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A Manual of Coast Guard Vessels

With References to Construction, Equipment Repairing, and Handling

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Practical Shipbuilding, by A. W. Carmichael, McGraw-Hill Book Co., Inc., New York, N. Y.

Practical Shipbuilding, by A. Campbell Holms, Longmans Green & Co., Ltd., London, England.

Nautical Stability, by Thomas Green, B. Sc., M. I. N. A., The Journal of Commerce, Liverpool, England.

Handbook of Ship Calculations, Construction and Operation, by Charles H. Hughes, D. Appleton-Century Co., New York, N. Y.

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SYMBOLS

A = Area.
A. P. = After perpendicular.
c = Constant.
B = Center of buoyancy of ship.
Butt = Buttocks.
C of B = Center of buoyancy.
C of G = Center of gravity.
D = Displacement of ship.
d = Difference in draft.
F. P. = Forward perpendicular.
G. = Center of gravity of ship.
h = Common interval.
I = Transverse moment of inertia of waterline plane.
L = Length of ship.
M = Transverse metacenter of ship.
T = Tons per inch immersion.
V = Volume of displacement of ship.
W = Displacement or weight of ship.
w = Weight.
W. L. = Waterline.
W. R. = Wardroom; wash room.
y = Any ordinate.
θ = The angle of vessel's heel used in inclining experiment.
$\mathfrak{X}$ = Midship section.
Σ = Summation.

CHAPTER I

STABILITY

101. It must be remembered that the whole matter of stability is dependent upon a safe position of the center of gravity called *G*. Builders' data give the location of the vessel's *G*. Then it is a very simple matter to determine the center of gravity of any weights added to the vessel. Refer to figures 1, 9. The center of gravity of a system of weights is that point at which the whole system is considered to be concentrated. The method of obtaining the center of gravity is by taking the "moments." By definition, the moment of a force, about a certain datum line, is the product of the force into its perpendicular distance from the given line. In figure 9, *AB* represents a vertical beam with a horizontal beam *LX* projecting 16 feet from *AB*. Weights of 2 and 5 tons are hung 6 feet and 8 feet, and 8 tons located 16 feet from *AB*. Taking the moments about *AB* we have:

$6 \times 2 = 12$-foot tons
$8 \times 5 = 40$-foot tons
$16 \times 8 = 128$-foot tons

$180 \div 15 = 12$. The center of gravity of the three weights is represented by a weight 15 tons suspended 12 feet from *AB* at *K*. The three weights could be removed and a single weight of 15 tons located at *K*, 12 feet from *AB* replace them.

Had the moments been taken about some other point, as for example, about the point of suspension of the 2-ton weight, which is 6 feet from *AB* we have:

$0 \times 2 = 0$-foot tons
$2 \times 5 = 10$-foot tons
$10 \times 8 = 80$-foot tons

$90 \div 15 = 6$ feet. The center of gravity of the three weights is distant 6 feet from the point of suspension of the 2-ton weight, and from *AB* $6 + 6 = 12$ feet.

See figure 1. Exactly the same method is used in obtaining the center of gravity of several weights (such as cargo) which have been added to a vessel. By multiplying each weight by the vertical height of its center of gravity above the base line (which is coincident with the top of the flat plate keel for vessels without drag) their moments are obtained. Then by adding together all of the moments and then dividing the total moments by the total weights, the height of the center of gravity of all the weights above the base line is obtained. This is illustrated in figure 1.

Vertical position of the center of gravity of ship, including added weights

[See fig. 1]

	Weight	Height of center of gravity	Moment
	Tons		
Ship light	1,927	15.0	28,905
Paints and oils	1	29.0	29
Paints and oils	2	20.0	40
Fore peak	20	10.1	202
Chief petty officers' washroom	1	27.9	28
Store and brig	1	20.6	21
Chain locker	23	10.9	251
Crew space	5	27.3	136
Passage	1	19.5	20
Fore hold	8	10.0	80
Cabin and pantry		23.5	23
Passage	1	16.0	16
Engineer's stores	4	6.5	26
Steering gear space	1	22.3	22
Hawsers and lines	4	17.0	68
Store room	6	8.1	49
Total	2,005	14.92	29,916

$\frac{29916}{2005} = 14.92$ feet, the height of the center of gravity of the ship and added weights above the keel or base line.

