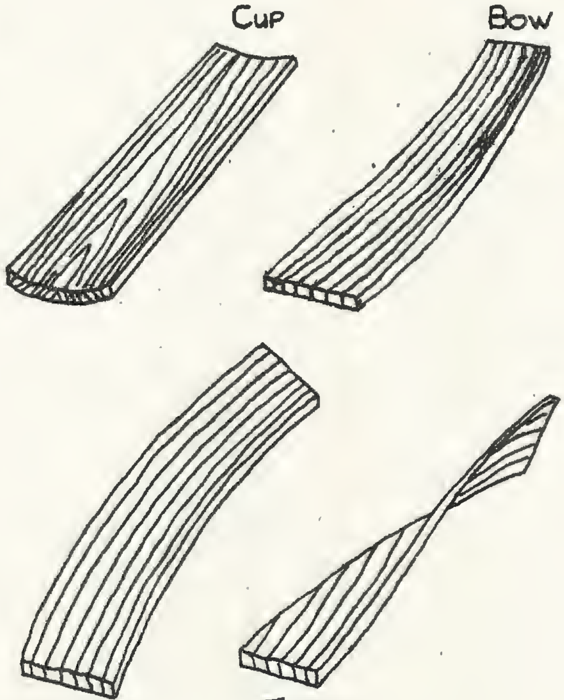


BATTEN

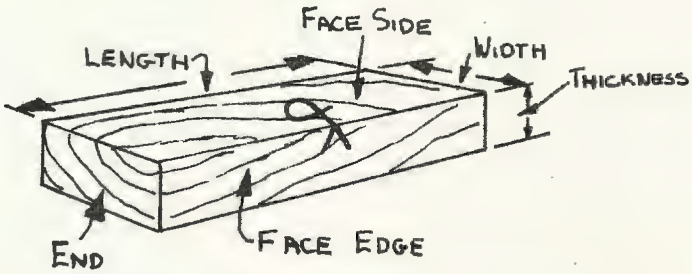

SCARPH JOINT



MOULDINGS.



EXAMPLES OF WARPING



TERM USED TO DENOTE PARTS OF A PIECE OF WOOD.

TERMS AND DEFINITIONS

This short list is appended as a useful guide to potential boat builders. A more comprehensive list is contained in the Standards Association of Australia's Standard AS01-1964: *Glossary of Terms used in Timber Standards.*

TIMBER TERMS

Backsawn: Sawn so that the wide face of the piece is a tangential plane to the growth rings.

Batten: A piece of sawn or dressed timber of rectangular cross-section, usually between 19 mm and 40 mm thick, and between 25 mm and 75 mm wide.

Beam: A structural timber, supported at two or more points along its length.

Board: A relatively thin piece of sawn or dressed timber, of width greater than thickness.

Bow: A curvature from the plane of the wide face in the direction of the length.

Cover Strip: From 10 mm to 20 mm thick and various widths, used to cover joints to prevent entry of rain or to improve the appearance of the joints.

Dressed: Planed smooth, straight and square.

DAR: Dressed all round.

DBF: Dressed both faces.

DD: Double dressed or dressed both faces.

D_1F_1E: Dressed one face and one edge.

D_2E: Dressed two edges.

D_1E: Dressed one edge.

Flitch: A large segemnt of log with saw cuts on at least two surfaces.

Growth rings: Rings visible on the transverse or cross-section of a trunk or branch which mark a cycle of growth.

Lagging: Timber, of small section, used to cover the surface of a jig or mould.

Milled timber: Timber which has been passed through a machine to shape it to a desired profile.

Nominal sizes: The named size, or ordered size, which may vary from the actual size of the piece because of variations due to sawing, shrinkage and dressing and the tolerances allowed on these operations.

Plank: A piece of timber sawn or dressed to rectangular section 40 to 75 mm thick and more than 150 mm wide.

Quarter sawn: Sawn so that the wide face of the piece is a radial plane of the log. Trade practice in Australia is to class timber as quarter sawn when the average inclination of its growth rings to its wide face is over 45°.

Rough sawn: Surface condition of wood as it leaves the saw.

Round timber: Items such as piles, poles and posts utilized in the natural form of the tree.

Scantling: Timber of rectangular cross-section and of dimensions used in construction. Usually 35 to 100 mm thick and up to 150 mm wide.

Scarf joint: A joint made by bonding together two matching bevelled ends or edges.

Spring: Curvature from the plane of the edge, or narrow face, in the direction of the length.

Surfaced: Planed or dressed on one or more faces.

Timber: Wood in a form suitable for construction or manufacturing purposes.

Veneer: (a) A thin piece of wood produced by slicing or rotary cutting.
(b) Rotary cut: cut from a log by turning the log against a knife.
(c) Sliced: produced from a flitch by slicing with a knife.

Wane: The original underbark surface with or without the bark.

Want: The absence of wood other than wane from corner or edge of a piece.

Warp: Any variation from a flat surface. It may consist of bow, spring, twist or any combination of these.

TERMS USED IN BOATBUILDING

ACCOMMODATION PLAN—The drawing showing the interior layout of a vessel.

AFT—Astern, or towards the stern.

AHEAD—Forward, or in front.

AMIDSHIPS—The central portion of any boat, or neither to port nor starboard.

ANTI-FOULING PAINT—A specially prepared paint containing various poisons which discourage the attachment of marine growth to a vessel's hull.

APRON—A strengthening timber placed behind the stem.

ASTERN—Behind.

BALLAST—Weight, usually lead or iron, added to a vessel low down either internally or externally to provide stability.

BEAM—The maximum width of a vessel. Also a timber laid athwartships to support the decking; this is known as a deck beam.

BEARERS—Longitudinal supports for an engine.

BERTH—A sleeping place or bed aboard a vessel. Also refers to a place at a jetty where a vessel may moor.

BILGE—The lower part of any hull. Can refer to either inside or outside.

BILGE KEEL—A rubbing strip, usually fixed to the bilge of dinghies and small boats to stop chafe to the planking.

BITTS—Posts fitted in the foredeck to take the aft end of a bowsprit, which are also used for making fast an anchor warp or chain.

BODY PLAN—A drawing showing the shape of various sections of a boat if it were cut athwartships.

BOOM—A horizontal spar to which the foot of a sail is set.

BOW—The front of a vessel.

BOWSPRIT—A spar projecting beyond the bow from which a jib is set.

BREASTHOOK—A knee, either wood or metal which is fastened to longitudinal members such as stringers, deck shelves, etc., and to the stem, thus tying them together strongly.

BRIDGE DECK—The decking which separates the cockpit from the main cabin.

BRIGHTWORK—Woodwork on a yacht which is finished with varnish.

BULKHEAD—A partition below decks which separates one section from another. Used commonly to give extra strength to a vessel.

BULWARKS—A continuation of the planking, often above the deck to prevent the loss of gear or people overboard.

BUMPKIN—A spar which extends beyond the stern to which a standing backstay is attached.

BUNKBOARD—A canvas or timber bulwark fitted so as a sleeping person will not be thrown out of a bunk by the vessel's motion.

BUOYANCY TANKS—Airtight compartments in small vessels to give added buoyancy in case of the vessel becoming water-logged.

BUTT—The squared end of a piece of timber. Planks are butted when the squared ends are placed together.

CAMBER—The amount of curve athwartships in a deck.

CARLINE—Fore and aft members which support the cabin sides or cockpit and to which the deck and cabin top beams are secured.

CARVEL—A method of planking where the planks are fitted to lie alongside each other, presenting a smooth exterior finish.

CAT RIG—A sail rig which has one mast right for'ard and only one sail.

CAULK—To fill the seams between planks with caulking cotton so as to make them leakproof.

CENTREBOARD—A central keel which can be raised or lowered at will.

CHINE—The angle formed where the topsides meet the bottom in a V bottom or hard chine boat. Also refers to the longitudinal timber which runs fore and aft at this point.

CLEAT—A fitting to which a line may be easily fastened.

CLENCH—Term used when referring to copper nails which are turned back into the timber.

CLINKER (or clincher)—Type of construction where hull planking overlaps.

COACH HOUSE—The raised cabin of a boat.

COACH ROOF—The roof of the coach house designed to give extra height below.

COAMING—The raised sides of a hatch or cockpit.

COCKPIT—The well, usually placed aft, from which a yacht is steered.

COVERING BOARD—The plank running around the outer edge of a deck.

DEADWOOD—The strengthening piece which joins the keel to the sternpost.

DISPLACEMENT—The actual weight of the vessel.

DOGHOUSE (or dodger)—The raised cabin aft which gives added headroom or protects the helmsman.

DRAUGHT (Draft)—The depth of water necessary to float a vessel.

DRIFT—A tool used for driving plank fastenings home.

DRY ROT—Rot in timber which seems to flourish in badly ventilated, damp spots. Fungus attack. The term "dry rot" is not really correct: all decay results from damp conditions.

FALSE KEEL—A piece added to the main keel often used to fair in with the ballast keel.

FASTENINGS—Nails, screws, bolts etc., which are used to hold components together.

FIDDLE—A removeable strip of wood, which when in place prevents crockery etc., from falling off a cabin table, shelf etc.

FLARE—The outwards curve of a vessel's sides above the waterline.

FLOOR TIMBER—A transverse piece of either metal or wood which is fastened to the planking and timbers and to the keel, tying the construction together strongly.

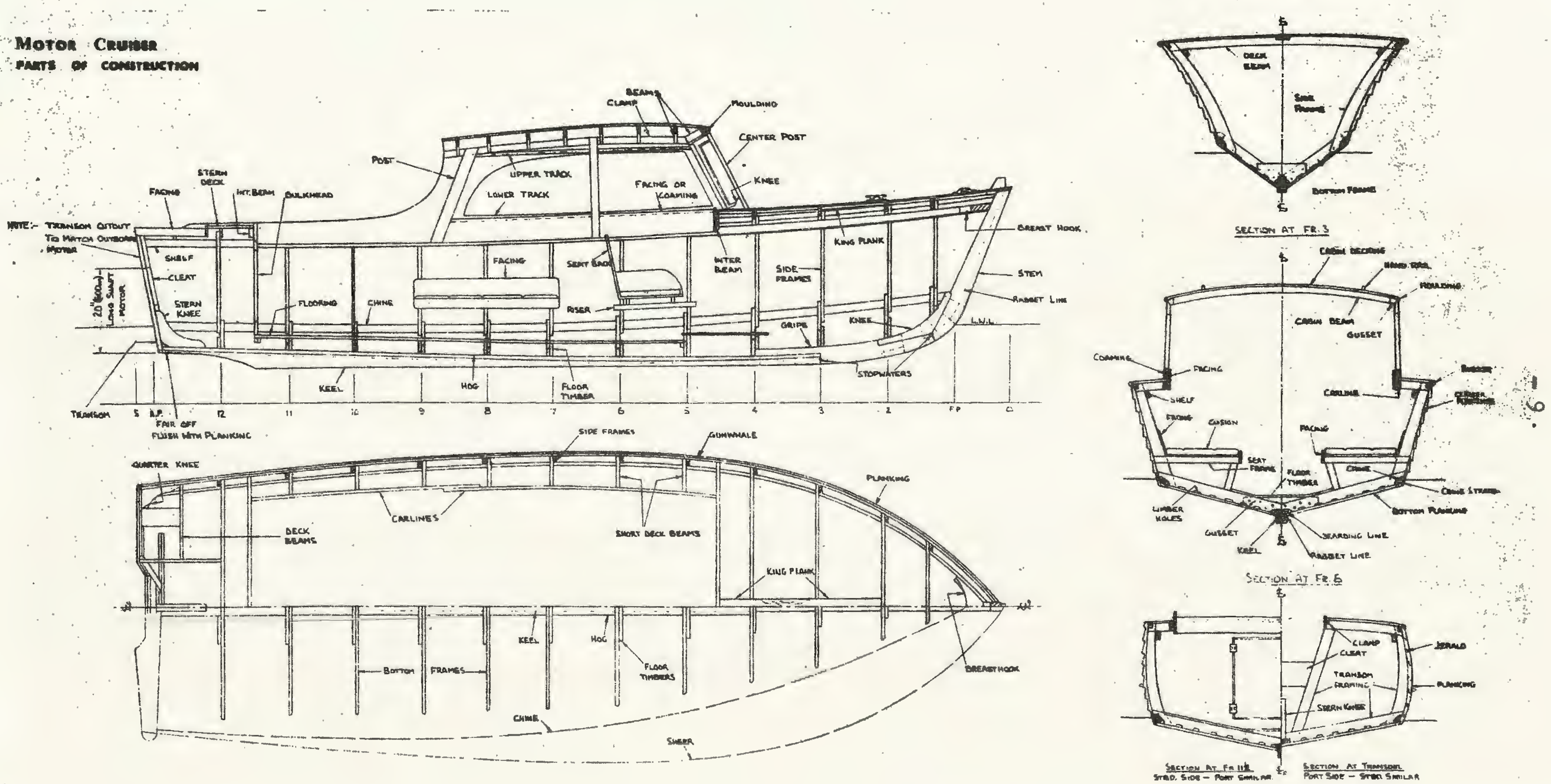
FORECASTLE—The accommodation in the bow.

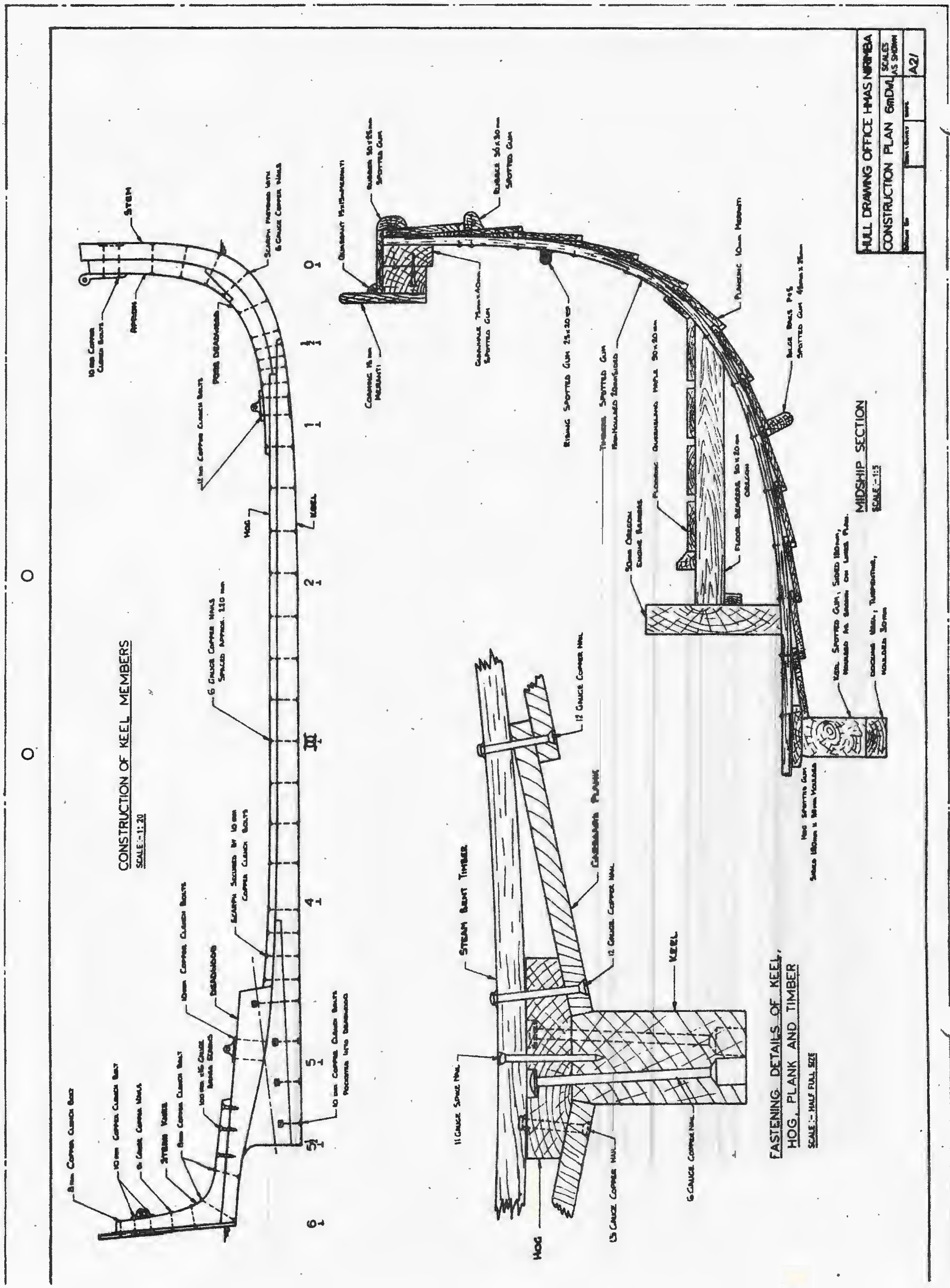
FOREFOOT—The section of bow between the waterline and the keel.

FOREPEAK—That section below deck which is right in the bow. A very cramped space used for stowing anchors, warps etc.

FRAME—A large rib of boat which is usually laminated, sawn or of metal, used particularly in plywood construction.

Motor Cruiser
Parts of Construction





CONSTRUCTION OF KEEL MEMBERS
SCALE :- 1:20
STEM
HOG
KEEL
MIDSHIP SECTION
SCALE :- 1:5
FASTENING DETAILS OF KEEL, HOG, PLANK AND TIMBER
SCALE :- HALF FULL SIZE
STEAM BENT TIMBER
12 GAUGE COPPER NAIL
11 GAUGE SPIKE NAIL
13 GAUGE COPPER NAIL
6 GAUGE COPPER NAIL
HULL DRAWING OFFICE HMAS NIRIMBA
CONSTRUCTION PLAN 6m DV
SCALES AS SHOWN
A2/

FREEBOARD—The height of a vessel's side above the waterline.

GAFF—The spar to which the head of a quadrilaterial sail is set.

GARBOARD (or garboard strake)—The plank which lies adjacent to the keel on each side. Often said to be the most difficult to fasten, yet the most important.

GRAVING—Taking the boat from water to repair.

GUNWALE—The upper edge of the topsides on a boat.

HACK KNEE—A knee bracket cut out of a solid piece of timber about 30 mm thick.

HALF BEAM—A partial deck beam or one that does not extend the full width of the boat.

HALF BREADTH PLAN—The drawing showing the shape of waterlines and level lines.

HATCH—A deck opening usually covered by a hinged lid.

HEADROOM—The height of the cabin roof from the cabin sole.

HEEL—The lower end of a mast or the aft end of the keel.

HELM—The wheel or tiller by which a boat is steered.

HORN TIMBER—The fore and aft timber between the stern post and transom.

JOGGED FRAME—A section is cut away to take transverse members.

KEEL—The back bone of a boat upon which the rest is built.

KEELSON—Inside the planking, above the keel, but separate from the keel.

KING PLANK—The centre plank of decking.

KNEE—A shaped piece of timber, preferably with the grain running with the shape, which is used to the together such parts as deck to topsides, cabin roof to cabin sides etc., now replaced by plywood.

KNIGHTHEADS—Timbers supporting the bowsprit and giving additional support to the planking just abaft the stem.

LAMINATED—Made up of thin strips glued together.

LANDS—The ledgers which overlap in clincher planking.

LAP STRAKE—A method of sheeting a boat.

LEE BOARD—Used to increase the height of the side.

LEVEL LINES—Lines drawn at regular intervals on a lines plan which are parallel to and above the L.W.L.

LIMBER HOLES—Holes drilled in floors and frames to allow bilge water to run to the lowest part so it may be pumped out. Drainage holes between the sheeting and the ribs.

L.O.A.—Length over all, or the extreme length.

LOCKER—Boating term for cupboard.

LOFTING THE PLANS—Laying down the lines or drawing the plan of the boat full size on the floor.

L.W.L.—The length of a boat measured in a straight line at the waterline where she floats.

MAST STEP—The timber on which the mast is stepped.

OAKUM—Fibrous material used for caulking.

OFFSETS—Measurements supplied with a plan which enable the builder to lay the boat out to full size.

OVERHANG—That part of a hull which extends beyond the extremities of the L.W.L.

PARTNERS—A strong wood framework to support a mast as it passes through the deck.

PAY—To put pitch in the joints and seams of the boat.

PLANK STEALERS—Short planks used to make up the total length.

PORT—The left hand side of a boat when looking forward.

PRAAM—Refers to a dinghy which has a transom at both ends.

PULPIT—Strong safety rail fitted around the bow.

RABBET (Rebate)—A groove cut in the stem, keel etc., to receive the edge of a plank.

RAIL—A narrow plank fitted to the top of a bulwark. Often finished bright for effect.

REVERSE SHEET—A deck line which in elevation is higher amidships than at either end.

RIBBAND—A light, flexible timber used in fairing the hull shape. (A fairing batten).

RISER—A fore and aft timber which supports the thwarts in a dinghy.

ROVE—Cup-shaped copper washer used in boat building to rivet copper nails.

SAMSON POST—A strong post in the foredeck to which anchor or mooring chains are secured. May also be placed after for towing etc.

SCARF—A long diagonal join between two pieces of timber.

SCUPPER—Drain hole in bulwark which allows water on deck to drain overboard.

SHEER—The shape of the vessel at deck level when viewed from one side.

SHEER STRAKE—The top plank on each side.

SHELF—The longitudinal member which supports the outer end of deck beams.

SKEG—An extension beneath the hull which protects the propeller, also called a shoe.

SOLE—The cabin floor.

SPALL—A supporting secondary timber.

SPLINE—A thin wedge-shaped piece of wood which is glued between planks in place of caulking.

STARBOARD—The right hand side of a vessel when facing for'ard.

STEM—The most for'ard timber in the hull to which the for'ard end of planks are fastened.

STOPPER—A plug.

STOPPING—Material for filling gap.

STOPWATER—A softwood plug which is driven across joins which cannot be caulked.

STRINGER—A longitudinal strengthener fastened to the frames or timber.

STRAKES—The boards used to plank the hull of a boat. Usually comparatively thin in relation to width.

TAFFRAIL—A raised rail around the stern.

TINGLE—A patch repairing a hole in the hull.

TOPSIDE—The sides of the hull above the waterline.

TRANSOME—The single board etc., used to make up the stern.

TRENAIL (or trunnel)—A wooden "nail", not often seen today.

TUMBLE HOME—The opposite of flair, i.e., the inwards curve of the topsides from the waterline, or some place.

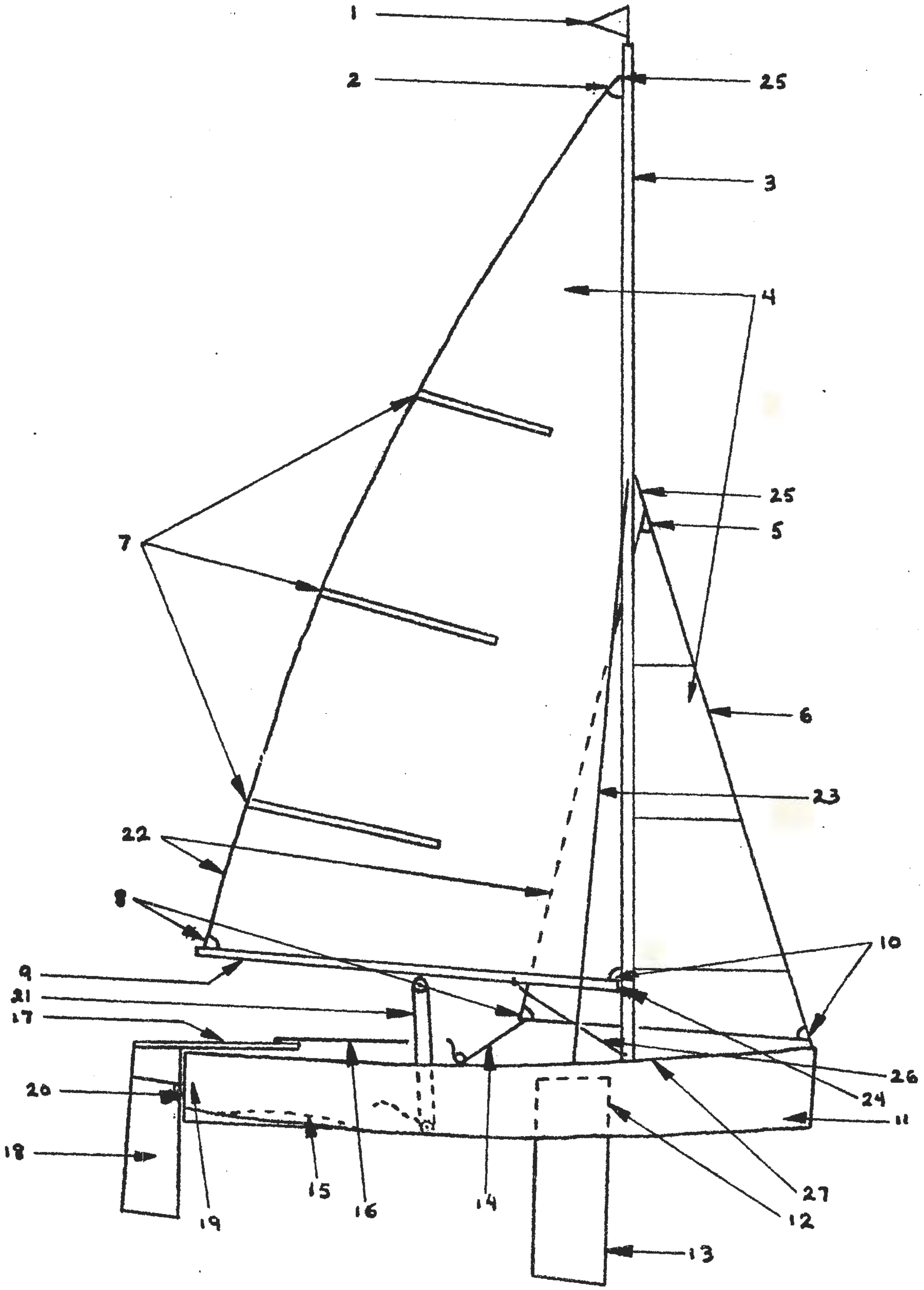
WALE—A horizontal protecting strip.

WET ROT—Fungus attack. The term "wet rot" is not correct. *See* "dry rot" also incorrect.

Parts of a Sailboat

1. Burgee - a small flag flown at the masthead.
2. Head of mainsail - the top corner of the mainsail, reinforced to take the Halyard which pulls the sail up.
3. Mast - a metal or wooden Spar used to hold the sails aloft.
4. Luff - the forward or leading edge of any sail.
5. Head of jibsail - the top corner of the jibsail, or headsail, reinforced to take the Halyard which pulls the sail up.
6. Forestay - main support wire to prevent the mast moving forward or Aft. Normally the jibsail is attached to the Forestay.
7. Battens - long, flat strips of wood or plastic used to assit in setting and keeping the shape of the mainsail.
8. Clew - the bottom, rear, corner of a sail. With the mainsail, the clew is attached to the Boom, and the jibsheets are attached to the clew of the jibsail.
9. Boom - a spar used to extend the Foot of the mainsail.
10. Tack - the bottom, front, edge of either the mainsail or jibsail.
11. Bow - the front part of a boat.
12. Centerboard case - used to house the centerboard.
13. Centerboard - a flat, wooden board which is lowered through a slot in the boat's keel. It is designed to prevent the sideways movement of the boat while moving through the water.
14. Jib Sheets - two lines (ropes), one on either side of the boat, both attached to the clew of the jibsail. Used to control the angle of the jibsail.
15. Hiking straps - webbing straps attached to the floor of the cockpit, used to allow crewmembers to lean out of the boat (to control heel) with safety.
16. Tiller Extension - extended part of tiller, used by helmsman while hiking out of the boat.
17. Tiller - wooden handle attached to rudder head for steering boat.
18. Rudder - a flat piece of timber used for steering, controlled by Tiller.
19. Stern - the end section of a boat.
20. Transom - the very end of the Stern.
21. Mainsail sheet - a line (rope) used to control the angle of the mainsail, attached to the Boom.
22. Leach - the after (aft) edge of the main or jibsail.
23. Shrouds - main support wires (one either side of mast) to prevent sideways movement of the mast.
24. Gooseneck - a fitting attaching the Boom to the mast, allowing it to hinge.
25. Halyards - wires, with rope ends, used to raise and lower the sails.
26. Boom vang - a device attached to both the Boom and the bottom of the mast, preventing the Boom from lifting when running before the wind.
27. Gunwhales - (pronounced "gunnels") the edge of the deck and cockpit where the sides of the boat join the top.

Parts of a Sailboat



SEASONING OF TIMBER

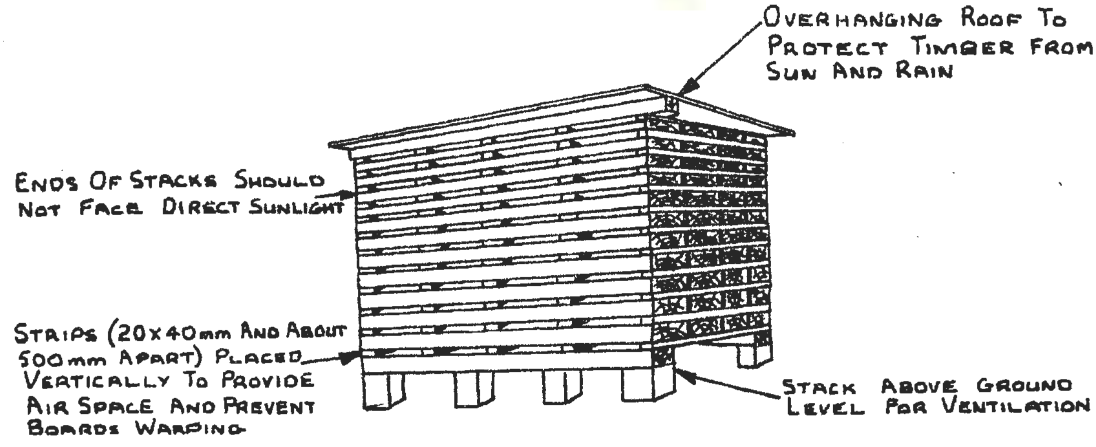
Generally the timber used in boatbulding should not exceed 20 per cent moisture content, except when the craft is usually moored: then the planking below the water line should be above 20 percent. Laminated masts and spars, as well as joinery should be in the range of 10 per cent to 15 per cent moisture content.

The most accurate method of checking the moisture content of timber is by determining the loss of moisture when a weighed sample is completely dried in an oven using the techinique described in Australian Standard 1080 - 1972: "Methods of Test for Moisture Content of Timber" and Forestry Commission of N.S.W. Technical Paper No. 13: "Methods of Determining the Moisture Content of Wood". A fast, non-destructive but less accurate method is to use a battery operated moisture meter which in the range below about 30 per cent is sufficiently accurate for boatbuilding purposes. This meter measures the resistance of the wood to an electric current and indicates the moisture content of the piece on a dial. The relationship between electrical resistance and moisture content is not the same for all timbers so it is necessary to apply species correction figures; they are given in Foresty Commission Technical Publication 13 mentioned above. The electrodes fitted to the meter are intended for the testing of nominal 25mm thick stock, but thicker material can be tested by first driving nails to the centre of the piece, at the same distance apart as the electrodes, and resting the electrodes on the nails to make the reading.

Timber may be seasoned by these methods:-

1) Air - drying
2) Kiln drying
3) Combined process of air and kiln drying.

1) For the air-drying process the timber must be stacked so that there is good air circulation around each piece in the stack. To obtain this circulation the timber must be spaced by placing 20 to 25mm thick strips between each layer of boards in the stack, the strips being placed on vertical lines, at 500 to 1000mm intervals so that the boards will not become distorted. It is very desirable that drying stacks should be covered to prevent the entry of rain and the excessive splitting of the top layers of boards. Further information on drying procedures is given in Forestry Commission Technical Publication 9: "Seasoning of Timber".



Timber contains free water (that inside the cells) and "hydroscopic" or "combined" water (that held in the cell walls). The free water will evaporate first at quite a rapid rate but the combined water will leave the wood much more slowly. When the combined water begins to leave the cell walls, the cells begin to change shape and shrinkage takes place. As the outer part of the wood can dry more quickly than the centre, shrinkage is not uniform and surface checking may occur because of the resulting development of stresses.

Moisture can escape more readily through the end grain and may cause considerable end splitting. This can be reduced by the use of a heavy bodied paint, bituminous paint or a wax preparation brushed onto the end of each board to slow down the rate of escape of moisture.

2) Kiln drying or the artificial drying methods requires that the timber be stacked in a similar manner to that for air-drying, placed on special trucks and wheeled into oven-like rooms called kilns, where heat and humidity are controlled. The timber is dried by air circulated by fans over steam heated coils. Steam inlets supply moisture to control the humidity.

Care must be exercised in the early stages to ensure that the free moisture in the cell cavities is not drawn off too rapidly resulting in serious degrade in the form of collapse. This is a flattening of the soft wood cell structure causing distortion, severe shrinkage and great loss in overall strength. Kiln drying is particularly suited to softwoods as they are not prone to collapse.

The advantages of kiln drying are a considerable reduction in the time required for seasoning, destruction of insects and fungi, reduction of moisture content to any desired level, and a measure of control to minimise the causes of seasoning defects.

3) Combined process combines the advantages of both the air drying and kiln drying and is particularly suitable for seasoning Australian hardwoods which are susceptible to checking and distortion if the removal of the gree moisture from the outer wood cells is too rapid.

It has been found in the case of hardwoods that it is more economical to air dry the stock from green to 25 to 30 per cent moisture content and then kiln dry to the required moisture content.

TIMBER SPECIES

Because of the wide variety of marine craft it is not possible to list individual species in order of preference as design considerations must be taken into account when selection is being made. It is presumed that the designer will relate the known characteristics, strength, density, bending properties, permeability to preservative treatment and ability to take and adhesive bond when making a selection for a particular purpose.

Some of the more common species listed in Ausgralian Standard 1738-1975 for the various boat parts given below.

Part	Timber	Strength group (see note *a* below)	Seasoned weight (kg/m³)	Durability in marine craft (see note *b* below)
Planking and bulkhead sheathing	Beech, white	D	510	High
	Blackbutt	B	900	High
	Cedar, red	D	420	High
	Fir, Douglas	D	540	Medium
	Gum, spotted	A	930	High
	Gum, Sydney blue	B	910	Medium
	Kauri species	D	460-540	Low to medium
	Maple, Queensland	D	540	Medium
	Meranti, red	C-D	Must exceed 540	Medium
	Messmate	C	830	Medium
	Pine, celery top	D	640	High
	Pine, hoop	D	540	Low
	Pine, Huon	D	540	High
	Pine, King William	D	420	High
	Pine, klinki	D	450	Low
	Stringybark, yellow	B	860	High
	Tallowwood	A	990	High
Decking	Beech, white	D	510	High
	Bollywood	D	500	Medium
	Gum, rose	C	700	Medium
	Gum, spotted	A	930	High
	Gum, Sydney blue	B	910	Medium
	Kauri species	D	460-540	Low to medium
	Pine, celery top	D	640	High
	Pine, hoop	D	540	Low
	Pine, Huon	D	540	High
	Pine, klinki	D	450	Low
	Pine, white cypress	D	690	High
	Stringybark, yellow	B	860	High
	Tallowwood	A	990	High
Steam bent timbers	Ash, silver	C	690	Medium
	Beech, myrtle	C	700	Low
	Brigalow	C	990	High
	Gum, spotted	A	930	High
	Oak, tulip	C	840	Medium
	Pine, celery top	D	640	High
	Pine, Huon	D	540	High
	Quandong, silver	D	540	Low
	Yellowwood	C	700	Medium

Part	Timber	Strength group (see note *a* below)	Seasoned weight (kg/m³)	Durability in marine craft (see note *b* below)
Sawn worked frames Floor frames Bulkhead frames Engine beds	Blackbutt	B	900	High
	Box, grey	A	1 110	High
	Fir, Douglas	D	540	Medium
	Gum, grey	A	1 080	High
	Gum, mountain grey	B	960	High
	Gum, rose	C	700	Low to medium
	Gum, spotted	A	930	High
	Gum, Sydney blue	B	910	Medium
	Ironbark species	A	1 120	High
	Messmate	C	830	Medium
	Stringybark, brown	B	900	Medium
	Stringybark, white	B	900	High
	Tallowwood	A	900	High
	Tea-tree, broad-leaved	C	740	High
Straight stems Deadwoods Keels Keelsons Stern Posts Horn Timbers	Blackbutt	B	900	High
	Box, grey	A	1 110	High
	Gum, grey	A	1 080	High
	Gum, river red	B D in bending	850	High
	Gum, spotted	A	930	High
	Ironbark species	A	1 120	High
	Mahogany, red	B	960	High
	Mahogany, white	B	990	High
	Stringybark, white	B	900	High
Stringers Chines Gunwales Deck framing	Ash, silver	C	690	Medium
	Blackbutt	B	900	High
	Fir, Douglas	D	540	Medium
	Gum, spotted	A	930	High
	Gum, Sydney blue	B	900	Medium
	Mahogany, red	B	960	High
	Mahogany, white	B	990	High
	Spruce, Sitka	D	430	Low
	Stringybark, yellow	B	860	High
	Tallowwood	A	990	High
Mooring and Towing Bitts	Box, grey	A	1 110	High
	Gum, grey	A	1 080	High
	Gum, spotted	A	930	High
	Ironbark species	A	1 120	High
	Mahogany, white	B	990	High
	Tallowwood	A	990	High
Masts Spars Derricks	Ash, alpine	C	610	Low
	Ash, silver	C	690	Medium
	Fir, Douglas	D	540	Medium
	Gum, spotted	A	930	High
	Maple, Queensland	D	540	Medium
	Pine, klinki	D	450	Low
	Quandong, silver	D	540	Low
	Spruce, Sitka	D	430	Low
	Stringybark, yellow	B	860	High

NOTE (a)

Strength Groups

Average Properties of Clear Material

Group	Modulus of rupture MPa		Modulus of elasticity MPa		Crushing strength parallel to the grain MPa		Shear strength MPa	
	Green	12% moisture content	Green	12% moisture content	Green	12% moisture content	Green	12% moisture content
A	105	168	16 800	21 000	52.5	84	14	17.5
B	84	140	14 700	18 200	42	70	10.5	13.3
C	70	112	11 900	15 400	35	56	8.4	11.2
D	49	84	10 500	13 300	24.5	42	5.6	7.7

NOTE (b) Durability

The term durability as used in Australian Standard 1738-1975: "Timber for Marine Craft" refers to the natural resistance of unpreservatized heartwood used in most extreme conditions and in the most vulnerable applications existing in a craft kept continuously at mooring.

RATING	DESCRIPTION
High	Indicates that the heartwood should be satisfactory under the above conditions.
Medium & Low	Species with such ratings should be treated with more caution and preservative treated, if accessible, for rigorous conditons. Timbers of these ratings may be suitable without preservation when used in applications where durability is not particularly called for, as in craft which are usually stored on shore under cover.

MEASURING AND MARKETING OF TIMBER

1) Methods of Measuring Timber: For short lengths (up to about 4 metres) use a 1 metre folding rule. For long lengths use a steel tape (up to 30 metres). If long lengths are measured with a 1 metre rule any inaccuracies in marking off will be multiplied by the number of times the rule is shifted.

Timber sizes are usually quote in the following manner.

200 x 50mm x 3m

50 x 25mm x 1m

Several different lengths of the same section size.

100 x 50mm 2/4m 3/2m 2/1m

75 x 25mm 3/4m 3/2m 4/1m

2) Allowance For Dressing: Dressed timber is finished under size from the nominal size. In smaller sections and scantlings5mm is generally allowed for machining. In very large sections say 300mm or more, up to 20mm is allowed. For example:-

(a) Nominal size 75 x 50 mm
Finished size 70 x 45 mm

(b) Nonimal Size 300 x 50 mm
Finished size 280 x 45 mm

(c) Nominal size 300 x 300mm
Finished size280 x 280mm

3) Method of Ordering Timber: The timber order should be placed in writing and a copy should be retained by the purchaser.

The order should state the name and quality of timber species required, dressing if required, width and thickness, length and number of pieces.

The order should also state the seasoned conditioned required e.g., 10% to 15% or 15% to 20%, the time and place of delivery.

It is sometimes advisable to state purpose for which the timber is required so that the merchant can recommend a substitute if the particular species of timber originally ordered is not available.

The Forestry Commission has a timber inspection service available at a small fee for checking timber for compliance with specifications. The inspector will grade the timber according to standards as laid down by the Standards Association of Australia or by such other grading rules as are acceptable to both buyer and seller.

TIMBER BENDING

The main considerations involved in the bending of timber are:-

Selection of suitable stock.

Softening the timber.

Reaction of the timber to the stresses arising from the bending process.

Drying after bending so that the bent piece will retain its shape without failure.

SELECTION AND PREPARATION OF SUITABLE STOCK

Choose stock from a species known to have good bending properties and which in addition is raight grained and free from such failur producing defects as knots, checks, shakes and brittle wood.

Brittle wood may be defected by digging into the surface with a sharp pointed instrument. A tough timber will yield a strong splinter whibh tends to run along the grain. If the timber is brittle, the splinters will be short and "carroty".

The timber should be reduced to the smallest possible size before bending and should be dressed all round. Saw marks on the surface of a piece of timber assist failure and therefore should be removed by planing.

Too high moisture content may cause crumpling on the compression side of the timber and the timber will also be more difficult to dry after bending. On the other hand if the moisture content is too low more force will be required to make the bend and the strapping must be very efficient to prevent failure on the tension side of the curve.

It is generally considered that timber dried to a moisture content of 15 to 20 per cent is in the best condition for bending, but suitable moisture content for dense, hard, strong timbers may be somewhat in excess of 20 percent.

SOFTENING

The most common method for softening timber before bending is to steam it. This is most frequently carried out at atmospheric pressure, although higher pressures are sometimes used.

For steaming at atmospheric pressure the usual time allowance is up to one hour per 25mm of thickness. Steaming at from 70 to 110 kilopascals reduces the steaming time but the equipment is more expensive and there is a loss of time while the pressure is released.

Steam chambers for steaming at atmospheric pressure may be made of wood, sheet metal, concrete, brick or asbestos cement sheeting, depending on the working life required. All chambers should be built so that condensed moisture can drain away. The steam chambers, if other than of a temporary nature, should be painted inside with a bituminous paint.

A simple steam chamber of a temporary nature would consist of a 20 litre can to boil the water, connected by means of a hose to a length of 75mm (inside diameter) galvanised iron or asbestos cement pipe. The wood to be bent is placed in the pipe and the exhaust end of the pipe is partially closed, to reduce the rate at which the steam can escape. The exhaust end of the steam chamber should be slightly lower than the inlet end, to drain the condensed moisture.

DRYING AFTER BENDING

It is necessary for the bent piece to set and dry before it may be used. Setting is usually completed by the time the timber has cooled to atmospheric temperature but drying will take much longer. Individual pieces should be so stacked that there is a uniform circulation of air throughout the stack.

Bends generally straighten out slightly when released from restraint so they should be slightly over-bent. Bent pieces should not be wetted again as they will tend to open out, and if restrained may fracture. They should be sealed with a suitable coating to prevent an increase in moisture content, once the necessary drying has taken place.

Laminated construction may be necessary where a severe bend is required in a thick member, the laminations being up to about 3mm thickness.

BENDING EQUIPMENT

Heated timber will accept a lot of compression but will not stretch very much. To make use of these facts in bending timber, strapping is applied to the outside of the bend to prevent the timber from stretching and to force the inner edge to compress.

The end blocks, to which the strapping is fixed must be firm and strong and must not allow any "give" during the bending process. The reversed lever type of equipment is said to be the most efficient and the lever should be about as long as the stock being bent.

Bends, in which the ratio of the thickness of the piece to the radius of curvature is less than on-thirtieth, can often be made without taking any special precautions but tighter curves will require assistance from the strapping.

The form about which the bend is to be made should be as strong as possible and must be firmly fixed to prevent any rotational movement. Screw presses, hydraulic presses and steam heated presses are often used for mass production of bent pieces when the bends are not severe.

FASTENINGS

The kind, size and location of each fastening must be carefully determined by taking into consideration the task it will perform. Fastening must be driven in carefully drilled holes of proper size so that the holding power will be maximum. Under no circumstances must bare iron or mild steel be used and fastenings which have been zinc coated by electroplating should be avoided and preference given to those that are hot dipped.

CLINCH BOLT: A long through fastening having the ends riveted over washers or clinch rings. Usually of galvanised iron or copper and are used for fastening scarphs, stems, deadwoods, keelsons, stringens, clamps knees, etc.

SCREW BOLT: An ordinary machine bolt having a head on one end and a nut on the other. The head may be square or hexagonal. They may be substituted for clinch bolts and are used for fastening engine beds. Made in silicone bronze, monel and galvanised iron.

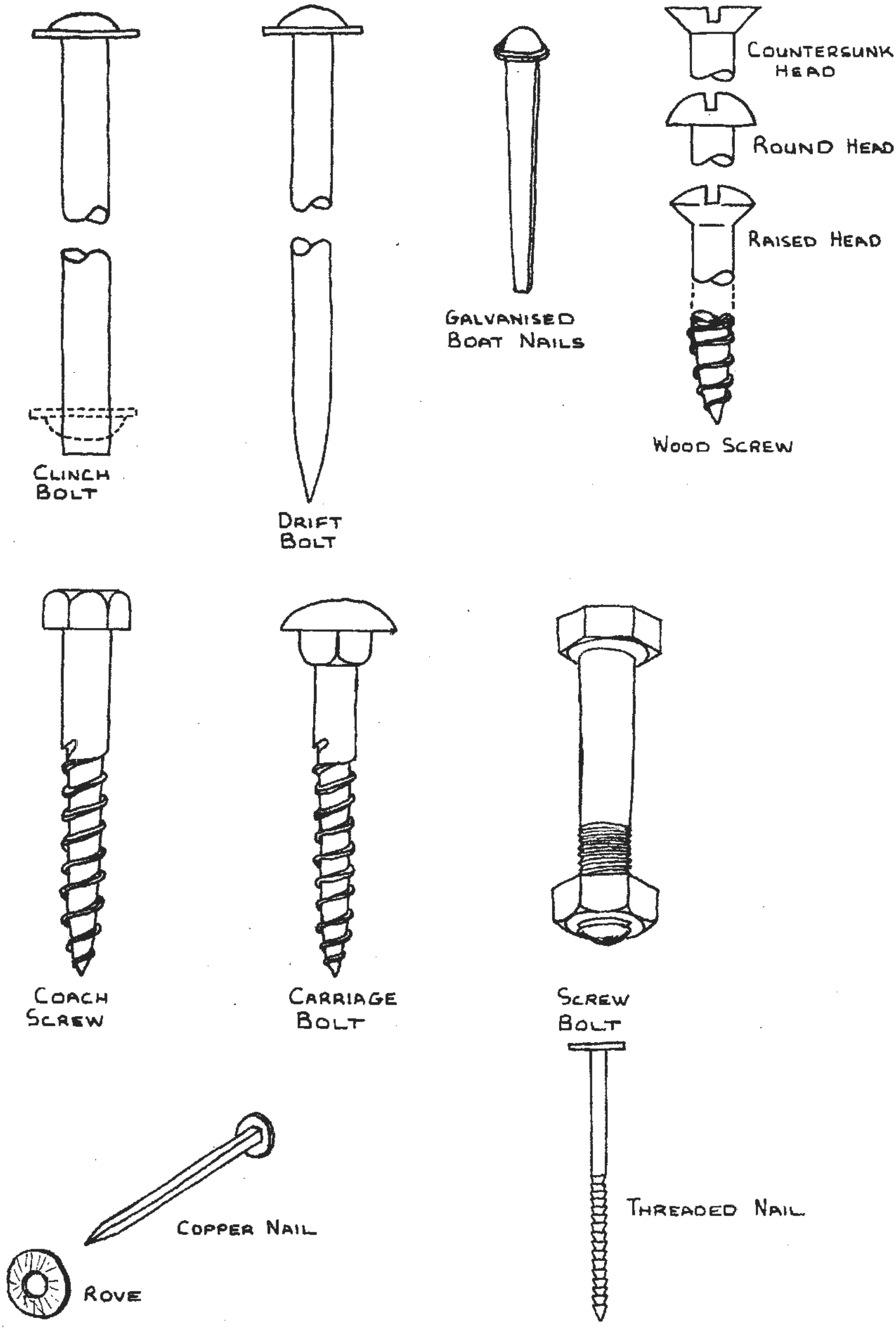
Screw bolts have the advantage over clinch bolts of being able to be tightened when the wood shrinks.

CARRIAGE BOLTS: A screw bolt having a round button head with a square shank under the head to prevent turning in the wood. They are used for fastening frames to floors, stringers to clamps, and frames and deck beams to clamp or shelves and are made of galvanised iron, silicon bronze and stainless steel.

DRIFT BOLTS: A length of round bar having a washer or clinch ring and upset head one end only and slightly pointed the other end, driven like a spike. The hole should be slightly smaller in diameter than the bolt and about two diameters shorter than the length of bolt. Use where it is not practicable to use clinch bolts, screw bolts or carriage bolts. Used in keels, deadwoods, rudders, centre-boards and similar places. Made from bronze or galvanised iron.

COACH SCREWS: Have a wood screw thread with a hexagonal or square head and is driven with a spanner. Made of galvanised iron, bronze and silicon brass, and are used instead of spikes or drift bolts where greater strength is required.

GALVANISED BOAT NAILS: Are cheap fastening and not to much life can be expected from them. They are heavy forged nails with irregular section, tapering to a blunt chisel point. They are used for planking decking and fastening frames to floors etc.,. Where the frames are about 30mm to 38mm the nail may be driven through with about 5mm projecting and clinched. If there is sufficient thickness in the frame, it will hold without clinching. To prevent splitting the frame the nail is driven with the chisel edge across the grain.


Countersunk Head
Round Head
Raised Head
Galvanised Boat Nails
Wood Screw
Clinch Bolt
Drift Bolt
Coach Screw
Carriage Bolt
Screw Bolt
Threaded Nail
Copper Nail
Rove

<u>COPPER NAILS</u>: Are made with flat heads and can be bought in various lengths and gauges. They are used for fastening planks to frames, laps in clinker planking, and intermediate fastenings in double planking.

For many applications copper nails are used in conjunction with roves, tight fitting conical washers. The nail is driven through a bored hole small enough to ensure a tight fit and large enough to ensure the timber will not split. A "dolly" is held against the head of the nail whilst the rove is driven down the nail to fit tightly on the timber or plank using a rove punch, which is a piece of steel with a hole in the end to fit over the nail, and hammer. The surplus nail is cut off using pliers or pincers leaving a length equal to one and a half times the diameter of the nail for riveting. To form the point and draw the wood together a "dolly" is held against the head of the nail and the excess nail is rivetted over the rove using light blows from a light ball-paned hammer.

<u>THREADED NAILS:</u> Are nails with annular rings around the shank. As the nail is driven the grooves on the shank shape the wood fibres into countless minute wedges that grip the shank to resist withdrawal. They are made from monel or silicon bronze.

When mixed fastenings are used care should be taken that iron and copper do not come in contact, or very near together, otherwise electrolysis will destry the iron.

For the same reason a copper washer should never be used with an iron bolt or visa versa.

Most fastenings in boat construction require holes bored for them and it is very important that the holes are of proper size, so that the bolt, nail or screw may be driven as tight as possible without danger of splitting the wood or injuring the fastening.

When boring a long hole it is necessary to withdraw the bit frequently to clear the bit and if there is a tendency to bind and become hot an occasional dip in grease will help.

Boat nails and square spikes must be driven so that the flat chisel points across the grain, because if turned the other way the point acts as a wedge, tending to split the wood.

ADHESIVES

Adhesives are used in a wide variety of applications and require careful preparation and mixing. Instructions should be followed closely and where any problems arise the manufacturer should be contacted. Those containing formaldehyde or amine hardeners may cause dermatitis, thus making special precautions necessary, such as removal of the adhesive from the skin before setting takes place. Barrier creams may be used as a protective measure. The adhesives should be mixed in clean containers and kept covered to exclude all dirt.

CONTACT

Form	Viscous cream or coloured liquid.
Preparation	No preparation required.
Shelf life at 20° C in suitable closed container	Greater than 1 year.
Assembly time at 20° C	10–20 minutes (longer with special formulations).
Pressing time and temperature	Several seconds to several minutes at room temperature.
Setting mechanism	Loss of solvent.
Time to develop ultimate strength	Several weeks.
Gap-filling properties	Good.
Weather resistance	Fair.
Applications	Universal adhesive, but copper and its alloys unsatisfactory with many formulations.
Remarks	Bond can be achieved by hammer blow without pressure, but orthodox pressure application gives higher strength. At best, strength lower than other wood glues, still lower under permanent load. Adhesive will deteriorate after prolonged period. Inflammable.

UREA FORMALDEHYDE

	A	B	C	D
Form	White viscous liquid with liquid or powder hardener.	As for A together with wheaten flour extender.	White powder, sometimes with liquid or powder hardener.	As for C together with wheaten flour extender.
Preparation	Mixing of resin and hardener, or separate application*.	Mixing of resin, hardener, flour and water, or separate application*.	Mixing with water and sometimes hardener or separate application*.	Mixing of resin, hardener, flour and water or separate application*.
Shelf life at 20° C in suitable closed container.	Resin 3–6 months. Hardener no limit.	As for A.	Hardener no limit.	As for C.
Assembly time at 20° C	Cold-set glues up to ½ hour, hot-set glues up to 12 hours or more.			
Pressing time and temperature	2–24 hours at room temperature. Several minutes at 90–125° C.			
Setting mechanism	Polycondensation.	Polycondensation and loss of water.	Polycondensation.	Polycondensation and loss of water.
Time to develop ultimate strength.	One week for cold setting. Stacked after hot setting.		48 hours if block.	
Gap-filling properties	Poor, but may be improved by use of gap-filling resin or hardener.			
Weather resistance	Unprotected glue line withstands weathering for at least 1 year.	Weather resistance lowered by extension.	Unprotected glue line withstands weathering for at least 1 year.	Weather resistance lowered by extension.
Applications	Plywood, particleboard, assembly gluing, R.F. gluing.			
Remarks	Setting temperature for cold-setting formulations should be above 12° C. Weather resistance of liquid mixes may be improved by addition of melamine or resorcinol. Flour extensions of more than 50 parts by weight of flour to 100 parts of liquid resin may cause the glue to weaken and possibly fail after several years. *With separate application the resin is spread on one face to be glued, and the hardener on the other. Hardening then takes place when the two faces are brought together.			

MELAMINE FORMALDEHYDE

Form	Solid thin film.	White powder—usually with powder hardener.
Preparation	No preparation required.	Mixing with water and hardener.
Shelf life at 20° C in closed container	Up to 3 months.	At least 2 years.
Assembly time at 20° C	Equal to shelf life.	Up to 24 hours.
Pressing time and temperature	Several minutes at 90° C.	
Setting mechanism	Polycondensation (cross linking and splitting-off of water).	
Time to develop ultimate strength	After block stacking for 48 hours.	
Gap-filling properties	Poor.	Good.
Weather resistance	Unprotected glue line will withstand weathering for several years.	
Applications	Veneering using light and permeable veneers.	

CASEIN

Form	Ready-mixed cream powder.	Granules of lactic casein.
Preparation	Mix with water.	Mix with water and alkaline materials.
Shelf life at 20° C in closed container	9–12 months.	Up to 2 years.
Assembly time at 20° C	Up to 40 minutes.	
Pressing time and temperature	2 to 4 hours at room temperature. Several minutes above 100° C.	
Setting mechanism	Chemical action combined with loss of water.	
Time to develop ultimate strength	1 week.	
Gap-filling properties	Good.	
Weather resistance	Moderate.	
Applications	Assembly gluing, plywood production, laminating.	

RESORCINOL FORMALDEHYDE AND RESORCINOL PHENOL-FORMALDEHYDE

Form	Viscous reddish-brown liquid with liquid or powder hardener.
Preparation	Mixing of resin and hardener.
Shelf life at 20° C in closed container	Resin: 3 months or more. Hardener: 6 months or more.
Assembly time at 20° C	Up to 60 minutes.
Pressing time and temperature	24 hours at temperature above 20° C. Several minutes at 90° C.
Setting mechanism	Polycondensation.
Time to develop ultimate strength	1 week at 20° C.
Gap-filling properties	Good.
Weather resistance	Excellent.
Applications	Laminating, assembly, R.F. gluing.
Remarks	Setting temperature should be above 20° C and for maximum wet strength with some hardwoods, above 60° C.

EPOXY RESIN

Form	Honey-like liquid or coloured paste, with liquid hardener.	Solid sticks, powder.
Preparation	Careful mixing with hardener.	No preparation: resin melted onto surface to be glued.
Shelf life at 20° C in suitable closed container ..	Resin at least 6 months, hardener at least 1 year.	At least 2 years.
Assembly time at 20° C	Several minutes to 1 hour.	Equal to shelf life.
Pressing time and temperature	Up to 48 hours at 20° C; approx. 1 hour at 90° C.	48 hours at 110° C; 30 mins at 200° C.
Setting mechanism	Polymerization.	
Time to develop ultimate strength	Up to several weeks.	
Gap-filling properties	Excellent.	
Weather resistance	Moderate to good.	
Applications	Wood-to-metal, metal-to-metal, universal glue. High chemical resistance glue.	
Remarks	Adhesive not soluble in water, hardeners may be severe on unprotected skin. Shrinkage during setting negligible.	

BONDING PRESERVATIVE TREATED TIMBER.

1) Casein Adhesives: Use in dry situations only. Like alkaline conditions.

2) Urea Resin Adhesives: For water resistant uses. Urea resin adhesives should not be used on greasy surfaces. Like acidic conditions.

3) Resorcinol Adhesives: May be used in situations exposed to chemically polluted atmospheres etc.,. Resorcinol adhesives usually contain industial methylated spitit and thus can "wet" surfaces which are water repelent. Set under neutral conditions by chemical action initiated by the addition of a hardener.

PROBLEMS TO BE CONSIDERED

1) Moisture content of timber
2) Adhesive penetration
3) Curing temperatures
4) The alkaline character of casein adhesives
5) The acid setting conditions of urea resin adhesives
6) The neutral setting conditions of resorcinol resin adhesives
7) The special preparation of the surface to be bonded.

TYPES OF PRESERVATIVES.

(a) Tar Oil types such as creosote
(b) Types requiring Organic Salvents, such as chlorinated naphthalnes, copper and zinc naphthalines, pentachlorphenol.
(c) Water Borne types such as copper/chrome, copper/chrome/arsenic, copper sulphate.

TO BOND TAR OIL PRESERVATIVE TIMBER

(Tar oils are mainly used in applications which do not call for bonded sections).

Wipe the joint surfaces clean with a solvent such as acetone, using rags.

Timbers which have a tendency to bleed may be steam cleaned. Use a resorcinol resin glue which in this case will require elevated temperature curing.

TO BOND TIMBER TREATED WITH AN ORGANIC SOLVENT PRESERVATIVE.

Casein glue is satisfactory; however the alkaline properties of the adhesive may cause the preservative to be deleteriously affeted.

Urea resin adhesive set as the result of introduction of an acid hardener. Small changes in acidity will alter the setting time. Acid will accelerate, alkali will retard. This is particularly noticeable with gap filling urea resins.

Resorcinol resins set best under neutral conditions. Acid will retard, alkali will accelerate.

The physical compatibility of the adhesive and preservative will depend on the nature of the vehicle. A light volatile solvent will present no difficulties provided sufficient time is allowed for evaporation of the solvent.

Degreasing treatment will be required where heavy oils have been used and crystalline blooming should be removed by brushing, sanding or planing.

Pentachlorphenol and copper naphthenate can be applied using a variety of solvents of which naphtha and light mineral spirits give good results. Fuel oil solvents are unsatisfactory.

It is often beneficial to spread adhesive two or three times to obtain uniform coverage.

Waxes and water repellents will interfere with adhesion.

TO BOND WATER BORNE PRESERVATIVE TREATED TIMBER

Timbers treated with a waterbourne preservative are often put into service at a high moisture content, as this is the nature of their end-use position. However the moisture content of the timber must be reduced to a level indicated by the adhesive manufacturer if it is to be glued satisfactorily.

Satisfactory bonds are obtainable with timber treated with fluor/chrome/arsenic/phenol when using resorcinol resin cured within the temperature range of 25° to 90°C. The hardener timbers require the higher temperatures. Copper-chrome-arsenic treated timber may require higher temperatures.

PRESERVATIVE TREATMENT OF ALREADY BONDED TIMBER.

Casein adhesives will not withstand this treatment. If urea resin adhesives have been used consult the manufacturer to ensure that the particular grade of adhesive will withstand the treatment in the pressure chamber and subsequent drying. This glue may fail during kiln drying.

Resorcinol resin adhesive is satisfactory when preservative treatment is to be carried out after gluing and subsequent drying, but the adhesive must first be allowed to cure for 5 - 7 days at 15° - 20°C.

Dipping or other surface treatments will probable not affct any of the more waterproof adhesives if the treatment and the adhesive and chemically and physically compatible.

PLANS AND SPECIFICATIONS

Plans: The design drawings of the vessel, usually to scale, showing layout, shape, sizes and dimensions.

Specifications: Written matter setting out further information and requirements to be read in conjunction with the plans. Specifications cover such items as types of material, fittings, standards of finish and workmanship required, amounts of material, any special methods involved, and types of adhesives, caulking materials, paints and other finishes necessary for the job.

Some designers provide full size drawings or templates for the smaller craft being made by the boatbuilder. These templates shall be glued to plywood or hardboard, if they are to be retained. Otherwise they may be glued to one of the member pieces and then all the other similar members can be shaped to the original member.

Where scale drawings or plans are provided the plans must be "lofted". That is set out on the floor, full size. The markings must be heavy enough to last until the job is completed.

All templates should be checked and double checked for size, shape and for being either left or right-hand set-out. It is cheaper to check than to waste a piece of select timber.

When marking out, the template should be tacked in position with two or more panel pins or nails, as necessary.

It is desirable that templates, plans and specifications should be carefully stored away so that future repairs may be more readily made.

There is a general tendency to draw thick lines in the belief that is necessary to be able to see the set out under all working conditions. Fine dark lines will be just as easily seen and permit a much greater degree of accuracy. Where a template has been traced the member should be dressed down to the template side of the pencil line, as the thickness of the pencil line may increase the size of the member too much.

Jigs and forms must be accurately made and strong enough to stand up to all necessary hammering. Any inaccuracies in the jig will be transferred to the part to be formed. It should not be assumed that the floor is flat and the jig must be carefully squared, plumbed and braced.

MAKING A FRAME

There are various means of lifting the shape on to the frame timber.

1. By means of tracing paper placed over the plan and the lines marked through this and in turn marked on to the timber. Do not stick with an adhesive as it may make the paper stretch.

2. By placing cut tacks so that the heads are lying along the shape drawn on the sheet, the frame timber is then carefully lowered on to the tacks and struck a sharp blow with a mallet: the tacks will indent the timber and by bending a plywood batten round the tack marks the required shape is obtained.

3. By placing the timber beneath the plan and running around the shape with a dress makers wheel, piercing holes through the paper on to the timber and again fairing with a plywood batten. (See Fig. 1.)

When the shape of each member (1 side) has been determined, nail the other side member to it and cut to the required shape marking certain to cut the waste side of the line.

Lay these members still nailed together onto the full size plans accurately, and fasten the plywood gusset pieces on the top face. (See Fig. 2). Mark any datum line, e.g., building jig, brace line on to both members. Turn members still nailed and secure plywood gussets on the other side of the frame.

Separate the members, place both members port and starboard into position on the full size plan, checking the accurace of position by means of the datum lines, and when satisfied that all is well attach the other gussets together with the centre gusset forming the two sides. At this point check the accuracy of the shape and if necessary adjust.

Fasten the cross spall or batten at the required height, mark centreline on the frame at the keel and on the cross spall (See Fig.3) turn the frame over and fasten the other centre gusset, place back on to full size pattern and check again for accuracy.

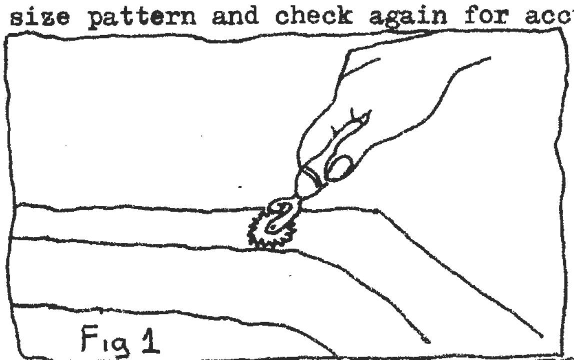


Fig 1

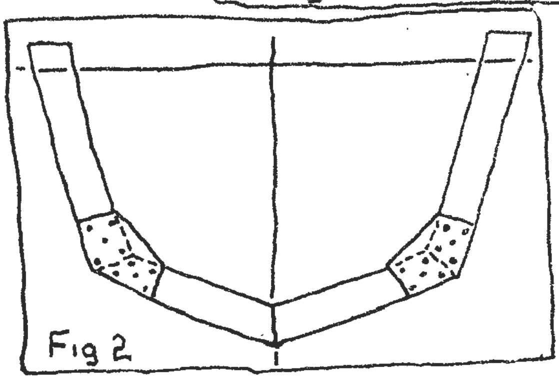


Fig 2

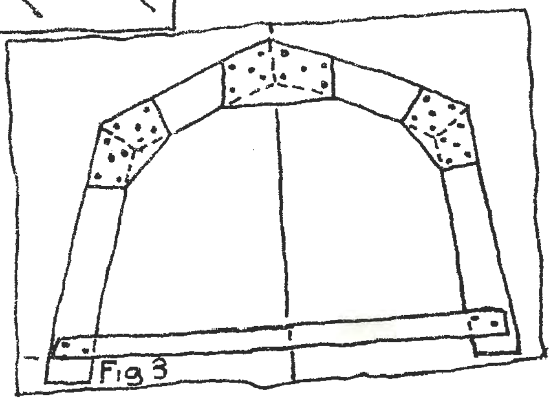


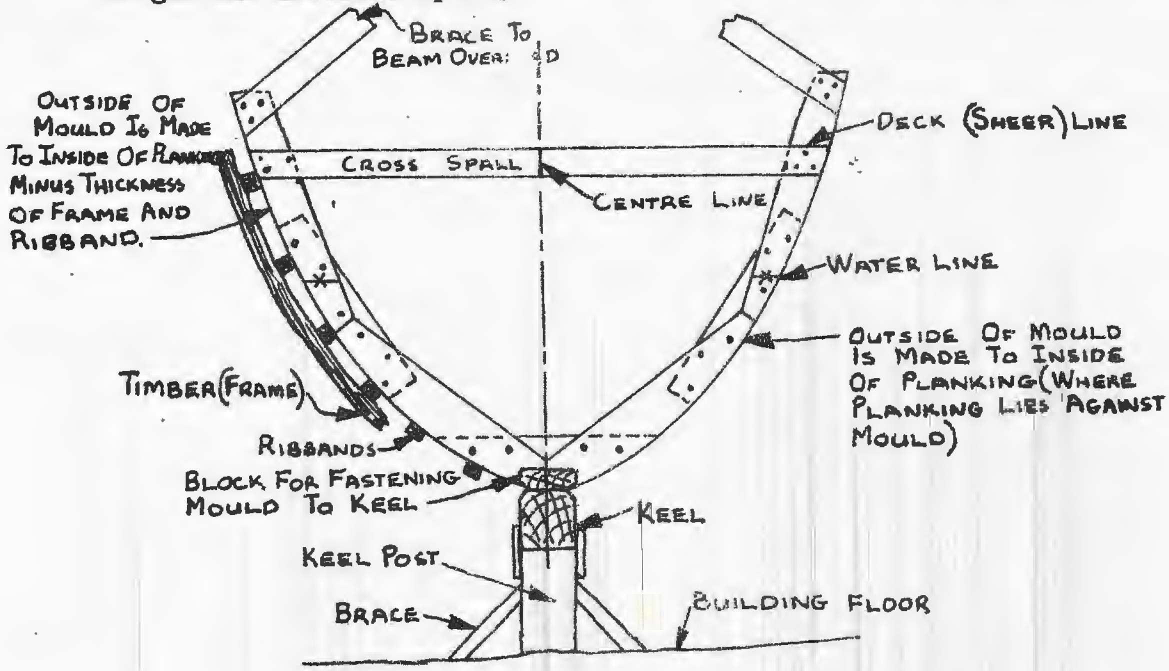
Fig 3

SETTING UP MOULDS

Although the majority of boats are constructed right side up it would be impractical to copy this routine in building flat bottom boats like vee and arc bottom hulls when it is so easy to fasten the bottom planks with the hull inverted, upside down.