Or by using the center of gravity of only the added weights, omitting the first item, i. e., the weight of the ship, by simple compilation which follows later in this chapter, the effect of the added weights upon the location of the center of gravity of the *vessel* is determined. Also the effect on the center of gravity of the ship by the movement of weights already on board is explained. All officers should be familiar with such computations, as cutters are frequently required to carry heavy deck loads.

TRANSVERSE STABILITY

102. Figure 1 (d) represents a ship which, as the result of rough weather, has been heeled over 30°. When the ship was in an upright position the center of buoyancy was at B_1, at 10° it moved to B_2, at 20° to B_3, at 30° to B_4. Since the center of buoyancy is the point at which the ship is supported, this curve may be considered as a rocker upon which the ship rides and upon which the vessel oscillates along the imaginary surface *PQ*, the position of contact for any instant during the roll being the center of buoyancy. The center of gravity, *G*, remains in fixed position. Should the vertical, through any position of *B*, intersect the middle line of the ship at a point lower than

G, a negative couple would result and the vessel would capsize from lack of righting arm.

Figure 2 represents the center of gravity and center of buoyancy points of a vessel. The total of all water pressures, acting perpendicularly against the entire surface of the underbody, represent the buoyancy, which is equal to the displacement of the ship, or weight of the vessel. The force of buoyancy must be equal to the displacement weight if the vessel is to float.

Figure 1 (a) shows a ship in stable equilibrium. $W.\ L.$ represents the water line when the vessel was in the upright position or the initial stability condition; $W.'\ L.'$ is the water line after an inclination of about 10°. G is the center of gravity and B the center of buoyancy, both in the same vertical, when the vessel is in the upright position. (To avoid any confusion keep in mind the difference between the surface of the water, which remains fixed, and the water line of the vessel, which changes for each angle of inclination.)

As the ship assumes the inclined position the center of buoyancy moves from B to B'. The *center of buoyancy* of a vessel is the center of gravity of the immersed portion. Draw from B' a vertical upward. Where this line intersects the vertical of the upright position through B and G, is point M, called the *transverse metacenter*. In order to obtain the position of point M the vessel must not be inclined more than about 10°. The location of M depends upon the form of a ship and its displacement. The *metacenter* is that point in a floating body, slightly displaced from equilibrium, through which the resultant upward pressure of the buoyant fluid always passes. It is the maximum point to which the center of gravity can be raised without the vessel becoming unstable. The angle Θ in figure 1 (a) is the angle of inclination. The distance GM is the *metacentric height*. It is the measure of *initial stability* which indicates the resistance by a ship to inclination from the upright position. Now through G draw $GZ \perp$ to $B'M$. GZ is the *righting arm*. *Statical stability*, by definition, is the displacement of the vessel in tons times GZ in feet. It represents the force by which the vessel endeavors to regain its upright position when inclined from the upright by an external force. Note $GZ=GM$ sine Θ. The value of GZ changes for different angles of heel, the greater the angle of inclination, up to a certain point, the larger it becomes. The *righting moment* values, which govern the force available to return the ship to an upright position, are controlled by the values of GZ (the righting moment being equal to GZ in feet times displacement in tons). The force of buoyancy acting vertically upward through B' is equal to the force of gravity acting downward on the weight of the ship through G, thus forming a *couple* (see glossary), tending to right the ship. This is a condition of *stable equilibrium*.

It will readily be seen that with a ship as shown in figure 1 (b), with G and M located at the same point, there will be no righting arm GZ and consequently no couple tending either to bring the vessel back to an upright position or to increase its inclination. This condition is called one of *neutral equilibrium*. In figure 1 (c), with the center of gravity above the metacenter, we have an unstable set-up, there being an upsetting couple which will cause the vessel to capsize. This condition is one of *unstable equilibrium*.

See also figures 2 (a), (b), and (c) which graphically represent, by means of a swinging board suspended at point M, conditions of neutral, stable, and unstable equilibrium.