As the moulds are designed to give shape to the hull, they must be set up correctly, and properly braced to avoid distortion through movement under pressure when ribbands are bent around them.

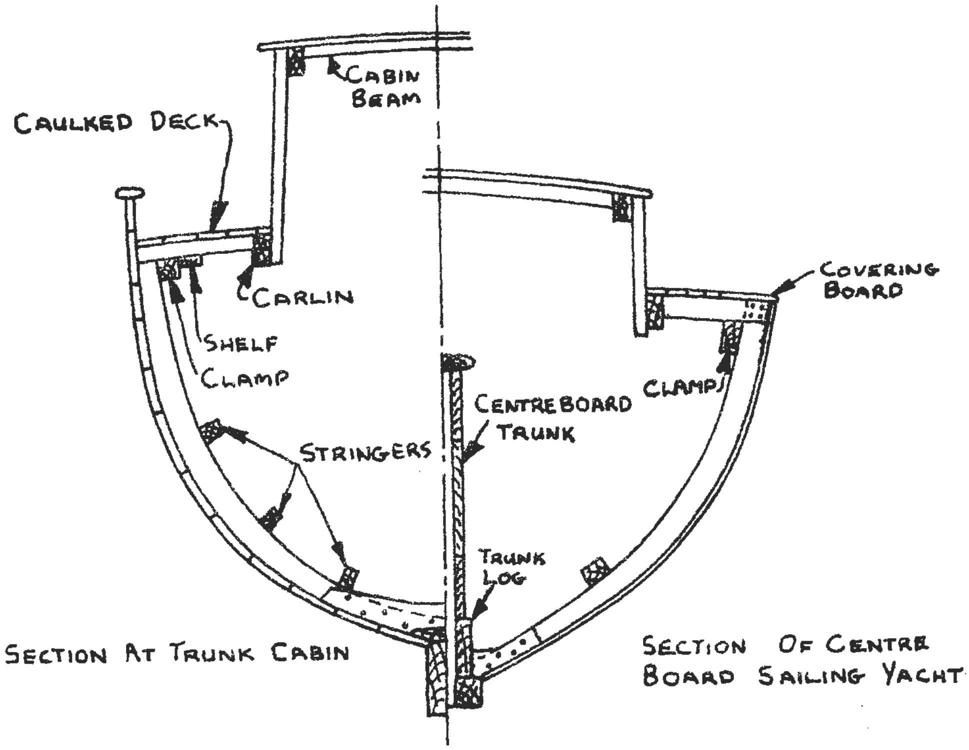
The position of each mould is marked by the frame, station, line from the lines plan; aft of amidships they are fixed aft of the line, and forward of amidships they are fixed forward of the line. The frames must be plumb, level, square to the centre line and at the correct height and distance apart.



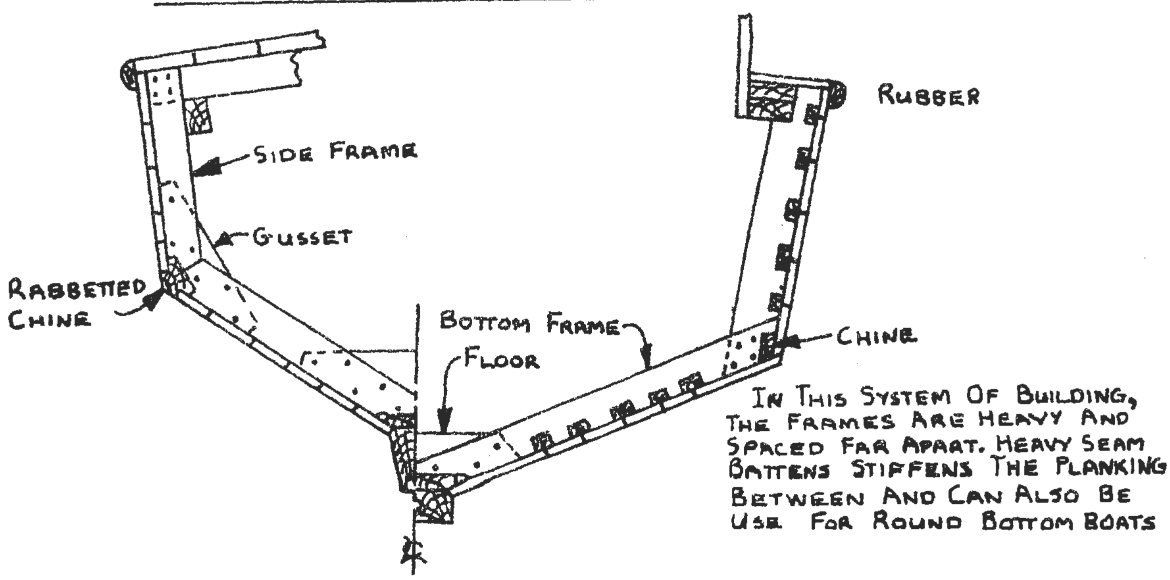
HULL FORM

There are two distinct types of hulls and they are known respectively as the ROUND BILGE and HARD CHINE forms. The former term is self explanatory, and the latter implies that there is a sharp angle between the sides and bottom of the boat. The round bilge construction is more widely employed than the other and is held to be a more seaworthy form. On the other hand, correctly designed hard chine boats have proved that they are in no way deficient in seaworthy qualities. Fast craft are usually built on the hard chine principle.

Various types of sections are illustrated showing their construction.



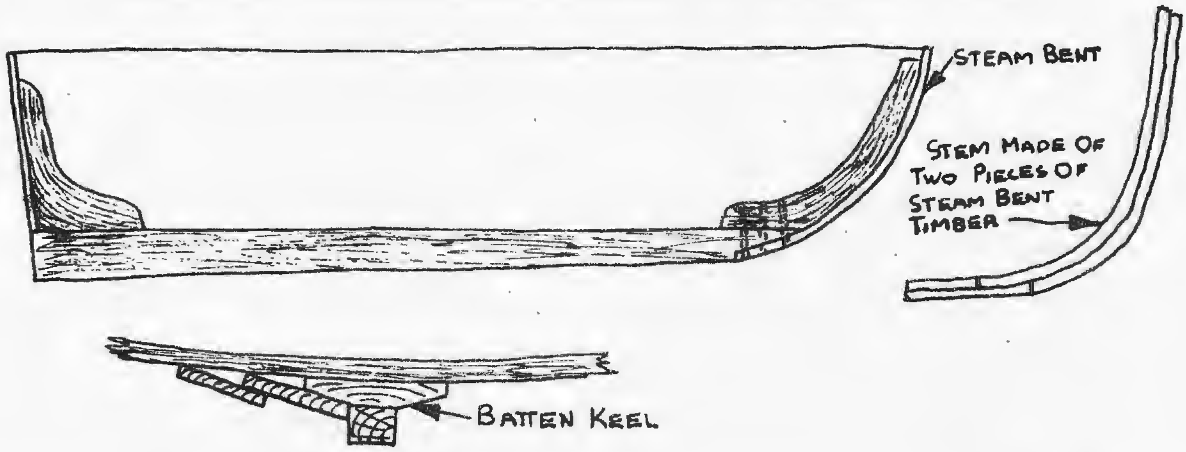
SECTION OF ROUND BILGE BOATS



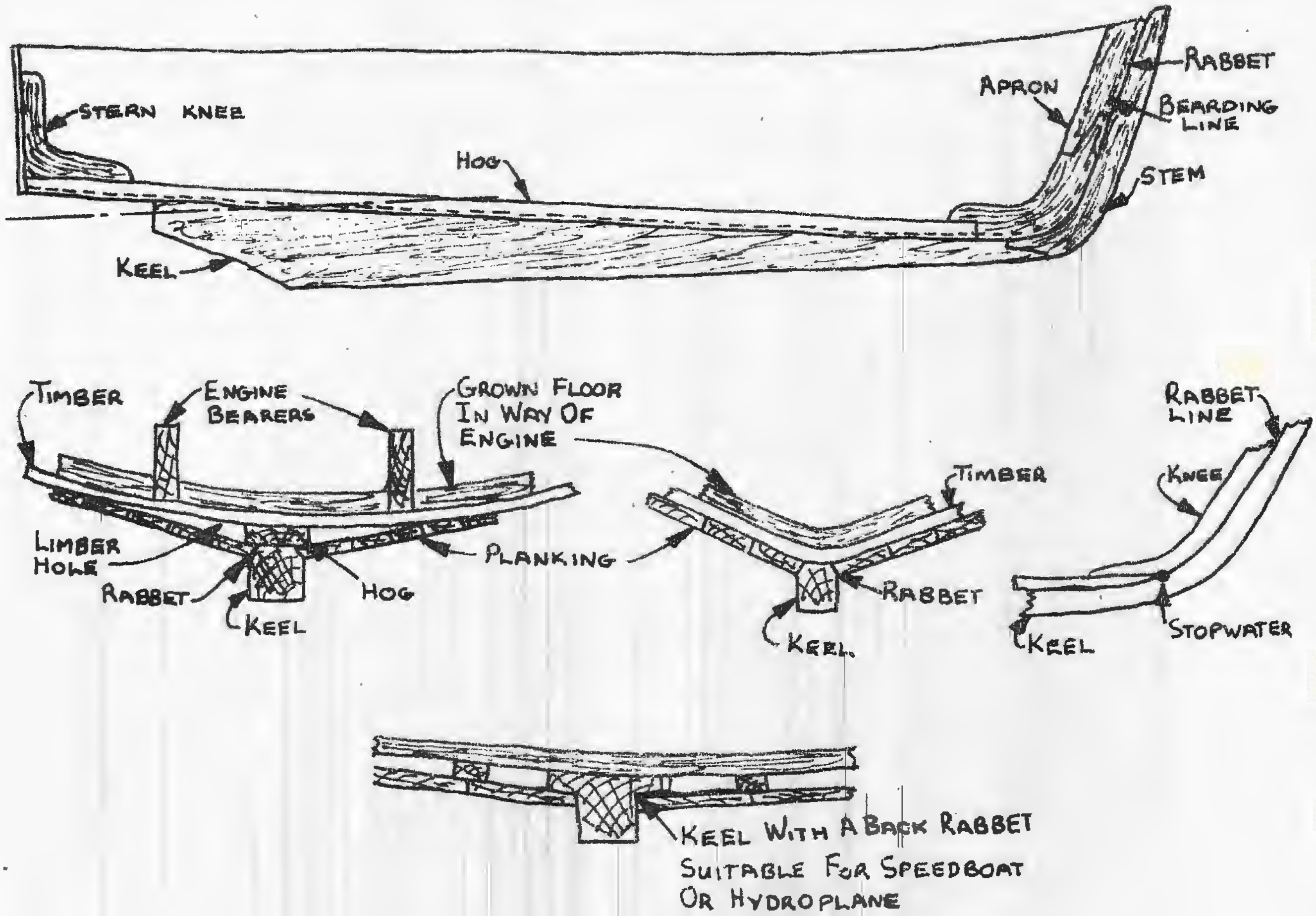
SECTION OF HARD CHINE BOATS

Along with the moulds the stem, keel, deadwood. stern post form virtually the back bone of a boat and are foundations upon which the hull is built. Each distinct type of boat requires different treatment, at the same time there may be several ways of accomplishing the same result, so that designers either follow pet ideas or are governed by cost or other considerations.

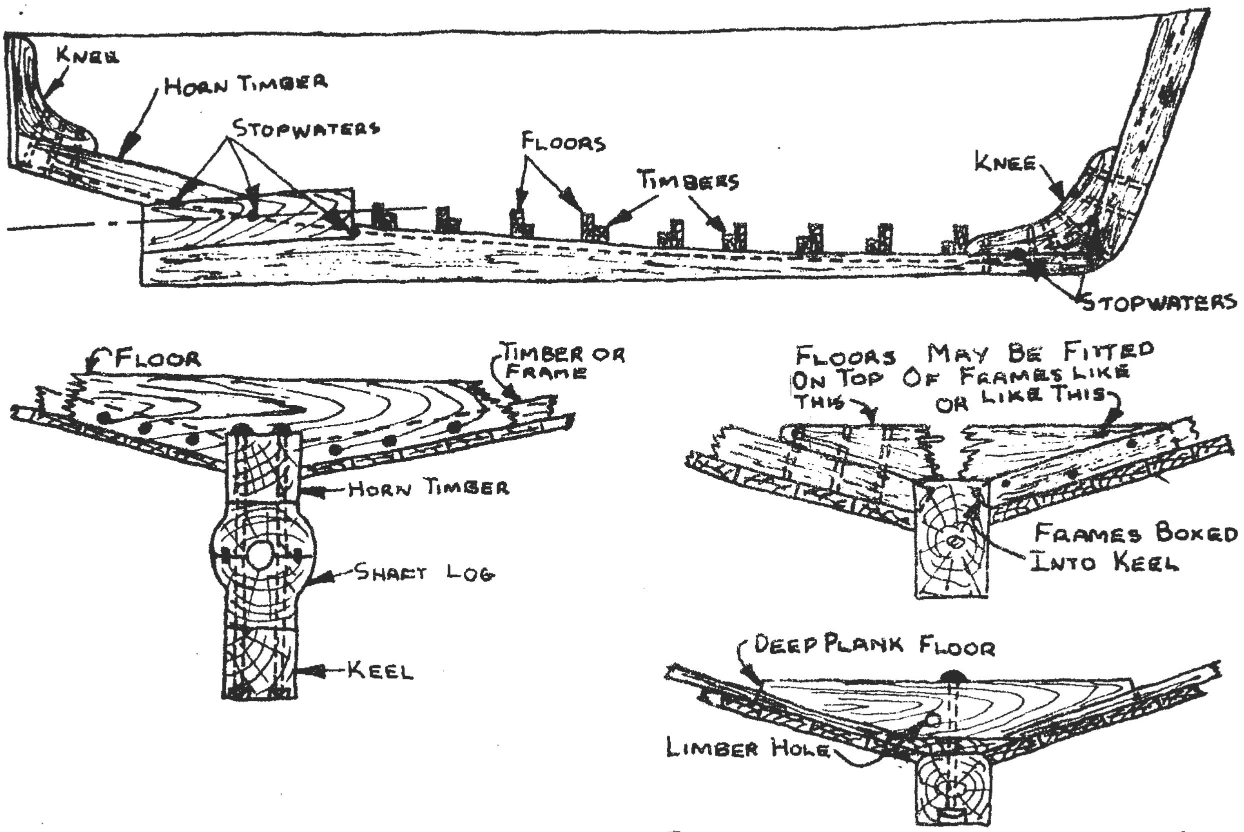
Typical keel constructions are shown in following sketches.



DINGHY

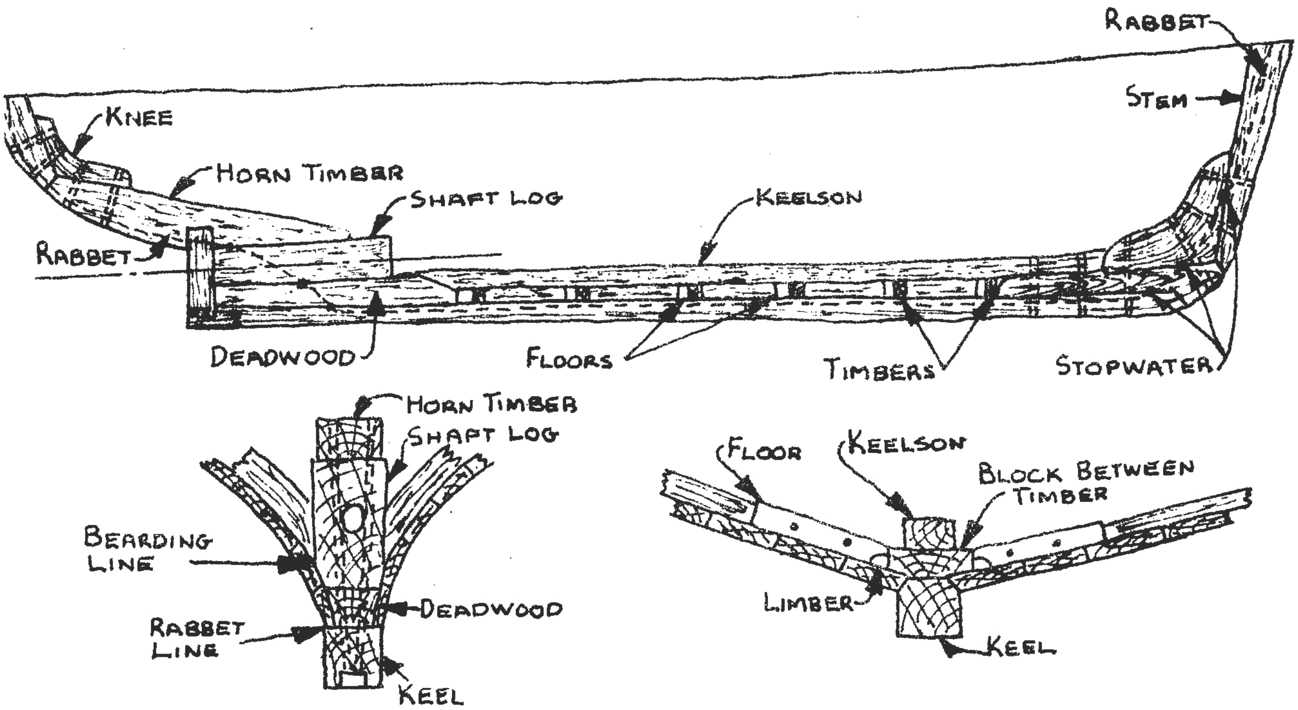


CONSTRUCTION OF "V" OR ROUNDBOTTOM RUNABOUT

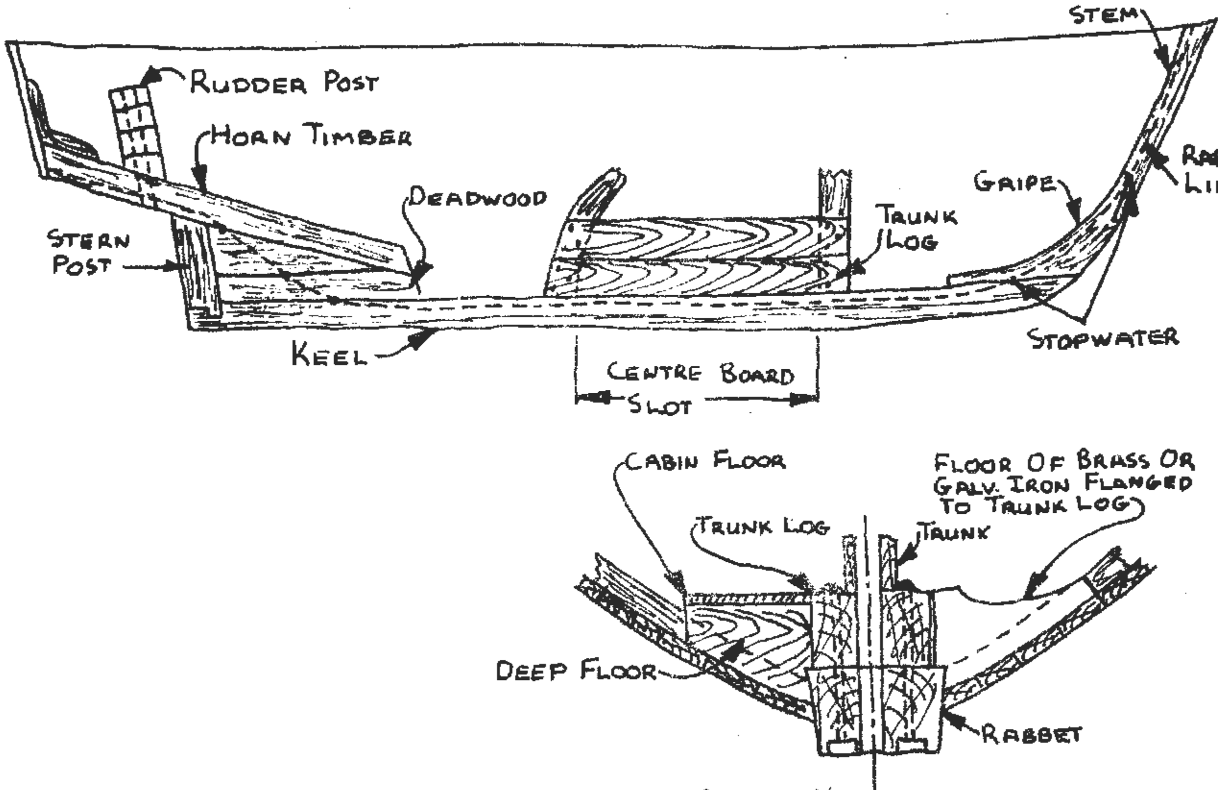


In Many Cases Floors Of This Type Are Made Of The Proper Depth To Take The Cabin Floor

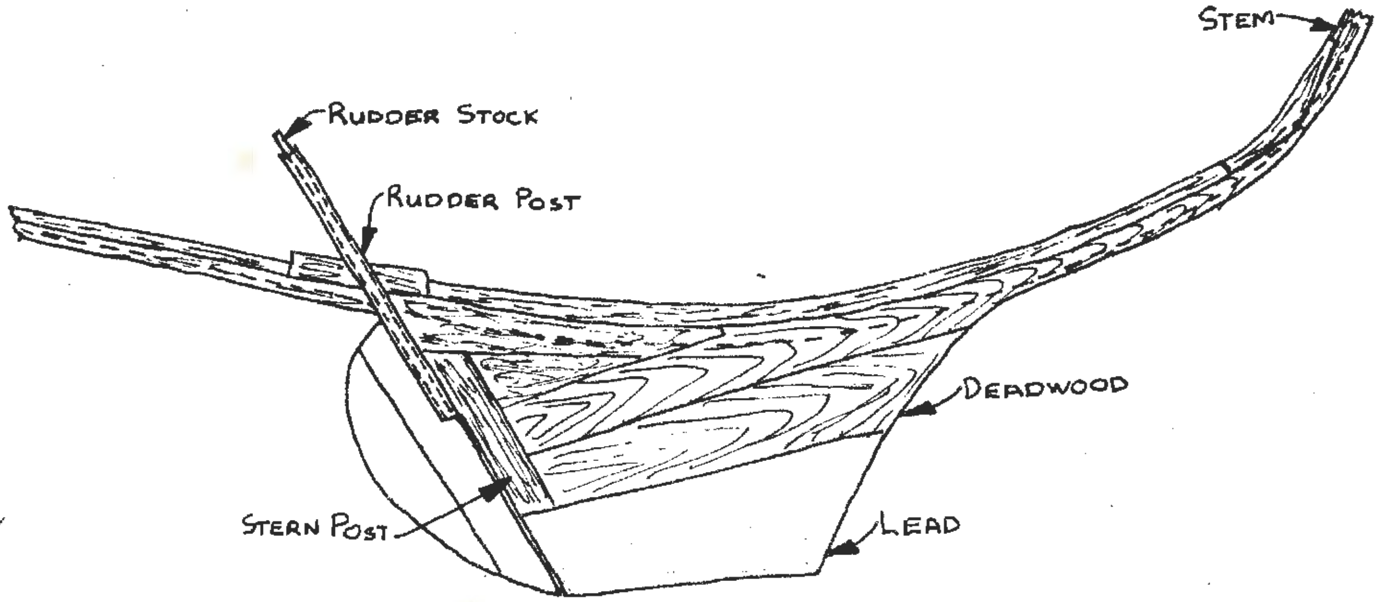
KEEL CONSTRUCTION SUITABLE FOR SMALL AND MEDIUM SIZED BOATS



KEEL CONSTRUCTION SUITABLE FOR MEDIUM AND LARGE CRUISERS



Keel Construction For Heavy Centre-Board Yacht



Keel Construction For Fin Keel Sailing Boat

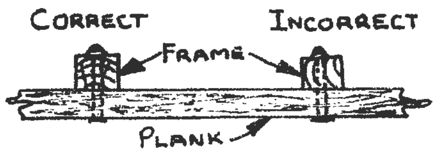
FRAMING

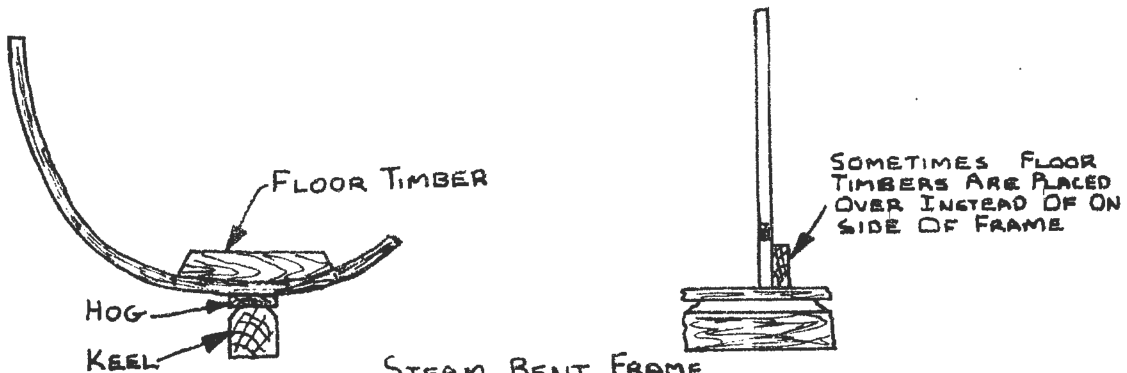
There are two basic systems of framing a hull transverse and longitudinal. Transverse is the most common and, due to the framing being located athwartship or across the boat, has led to the expression "ribs". Transverse framing for round bilge boats are either in one piece, laminated from two or more pieces bent on top of each other, sawn from natural crooks of wood, or "double sawn" from boards and made up of two layers of staggered joints.

For the longitudinal framing system in general, transverse frames are used to shape the hull, but are spaced further apart than in transverse framing system, then fore and aft longitudinals are used to build up the necessary framing strength.

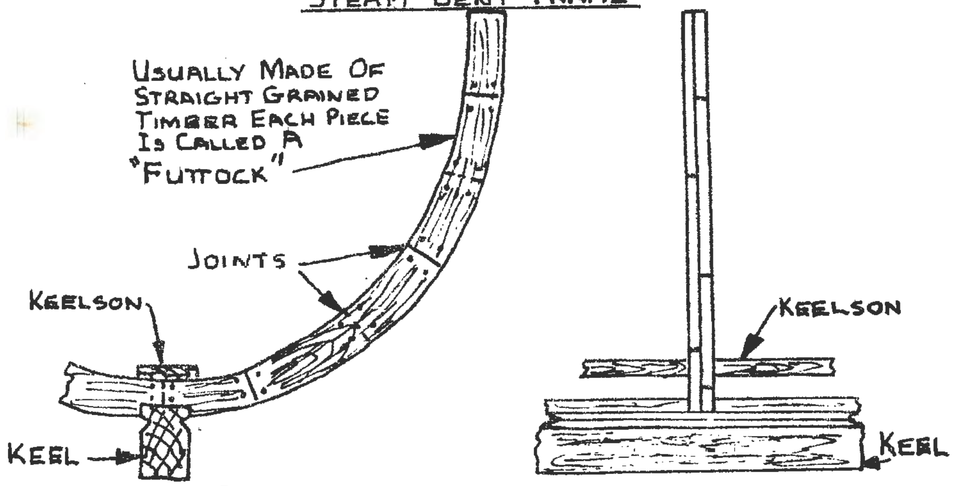
Frames sawn from natural crooks are seldom used except in combination with steam bent or for special construction. Steam bent frames, are made in two ways, i.e., bent over a form and fitted in the boat cold, or bent directly into place while hot. The latter method is by far the simpler, and may be employed for frames up to 25mm square but above this size they are rather stubborn to bend and apt to break. Even if a larger frame can be handled there is always a continual tendency of the frame to straighten out.

The best material is straight grained timber, not too dry. If possible bend the frame so that the plank fastenings will cut across the annual rings and not between them, as the wood bends better this way and there is much less tendency to split when the planking nails are diven.

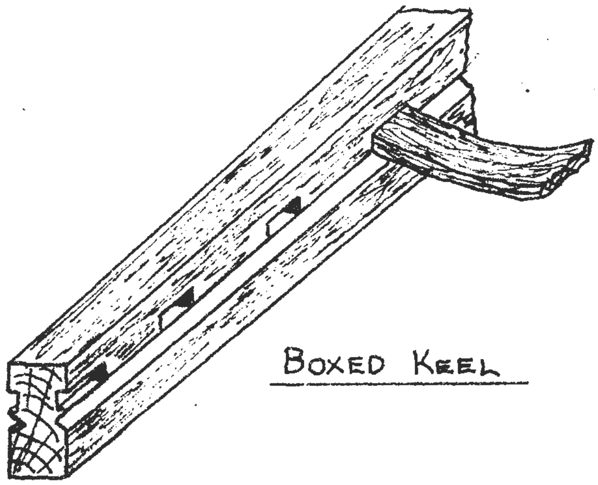




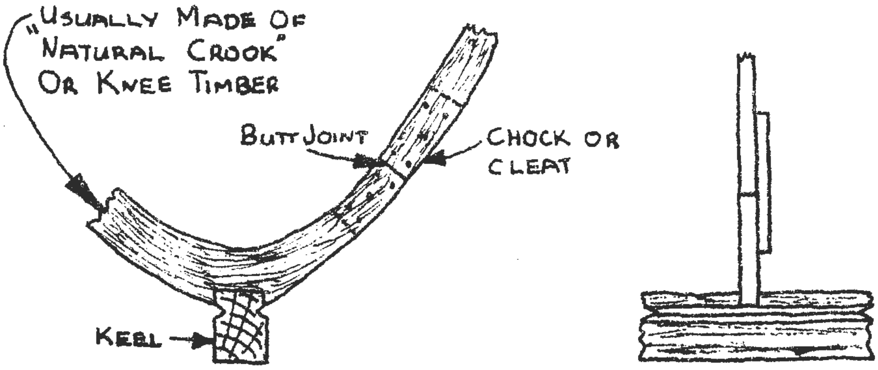
STEAM BENT FRAME



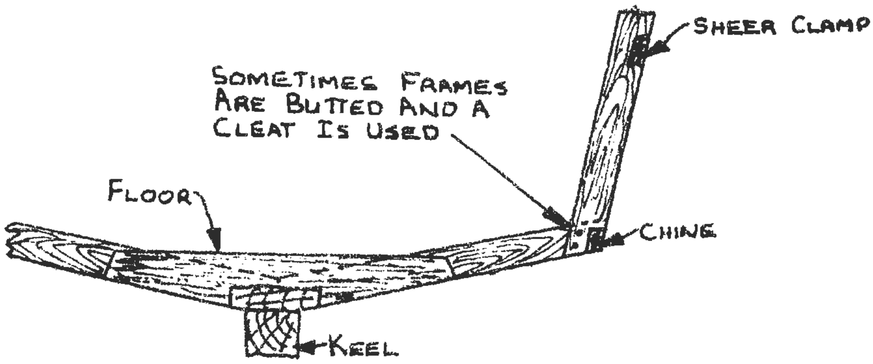
DOUBLE SAWN FRAME



BOXED KEEL



SINGLE SAWN FRAME



SAWN VEE FRAME

NOTE: FLOOR TIMBERS ARE USUALLY NOTCHED TO KEEL; UNLESS LATTER IS DEEP WHEN BOTH KEEL AND FLOOR TIMBERS ARE NOTCHED OR "LOCKED" INTO ONE ANOTHER.

PLANKING

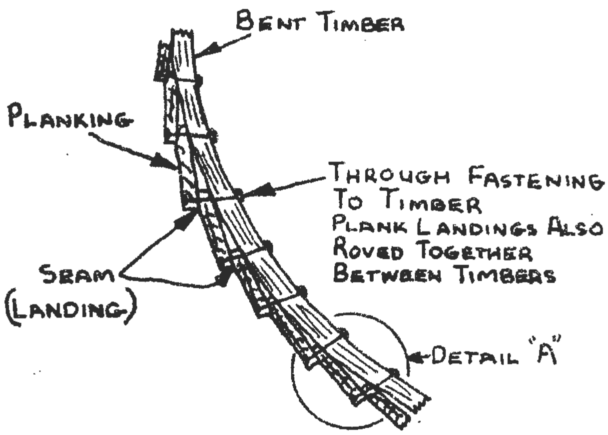
The individual planks are called strakes, and for appearance most systems require nicely porportioned planks, shaped so the lines of the seams are pleasing to the eye from every direction.

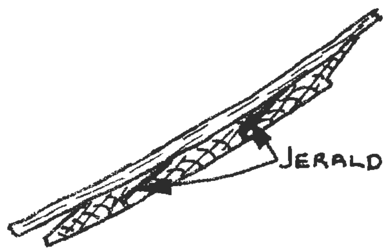
Various methods are:

1) CLINKER

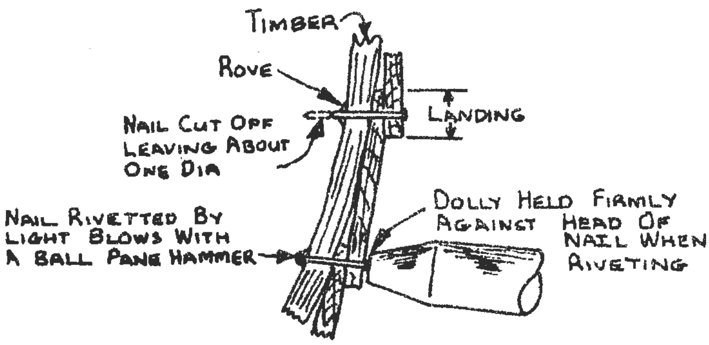
The planks run fore and aft with the lower edge of one plank overlapping, outboard, the upper edge of the plank below it; the overlap is termed the "land". The planks are fastened to the timbers and to each other through the lands by copper nails driven from the outside of the hull and riveted over roves on the inboard side.

The upper edge of each plank is beveled so the next on is tight against it for the width of the land. The bevel varies from one end of the plank to the other end due to the changing shape of the sections. The ends of the planks must be flush where they fit in the stem rabbet or against the transom. This is done by changing the bevel to a beveled rabbet about 500mm from the ends. This bevelled rabbet is termed the "jerald" and is done in order to avoid a feather edge on the outside of planking.





Landing At Stem Or Transom



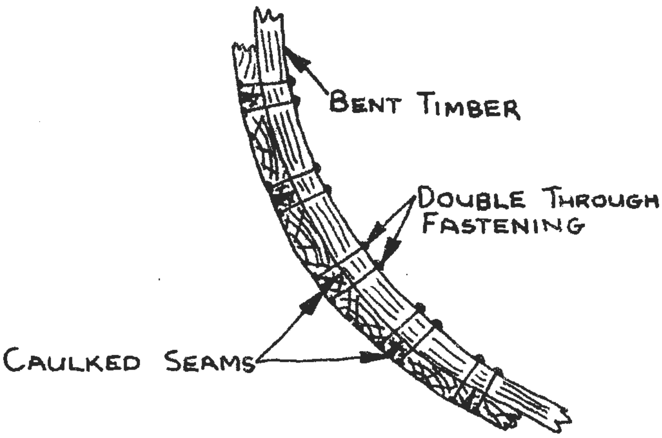
Detail "A"

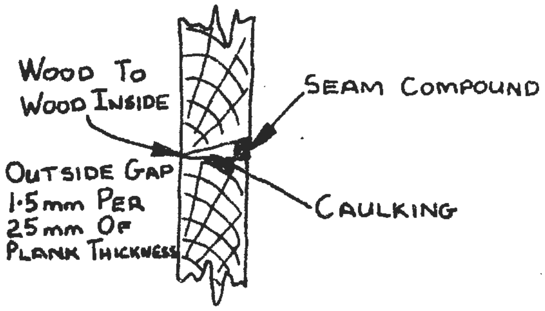
Clinker Planking

CARVEL PLANKING

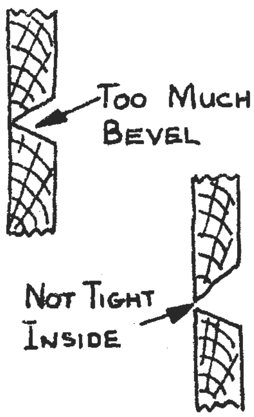
In this system each plank, after being steamed to shape if necessary, is carefully planed along the edge to make a perfect fit with the neighbouring plank. The two surfaces simply butt together and the planks through fastened to the timbers. Ordinarily the seam thus formed is wedge shaped, and, to make it watertight it is caulked, that is, cotton yarn is packed hard into the seam with a caulking iron. To make a fihished job, the seam is filled over the cotton with putty or some other stopping.

In the highest class of boat-building close seams are used without caulking, the planks being so carefully prepared that they fit perfectly and can be nailed in place, making contact all over the seam, with the aid only of varnish. As soon as the boat is placed in the water the wood of caurse swells and so makes a perfect joint. The close-jointed seam is usually employed where the planking is under 12mm thick.





IDEAL CAULKING SEAM



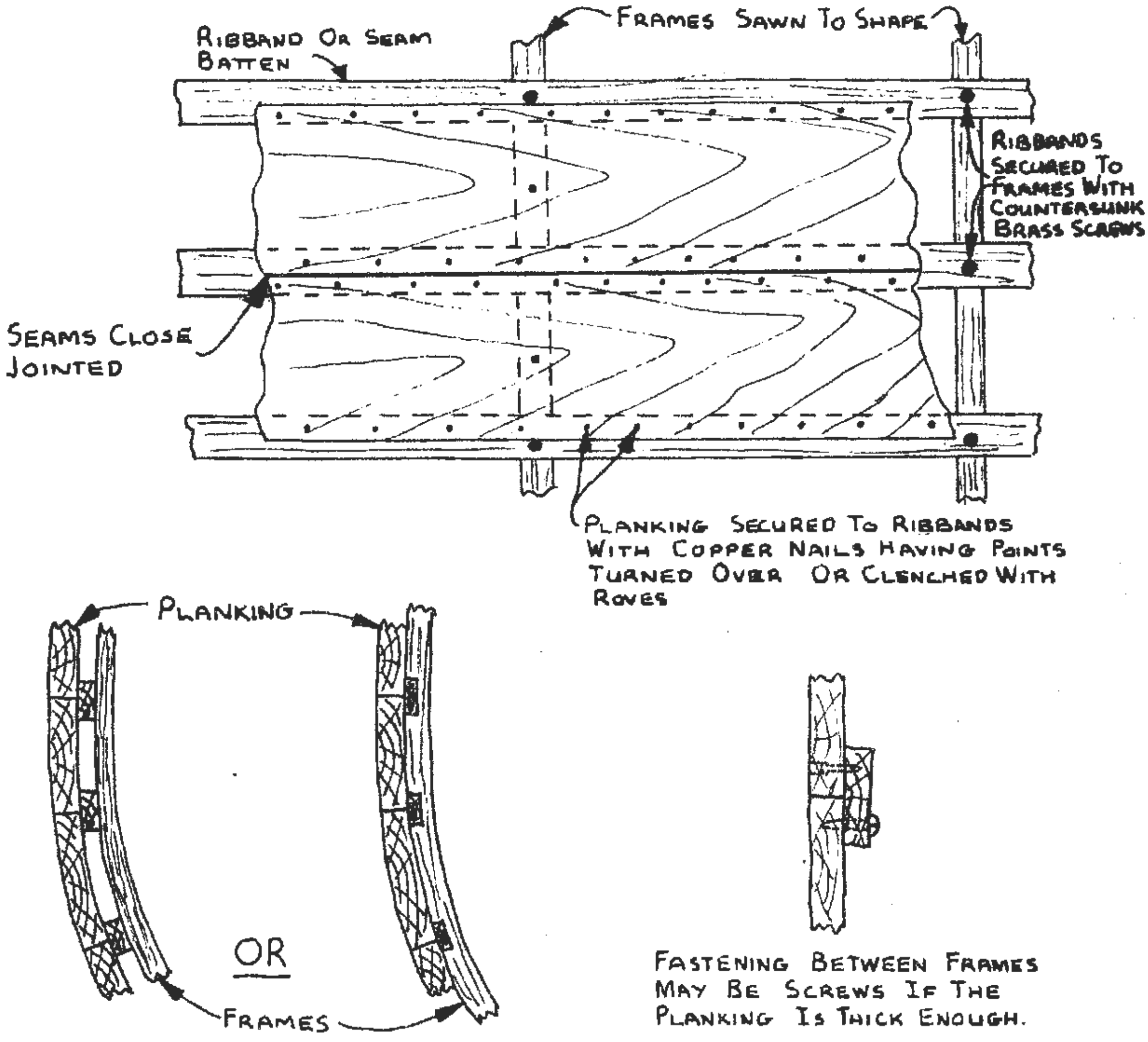
POOR SEAM

CARVEL PLANKING

RIBBAND OR SEAM BATTEN CONSTRUCTION

This planking system is so called because the seams are backed on the inside by battens to which the planks are fastened along the edges. The planks may be a little wider than ordinary single skin carvel-built boats. Waterproof adhesives with gap filling properties is applied to the battens before fastening the planks to eliminate caulking the seams.

This method of planking is used for hard-chine vee bottom boats and sawn frames are usually employed.

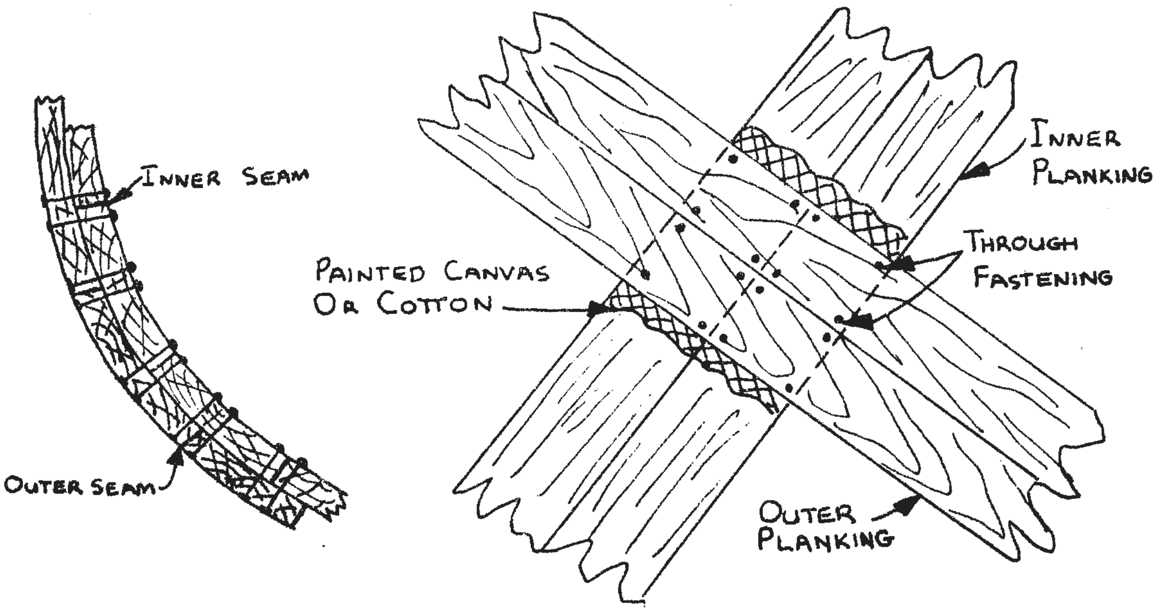


Ribband Or Seam Batten

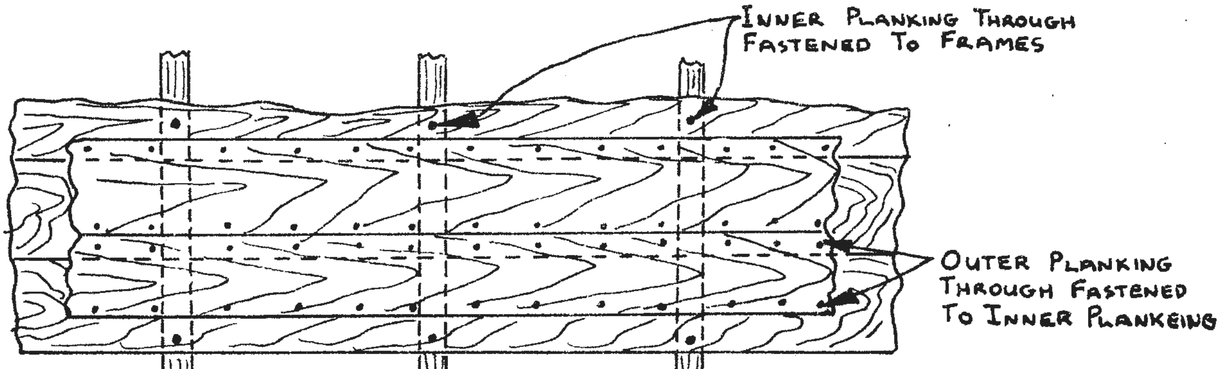
DOUBLE OR MULTI DIAGONAL PLANKING

With any single layer of planking very good workmanship is required to prevent leakage. This difficulty is however got over to a considerable extent by using two or more thin skins fastened at varying angles to each other. Synthetic resins glue makes it possible for planking to be guled together on the faces and edges to form a uniform construction, eliminating the use of oil fabric between the skins. Only gap filling adhesives should be used and sufficient pressure must be applied to ensure that the faces of the planking are held in contact until the bond cures.

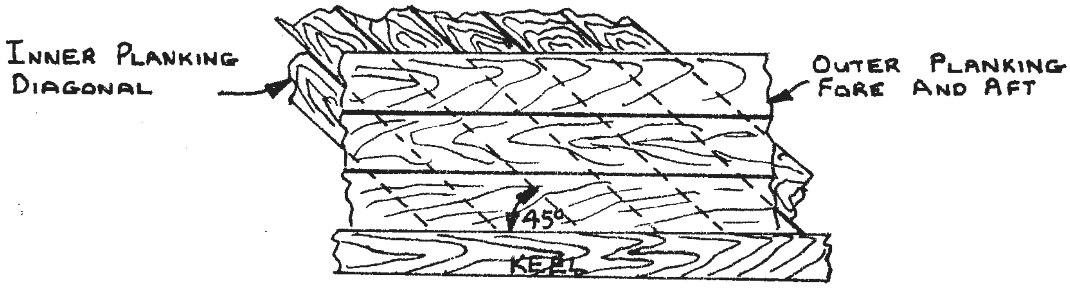
The planks can be laid diagonally and at right angles to each other, or a more common arrangement in practice is a horizontal outer skin and diagonal inner one. With three skins, there are two inner diagonals and one outer horizontal; triple skin is only employed in special cases.



DOUBLE DIAGONAL



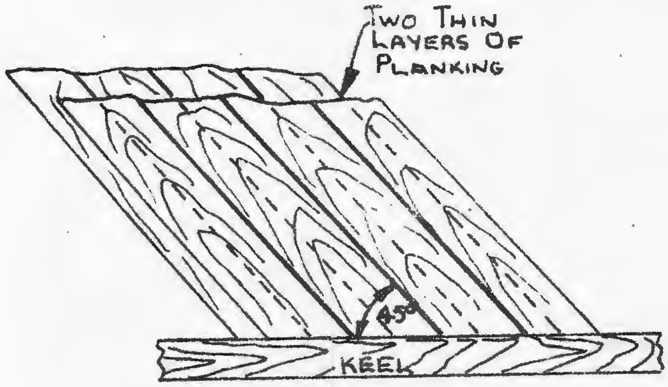
DOUBLE FORE AND AFT.



DIAGONAL — FORE AND AFT

ASHCROFT SYSTEM

This system has two diagonal-laid skins, with the seams offset, running in the same direction instead of crossing at right-angles; this is very good for amateur work, and a strong watertight hull is obtained, with less skill and practice than by other methods of planking.



ASHCROFT SYSTEM

STRIP PLANK CONSTRUCTION

Strip plank construction involves the use of parallel strakes. Material costs are lower and wastage through cutting is less than for orthodox forms of construction. Strakes can be produced ready planned and spindled to size. The strip plank system gives a good appearance, has added strength and because of the thickness, a good fastening system for deck or covering board may be planned.

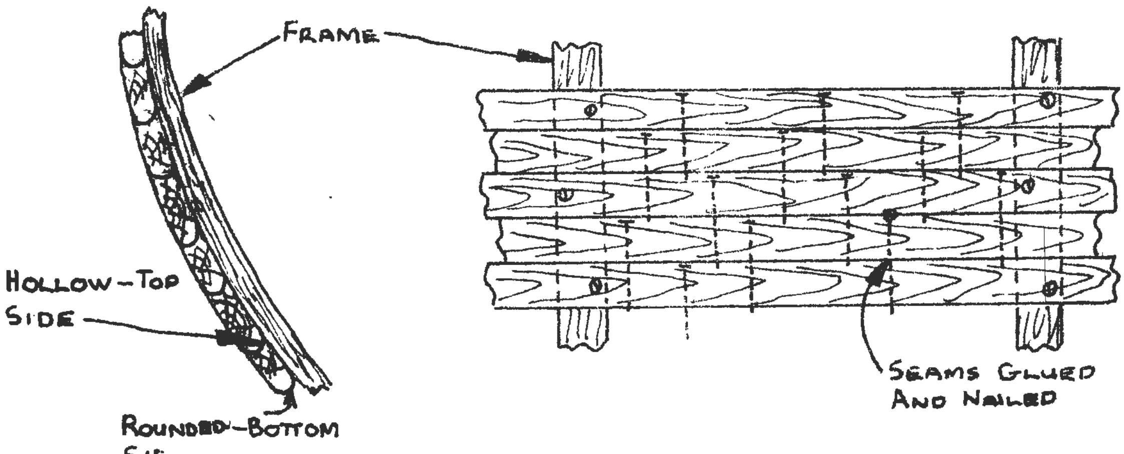
It is usual to spindle mould the strips with a round on the bottom edge and a corresponding radiused hollow in the top edge. This affords a larger gluing or bedding surface and enables moderate transverse hull curvature to be negotiated without the necessity of lifting plank bevels. Where the curvature is sharp it is necessary to plane the inside surfaces of the strakes to fit the timbers and also to modify the hollowed or rounded top and bottom edges so that they are in close contact when fitted.

In addition to edge fastening, the strips are usually bonded to each other with a waterproof adhesive which must be used in accordance with the manufacturer's instructions. These bonds must be kept under pressure while curing.

Serrated fastenings, driven into closely spaced pre-drilled holes as tight as the material will allow without splitting, are suitable for this job. They can be obtained in various lengths and gauges and must be of non-ferrous metal.

With any glued-edge form of single skin construction the problem arises of hull form distortion or frame breakage through stress exerted by the planking swelling when it is wet. To reduce this, material used for planking should not be of lower moisture content than the maximum allowed for satisfactory bonding by the adhesive used and the manufacturers advice on this point should be taken. Some boatbuilders prefer to use timber strips at 10 to 14 per cent moisture content so that any increase in poisture content will cause swelling and this compressive stresses in the sheathing, which may be more acceptable than cracking due to shrinkage. This Strip Plank method of construction involves a large area of timber being bonded into one piece and such planking has been known to crack open as much as 3mm.

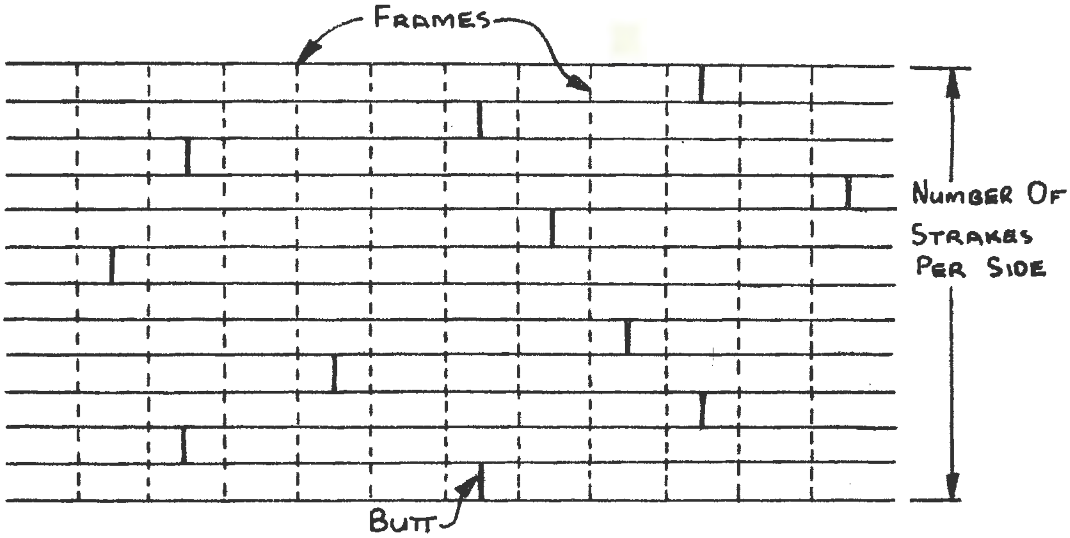
Elastic seam-filling compounds may overcome the swelling stress problem where sheathing is used. These compounds may be used instead of other adhesives for underwater joints. The advice of the manufacuturers should be sought on the application of thes compounds. Due to the necessity for edge fastenings, stip plank, construction is only suitable for shell thickness of 12mm and over. One difficulty in this system is the number of feather edges that occur at the shear line. This can be overcome if a thicker and wider sheer strake is fitted and rebated out to cover and seal the feather edges.



STRIP PLANKING

Some small boats can be planked with strakes running the entire length of the boat but because of restriction in length of timber stock, strakes for larger boats are required to be made from two or more lengths of timber. Two methods are used to join the lengths of timber together; the first one being a scarph and the second a straight butt.

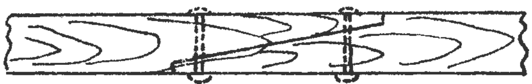
Scarph and butts should be so positioned that they fall midway between a pair of timbers, or frames, and scarphs and butts in adjacent strakes should have three frame spaces between them. Scarphs and butts falling between the same two timbers or frames should be seperated by at least three strakes.



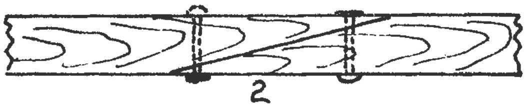
Layout Of Planking Butts

Three types of scarphs are used for joining planks.

1) Square shoulders
2) Feather edge, care must be taken not to split the feather edge, when securing the planks together.
3) Combination of 1 and 2. The square shoulder outboard and feather edge inboard.



1



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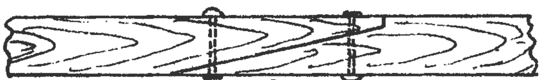

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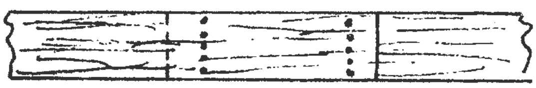
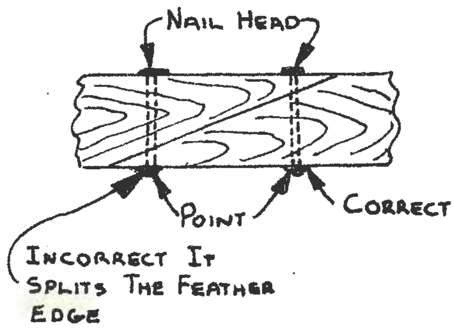
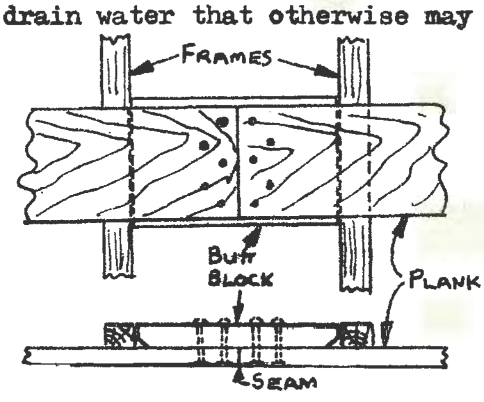




Where a scarph is not used a butt block is placed on the inside of the butt. The block should be sawn to length to fit between the timbers, planed on the outside to fit snugly against the planking and the outboard corners chamfer to drain water that otherwise may be trapped on top of the block.



DECK CONSTRUCTION

The deck of a vessel is a most important strength member, complementary to the keelson in ensuring longitudinal rigidity. Decks "work" when their strength is not up to the strain thrown on them, and they not only leak, but transmit strains to the hull which as a consequence, may also arrive at a leaky condition.

The thickness of deck planking has very little bearing on the strength of a deck considered as a structural unit. Much more depends on the uniting of the planks in such a way that the deck retains its shape.

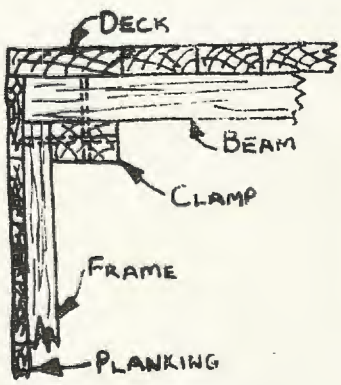
DECK FRAMING

The deck frame of a boat is made up of beams, carlins, breast hook, quarter knees, lodger, bosom knees, hanging knees, partners, tie bolts.

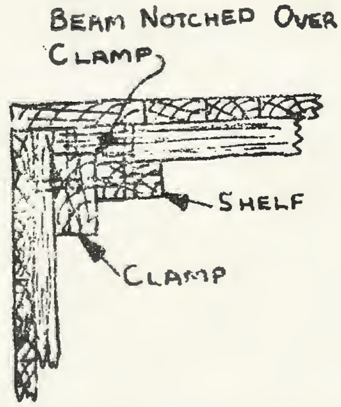
The principal members are the BEAMS, which extend from side to side and are fastened to the clamp, shelf if any, and the frame heads if the size permits. It is customary to fit one at each frame except in special cases when the spacing may be greater. At the ends of deck openings, such as cockpits, cabins, hatches, etc., and in way of masts, extra heavy beams are fitted which are about the double the "sliding" (thickness fore and aft) of regular beams. All beams are cambered which sheds water and stiffens the deck.

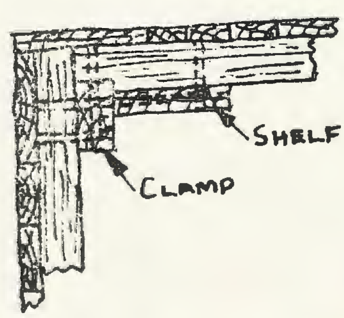
CLAMPS run fore and aft, port and stbd., on the inboard side of the timbers or frames immediately below the deck or covering board. Its function is to stiffen the topsides and provides a sill for the beams in a decked boat. In open boats it is called a gunwale.

As hulls increase in size on additional stiffening member called a SHELF is fitted to the clamp. The inner edges of the shelf may be left square but the outer edges are planed to fit snuggly against the clamps and bolt to the clamps between the frames. To have the deck beams bear on their entire width the shelves must be fitted with a pitch to correspond to the camber of the deck beams.



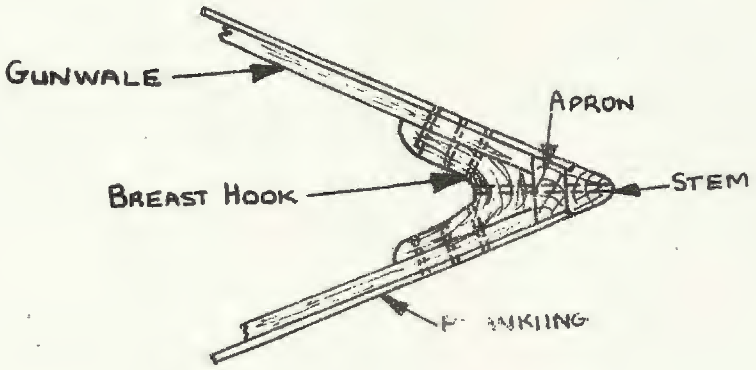
CLAMP BEVELLED TO SUIT BEAM



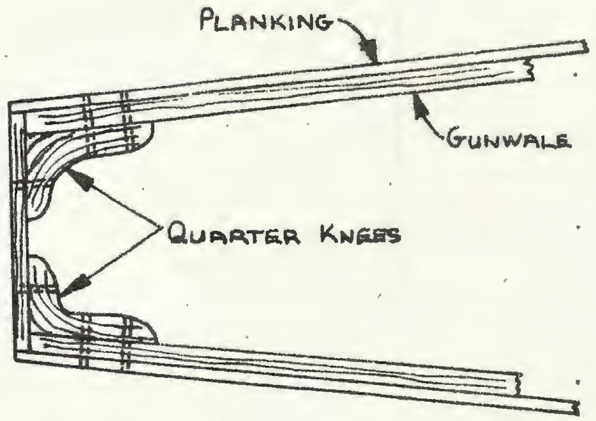


SHELF USED MOSTLY ON YACHTS – NOT ON ORDINARY LAUNCHES – FASTENINGS DO NOT PASS THROUGH DECK. FRAMES CONTINUE TO UNDERSIDE OF DECK – LEAVES NO WEAKNESS – BEAMS REST ON CLAMP

BREAST HOOKS are fitted in the bows of the boat and fastened to the stem, clamp (gunwale) and sheerstrake to tie the forward ends of the clamps together and stiffen the bows.

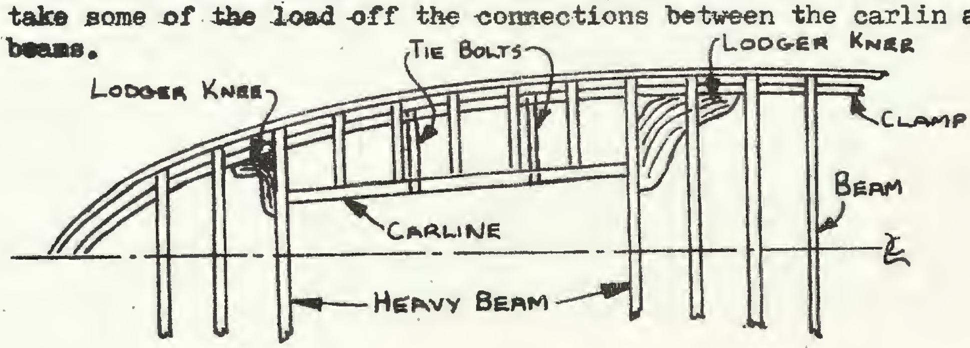


The after ends of the clamps are tied to the gunwale, sheerstrake and transom by QUARTER KEES.

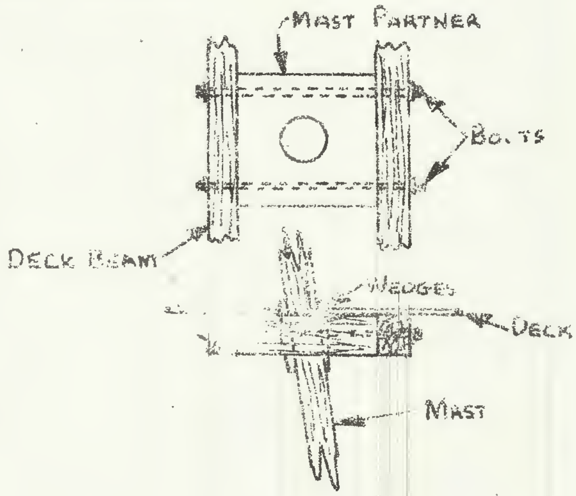


At the sides of large openings in the deck the beams are short and are termed half beams and are notch into the CARLIN which is the fore and aft member along the sides of the opening. To provide additional stiffening in way of large opening LODGING KNEES are bolted to the heavy beam and clamp.