Figure 1 (e). The left small figure shows a heel of 20° and the one on the right a heel of 60°. As will be noted from the stability curve shown, the maximum value of GZ, the righting arm, occurs at 50° heel. At 60° it has started to decrease. The downward arrow through G and the upward arrow through Z indicate the righting couple. The point on the curve where it crosses the base line, at 88°, is the vanishing angle of stability, the point at which the value of GZ becomes zero. Of course the vessel would be doomed to capsize long before the vanishing angle of stability was reached. Any heel beyond 50° for the vessel shown would likely be fatal. Because of their tendency to roll deeply, destroyers are designed with effective righting arms to provide transverse stability under deep heeling conditions. (See art. 126.)

THE COUPLE

103. A consideration of the force applied to the steering wheel and its moment is illustrated in figure 10.

A couple is found to exist when force is applied at X upward and at Y downward. The two equal and opposite forces combine to turn the vessel; the couple represents the two forces working to produce the same effect:

$$\text{Moment of } F \text{ at } X = F \times XO$$
$$\text{Moment of } F \text{ at } Y = F \times OY$$

Because the forces supplement each other the two moments are added together.

$$(F \times XO) + (F \times OY) = F\ (XO + OY) = F \times XY$$

The moment of a righting couple is the product of the forces comprising it and the arm, or distance, between the lines of action of the forces. The parallel case in stability of vessels is the couple of the force of buoyancy acting vertically upward through B and the weight of ship downward through G, times the righting arm GZ.

Figures 7 and 8 represent an ordinary kitchen table. In figure 7 the weight of the table is shown acting downward through the center of gravity G. Point B, where it touches the floor, is synonymous with the center of buoyancy, the load of the table

being entirely supported there. This counterbalancing force acting upward along line *BM* is equal and opposite to that acting downward through *G*. The force along *BM* is one tending to upright the table. *M* represents the metacentric point.

Now consider the table in the same tilted position, but with a large weight superimposed upon the table top sufficient to raise the center of gravity to *G* (figure 8). It is important to note that the inclination remaining the same, the point *M* remains in the same position as in figure 7. Nevertheless, the table, as the result of the raised *G*, is in unstable equilibrium and will capsize to the right. With *G* below *M*, the table was stable. The analogy between the table and that of a ship inclined as above explained should clarify the subject of the metacenter and metacentric height.

VISUAL ESTIMATION OF A VESSEL'S STABILITY

104. There is only one definite way to determine the the stability of a vessel and that is by the *inclining experiment*, figure 2 (*d*), which will be taken up later in this chapter. However, a very good practical estimate of a vessel's stability may be gained by studying the actions of the vessel while rolling. An ocean liner may have a metacentric height of one foot or less and a consequent period of roll as great as 22 seconds; on the other hand, destroyers, having a metacentric height of between 2 and 3 feet, will have a period of roll of between 4 and 8 seconds. Thus it is almost invariably the case that the less the metacentric height the slower the vessel will roll.

By keeping a record of every weight that goes into the fabrication of a vessel in its building it is possible by computing the moments of all of the weights to obtain the center of gravity of the vessel. However, this method is not only arduous, but one liable to error.

CENTER OF BUOYANCY VARIES

105. The total weight of a vessel is concentrated at its center of gravity, *G*. The center of volume of the underwater portion is located at the center of buoyancy, *B*. For each draft the center of buoyancy is variable. Its location for different drafts is easily obtained from the drawings of the ship's lines. With a ship at rest in an upright position the center of gravity, the center of buoyancy, and the metacenter must be in the same vertical line.

Next consider an external force acting on a ship while at sea, such as the side-wise pressure of the wind on the sails, or the side-wise pressure of a wave. The vessel will heel over until the resistance to the heeling of the ship, which is the *Righting moment* (*GZ*×displacement) becomes equal to the moment caused by the wind or sea which tended to heel the vessel. The *righting moment* then causes the vessel to right herself. The stability curve, figure 1, *E*, gives a reference for determining the values of the *righting arm*, *GZ*, for different inclinations. If, for instance, a wind force of 25 tons is acting on the sails at a distance of 40 feet above the center of lateral resistance of the ship, the heeling moment will be 25 times 40, or 1,000 foot-tons On the other hand, the opposing force, the *righting moment*, which keeps the vessel from capsizing, must, in the case of the vessel with 1,000 tons displacement also be 1,000 foot-tons. The 1,000 foot-tons divided by 1,000 tons=1 foot, which is the length of the lever of the righting arm, *GZ*. (Since a *GZ* of 1 foot×1,000 tons=a righting moment of 1,000 foot-tons.)