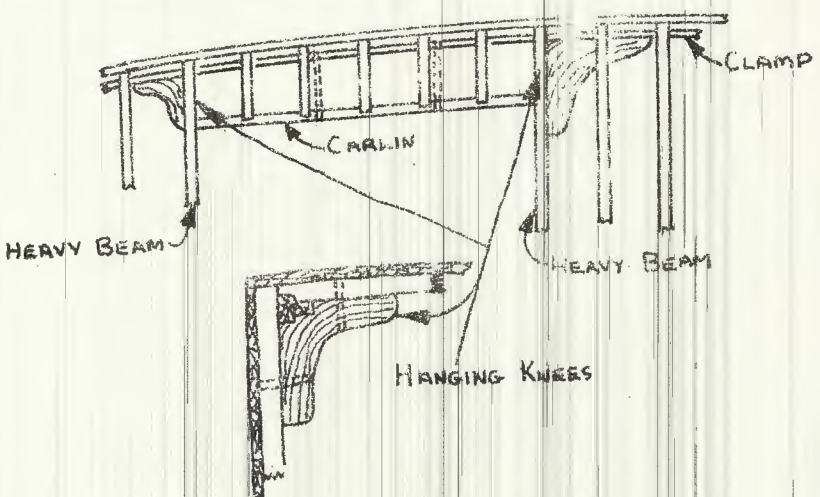
TIE BOLTS are installed between the clamps and carlins at intervals between the frames. These bolts stiffen the deck framing and also take some of the load off the connections between the carlin and half beams.



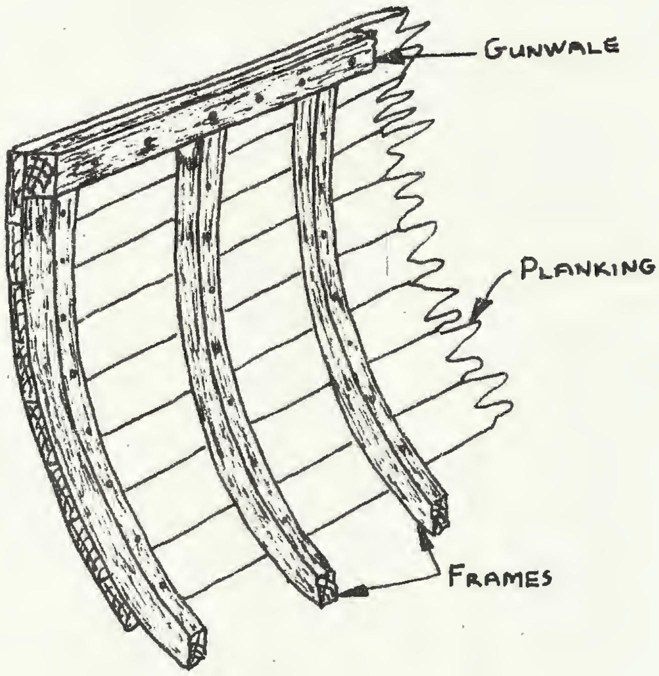
Where there are fittings on the deck such as cleats, blocks are fitted between the beams to take through fastenings. The blocks should should be a tight fit between the beams and fasten to the beams with long bolts where possible. The same arrangement is made where a mast passes through the deck and is stepped on the keelson, these blocks are called the MAST PARTNERS.



HANGING KNEES are generally used in pairs at the masts and singly at the ends and midlength of long deck openings and are fitted for strengthening the hull to resists sideways forces.



An important fore and aft stiffening piece is work immediately below the deck or covering board either against the top strake inside or against the timbers. This in open boats is the GUNWALE (sometimes called the "inwale"). Its function is to stiffen the top-sides. In the case of decked boats it is called a Shelf and provides a sill for the beams. In open boats, without side coamings, it is generally fitted close against the top strakes, the timbers having been previously cut off short to make room for it.



DECK PLANKING

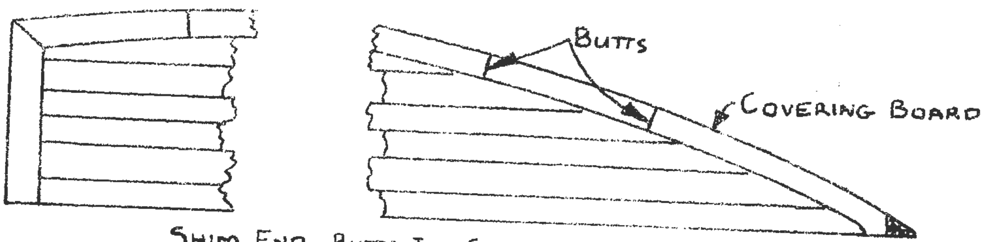
In a normal deck with a single thickness of planking the problems of producing a rigid unit is not solved, for the planks are only attached to the deck beams and shelf and not to each other, except in the case of very narrow planks which can be through-nailed each to the one adjoining. In a "laid" deck, with planks curved parallel to the covering-boards and lodged at their ends into king planks, there is less working because the planks can only move by flexing edgewise and from this they are restrained by their deck beam fastenings. Working can occur, however, and in singl-thickness decks can only be met by diagonal bracing. The bracing pieces can be quite small scantlings, say 75mm wide and 15mm thick, but they must fit with absolute firmness, against the under side of the deck and, as to their ends, against the deck beams shelves and coamings. They should be set in thick varnish or similar and brass screwed from below to each individual deck plank.

A much more satisfactory deck results from the use of two thicknesses of planking. Lightness is almost as important of rigidity, and both qualities are present in combination where the thicknesses are laid diagonally at an angle of 60 degrees or thereabouts, the one to the other.

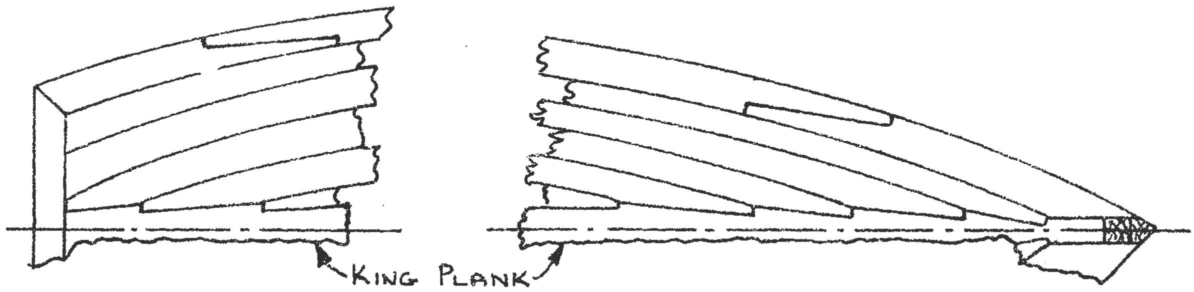
A great many fastenings are, of course, required to unite two layers, but they can be thin copper nails turned and sunk into the wood without recourse to roves and riveting. A point of great importance, which is not given sufficient recognition is that of deck camber. A deck with a well designed thwartship arch, say 150mm in 1800mm of breadth is far stronger than a flat deck; it calls for much lighter deck beams, is drier and gives increased headroom. As an example, a deck of double planking totalling a brar 12mm thick, but given a high camber, was found amply strong enough, where 21mm planking at least would normally have been the thickness.

Another method used for decking boats is marine plywood and sheathed with a fibre glass cloth laid with extremely weather resistant resin such as polyester or epoxy. This method has largely replaced the method of employing canvas, which was used in conjunction with tongue and groove boards.

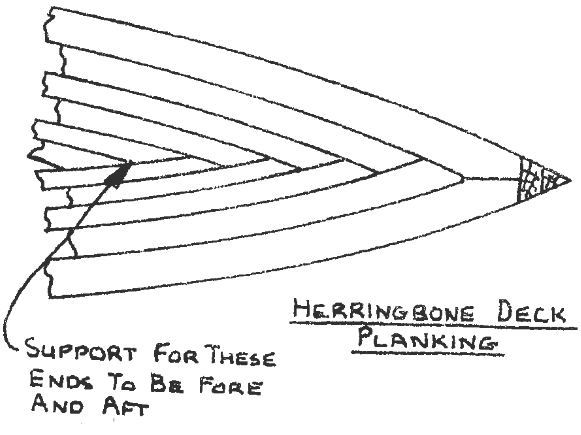
Various methods of planking "laid" decks are shown in the following sketches.



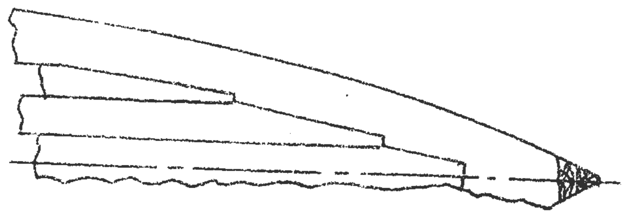
SHIM END, BUTTS IN COVERING BOARD
DECK FOR OPEN LAUNCH



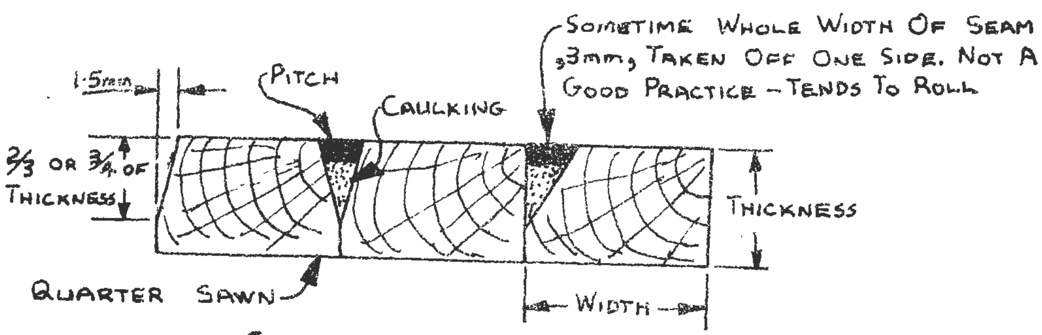
SPRUNG DECKING — NIBBED KING PLANK — SCARPH IN COVERING BOARD.



HERRINGBONE DECK PLANKING

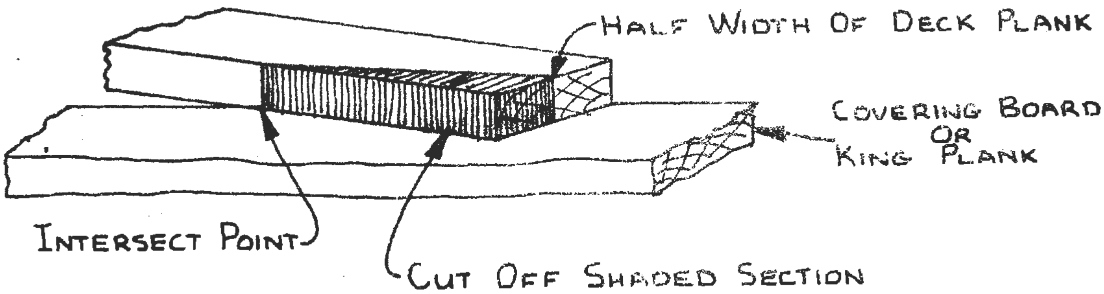


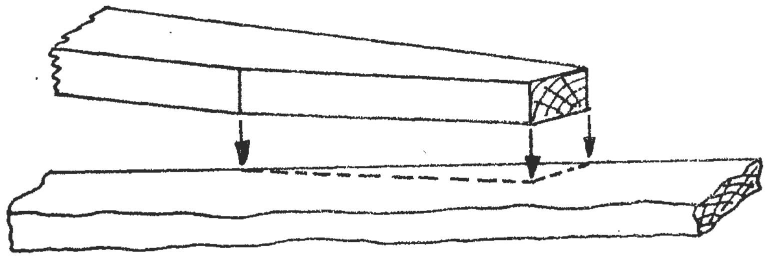
STRAIGHT DECKING NIBBED ENDS IN COVERING BOARD



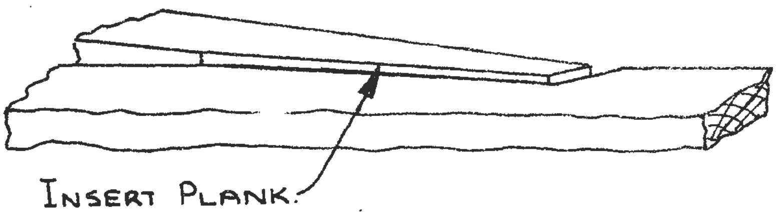
CAULKING SEAM

CUTTING IN THE NIBBED END OF DECK PLANKING.





PLACE PLANK BACK IN POSITION MARK OFF SHAPE AND CUT OUT CAREFULLY



WOOD CAULKING

The common tools used in wood caulking are as follows:-

CAULKING MALLET (BEETLE) required to apply the impact necessary to force the oakum or cotton into the seams.

COMMON CAULKING IRON for driving in the threads of oakum or cotton into the seams.

CREASE IRON OR MEAKING IRON for dressing down the layers of oakum or cotton after insertions by the common caulking iron into the seams. In the case of thick decks, the Horsing iron would be used.

CROOKED IRON for use in place where obstructions prevent the use of the common caulking iron.

SPIKE IRON for use around sharp corners, e.g., hatchways, vent trunks, etc.,.

JERRY, RAVE OR CUTTING IRON is used for removing old threads of oakum from seams; the iron having a tapered section so as to clear itself when being driven along the seam.

HORSING IRON is used for hardening down existing threads in seams, and generally in conjunction with a beetle or large mallet.

REAMING IRON is used for opening seams of plank, prior to caulking.

MATERIALS USED IN WOOD CAULKING

COTTON AND OAKUM. In planking up to 35mmthick, cotton is used, and, for thicker planking, oakum.

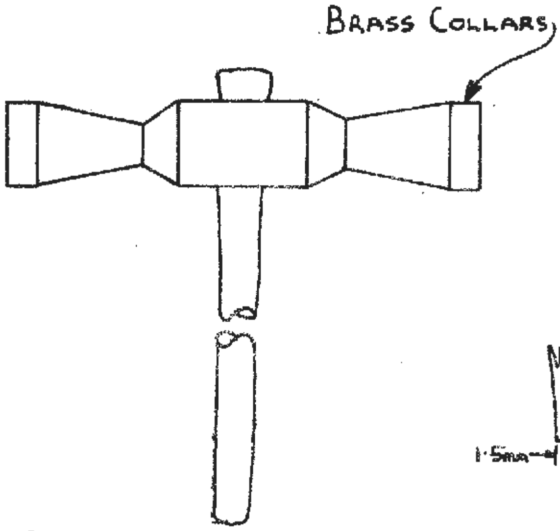
In the case of cotton, the caulking material is ready for immediate use, whereas in the case of oakum, it has to be spun and coiled into threads before use.

PITCH OR MARINE GLUE, used for filling in the seams of the planking after the threads of cotton or oakum have been inserted to make watertight.

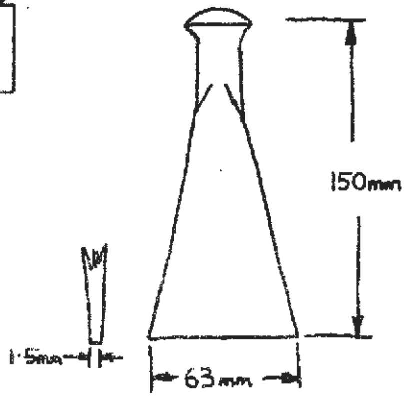
These compositions have to be heated in a container and applied hot by a lipped ladle. The alternative for Marine Glue in C.M.Ss and I.M.Ss is "Thiokol".

TO DETERMINE THE NUMBER OF THREADS TO BE INSERTED IN A SEAM.

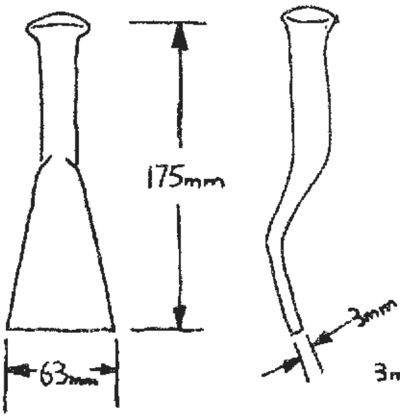
The number of threads is determined by thickness of planking and is usually one for every 25mm thickness of planking to be caulked plus one. Thus a 75mm deck would take four threads. At all times the caulker's discretion is called for; the object is to make a seam or seams watertight and so the number of threads, which can vary with the width of the seam, is of secondary importance.



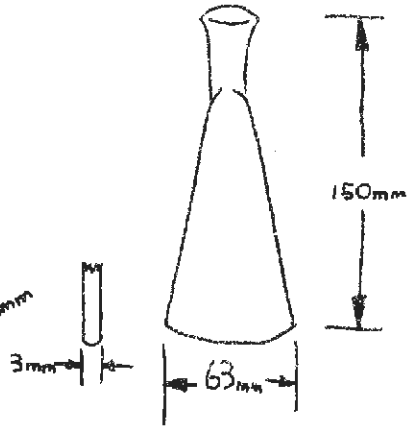
CAULKING MALLET (BEETLE)



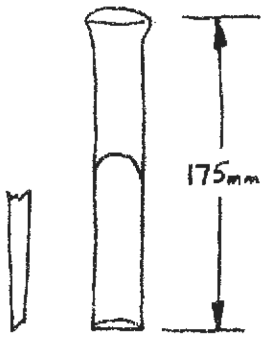
CAULKING IRON



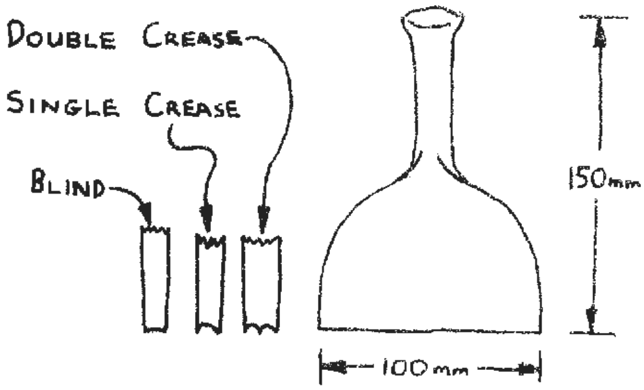
CROOKED IRON



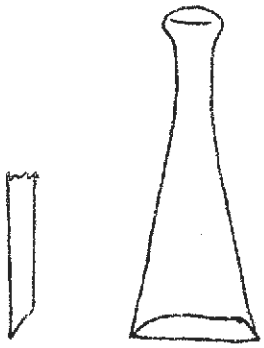
MEAKING IRON

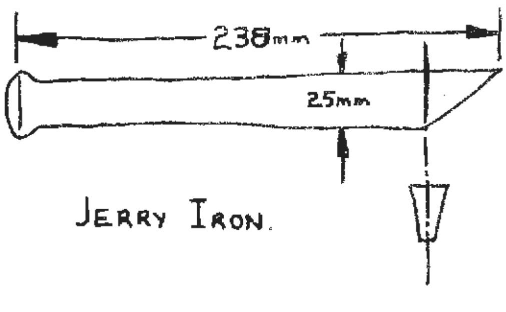


SPIKE IRON

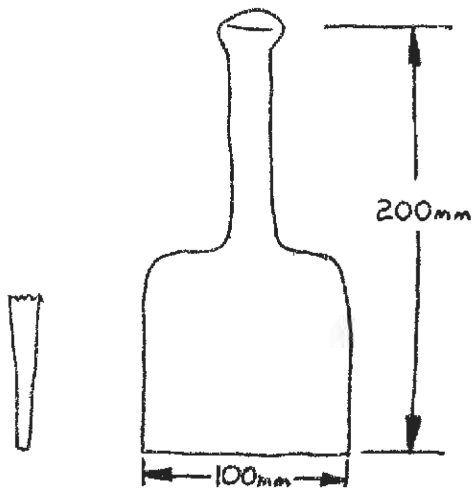


HORSING IRON


SHARP IRON



JERRY IRON.



REAMING IRON

METHOD OF PREPARING A THREAD OF OAKUM

Oakum is picked Hemp steeped in stockholm tar and is usually supplied to ships in bales.

Before oakum is spun into the required size of thread, sufficient quantity is "teased" out to remove lumps. The "spinning" of oakum threads is usually done by folling the oakum over the knee with the palm of the right hand, the oakum being further "teased" out before rolling.

CAULKING THE SEAMS

The caulking iron is held between the thumb and second finger of the left hand while the extended first finger guides the strand of aulking and controls the size of the loops.

Fold an inch or so of a double strand of cotton over and tuck it into the end of the seam with the blade of the iron, anchoring it there securely. Feed the cotton through your left hand with a twisting motion to form a series of small loops, about 12mm in length over the open seam, tucking each one in against the other with a rocking motion of the iron held in the right hand.

When the seam becomes wider, increase the frequency of the loops or add a third strand of cotton. If the seam becomes more narrow, decrease the frequency of the loops or lay the double strand of cotton in the seam without looping it. If the seam should become extremely narrow use only a single strand of cotton.

As you proceed in this work you should leave behind a "braided" effect of the cotton, which is partly in the seam and partly out.

It is the "tucking in" of the cotton that is the secret of success. You must more-or-less "feel" the requirements of the seam for the amount of cotton it needs. Contrary to what you might suppose, it is not difficult to grasp, by the time you have gone a few feet you will have the knack of it.

The caulking must not be wedged in so tightly that this expansion cannot take place. This condition is known as "Over caulking" and could result in causing the planks to buckle. The reverse effect or "under-caulking" does not leave enough cotton in the seam for it to make properly and leaky seam in the result.

CHINTZING

If it is found necessary to carry out a temporary caulk in wood deck, only one thread of oakum is used irrespective of the thickness of planking. This thread is coiled very closely at the top of the plank seam, then being punched and hardened down to about 18mm from top edge of plank. The seam is then payed; this temporary caulking is called "chintzing".

HARDENING DOWN

This is a process used to finish off the new caulking or the renovation of old caulking. It is done either with a meaking iron and mallet, and for wood dedking not laid on steel plate deck with a horsing iron and beetle. (A large size mallet manipulated with both hands). When hardening down, particularly for old caulking the oakum will sometimes hardening down, particularly for old caulking the oakum will sometimes break away and rise above the seams. This is cut out by means of the rave, cutting or jerry iron , through the length of the seam. Seams that are considered slack after hardening are recaulked with additional threads and those that have been jerried out being tightened also by the addition of new threads. On completion of hardening down seams are payed up with pitch or marine glue and process repeated after 24 hours to cover and fill in any air holes or cavities.

PITCH

Was very commonly used for paying up seams, but has been almost superseded by the use of Marine Glue. Pitch is a by product obtained from the distillation of coal tar, etc. The usual test applied to the pitch for suitability is carried out by burning a sample and seeing if there is any ash left and noting if it is brittle when cold. The brittleness is tested by means of a pricker driven into the pitch in the seams which operation should not cause any of it to be chipped out. Pitch may be softened by the addition of tar, if this cannot be got, by oil or tallow.

MARINE GLUE

Marine Glue is a proprietary product and is made by a number of manufacturers.

Briefly the specification for marine glue is bitumen and a few natural asphalts. Marine glue is entirely free from coal tar products.

The glue must be of such a nature as to allow for its use in all climates and must not appreciably soften at a temperature below 115°C.

In a practical test the marine glue should be heated and payed out into a deck seam as is usual in Shipyard Practice, and, when cold, scraped flush with adjacent deck planks.

The glue in seams has to closely adhere to deck planks and surface. Free from any sign of porosity, inclination to fall away from deck planking seams, tendency to crumble, and finally must be watertight.

THE APPLICATION OF MARINE GLUE OR PITCH

(a) PREPARING THE GLUE

Marine glue should be melted slowly until it becomes entirely fluid, stirring frequently, when properly melted and ready for use it should drip like oil; if allowed to cool it will thicken, will not run freely into the seams and will likely form air pockets or bubbles.

If heated to boiling point it becomes brittle.

Only sufficient for the job in hand should be heated at one time and the melting pot cleaned out after use; continual re-heating also causes brittleness.

(b) PREPARING THE SEAMS

If the seams have been previously payed, clean them out throughly and remove all traces of pitch which may be there. Any of the old material that adheres to the side of the seams should be scraped off.

Caulk the seams carefully leaving space above the caulking for marine glue to attach securely to the sides of the seams. During caulking, irons should be dipped in white spirit, but not in linseed oil or grease as these prevent the glue from adhering to the planking.

(c) APPLYING THE GLUE

Special care should be taken to have and keep the seams absolutely dry as the slightest moisture under the marine glue will impair its effectiveness. The glue is preferably applied on a clear day or under cover.

The glue should be poured into the seams from a paying ladle with a spout issuing a fine stream. The spout should be held sufficiently above or away from the seam to allow the air to escape; it should not be drawn on the seams as this permits air to be enveloped which cannot escape before the glue sets and the resultant air pockets leave the seams hollow and unsound.

It is preferable to apply the glue in two operations; the first filling to consist of a small quantity payed into the bottom of the seam and allowed to set before applying the second one.

It is advisable to allow the glue to overflow the seams slightly, permitting the excess to remain for several days; this allows the gradual settlement of the glue into place, after which the excess should be removed with a scraper, flush with the deck, scraping diagonally across the seam. In hot weather when glue is soft, application of water to deck will facilitate scraping. Frothing or air bubbles should especially be guarded against in paying up seams, as such impair the eveness of the filling, and the watertightness of the seams. Air bubbles may be due to:-

(a) Too high a temperature of the glue
(b) An excess of oil in the oakum
(c) Wet weather or presence of water in the seams
(d) The presence of any sulphur or similar chemical in the oakum or oils.

TESTING OF WOOD CAULKING

This is usually carried out by trial on some selected portion of work completed, with the exception of paying up and done by the use of the meaking iron and mallet. By experience it is said that the caulker or examiner oan tell by the ring or tune of his caulking mallet on the head of the making iron whether the work has been performed efficiently. The more general method is to use the rave, cutting or jerry iron to remove some of the seam which is closely examined for compactness, general condition and smell of the oakum.

PIERCING OF WOOD DECK PLANKING

Deck planking in many positions, such as at the foot of access ladders, in way of access doors, shows considerable wear and forms hollows in the planking and a reduction in the depth of seam available for caulking and paying up.

The extent of this wear very often does not warrant the complete renewal of the plank or planks concerned.

A similar situation is caused by the planking being cut or scored by accident.

To restore the condition of the affected areas, the planks are "pieced" by the insertion of wood patches.

The patches are commonly referred to as graving pieoes, shape and size being dependent upon the circumstances.

PLYWOOD FOR MARINE CRAFT

The decay hazard to which marine plywood is subjected varies greatly with the use to which it is put, and it should be noted that a durable adhesive does not impart its qualities to the wood and cannot prevent its decay. The use of rot-proofed plywood should be considered if boats will be in the water for long periods.

Careful sealing of end grain or panel edges and the provision of good drainage together with good ventilation and the avaidance of damp pockets and excessively high humidities will help to keep decay hazard at a minimum.

In boatbuilding it is often difficult to avoid a construction that is likely to lead to the growth of the wood destroying fuingi. In situations where water entry into the plywood cannot be entirely prevented, the use of permeable coatings or the omission of paint on the dry side will allow it to dry out. If decay hazards are relatively low these constructional techniques, combined with the use of suitable brush or spray preservatives, can give protection.

Plywood which has been completely impregnated with approved fixed preservatives is very resistant to wood decay. All timber that is susceptible to lyctid borer attach should be immunized in accordance with Australian Standard 1604-1974: Preservative-treated sawn timber, veneer, and plywood, if it has not been otherwise preservatized.

Scarf joints through the full thickness of sheets are permitted by agreement between the manufacturer and the purchaser. The slope of the bevel of the edges to be joined should be not less than the following:

For sheets under 13 mm in thickness, 1 in 10.

For sheets 13 mm and over in thickness, 1 in 8.

Scarf joints should be bonded with an adhesive of quality and type at least equal in durability and strength to that used in the manufacture of the sheets.

Plywood sheets must be stored flat on a level bed to prevent distortion, in a well-ventilated place and shaded from sunlight through windows, which will cause changes in colour.

Marine grade plywood should be used for the hull, decking, all stressed components, and any other exposed parts.

SOME HINTS FOR PLYWOOD USERS

By your plywood from a reputable, well-known dealer or manufacutrer, whose name depends on selling a quality product.

All hull and deck cladding must be marine grade plywood-refer Australian Standard 086-1964 Plywood for Marine Craft. Exterior plywood with Type A waterproof bond may be used for linings, cabinets, etc., not of primary structure importance-refer Australian Standard 087-1963: Plywood for Exterior Use.

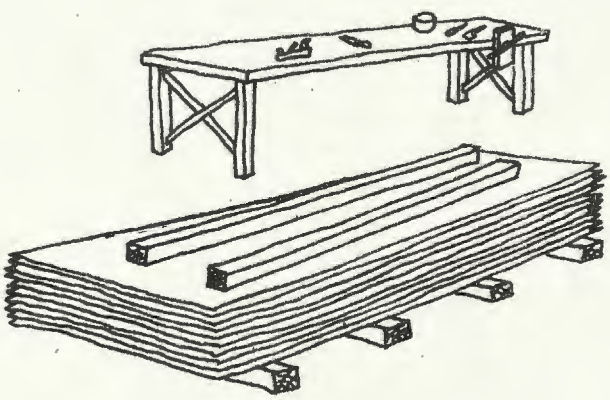
Sound, adequqte interior framings are essential.

A heavily-built transon (back of the boat) and hull-bracing are "musts". Outboard designs should feature a partitioned-off motor well, rather than a low-cut transom which can ship water in heavy seas.

Check inside the hull to see that any exposed plywood edges are fully sealed against moisture.

There is not need, however, for the superstructure to be too heavily built. In fact, lightweight construction helps lower the centre of gravity for improved stability and performance.

Plywoods made from NSW Veneers are sophisticated materials, precision manufactured to perform excellently in their appropriate marine applications. So that it goes into your craft in top condition, always store plywood flat on a level bed to prevent distortion. The storage area should be dry, well ventilated and provide shading from direct sunlight.

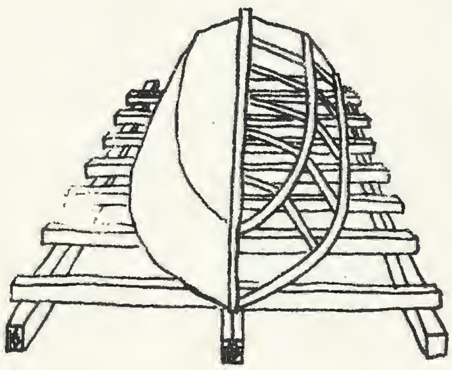


Spend some time in planning the fit of your pattern in your plywood so that when you cut the sheet there is the minimum of waste. Sometimes a small movement of 25mm may enable another piece to be cut from it.

KEEP YOUR CRAFT STRAIGHT

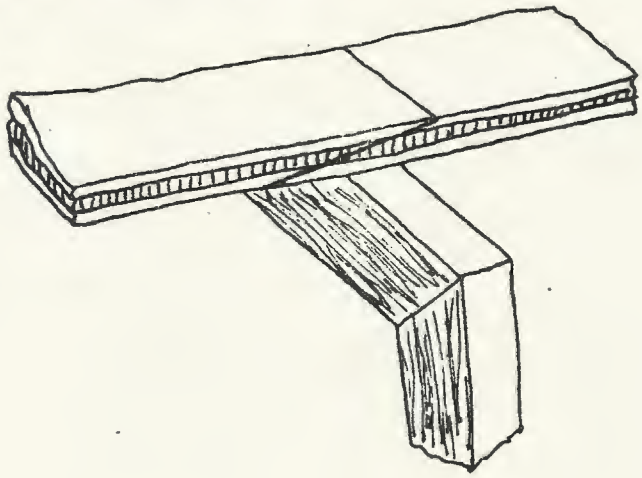
To ensure consistent good fit of sheathing, and to eliminate the possibility of building a twist in your boat, it pays to put some time into constructing a really accurate building jig. Make the jig exactly according to the plan, checking the levels in both planes, and making sure there is no twist in the structure. Run a taut string line down the centre of the jig, accurately marking frame stations at right angles to the line. When you are satisfied the jig is true in all respects, fasten it down and brace securely so that no movement can occur.

When the frames are in place on the jig, go over the framing and check the stem keel transom and frames for perfect positioning. Inset all chine pieces, clamps and battens and glue and screw into position, setting the screw heads deeply enough for the plane not to strike them during the bevelling operation. While planing, have a piece of plywood of the same thickness as the planking and use it as a guide for fairing the frames, chines and stringers to receive the plywood.

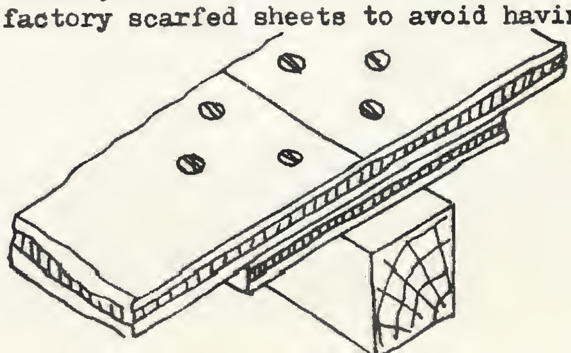


MAKING JOINTS

Where Scarf or Butt Joints, not factory made, are called for in the plans they must be made over a frame or other support. Bevel carefully the plywood for a scarf to a slope of 1 in 8 and carefully glue and screw or nail using a waterproof adhesive.



Butt Joints are easier to make when a joint must be made between plywood sheets on the job. Wherever possible plans should call for factory scarfed sheets to avoid having to make joints on the job.



PLYWOOD - CONSTRUCTION.

PLYWOOD-CHINE CONSTRUCTION

Plywood-chine can be used by boat builders without difficulty. The design of a single chine craft is prepared in such a way that the side and the bottom are both conical projections of flat sheets of plywood.

Lay the plywood sides against the hull, and mark them along the chine and gunwale and down the stem and transom. Remove and cut out well on the waste side of the line, cramp up again into position and mark the position of the frames and longitudinal stringers on the inside. (Sometimes a couple of positioning screws will save a lot of time.) When replacing the plywood, first remove it and place glue on the framework as well as between the lines marked on the plywood with positioning screws. Then, commencing from the middle of the hull, iron-out the plywood and fasten it to the longitudinals (not the frames) with boat nails, top and bottom, until you reach the ends. Then fasten-down the transom and bow.

The fitting of the bottom ply to the keel, stem and transom varies with the type of construction.

1. If no deadwood, skeg or keel batten is required it is necessary for the ply edges to be mitred down the entire length of the keel. (See Fig. 1)

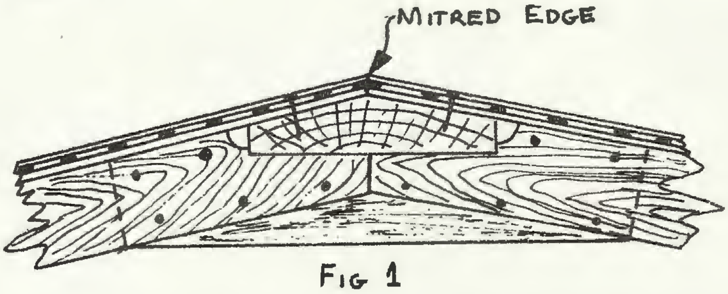


FIG 1

2. If deadwood, skeg or keel batten is required the previous method may be used, the plywood being planed flat to accommodate the deadwood, etc., or alternatively one plywood sheet may overlay the other, again the surface being planed flat to accommodate the deadwood, skeg or keel batten. (See Figs. 2 & 3).

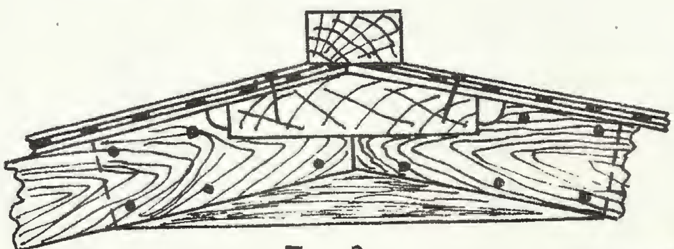


FIG 2

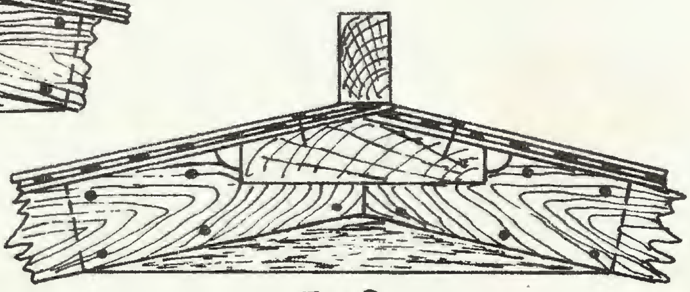
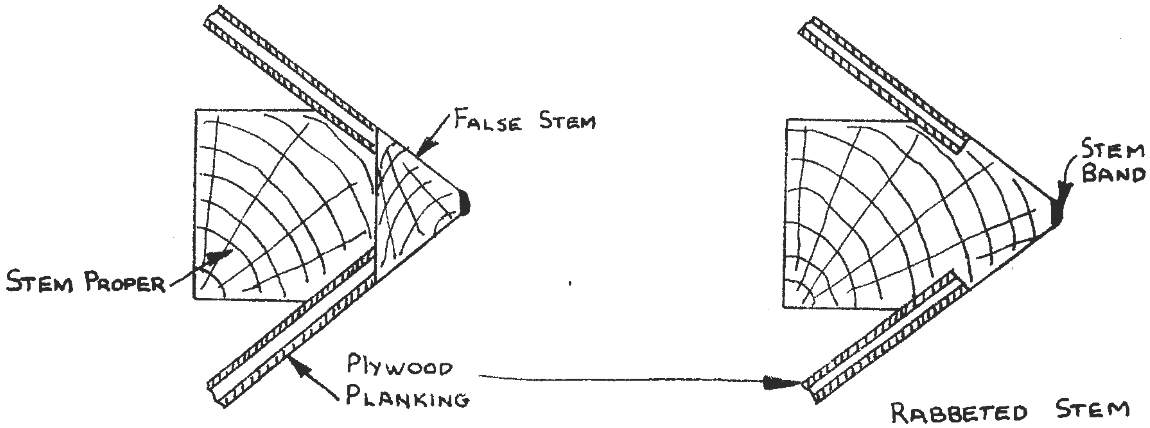
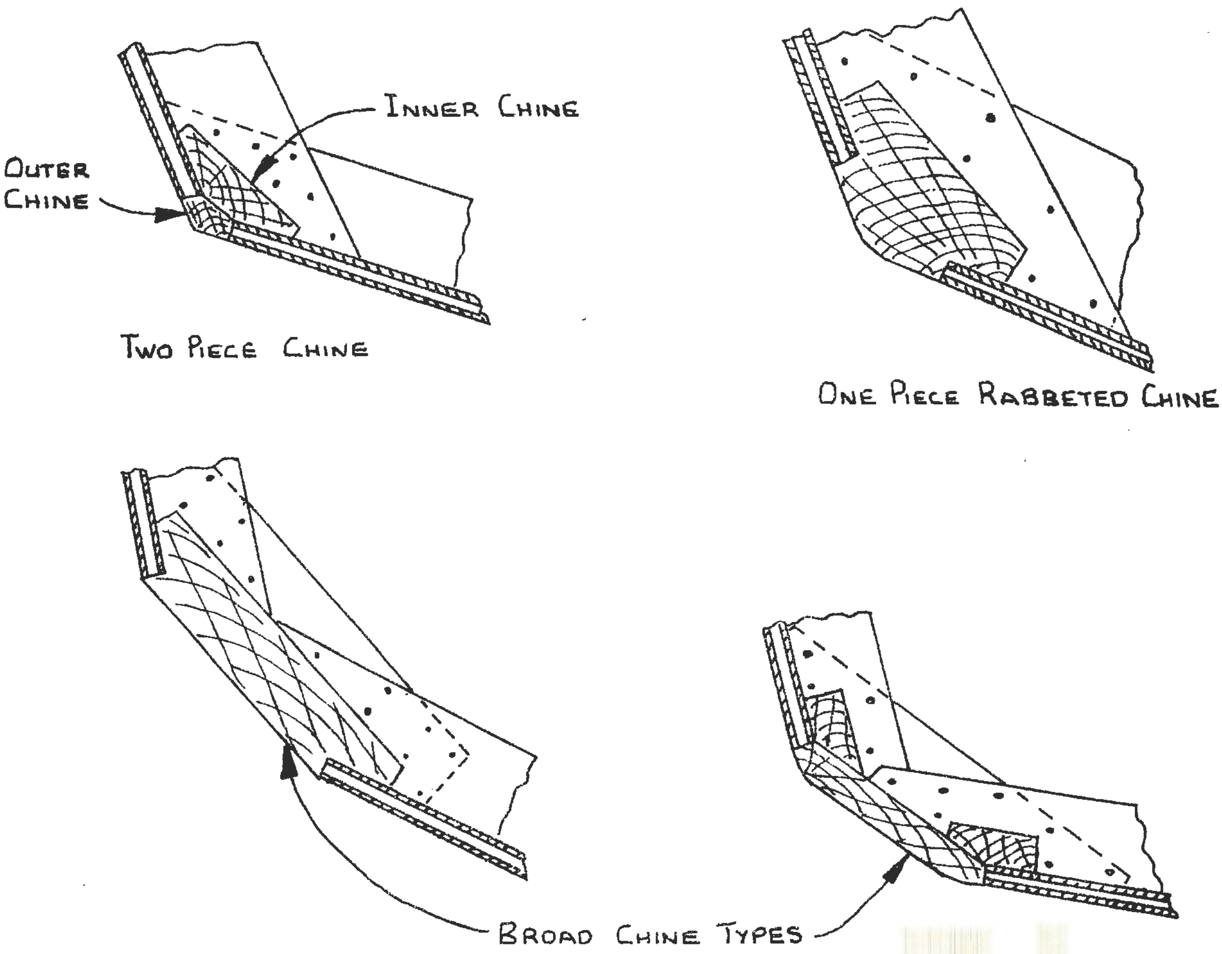


FIG 3



STEM CONNECTIONS



CHINE CONNECTIONS

Depending on the designer's requirements this may mean the after end of the vessel being laid in two sheets of plywood, the first layer being fastened to the chines, stringers, keel, gunwale and transom not the frames, the second layer of plywood being laid up, glued and fastened with boat nails to the keel, stringers, chines, gunwale, transom, etc., whilst staples may be used to compress the glue and force the plywood into the required shape between these members. Unless copper staples are used each staple must be removed after the glue has set.

The rough edges of the plywood are then cleaned off to the bevel of the chine so that the bottom overlaps the side ply. As the bow is approached, this bevel may become excessive, so that it becomes necessary to convert from an overlap to a mitre joint, by means of a transition joint. (See Figs. 4 & 5). It would be wise to practise this joint first on several pieces of scrap plywood.

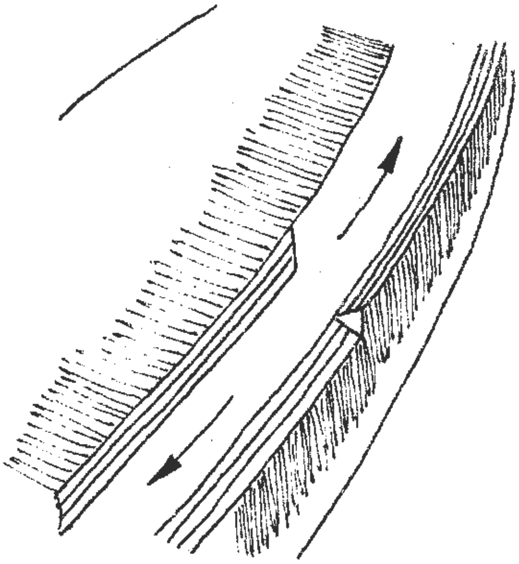


FIG. 4

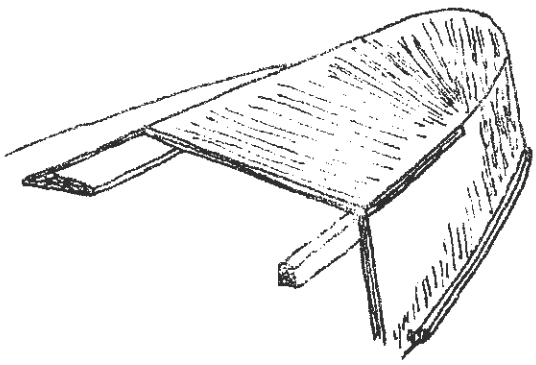


FIG. 5

The bottom plywood is marked in a similar way to the sides, and in most cases can be put on cold.

Occasionally, when the shape forward develops an excessive wind heat must be used to shape the plywood. When the plywood has been faired in and marked for longitudinals and frames, remove and place glue on hull and plywood as with the side plys. Fasten only to longitudinals—not frames. Clean up the edges of the plywood. If reinforced fibreglass plastic is to be used to stiffen the chine and keel, it should now be placed on and the keel and chine battens applied. In some cases this can be done while the resin is still tacky.

If the vessel is of the inboard type, a jig can be made to determine the position of entry and the angle of the shaft and the hole for the shaft bored while the vessel is still on the building jig and turned over. A cradle should be made so that the vessel can sit upright with adequate support. Clean-up the gunwale line, attach and fair the deck framing, apply the plywood deck. From this point onwards the craft may be finished to individual requirements.

Double chine and three-strake clinker constructions have been developed to improve the performance of sailing dinghies and roundabouts. Here a third flat sheet of plywood is added as a conical projection so that the sides are made up with more shape, but the principle is the same. On some craft a third sheet is added at the chine, as for clinker planking, giving a more curved effect to the midships section but adding very little to the difficulties of construction. The centre plank is relatively narrow compared with the upper and lower strakes.

DOUBLE OR MULTI - DIAGONAL PLANKING

Double or multi-diagonal planking consists of two or more skins at varying angles to each other. Synthetic resin glues make it possible for planking to be glued together on faces and edges to form a uniform construction, eliminating the use of oil fabric between the skins. Only gap filling adhesives should be used and sufficient pressure must be applied to ensure that the faces of the planking are held in contact until the bond cures.

HOT MOULDING BY VACUUM PRESSURE.

The hot-moulded veneer hull sprayed with polyester resin paint is said to require a minimum of maintenance. A timber mould, mounted on a trolley with a flat metal plate top, is used to form the hull.

Planks about 150mm wide x 2.5mm thick are layered over the mould. Wads or bundles of planks are cut to templates and stored in racks ready to use. The first layer is put on dry and the second and subsequent layers are glued, on one side only, by passing them through the rollers of a glue spreading machine. As the second and subsequent skins are applied the staples holding each previous skin are removed.

Stems, hogs, keels and transoms of preformed, laminated construction may be integrally moulded into the hull.

A rubber bag is then lowered over the hull and secured a vaccum applied to stretch it tight. The whole assembly is now wheeled into an autoclave where steam heat of over 100°C and 350 Kiloscals of pressure are applied. After about half and hour the hull is removed and allowed to cool and is then ready for further construction work. This method is suitable for quantity production but involves considerable capital investment for tooling, jigs and autoclaves.

COLD MOULDED CONSTRUCTION

This is comparatively simple method of construction using temporary fastenings for applying pressure to the skins during setting of the adhesive.

ADVANTAGES:

(a) The mould is simple to construct as little pressure is required.

(b) Although it is an advantage to use a close planked mould, good hulls can be constrcted by using stringers spaced at about 75 to 100 mm centres.

(c) Because of the simplicity of the mould, alterations to the shape and design of the hull are easily made.

APPLICATION:

Pressure to hold the skins together while the adhesive is setting is obtained by the temporary use of staples or panel pins. Since pressure is localized, the width of the strip to be glued must be limited to allow even distribution of the adhesive and dispersion of any air pockets between the panels. Although the width of the strip is largely controlled by the curvature required, it is recommended that the strip's should not be more than 100 to 125 mm wide.

A fast setting combination of adhesive and hardener can be used as the closed assembly time required is comparatively short. Each skin, however, must be cleaned before the next skin is bonded to it.

MATERIALS - VENEER OR PLYWOOD?

In general three skins of veneer are used but it is possible to use two skins of plywood or a combination of plywood and veneer. The Thickness of the veneer ranges up to 2.5 mm and the plywood from 1.5 mm to 3 mm. Except in special instances the final skin thickness should not be less than 6mm.

LAYING OF SKINS:

(a) Using three skins:

(1) Three layers of diagonal planking - the inner and outer skins laid in the same direction.

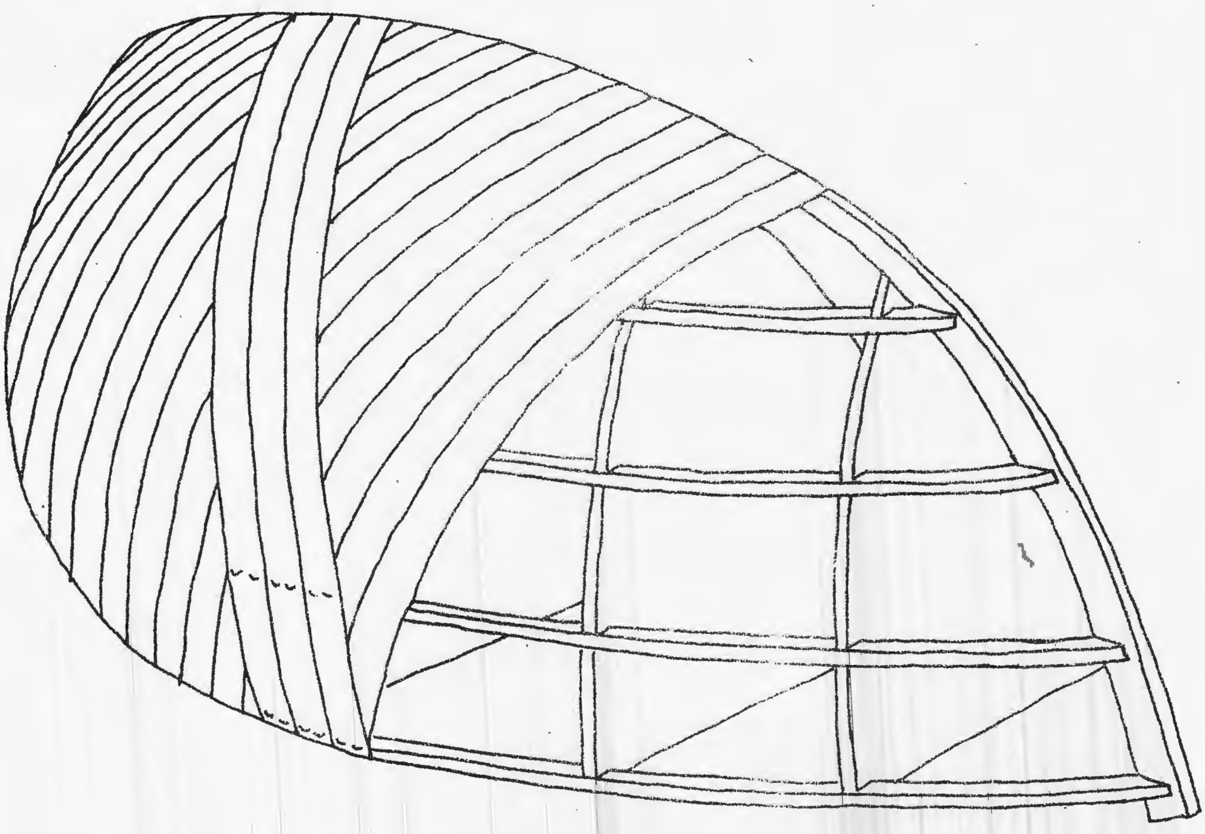
(2) The inner and outer skins laid diagonally and the middle skins fore and aft.

(3) The inner and middle skins laid diagonally and the outer skin fore and aft.

(b) Using two skins:

(1) Both diagonally laid, crossing at an angle of about 45°; with this construction the use of plywood only is recommended.

(2) The inner skin laid diagonally and the outer skin fore and aft, the inner skin being plywood and the outer skin veneer.



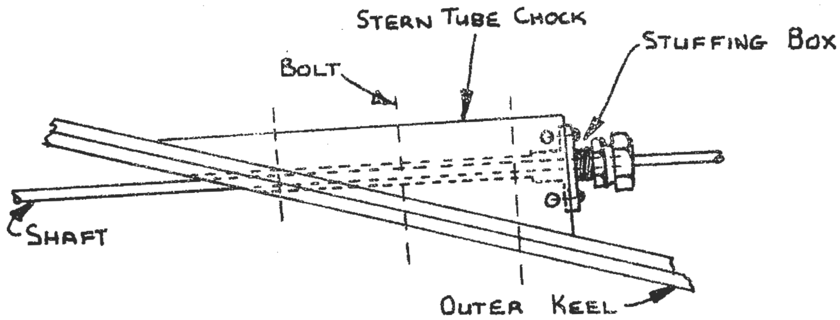
COLD CONTACT MOULDING (COLD MOULDED)

INSTALLATION OF INBOARD ENGINES

The problems to be encountered when installing engines in new boats are very similar for almost every type of craft and engine.

The engine mounting lugs seat on top of the bearers (or on chocks attached to them). The great length of the bearers is necessary to distribute the load and damp vibrations.

The propeller shaft passes through a bearing and a stuffing box, or gland, fixed to the shaft log and thence to another bearing set in the stern bracket.



ENGINE BEARERS.

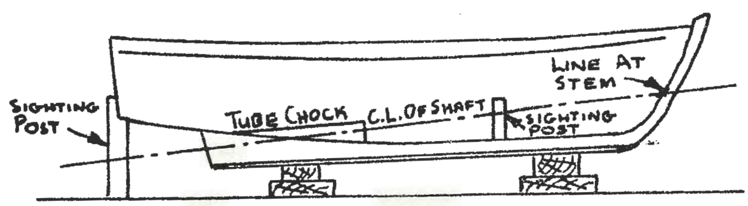
In fitting the bearers, templates are used in the same way as with the floors, but the work of fitting is altogether more elaborate. Great care must be taken to get them correctly spaced and parallel. Through fastenings must be employed to hold them rigidly in position. Stiffening is effected either by struts to the stringers or by knees.

STERNTUBE CHOCK OR SHAFT LOG

The tapered chock for the sterntube is cut nearly to shape from the design, being afterwards accurately fitted to the keel or hog and bolted in position. Naturally, there must be room between the two lines of bolts for the shaft and sterntube, the chock is bedded on a mixture of red and white lead.

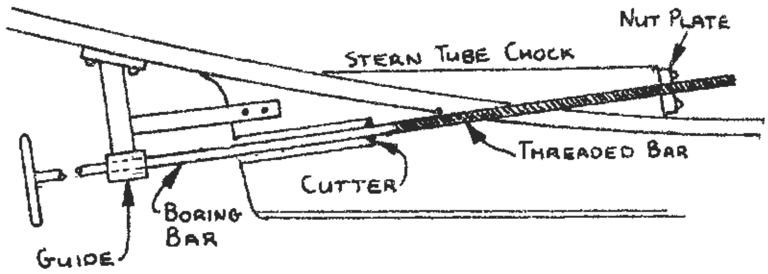
SHAFT LINE - BORING

The line on the design plan must be produced forward and aft, giving a point at which it touches the stem, also its position vertically under the transom. The correspoinding points on the actual boat can then be marked. Next, we want two intermediate points, one just forward of the sterntube chock inside the boat, the other a foot or so aft of the point where the line comes outside the keel. These points must be carefully marked on pieces of wood nailed in place.



MARKING OFF THE SHAFT LINE

With the help of the points thus obtained, a small auger can be put through the chock on the correct line, after which the hole is finished to the right diameter by means of a boring bar and cutter, usually fitted with a screw thread working in a nut plate.



BORING THE STERN TUBE CHOCK AND DEADWOOD

SHEATHING

TYPES OF SHEATHING MATERIAL

(a) Timber

(b) Plywood

(c) Copper

(d) Plastics

TIMBER SHEATHING

The timber used should be of species known to have a high natural resistance to marine borer attack, or timber which has been pressure impregnated with an approved preservative.

The timber should be straight, sawn to the dimensions ordered and free of knot clusters, splits, shakes and fractures. Moisture content of the timber sheathing should be in the range of 20 percent to 30 per cent at the time of fixing.

Planks should be 19 to 25 mm thick. The adhesive is usually a rubber based solution with good drying properties and should not deteriorate when in contact with salt water. Copper should be not less than 22 gauge.

Copper or galvanized iron fastenings may be used but it is advisable to use the same type of metal throughout so that no electolytic corrosive action takes place due to different metals being used in close proximity.

Wherever practicable, the heads of major hull fastenings should be sunk about 3mm below the surface of the hull and covered with a paste made of white lead and zinc oxide in oil. All seams should be properly caulked, payed and filled. Where metal sheathing is to be applied all sharp edges of timber should be rounded off

The metal sheathing should be so laid that a tuck of at least 20mm is covered by timber sheathing and any galvanized fixings should be at 50mm away from the metal sheathing. A coat, 1.5mm thick, of the adhesive should be applied between the wood and metal sheathing.

The hull is generally sheathed to a line 150mm above the loaded waterline of the vessel. The distance between fastenings should not exceed 450 mm in any one plank and end fastenings should be within 150 mm from the butt of the plank.

Butt blocks should be fastened over hull-plank butt-joints to give access to the joints for caulking purposes. Kraft paper or felt should be placed over the adhesive before fixing the butt block.

Where the keel has been sheathed with metal, a false keel at least 30 mm thick of solid timber may be fixed.

PLYWOOD SHEATHING (See Also Plywood For Marine Craft)

Plywood, preferably rot-proofed, may be used to sheath the hull of a light craft. The adhesive is usually a rubber-based solution with good drying properties and should not deteriorate when in contact with salt water. The edges of the plywood sheets must be properly sealed to restrain the plywood from absorbing moisture. Hull construction and the thickness of the sheathing will determine the spacing of edge nailing or screwing but spacing should not exceed about 150 mm because greater spacing will permit the plywood to lift between fixings.

Plywood sheathing may be used to repair an old hull or to strengthen a light hull which is to be used in severe operational situations.

COPPER SHEATHING

Generally the same requirements apply to metal sheathing as were mentioned for timber sheathing. Refer to Standards Association of Australia's Interim Specification 98-1945, Sheathing of Wooden Vessels with Copper.

Sheathing should be of hot rolled or cold rolled annealed sheets 1200 mm x 356 mm x 4.3 kg/m^2. Nails should be copper of not less than 16 gauge.

The sheathing underlay should be suitable adhesive. The hull should be sheathed so that all timbers including planking, keel, stem, and stern posts and rudder (if timber) are covered to 150 mm above the loaded water line. All sheets should lap adjacent sheets by 25 mm.

Edge nailing should be done on a centre line 12mm from the edge with nailed in addition to edge centres. All sheets should be nailed in addition to edge nailing on a diagonal pattern at 75 to 100 mm centres.

All sheets should be punched before nailing and the nails should be dipped in the adhesive. The length of the nail should be such that when driven home the total penetration is 20 mm. Where the hull is less than 25 mm thick the penetration should be 6 mm less than the thickness.

TYPES OF PLASTIC SHEATHING

1. Nylon
2. Fibreglass

Plastic sheathing has the advantage over metal that no electrolytic action can take place.

NYLON

A specially woven nylon cloth can be stretched over two-way curves is bonded to the wooden hull with a resorcinol-type adhesive. Adhesives are used to impregnate the nylon cloth and thus complete the water proofing process; colouring agents may be incorporated in the adhesive to give the desired appearance.

Knowledge of how to stretch and form the nylon is very important and the manufacturer's advice should be sought before commencing work. In the event of damage, the nylon sheathing can be easily repaired. The same material can be used for deck and roof covering.

FIBREGLASS

Two general methods of application are used:

(a) a pre-formed sheet of polyester reinforced with glass fibre-is bonded to the hull.

(b) liquid resin and glass fibre reinforcement are applied to the hull.

The basic resin components must be accurately measured before mixing, as the wrong proportions will upset the curing process. Such materials as bitumen, which contains phenol, will seriously interfere with setting or curing of polyester resin.

Polyester/fibreglass is stiffer than nylon and therefore is more likely to crack or part from the hull. Repairs to polyester/fibreglass are made with an epoxy resin repair kit.

New plastic materials and improved application techniques are being developed all the time so thorough enquiries should be made prior to selecting a material for use as sheathing.

REPAIRS

Tingles are patches used to repair the hull of the boat. Patches may be used to repair defects on timber or plywood hulls. The patches can be screwed or nailed and may be applied on the inside or the outside of the hull. Small repairs on plywood craft may be made by fitting a "doubling" piece to the inside skin and then letting a plywood section in from the outside.

Correct scarfing methods should be used. The patch should be bedded in with a suitable compound and sufficient overlap should be provided for fixing. Large areas of damage may be reapired using sheets of marine grade plywood, which may be screwed, nailed or bolted in place. Diagonal planking may be used to make temporary repairs where the hull is curved two ways. Where possible, the tingle should be fixed through the frame. All edges should be "faired in" to aid the flow of water the surface.

RESIN REPAIR KITS

Epoxy resin repair kits have been developed to allow quick repairs of wooden craft, and if correctly applied can continue to cure in the water. The repairs may be made on either the inside or the outside of the hull.

This type of repair work is applicable where only limited damage has occurred.

CARRYING OUT REPAIRS

The damaged inner skin of timber should be built up approximately to its original thickness by filling the fracture or indentation. The following are some of the means which have been employed for this operation.

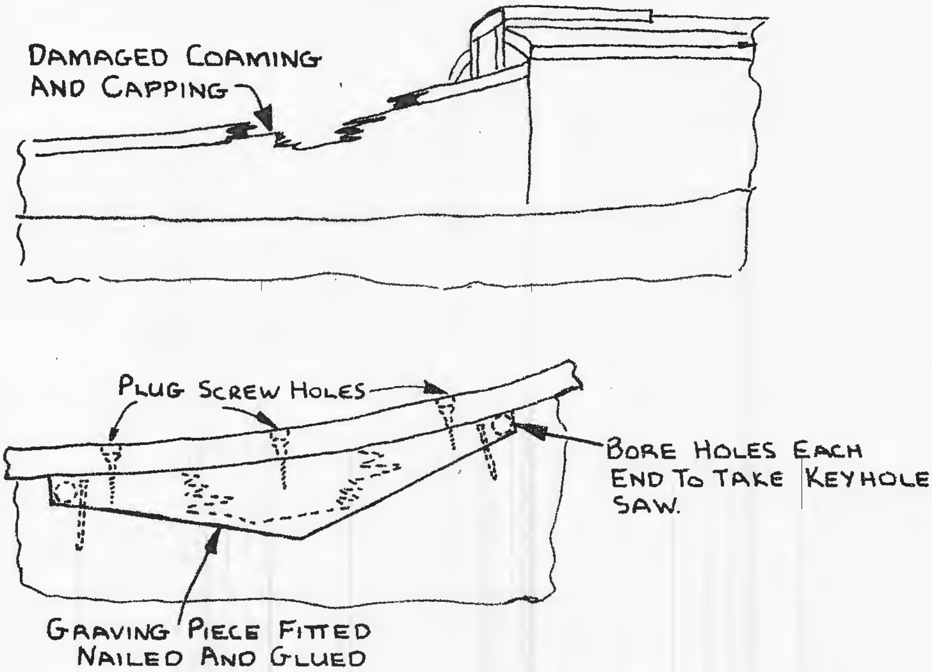
1. Fitting a piece of wood or plywood and bedding in with resin mix.
2. Filling with epoxy resin putty.
3. Fitting a piece of wire gauze over the fracture.
4. Filling with an expanded foam material.
5. Filling with a dough of shredded glass fibre reinforcement and resin mix.

Unless excessively large, holes produced by clenches need not be filled. Wooden plugs or putty can be used if filling is considered necessary.

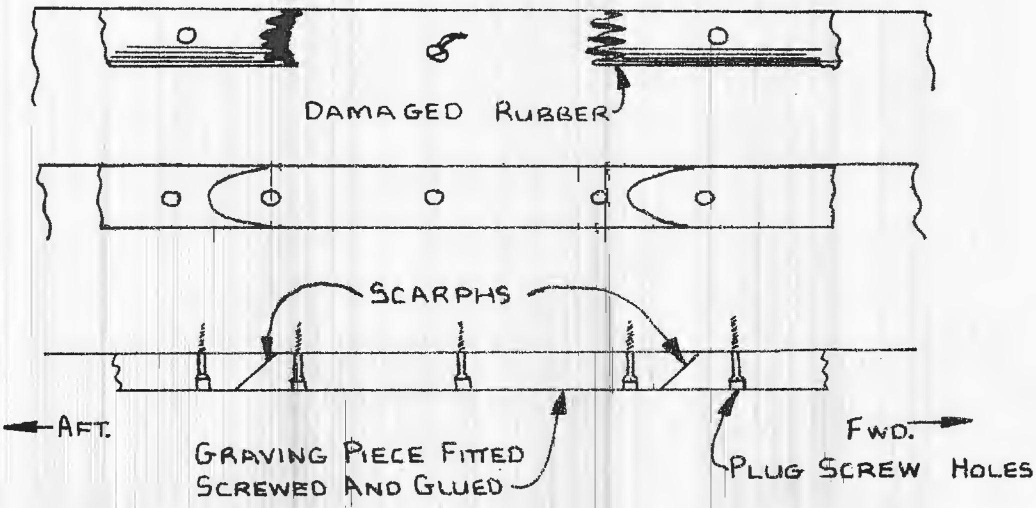
Following the flushing or filling of the inner skin and without waiting for resin or putty utilized for this purpose to set, the full repair can be effected.