In the case where point *M* is above *G*, figure 1 (*a*), the stability is positive and the vessel stable. The limits of this stability depend upon the distance from *G* to *M* (i. e., on the metacentric height). The greater this distance the greater the stability of the vessel. However, too great a *GM* will result in a *stiff ship*, one which returns from transverse inclinations to the upright position with undue suddenness. For this reason passenger vessels have a small *GM* to give them a slow, easy roll. To compensate, from the point of view of safety, they in turn have a large amount of freeboard. Too often officers neglect to consider this freeboard as a needed adjunct to the stability of the vessel and become careless in the inspection of port holes and calking of half-doors in the ship's side, etc.

The following are customary values of metacentric heights: First-class cutters, loaded, 2 to 3½ feet; battleships, 5 to 7 feet; cruisers, 2½ to 4 feet; destroyers, 1½ to 3 feet; submarines (submerged), 0.7 feet; liners, ½ to 3 feet; sailing vessels, 3 to 3½ feet; merchant vessels, 1 to 3 feet. The steamship *Conte de Savoia* has a *GM* of 2.2 feet; that of the destroyer *Davis* is 2 feet 3 inches when fully loaded. The *Sebago* at full load displacement of 2,029.6 tons has a metacentric height of 2.8 feet, and with a light load displacement, 1,451.7 tons, a *GM* of 1.3 feet. This is the result of a low center of gravity. Transversely, a *steady ship* has a high center of gravity and a small metacentric height but ordinarily it is not as stable as a *stiff ship*. A stiff ship has a low center of gravity and a large *GM*. A cranky ship is one with a small *GM*. A ship with a small metacentric height makes for the steadiness of the gun platforms, allowing a smooth, slow roll, which permits better following of the target by the sights. Flat scows have a large *GM*. Frequently they are so stable that if inclined they will not capsize but will lose their deck loads if heeled too much and then return to an upright position.

There is also a *longitudinal metacenter*, but inasmuch as vessels are so invariably stable for pitching, little use is made of it.

SAFE DECK LOADS FOR CUTTERS

106. The matter of safe deck loads which may be carried frequently comes up when carrying freight,

coal, etc., on deck. The following information was obtained from Constructor F. A. Hunnewell.

The safe deck load which may be carried depends on the beam strength and stability of the ship. The inclining experiment data furnished each cutter nearly always gives the decrease or increase in metacentric height due to the addition of a given load on various deck levels. The data is tabulated in simple form and illustrated by curves of static stability.

The following includes inclining experiment data for the cutters shown:

Tampa Class

Twenty tons added thirty feet above the base line on the upper deck will decrease the light (no. VI) condition metacentric height (GM) of 1.18 feet by 0.24 foot.

Itasca Class

Twenty tons added thirty-one feet above the base line on the upper deck will decrease the light (no. VI) condition metacentric height (GM) of 1.34 feet by 0.18 foot.

Escanaba Class

Twenty tons added twenty-seven and one-half feet above the base line on the upper deck will decrease the light condition metacentric height (GM) of 2.55 feet by 0.32 foot.

165-Foot Patrol Boats

Ten tons added nineteen feet above the base line on the upper deck will decrease the half load (no. III) condition metacentric height (GM) of 4.1 feet by 0.3 foot.

Weights up to two or three times the above will have approximately proportional effect on the metacentric height.

The safe loads supported by the decks themselves vary with location of pillars, girders, and other stiffening. The large portion of Coast Guard cruising cutters has been designed under American Bureau rules which permit deck loads of cargo tonnage of the usual 40 cubic feet per ton. In the way of gun foundations and machinery foundations the strength of the vessels is increased and will permit the application of concentrated loads. (See art. 125.)

In carrying deck loads on cutters a check by stability calculations should be made. The following points also should be considered: (*a*) See that the waterways and freeing ports are not blocked; (*b*) do not block steering cables; (*c*) allow a safe load margin for the upper deck freight absorbing water; (*d*) allow for fuel and water consumption; (*e*) do not leave port with any list; (*f*) great care should be exercised in securing the deck load. Look out for chafe. Small chain cables are particularly well adapted for securing.