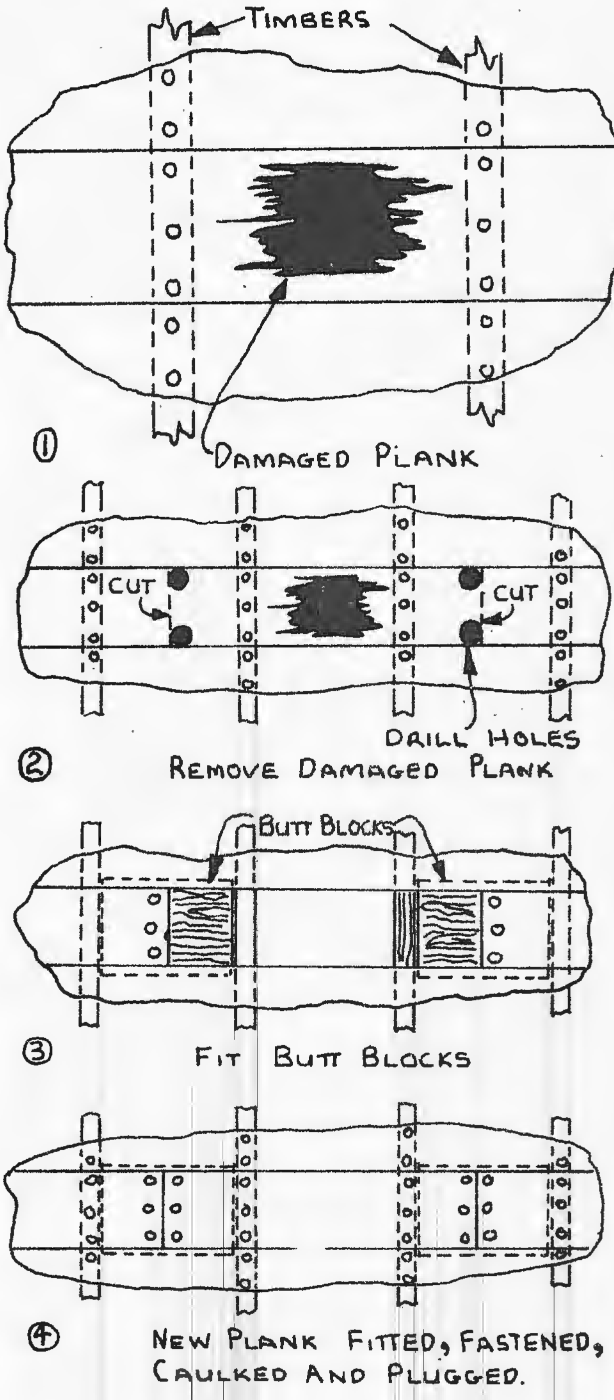
The outer skin of the hull should be cut away to expose some 30mm of sound inner skin, leaving the damaged inner skin alone. All edges should be well bevelled to allow adhesion of the reinforcement. Any oiled calico used between skins should be removed and area exposed should be thoroughly dried before applying the resin and reinforcement.

TYPICAL REPAIRS

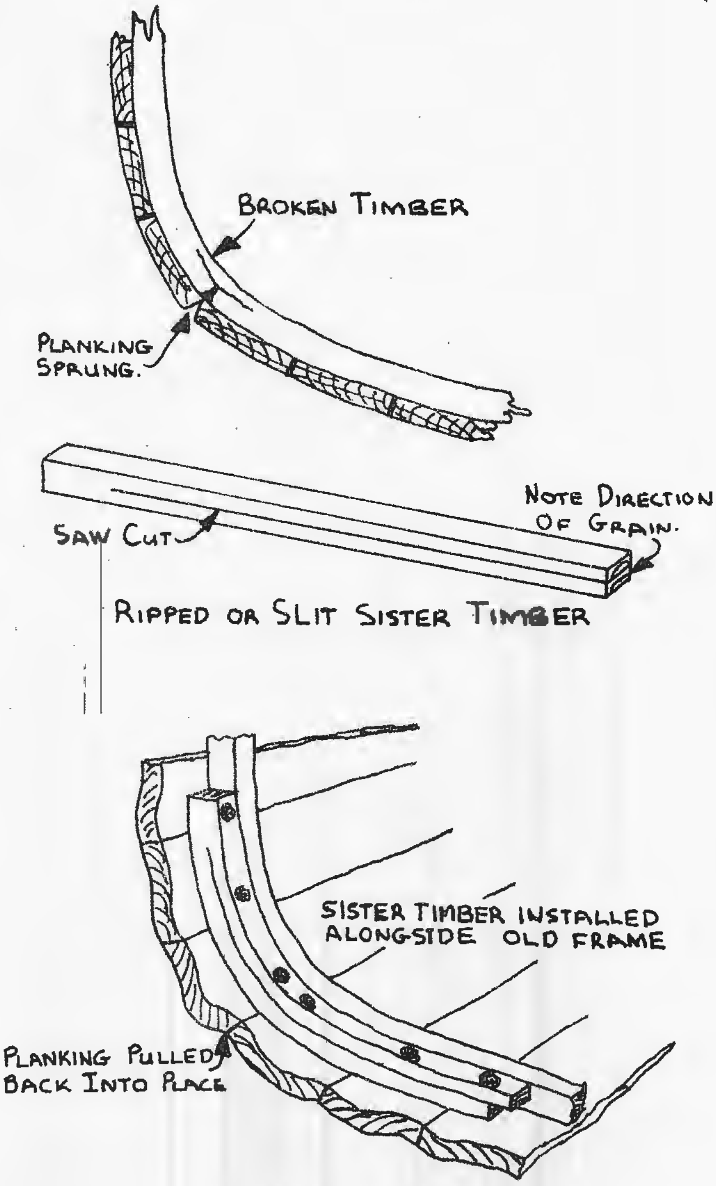


REPAIR DAMAGED COAMING AND CAPPING





REPAIR TO DAMAGED PLANK



REPAIR TO DAMAGED TIMBER

A thick layer of resin mix should be applied over the whole of the inner skin which has been exposed by the cutting back of the damaged outer wooden skin. The first piece of reinforcement which has been cut to size should be placed in position on top of the wet resin, and the resin mix worked through the reinforcement, if of glass fibre, by rolling. This operation is normally carried out by serrated washer rollers which are easily cleaned. Mohair paint rollers may be preferred as they minimize the possibility of damage to the glass fibre.

Application of the resin and reinforcement should continue until the repair has been built up flush or just proud of the original hull form. A polythene sheet can be laid over the final application of resin and skin and rolled with a non-serrated roller to produce a smooth external finish. After gelation and cure of the repaired surfaces, an application of a standard marine primer followed by the final hull finish will complete the repair.

The resin must be mixed in strict accordance with the manufacturer's instruction.

WOOD DECAY

CAUSES OF DECAY

Troubles arising from fungal decay are usually due to faulty design, the use of unsuitable or infected timber or the lack of adequate preservative treatment.

Wood decay is caused by fungi and will not occur when moisture is present in sufficient amounts to raise the moisture content of the wood above 20 per cent and maintain it thus for lengthy periods. Wetting does not harm timber provided it can dry out quickly. For this reason, the incidence of decay in open boats is slight when compared to decked boats.

How does moisture find its way into timbers of decked boats?

1. Use of unseasoned timber. Large sized members such as stern and stem posts are often inadequately seasoned.

2. Leakage of water. It is the leakage of the freshwater that encourages most decay. Direct wetting by sea water does not appear to encourage decay. However, moisture evaporating from sea-water in the bilges can condense as fresh water on the timbers above.

Leakage is most serious when it occurs at the edge of the deck and finds its way into the ends of beams and frames. If there is a lining to the hull, such leakage could go on for a long time before being detected. It is an advantage if parts of the lining are screwed so that portions can be removed for regular inspection.

Leakage and decay often occur at the junction between coamings and decks and when bulwark stanchions pass through covering boards. When surveying or refitting a vessel, a careful inspection should be made of these areas.

Faulty plumbing around lavatories and sinks can be a source of fresh water leakage and regular inspections should be made of these areas.

The absence of adequate ventilation, leading to condensation of moisture from the air, is a very common cause of timber decay in cabin boats which lie at moorings for long periods. The ventilation provided for little used places such as the forepeak, lockers, etc., is often totally inadequate and generally blocked by the goods stored in them.

RECOGNITION OF DECAY.

It is sometimes difficult to detect incipient decay in boats as decayed wood may hold its shape as long as it is in a damp condition. Often the only indication is a wrinkling of the paint on the surface. Usually, distortion of the timber only occurs when decay is at an advanced stage.

The most satisfactory method of detecting decay is the prod the suspected timbers with a sharp pointed tool. On testing an area of incipient decay, it will usually be found that the texture of the wood has been softened and it is impossible to prise up a long splinter. The

Fungal fruiting bodies on decaying wood produce billions of microscopic spores that can attack unprotected, moist wood.

An example of decay—serious decay—in a stern timber.

Double-planked areas are likely places to look for decay; fraying surfaces, such as this rub rail's make it doubly likely.

'Mycelial fans' of fungal filaments are evidence of advanced decay. Fans are usually found between adjoining wood surfaces in damp, dark areas. Poor ventilation? Trapped moisture?

fibres break off short owing to the loss of toughness. Obviously you cannot prod every piece of timber in the boat; but you should examine those parts where leakage of water may have occured and around ends of joints.

TREATMENT OF DECAY

1. Eliminate the source of moisture that caused the decay.
2. Completely remove the decayed wood, cutting back to sound clean timber some inches beyond the furthest sign of attack.
3. Liberally apply a suitable wood preservative to bare timber exposed during the work and to new timber used for replacement.

COMMON PRESERVATIVE

COPPER NAPHTHENATE

Copper naphthenate is sold as a green coloured solution and should contain at least 3 percent copper. Any recommendations by the manufacturer to reduce the copper content below 3 percent should be disregarded. Copper naphthenate usually takes 2-3 days to dry, after which it can be painted over.

PENTACHLORPHENOL.

Wood preserving oils which contain at least 5 per cent pentachloprhenol are satisfactory and should be used if a clear timber finish is required. They may also be painted over when dry.

It is recommended that gloves and protective clothing be worn when using these chemicals. Any liquid spilt on the skin should be washed off immediately with soap and water.

FIXED PRESERVATIVES

These may be applied by dip diffusion of the green veneers or by vaccum pressure treatment of dry veneers or plywood or timber. The chemicals used are based on copper and sodium pentachlorophenate or copper-chrome-arsenic salts which become fixed in the wood. Not all timbers may be treated by these processes and you are advised to seek further information in this regard.

FIVE WAYS TO DETECT DECAY

Brackets or conks (mushroom-likegrowths from wood) and white growth on or between wood members are visible signs of decay. Frequently, however, decay proceeds unrecognised until damage becomes extensive. There are five basic ways to detect decay:

1. Discoloured paint or cupping (indentations) on the wood surface may indicate decay.
2. Sounding with a hammer produces a dull sound in infected wood and is particularly useful in timbers that may have decayed interiors.
3. A sharp ice pick penetrates wood relatively easy. Slivers of decaying wood turned up by an ice pick or a knife tend to break off short, unlike long splintering sound wood.

4. Decayed wood is brittle when dry, breaks easily across the grain, and may even crumble into powder under pressure. Sound wood is difficult to break.

5. Drilled holes are best for inspecting large timbers: drill holes 9 millimetres (or 3/8 inch) in diameter, to no more than one-fourth of the thickness of the timber. The ease with which the drill penetrates and the condition of the chips indicate the soundness of the timbers.

Plug inspection holes with tight-fitting dry dowels that have been soaked in a wood preservative, then coated with marine glue before being driven into the full depth of the drilled hole. Borings should never be of such a number or so located as to impair the strength of the hull.

PREVENTATIVE MEASURES

1. Provide thorough air ventilation and water drainage at all times, whether afloat or in storage.

2. Keep all ventilation terminals open and mechanical ventilation systems operating whenever particable, for safety as well as to prevent decay.

3. Make sure that drain pipes, scuppers, limbers, and holes near deck-houses and toe rails are unobstructed.

4. Calk deck seams thoroughly, especially in the planksheer area. Note: The decay frequently encountered where frames cross planks indicates the hazard at faying surfaces, even where end grain is not involved.

An obvious remedy is to keep all seams well caulked especially where end grain is involved.

Paint or preserve insides of bolt holes and seams before caulking them. Careless use of caulkingirons (cutting gashes in the surface of the plank) can create moisture traps.

Water commonly enters around nails. exposed bolts, and other fastenings.

Condensation inside this cabin window means trapped moisture. Cabin ventilation needs attention; the steady flow of this condensed moisture to the side and bottom moulding created a breeding ground for decay fungi.

Break a paint bubble—and you may find decay underneath. This bubble was a good indicator of invisible condensation, moisture that passed through the wood to the paint layer. Poor ventilation? Trapped water?

MARINE BORERS

Wooden boats, like and wood exposed to sea water, are subject to damage by many kinds of marine borer. The type of borer, the timber,species, the location the time of year and the methods used for protecting the planking are all factors which determine the extent of likely damage.

TYPES OF BORER

TEREDO AND BANKIA

In the coastal waters of N.S.W., the most destructive borer is the "Shipworm" ("Cobra" or "Teredo") which in favourable circumstances can hole timber planking in less than 2 months. Certain timbers, such as turpentine, are resistant to this type of borer.

MARTESIA

This type, also known as "Shell-Borer" (it resembles a small sand pippy), occurs in some coastal areas of high salinity, usually in partially enclosed warm shallow water. No timber has natural resistance to it.

NAUSITORA

Nausitora occurs in the upper tidal reaches of coastal rivers, In appearance it is a similar type of borer to teredo. No timber has natural resistance to it.

LIMNORIA.

This crustacean borer occurs mainly in high salinity waters. It attacks the surface of timber, leaving a fine honeycomb structure. It is approximately 3mm long and resembles a minute garden slater. It normally attacks piles below mid-tide water level.

SHPHAEROMA

This is another type of crutacean resembling Limnoria, but is up to 13mm long. It closely resembles a garden slater and is often referred to as a "pill bug" or "putty bug". It does not normally attack smooth surfaced hull planking, but tends to infest the putty or caulking in the seams. In piles it is found in the intertidal section which it honeycombs. No natural or inpregnated timber is resistant to it because this borer uses the wood for accommodation and does not devour it. However, spraying with creosote will kill them.

DEGREES OF HAZARD

The most intensive attack occurs during the warmer months from October to April, with a peak intesity from December to February. During this period the free-swimming larvae settle on the surface and commence to bore.

Small craft which are placed in the water only occasionally for periods of a week or less do not require any special protection against marine borers. The larvae which may settle on the surface over this period die immediately on drying. The adult shipworms which are active in planking also die if the hull is left out of water for a sufficient period. Under hot dry conditions, a period of about 3 days is sufficient for extermination. Under cool, damp conditions, the adult borers have been known to survice for about a month.

The high salinity type borers are invariably killed by exposure to near fresh water over a period of more than 1 week. The low salinity borers are killed by exposure to water of high salinity.

It is important to realize that a timber which is resistant in one locality may be quite readily attacked in another area or position (e.g., turpentine is normally resistant below low water level in Sydney Harbour, but readily attacked by Nausitora at Wisemans Ferry).

EXAMINATION OF DAMAGE

All types of marine borer damage, except that of the shipworms, can be readily assessed by surface examination.

Shipworms are wormlike in appearance with the head enclosed by two white calcareous boring shels, and with two calcareous arrowlike pallets enclosing two siphons protruding from the tail. They maintain contact with water by projection of these siphons through a small hole of about 1.5mm diameter. These entrance holes are usually obscured by marine surface growth, mud, etc., and close examination is necessary. Occasionally the entrance hole may be indicated by the small calcareous pallets projecting from it.

The burrow of the shipworm increases in size from the entrance hole for a short length and then maintains a more or less uniform diameter. With local species the burrow, although normally considerably smaller, may be as musch as 15mm diameter and 600 mm long.

The condition of the plank can be indicated to some extent by sound of tapping. Single isolated borers in planks usually do not warrant removal, but care should be taken to remedy any substantially damaged planks which represent a source of weakness and danger. Generally, any section which possesses numerous holes at close spacing would be suspect.

PROTECTIVE METHODS

1. PRESERVATIVE TREATMENT BY PRESSURE IMPREGNATION

High resistance to marine borer attack (other than Sphaeroma) may be obtained by pressure impregnation of the wood with waterborne copper-chrome-arsenic salt formulations. These salts become highly fixed in the timber and are not subject to rapid leaching. Timber treated in this manner can be painted satisfactorily.

Creosote is also an efficient preservative. However, due to the "bleeding through" which occurs, its use is not recommended if the timber is to be painted. Not all timbers are suitable for treatment by this process and further information in this regard may be found under FUNGAL DECAY.

2. METAL SHEATHING

Metal sheet applied as sheathing provides a well established protective measure. While copper and muntz metal are widely used for this purpose, the application to small boats is limited by cost and additional weight. The occurrence of holes following damage permits access of marine borers to the wood and care is required to preserve the integreity of the sheathing. The sheathing should protect the hull for 75-100 mm above the waterline and the boat should not be allowed to lie on its side and expose the uncovered wood to the water.

The copper and muntz metal sheeting inhibits marine surface growth to some extent, but the use of anti-fouling paints is normal practice. It is generally an advantage to apply a good quality "anti-corrosive" paint directly over the copper sheet before applying "anti-fouling" paint.

3. PAINTING

Most damage in painted hulls occurs in areas which have not been coated, where paint has become unduly thin or where the paint has been damaged by mechanical action.

"Anti-fouling" paints, containing toxins such as cuprous oxide and mercuric oxide, are normally preferrws for paint protection. These paints are specifically designed to control marine surface growth by gradual leaching of the toxin from the paint. If the anti-fouling paint is applied directly to the wood, some deposition of toxin occurs in the wood surface and provides some additional protection in the case of thin paint or slight abrasion.

More definite surface protection is provided by swabbing the wood with copper naphthenate or other preservative before painting. Repeated treatments with this type of preservative have given very good protection with softwood timber hulls; one small launch in Sydney Harbour has been maintained free from marine borer damage for 25 years, the treatment being one swab coating of creosote three times per year (October, December, and April). This launch is unpainted and is left permanently in the water except for the treatment period. Wooden scows have been maintained in excellent condition for may years by using a hot tar coating twice per year.

The essential practice with any surface coating is to ensure that the coating is applied regularly and that, where abrasion has occurred, the coating is renewed. Protective strips of metal, preservative - impregnated wood, or naturally resistant wood should be attached where abrasion occurs frequently.

4. REINFORCED PLASTIC SHEATHING

Increasing use has been made of thick coatings of chemically cured resins reinforced with glass-fibre cloth or other laminates. Care to ensure satisfactory adhesion is necessary. Better adhesion is obtained on light to medium density timbers by abrasion of the surface with coarse sandpaper and applying thin initial coats of resin.

PROCEDURE WHEN PAINTING
EXTERIOR

If the boat is newly constructed, sand timber to a smoth surface. If the surface ia that of old paint in poor condition remove all paint back to bare wood.

1. Coat all timber with copper naphthenate of pentachlophenol making sure that "runs" caused by excess preservative are not left. Allow 2-3 days drying. Timber already treated with a fixed preservative will not require this initial coat.

2. Lightly sand. Apply a coat of primer which conforms to Australian Standard K 109: Wood Priming Paint-Oil Base. (This primer contains red lead whereas most "pink" primers on the market today are lead-free). Allow 2 days drying.

3. Stop all holes, joints etc., with a suitable caulking compound. Allow drying time and sand whole surface.

4. Apply an exterior undercoat and allow 24 hours drying.

5. Sand surfaces and coat with an exterior marine enamel. Allow at least 24 hours drying time.

6. Sand surface and apply another coat of exterior marine enamel.

If anti-fouling paint is required below waterline, omit the marine enamel and apply the anti-fouling over the undercoat.

Clear finishing, which is often desired by boat owners, is an inferior system to an opaque paint system. In general, clear finishes, when exposed to weather, have less than one third of the life of good quality opaque paint systems.

INTERIOR

Apply a coat of preservative to all bare timber.

Paint should be applied to internal surfaces of the hull, linings etc., only when required for appearance. In such cases, the procedure for exterior painting should be followed.

ELECTROCHEMICAL CORROSION OF METALS

THE PROCESS OF CORROSION

Corrosion is essentially electrochemical. The most common examples are the rusting of iron and the corrosion of dissimilar metals when in contact the presence of moisture. When iron comes into contact with air, a thin, patchy film of oxide forming on it. A voltage difference exists at all times between the iron and the oxide coat, and should the surface of the iron become wet, an electric cell will be formed resulting in the formation of rust deposits. Corrosion of dissimilar metals, or bi-metallic corrosion, is a process essentially similar to the rusting of iron. When dissimilar metals are adjacent in a damp situation, moisture will provide an electrolytic link between them. When electric cells are formed in this manner, the metals constiture the positive and negative poles, and the severity of the corrosion depends on the voltage difference which exists between dissimilar metals. The rusting of iron is a more active process at the seaside than in ordinary atmospheres because moisture containing salt is a more efficient electrolyte.

ELECTROCHEMICAL SERIES

The Galvanic table is very useful in predicting which metal will corrode in any bi-metallic pair and the probable severity of the corrosion. In the table the metals and alloys are listed in order of the voltages they develop while freely corroding. The metal closer to the negative end of the the scale (i.e., less noble) will corrode while the other will not, and the further apart on the scale the metals are the more severe will be the corrosion.

GALVANIC SERIES OF METALS AND ALLOYS

More negative end (Base End)	Metal or Alloy
	Magnesium Alloys
	Zinc
	Cadmium
	Aluminium
	Aluminium Alloys
	Iron and Mild Steel
	Stainless Steels (Active)
	Soft Solders
	Lead
	Muntz Metal
	Manganese Bronze
	Naval Brass
	Nickel (active)
	Nickel-Chromium Alloys (Active)
	Copper
	Red Brass
	Aluminium Brasses
	Composition Bronzes

..........Continued

GALVANIC SERIES OF METALS AND ALLOYS (CONT.)

More negative end (Base End)	Admiralty Brass
	Phosphor Bronze
	Silicon Bronze
	Gunmetal
	Silver Solder
More positive end (Noble End)	Nickel (Passive)
	Stainless Steels (Passive)
	Monel

Note: Nickels and stainless steels have varying positions in the scale according to their composition and the state of the coatings of oxide films.

PROTECTIVE COATINGS.

The oxide coating which rapidly forms on aluminium in the atmosphere protects it from further corrosion. By promoting this process artificially by anodizing, aluminium can be given a protective coating of pleasing appearance. However, zinc and aluminium suffer attack from the alkalis present in seaside atmosphere, the results being rather unsightly but not usually serious unless the metal is very thin or of unsuitable alloy. Bearing greases, which are really sodium soaps, should not be used to lubricate or "protect" aluminium components.

Copper alloys are more noble than most other metals and are therefore not so likely to corrode from electrochemical attack. Copper, bronze or brass should not be used in association with aluminium.

SACRIFICIAL COATINGS

Corrosion will usually be restricted to the less noble metal. A common instance of sacrificial protection is where the zinc coating on galvanized ~on corrodes in preference to the steel.

Steel boat hulls may be protected by attaching blocks of zinc at regular intervals the hull below the waterline. These blocks corrode in preference to the steel and must be replaced from time to time.

ELECTRICAL SYSTEMS

Fully insulated electrical systems are desirable, but where of necessity earthed, a negative earth is to be preferred. The use of lead covered cables is inadvisable. Wiring should not be run through bilges.

The setting up of undue resistance in wiring or at terminals must be avoided (e.g.) the use of too small a cable, or dirty or loose connections). Such conditions give rise to a voltage drop over a part of the system which may in turn cause a potential difference between underwater metal parts. Defective insulation on the live side of a of a circuit may apply battery voltage to otherwise isolated metal parts.

If wires to electrical fittings are inadvertently cross connected the fittings may still operate satisfactorily but heavy leakage of current may occur. Such leakage does not nessarily require a metallic path but may flow for long distances through wet wood.

Failure of the battery to hold a charge properly is common indication of a leakage. It does not necessarily mean that the battery is worn out.

Screws and nails should, where possible, be of the same metal as the item to be fixed. This is very important in regard to the fixing of sheathing or other metal parts below the waterline as unseen corrosion may take place rapidly.

"Nail sickness" is a term used to describe the action of acids, present in many timbers, on a nail or screw which has been driven into the timber. Assisted by moisture, the acid can corrode the nail or screw and this in turn may cause chemical deterioration of the timber surrounding the nail The net result of this is that the nail or screw will eventually fall out or fail to hold. The possibility of nail sickness occurring may be reduced by using galvanized or brass or copper nails and screws and by keeping the timber as dry as possible, e.g., by painting or sealing with bitumen or caulking materials.

Where two different metals have to be used close together, they may be separated by a thin layer of bitumen or other suitable material, but regular careful inspection should be made to ensure that corrosion is not taking place.

SWAMP TEST OF BOATS

All Pulling and Sailing Boats should be so buoyant that, when swamped i.e., filled with water, they should still be capable of supporting a weight of at least equal to one tenth of the total weight of the boat, complete with equipment.

MEHTOD OF TESTING FOR BUOYANCY

Before being placed in the water, the boat is weighed with all equipment in place, bottomboards and stretchers, etc., that are normally securable into position being lashed down to prevent them floating away when the boat is immersed; barricoes filled with water secured in place, but oars and boathooks are removed; the idea being to similate the condition the boat would be in if the boat was swamped in a gale, all unsecured gear being washed away. The weighing of the boat is usually done by means of a large spring balance or steel-yard.

The boat is lowered into the water, the falls being left hooked on but slack, (to prevent the boat being completely lost by accident), and the plugs withdrawn, and the boat allowed to fill with water. When the level of the water inside the boat is the same as the level of that outside, ballast is added, evely distributed over the boat so as to keep her on an even keel, until the boat is brought to a sinking condition, i.e., the gunwale or topsides being awash.

The boat can now be lifted out of the water very slowly, it taking quite a time for the water in the boat to drain out by means of the plughole, and the necessary calculations as to the size of any required buoyance tanks then made.

SIZE OF TANKS

The weight of the ballast added to the boat in the test is obtained, and if this is less than one tenth of the weight of the boat when it was weighed, then tanks are needed to give the boat the extra buoyancy necessary.

The following example is from the swamp test of a 6.7m. Cutter:-

Weight of the boat complete with equipment

2.354 tonne = 2354 Kg.

One tenth of weight of boat = 235.4 Kg.,

Weight of ballast req. to submerge boat

= 128.4 Kg.

Insufficient buoyancy = 235.4-128.4
= 107 Kg.

Weight of 1 cubic metre of sea water = 1.025 Kg.

Therefore insufficient buoyancy, i.e., volume of tanks required

$$= \frac{107}{1,025} = .104 \text{ cub. metres}$$

A good margin above the necessary .104 cub. metres has to be provided, and it is customary to add 50% to the calculated answer, so that tanks with a total capacity of .156 cub. metres approx., would be fitted, one in the bows and one in the stern to give an even distribution over the boat. If the other tanks are necessary to make up the total capacity required they are invariably fitted under benches or thwarts. The older type of tanks are made of copper sheeting, but with the advent of plastics, buoyancy blocks of expanded plastic of closed cell structure, of polyvinyl chloride or polyurethane base are coming into use. When it is necessary to swamp test a power-boat, the engine is removed and an equivalent weight of ballast temporarily secure in its place.

TYPICAL METHOD OF OBTAINING THE SHAPE OF A BOAT'S CRUTCH

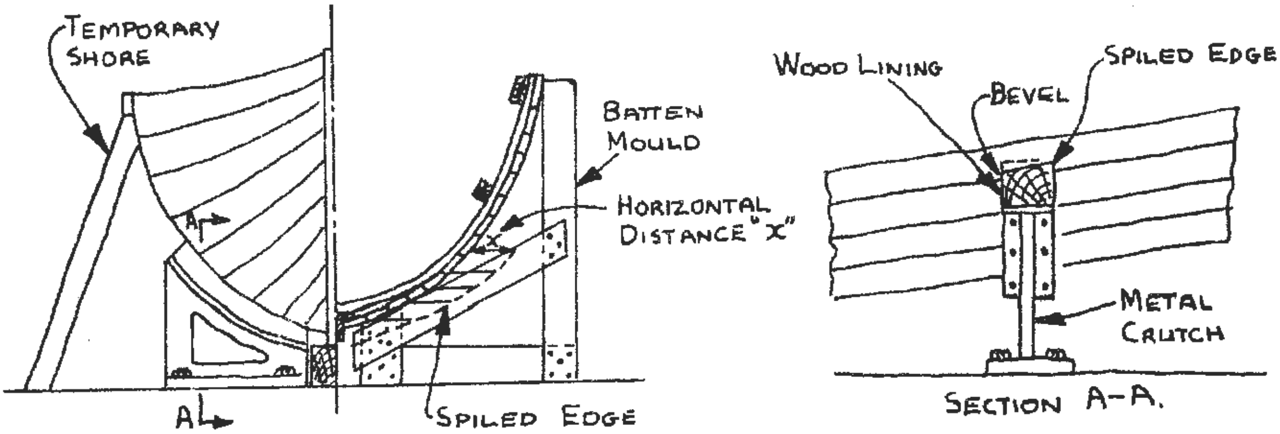
The sketch shows a typical section of a boat, the left hand portion shows the typical construction of a crutch, the right hand part showing the method of obtaining the necessary shape.

PROCEDURE: The boat is "plumbed" and secured in the position required, with the underside of the keel the desired distance above the deck. A batten mould is constructed and placed in position as shown. The forward face of the mould (if it is the Fwd. crutch being spiled for) being in line with the fore edge of the crutch position; likewise the after face of the mould, if it is the after crutch being spiled, being in line with the after edge of the crutch position. The greatest Horizontal distance X is then found and applied horizontally at a sufficient number of points to ensure accuracy, and the shape so obtained is then cut out and the mould again applied in position, care being taken to ensure that the mould is standing vertical. The mould is trimmed so as to fit along it's full length, and bevels are then taken at a convenient number of points and marked on the mould shown. This shape so obtained is that of the metal crutch complete with lining. To obtain the shape of the metal part of the crutch, a distance equal to the thickness of the wood lining is marked in perpendicular to the curved edge. When the metal part is complete, the thickness of the wood lining is added to the curved face, so bringing the whole up to the size of the original wooden mould. The bevels are then applied to the outer face of the wood and the wood lining secured, usually with through bolts, the heads of which are recessed and covered with wood plug.

It will be noted that the mould is made to the largest part of the crutch, and care must be taken when deciding on the thickness of the wood lining to allow sufficient that when it is bevelled, enough materials is left on the bevelled side, and not let it go off to 'feather edge'.

The wood lining, whenever possible is of teak, it being impermeable to the weather, and hard wearing.

Another method of fitting the wood lining to the boat, is to secure it to the metal crutch, offering it up in place and spiling it into the boat instead of taking bevels and applying them to the lining and the spiling being done on both the Fwd and after faces at the same time.



SLIPPING OF BOATS

THE BUILDING SLIP

The chief factors influencing the chpice of a suitable site for a slipway are the hardness of the ground, sufficient depth and width of water for the safe launching of vessels, direction of tideway and the variation in height of tided.

If the ground is so soft as to be incapable of sustaining the weight of the vessel it must be piled over those areas which support the boat during building and launching, i.e., under the positions to be occupied by the building blocks upon which the vessel is built and under the groundways down which she is launched.

This is necessary to ensure that no subsidence of the ground will occur, particularly during the actual launch when deformation of the ways might have disastrous consequences.

The depth of water into which vessels are to be launched must be adequate to suit the maximum draught of the vessel during her travel down the slipway, observing that it may be desired to launch vessels at tides lower than high tide.

Dredging of the sea or river bed may be necessary initially and at subsequent intervals.

The width of water must be sufficient to ensure the vessel does not ground and to permit her being manoeuvered.

SHORING

Some shoring and bracing are required in almost every line or work performed in boatbuilding.

In setting shores to support the boat they must be placed against the hull under frames, timbers, bulkheads or longitudinal strength members. If placed where no support is given to the planking, they are likely to fracture the planking as the full weight is applied.

The foot of each shore should be cut square or at right angles to its centre. The foot of all shores should be chamfered to afford better draw on the wedges and to avoid splitting of the sides of the shore.

Wedges should always be placed in an athwarships direction to afford room for removal and facilitate knocking out shores for launching.

A wedge, when cut, usually has one side with the grain straight, the tapered side being corss-grained owing to the tapered cut. In using the single set of wedges, the cross grain should always be placed against the packing, not against the shore. When wedges are married under the shore, the cross grain of the top wedge should always be placed against the straight grain of the wedge being used with it, otherwise, the wedges will jam and not tighten up in the way they should if the cross grain of one wedge is forced against the cross grain of the other wedge.

LAUNCHING

For repair work, boats are usually slipped into cradles than can be winched up and down steel rails that are fixed in cement foundations.

In new construction, the boat is built at other locations and the use of sliding ways can be assembled at the new side.

The sliding ways are placed in position and the cradle is shaped and braced to suit the hull.

The type of grease chosen depends upon the season of the year and the estimated pressures, experiments being carried out to determine its ability to withstand maximum pressure per square foot, and suitability of co-efficient or friction.

The principal consituent is tallow, and a mixture called "Tallene" is in general use.

All being ready and the tide having reached desired height the launching can take place. Levers can be applied to start the boat and cradle, but in the event of the boat failing to move under the force of her own weight, hydraulic jacks are used to give her initial momentum. These jacks are placed on the groundways bearing against a jack cleat recessed in latter, and exert pressure on the fore end of the sliding ways.

MASTS AND SPARS

Masts and spars are usually designed specially to suit the boat. Masts of solid or built up sections are made from a relatively light timber which is straight grained and strong in relation to its density.

The built up section may be a full section or a hollow section. The built up sections will usually have all grooves machined prior to assembly, and the timber selected should be one that will glue readily.

All the timbers recommended for masts and spars in the list in this publications. The timbers to be used must be completely free of all faults which would adversely affect the utility of the piece and be straight and true. Knots, sloping grain, shakes and compression wood must be regarded as "not acceptable", though where large sections in solid masts are to be used some knots may be allowed. Mast steps should be shaped, patterns made from the plan or the loft drawing being usded to shape and notch them correctly. The tenon socket for the heel of the mast should have drain holes, so arranged that the socket will drain completely when in position. The mast steps are usually made of hardwood.

The socket may be cut so that the rake of the mast may be adjusted.

Driven wedges in the socket are used to adjust the rake of the mast. The wedges should be tacked with a nail, after being driven, to hold them in place. The tenon on the mast should be long enough to cope with all possible adjustments of rake.

Sapwood is permissible only if it has been treated to a suitable loading with an approved non - leachable preservative.

SPAR PROPORTIONS.

The basic length on which a mast and spar lengths were calculated for the old sailing ships is the length between perpendiculars, which is from the inside of the stem - the rabbet - to the rabbet of the stern post both measured at the level of the upper continuous deck.

The method for determining the taper of a spar is work on the maximum diameter.

1). In the case of a mast stepped on the keel this would be where the mast passes through the deck, mast partners.

2). In the case of mast step on deck it would be at the heel of the mast.

3). Booms are equal diameter for the first third of their length and then taper down to two thirds the given diameter at the outer end.

4). Yards have their maximum diameter at the slings or centre of the yard and minimum diameter at the yard arm.

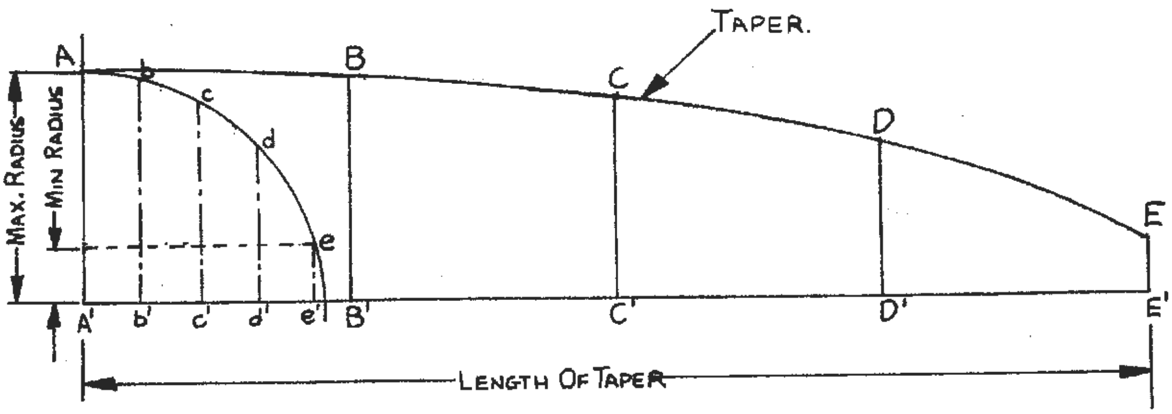
For a given length of spar diameters are given at five points namely the maximum diameter, 1st, 2nd, 3rd quarters and minimum diameter.

Draw a base line A'E' equal to the length of the spar taper. At A' scribe arc equal to the radius of the maximum diameter to cut A'E' and a perpendicular of A' at A. From A' meaeure off along A'A a distance equal to the radius of the minimum diameter. Project this point parallel to A'E' to intersect the arc at e. Project e vertically down to cut A'E' at e'. Divide A'e' into four equal parts, points b' c' d'. Project points b' c' d' perpendicular to intersect the arc at b c and d.

Divide A'E' into four equal parts, points B'C' and D'. From these points project lines perpendicular to A'E'.

From B' measure of distance b'b to give point B.
" C' " " " c'c " " " C.
" D' " " " d'd " " " D.

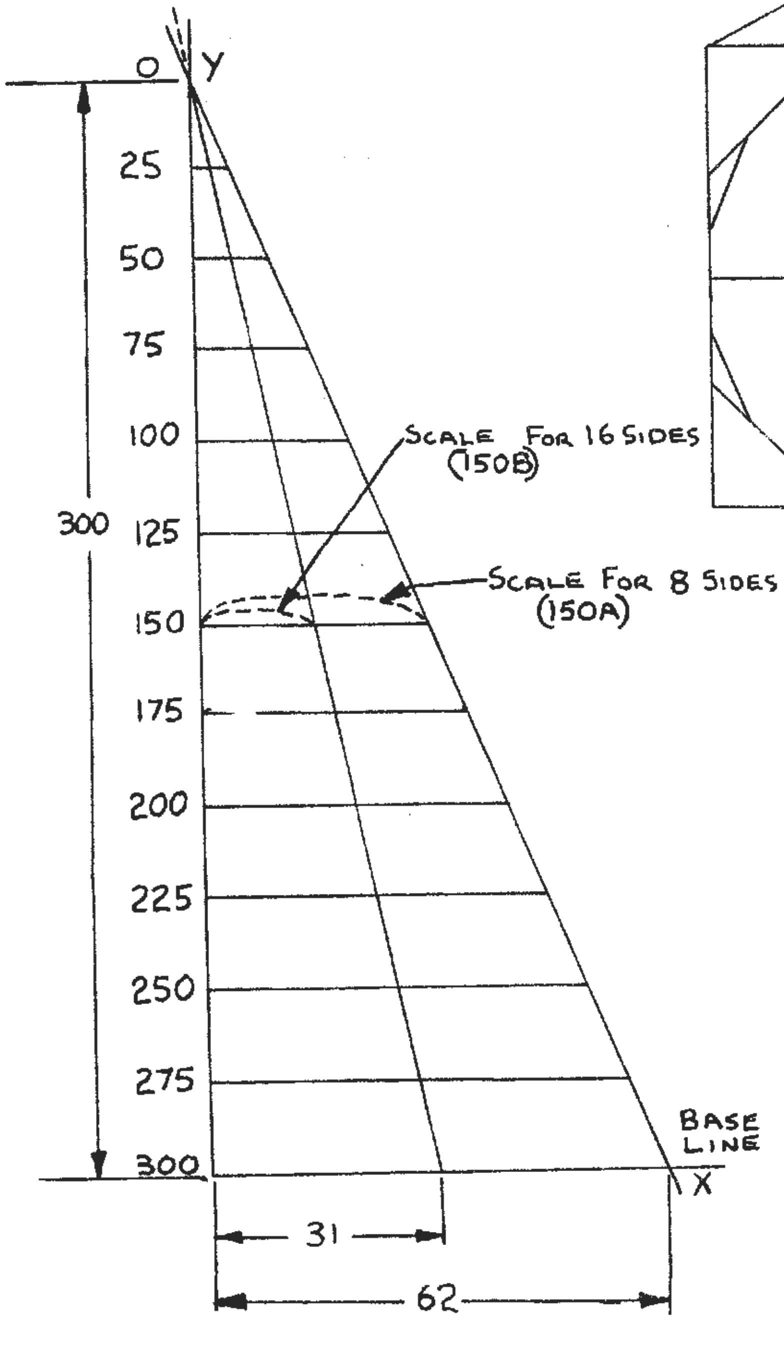
A fair line drawn throught points A B C D represents the spar taper and lengths A'A B'B, C'C and D'D are offsets for one side of the centre line only.

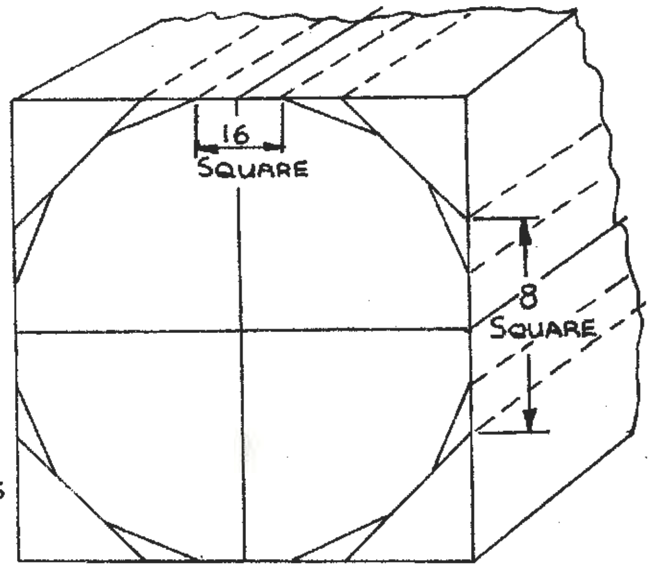


MAST AND SPAR WORK
PRACTICAL NOTES

SCALE RULE
8 AND 16 SQUARE

On a convenient piece of cardboard, plywood or marking board, a base line is "struck" and a perpendicular erected from it. On the base line a length of 62mm is cut off point X and on the perpendicular 300 point Y. Point Y is then joined to X. The length of 62mm on the base line represents half the 8 square for a spar of diameter 300mm, similar distance 150A represents half the 8 square of 150mm diameter. The length 31mm on the base line represents the 16 square for 300mm half diameter, similarly distance 150B represents the 16 square for 150mm.





To apply the eight and sixteen square rule;

The diameter of the yard at the slings is 225mm, the half diameter is therefore 112.5mm. To obtain the eight square for this diameter the distance 112.5, 112.5A is taken off by compasses and applied to the spar each side of the middle line and marked in. This is repeated for all remaining positions and points "faired". Spar is then turned over and operation repeated for all remaining three faces. Draw knife is then used to remove wood for "eight squaring".

To obtain the sixteen square for any particular diameter distance applicable is obtained from the scale by the compasses, in the case of 112.5 it is 112.5, 112.5B. This is applied to the spar each side of the middle line and marked in as for the 8 square, and points faired in. The operation being repeated for each remaining 7 faces. Draw knife is then used to remove wood for sixteen squaring.

The next operation is to "round up" spar by hollow bottom plane, size used being relevant to size for spar and cleaned off by glass paper.

Eyebands for braces, topping lifts, signal halyards, etc., and barrel are next driven on. These are usually driven on by large iron drivers manipulated simultaneously by each side of the band until it is in position. These bands, when in final position, are secured by a large wood screw through the band into the spar.

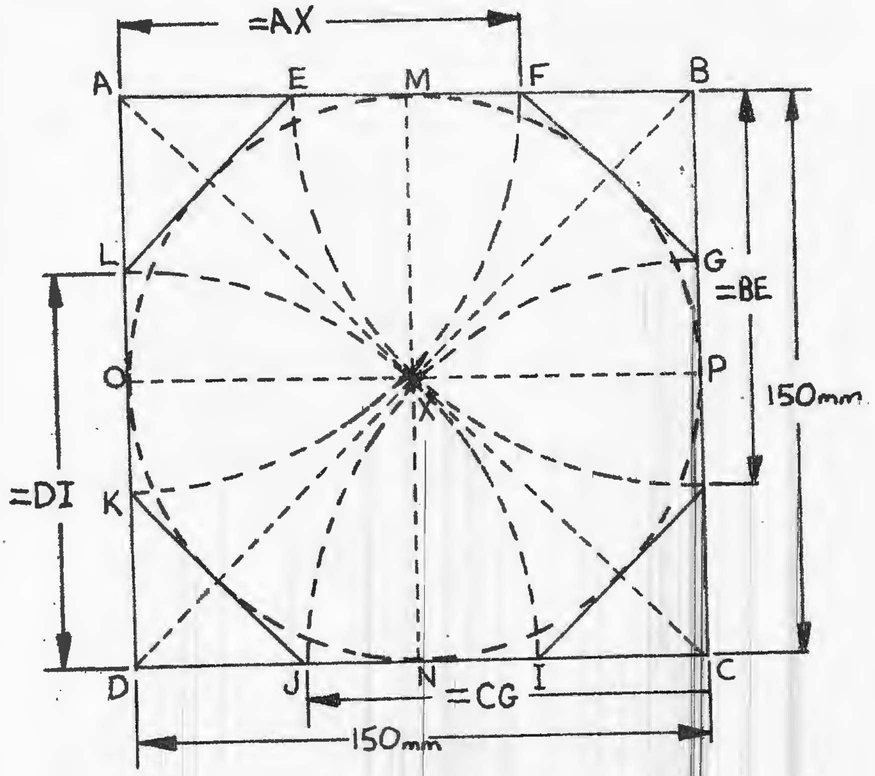
Finally, the spar is again cleaned up. Any large and deep shakes that have shown up during manufacture are lightly chintzed by caulking cotton and "puttied up". Yard or spar is then varnished or painted as required.

HALF DIAGONAL RULE
8 AND 16 SQUARE

A.B.C.D. is a 150mm square equal to the view or cross section of a spar. Mark the centre point of the spar on each side and join M.N. and O.P., bisecting at rightangles at point X. Join the diagonal points A.C. and B.D. bisecting the point X at right angles. Diagonals of a square are of equal length. Therefore the half diagonals AX, BX, CX, DX, equal one another. From the points A, B, C AND D four quarter circles are drawn with a radius equal to the half diagonal Join the adjacent sides at FK, EH, GJ, IL. Therefore AF= AK, BE = BH, CG = CJ, and DI = DL. Join FG, HI, JK, LE, to complete the eight square.

This rule can be used at any position along the length of the spar working off the centre line, simply by drawing a square of side equal to the diameter at that particular point, and find the size of the half diagonal for eight square. Fair in points along the spar with a wooden batten.

When the spar has been worked to shape, it is ready to be "sixteen squared". This is done by dividing each one of the eight sides into equal parts, or in halves each side of the centre line. The third quarter points Q and S, and the first quarter points R and T of the adjacent side in a clockwise direction are joined. This method is continued around the spar. When sixteen equal sides are completed the spare is ready to be rounded.



GAUGE RULE

8 AND 16 SQUARE

On spar 150mm square or less gauge rule 44.5, 108 in 150mm is suitable.

" " 300mm " " " " " 89 , 216 in 300mm is suitable

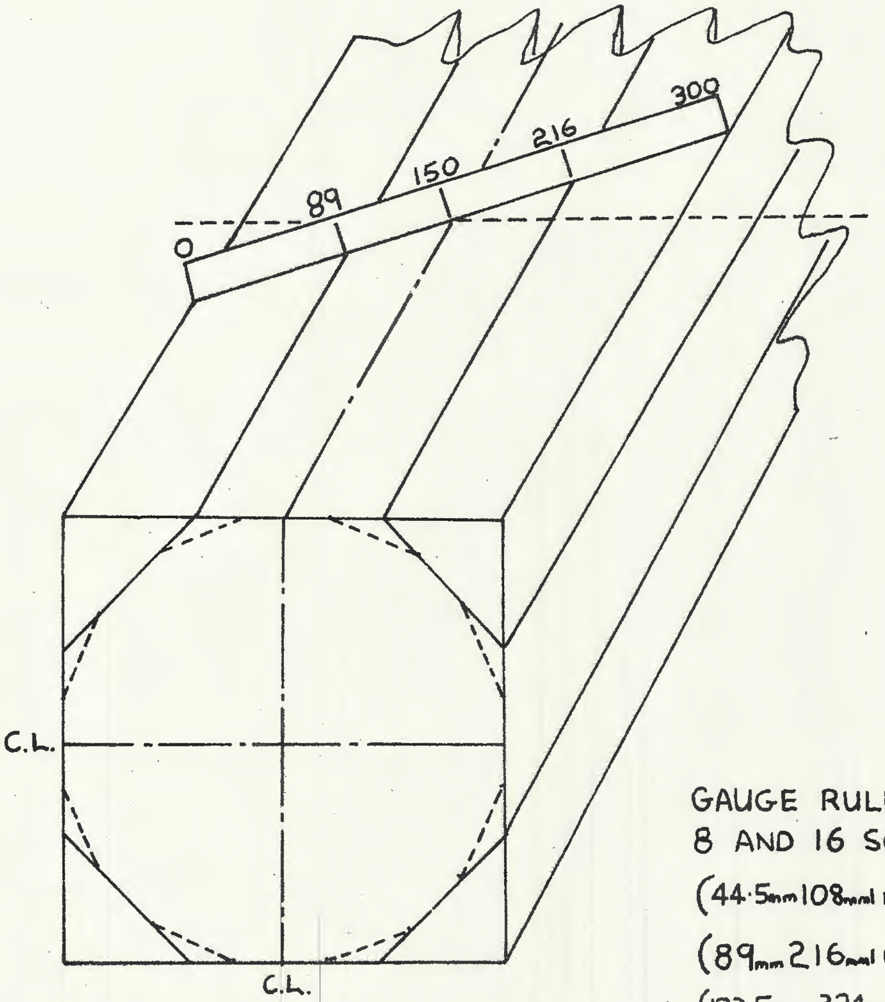
" " 450mm " " " " " 133.5, 324 in 450mm is suitable.

e.g., In drawing 89 216 in 300 gauge rule is shown.

The cenre line of the spare is "struck in", and by keeping the 150mm mark of the rule on the centre line at the required diameter, the rule is pivoted to pick up the radius each side of the centre line at 0" and 12" on the rule. This position is then held, points 89mm and 216mm being marked.

The same procedure is adopted to find any diameter along the length of the spar. The points each side of the centre line being "faired in" with a wooden batten. Prepare the other three face sides in a similar manner.

After the spar has been "8 squared" by removing the surplus wood, it can be "16 squared". This is done by dividing each one of the eight sides into four equal parts, or in halves each side of the centre line and proceed as explained in half diagonal rule.



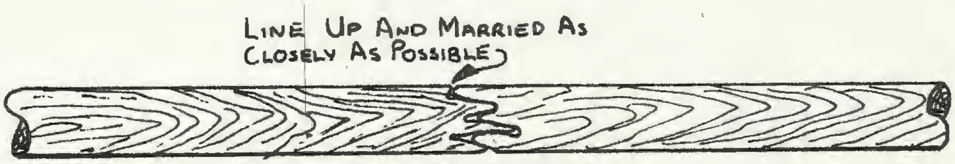
GAUGE RULE
8 AND 16 SQUARE
(44·5mm 108mm in 150mm)
(89mm 216mm in 300mm)
(133·5mm 324mm in 450mm)

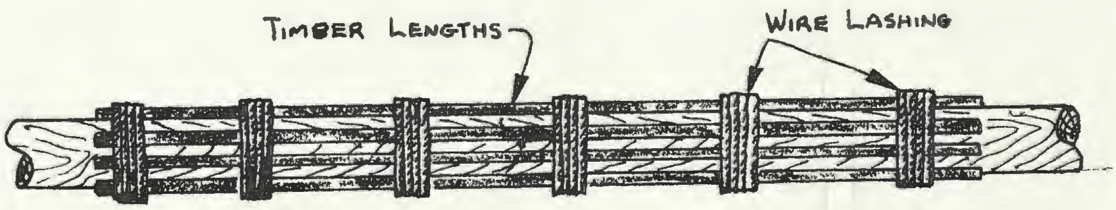
REPAIRING A SPAR.

TEMPORARY REPAIR. - - A broken spar can be repaired temporarily by "fishing" it, which consists of lashing one or more spars along the broken one, as when making a splint.

The correct method of fishing a broken spar is described below, and if thus fished it will be strong but rigid; the description given is, however, intended to be followed in principle only, as details of an emergency repair must necessarily depend upon the circumstances and upon the gear available.

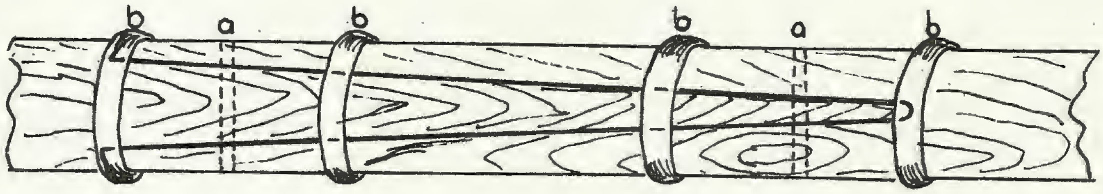
The broken ends of the spar are lined up carefully and married are closely as possible, usually with the aid of a maul, and are sometimes held in place with small pieces of wood or material nailed across the join. The "fishing" spars which can consist of lengths of any suitable material such as 75mm by 75mm quartering, are spaced equidistantly around the break and lashed temporarily in place; their length should be not less than nine times the diameter of the broken spar, and they should lie closely to it throughout this length, small wedges or strips of wood being used as packing where necessary if the spar is of an awkward shape. In addition, any space between the spars must be filled in, usually with odd lengths of wood, to prevent them from slipping sideways beneath the lashing. The full length of the fishing is then tightly bound with a wire rope lashing put on as for a serving or common whipping, and should the wedges beneath the temporary lashing tend to slack up they must be kept driven home as the binding proceeds. The temporary lashing removed, piece by piece, as it is reached by the permanent binding.





METHODS OF SCARFING A BROKEN SPAR

1



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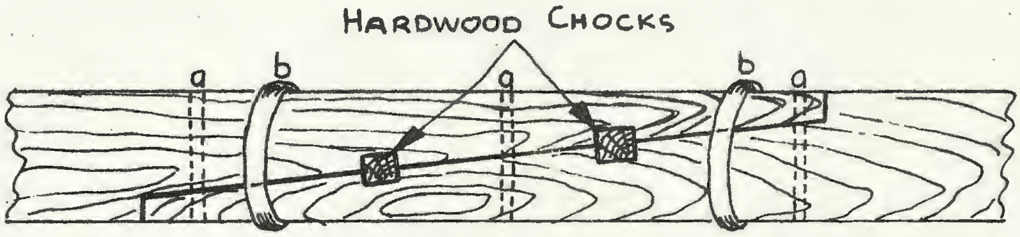

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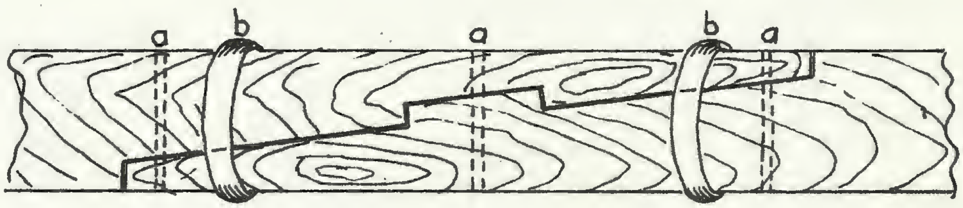


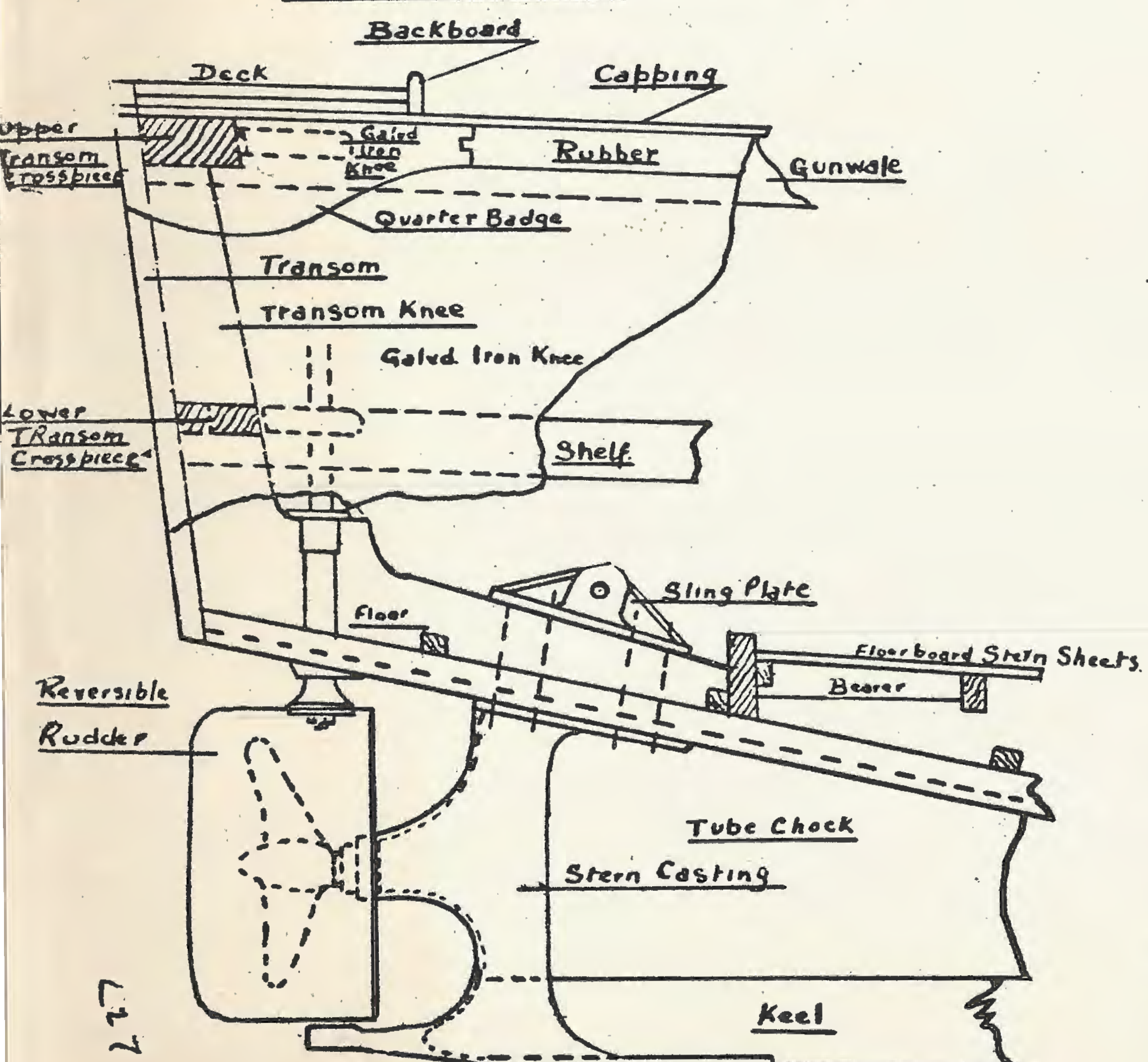
Length of Scarf or Tongue:- 300mm for every 25mm of diameter.

a = clenched bolts

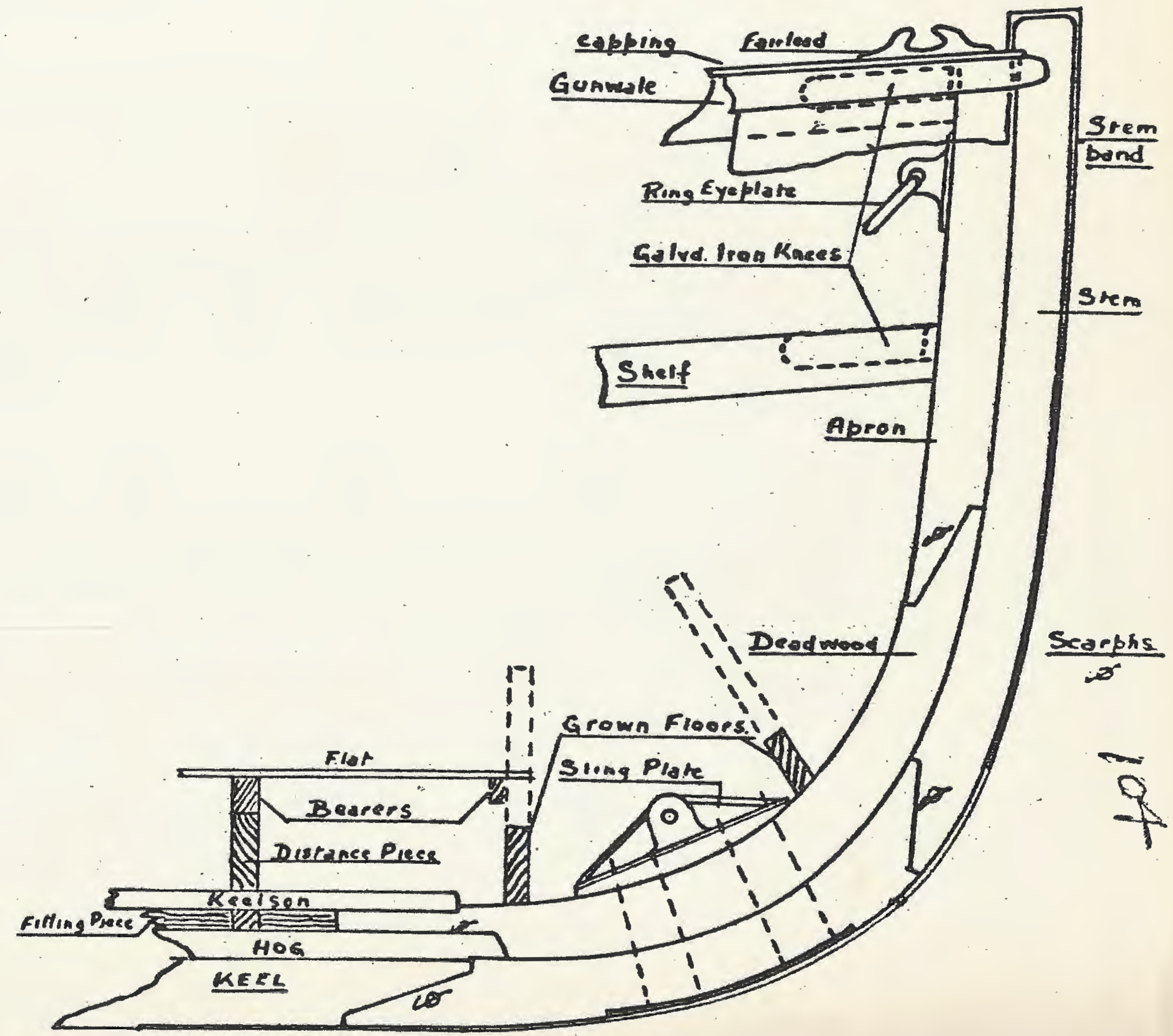
b = steel bands secured by screws

<u>PERMANENT REPAIR</u> A permanent repair, which is flexible, can be achieved by "scarfing", but this involves some shortening of the spar. Scarfing is a shipwright's job, the principles of which are shown above.

SECTION OF AFTER END OF 45'0" MOTOR LAUNCH



SECTION AT STEM OF 45'0" MOTOR LAUNCH



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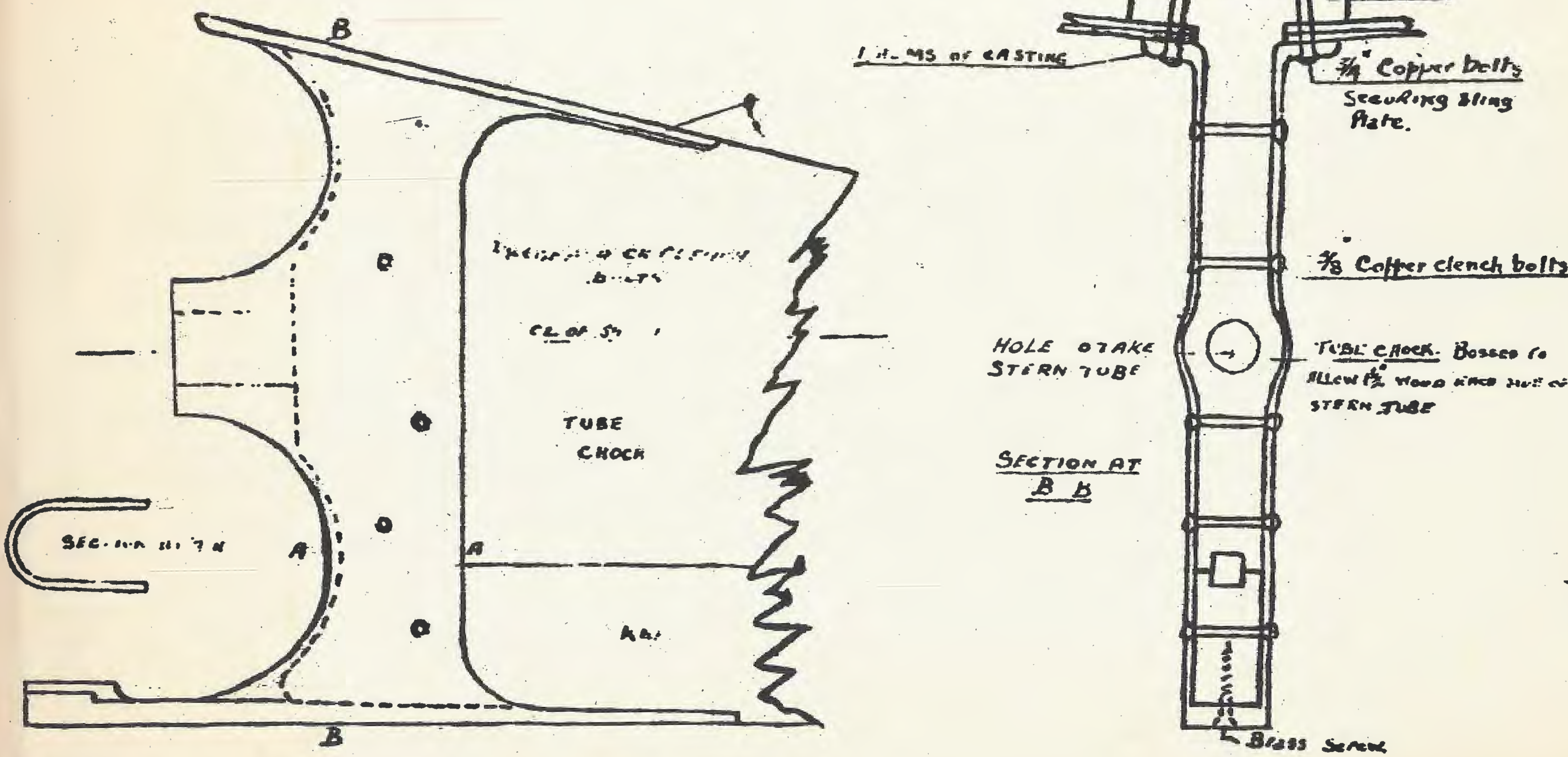
STERN CASTING - 45'0" MOTOR LAUNCH.



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