EFFECT OF LOWERING OR RAISING WEIGHTS ABOARD VESSEL

107. By taking a weight off the upper deck of a vessel and stowing it in a hold below, the displacement and trim of a vessel remaining the same, the center of gravity is lowered, the center of buoyancy remains unchanged, and the position of the metacenter remains the same. However, the metacentric height, GM is increased as the result of the lowering of the point G, and the stability is increased. Weights added on deck raise G and lessen GM and reduce the stiffness. If the weight is too great the vessel will become too tender and even unstable. (See art. 125.)

TO EASE A TOO STIFF SHIP

108. The remedies for easing over stiff ships are: the use of bilge keels and gyro-stabilizers; the moving of weights already on board outward from the center line, and moving upward of weights already on board.

GROUNDING

109. Take the case of a vessel aground. This is equivalent to raising the center of gravity, and lowering the metacentric point M in amounts depending on the loss of buoyancy. The vessel thus becomes less stable and with a rise in the tide may capsize. (See Damage Control.)

CHANGE IN DRAFT: SALT WATER TO FRESH WATER, VICE VERSA

110. In going from salt to fresh water, the metacentric height of a vessel and the position of the center of buoyancy will be slightly changed. In going from salt to fresh water, the vessel will be floating in water of lower density and therefore, for a given weight of hull equipment, etc., will displace a greater volume of fresh water than it did of salt water. This will result in an increase in drafts forward and aft. The increase in draft, d, equals displacement of the vessel in tons divided by 35 times the mean tons per inch immersion for the range of drafts dealt with. In going from fresh water to salt water divide by 36 instead of 35. In going from salt water to brackish water the change of draft is obtained by

$$d=\frac{W\left(\frac{36}{d'}-35\right)}{35\,T}$$

W=displacement of vessel in tons.
d'=density of brackish water.
T=tons per inch immersion for the range of drafts dealt with.

As the center of gravity has a fixed height above the keel at any one condition of loading, the fact that the vessel floats at deeper drafts in fresh water than in salt water does not alter the height of the center of gravity above the keel. However, the height of the metacenter above the keel does change as a result of

the increase in the moment of inertia of the water plane at which the vessel floats, and of the increase in the volume of hull under the water. Whether the height of the metacenter above the keel increases or decreases depends entirely upon the shape of the hull. For instance, in the case of the cutter *Sebago*, the height of the metacenter above the keel at full load will increase when the vessel goes from salt to fresh water; at light load it will decrease when the vessel goes from salt water to fresh water. This is illustrated in the following data taken from the inclining experiment and displacement curves for the *Sebago*:

	Salt water	Fresh water
FULL LOAD		
Displacement ..... tons	2,029.6	2,029.6
Mean draft ..... feet and inches	14 9	15 0¼
Height of metacenter above keel ..... feet	17.94	17.96
Height of center of gravity above keel ..... do	15.11	15.11
GM (metacentric height) ..... do	2.83	2.85
LIGHT LOAD		
Displacement ..... tons	1,451.7	1,451.7
Mean draft ..... feet and inches	11 6¼	11 9¾
Height of metacenter above keel ..... feet	18.20	18.15
Height of center of gravity above keel ..... do	16.86	16.86
GM (metacentric height) ..... do	1.34	1.29

This data shows the change in *GM* is due to a *change in the height of the metacenter above the keel* rather than to a change in the height of the center of gravity or change in the position of the center of buoyancy.

TRIM OF VESSELS

111. When a vessel gets into motion it will generally trim by the stern, that is, the draft forward will decrease and the draft aft will increase. The amount of this trim by the stern will depend upon the speed of the vessel and on the shape of the underwater body of the hull. Under some conditions the drafts forward and aft will both increase, so there is no set rule for the effect of motion of the vessel on its draft.

When a vessel is going at full speed, the stern "squats" and the bow rises somewhat, but the squatting of the stern is generally greater than the rising of the bow out of the water. Hence, the hull will sink into the water with reference to the level at which it was floating in still water, and since the center of gravity has a fixed position in the hull, it will be below its still position with reference to the original level by an amount equal to the sinkage of the hull below its original still-water level. Concerning vessels such as destroyers, the resistance of the water against the ship's side ordinarily will be greater in shallow water than in deep water. But with such a vessel making very high speed, the effect of shallow water is to increase resistance. This is due largely to the restriction imposed upon the flow of water around the ship, resulting in the generation of high pressures which are made manifest by waves of greater height. Another cause is that, in shallow water, the waves produced at a given speed of the vessel are larger than those produced in deep water. Since the energy in a wave depends upon its height and length, it follows that if in shallow water a ship's waves are longer and higher, her resistance is increased. The differences between the shallow-water resistance and deep-water resistance increases, reaching a maximum value at a "critical speed" depending on the speed-length ratio and the depth of the water. If the ship is capable of very high speed it may be driven beyond this speed of maximum increase of resistance and enter a zone of speeds wherein the difference between shallow-water resistance and deep-water resistance decreases, finally reaching zero. High-speed vessels, like destroyers, at speeds corresponding to values of speed-length ratio of two or greater, may actually encounter less resistance in shallow water than in deep water, or consequently make higher speeds on a measured mile in shallow water than in the open ocean. Further investigation is necessary to explain adequately the reasons for this decrease in resistance on a ship in shallow water when driven to extreme speeds.

THE EFFECT OF FREEBOARD ON STABILITY

112. As mentioned the reason that passenger vessels have such a high freeboard is that on a deep roll, up to the point her deck does not submerge, her emersed volume increases and this moves the new center of buoyancy to the right (with a roll to starboard) and it gives a righting arm, *GZ*, of greater value. On the other hand, consider a vessel with a small freeboard. With a deep roll, the upper decks submerge and the righting arm is decreased by the weight of the water on her decks and it is therefore necessary for such a vessel to have a greater *GM* than a passenger vessel in order to provide a sharp righting impulse. On cargo vessels excessive *GM* may result in violent returns to the upright position and result in shifting of cargo with a possibility of capsizing. Ordinarily a passenger ship in light condition will be less stable than when fully loaded. A cargo ship in light condition is almost always less stiff than when it is loaded. In the latter case the actual center of gravity is practically always higher in the light condition than when loaded, and when light the limit it may safely obtain is much higher.

FREE SURFACE LIQUIDS (see figs. 3, 4, 5)

113. Use of fuel oil has greatly added to the free surface menace. As a vessel rolls, free surface liquid piles up on the low side and causes a deeper roll, thus, as a result of the loss of stability it is more difficult for the vessel to return to the upright position. Officers should be able to find the *virtual* center of gravity (see Glossary) of such liquid. (See fig. 4.) When a vessel is upright, *b* represents the center of gravity of the free surface liquid in a partially filled tank. *G* is the center of gravity and *M* is the meta-

center of the vessel. When a vessel is inclined as in figure 5, the center of gravity has moved from B to B'. *As will be noted in this figure, free surface liquid has the resultant effect of adding a weight high up at point g* and results in the center of gravity of the ship being moved upward from G to G'.

To better understand the grave danger of *free surface liquid* and gain a clear conception of the term *virtual center of gravity*, refer to figure 3. Here b represents a large lead sphere suspended by a line made fast at g, high up on the mast of a vessel. It is readily seen that as the vessel rolls the lead ball will swing back and forth athwartships, with a *terrific surge*. It is an action quite similar to that of the pendulum of a grandfather's clock. The *actual center of gravity* of the pendulum is near the center of the bob, but in our study we are concerned only with the position at which the influence of the weight is exerted, i. e., the point of suspension, which corresponds to g and which is the *virtual center of gravity*. The *virtual center of gravity* may therefore be defined as the center of effect of a load free to swing across the ship, such as a free surface liquid in a partly filled tank.

Figure 5 shows how easily point g is found. In the same manner as M the metacenter was determined, draw a vertical through B', the center of gravity of the inclined free surface liquid. The point where the vertical cuts the middle line of the ship is g. This point is sometimes referred to as the metacenter of the free surface liquid. Summing up, the liquid which is free surface, is considered as being suspended at g, swinging back and forth in the same unruly and *dangerous* manner as a very heavy ball at b', figure 3. It has the same effect as if the free surface liquid became a top hamper weight at g. The reduction of GM, the metacentric height (which lessens stability), by the position of the G of the vessel, as the result of the free surface liquid, being changed to G', varies inversely as the displacement, i. e., the greater the displacement the less the reduction in GM.

Tables are furnished by shipbuilders, which by interpolation, show the reductions in GM for free surface liquid in any of the vessel's tanks, and for any load condition of the tanks. The *gravity* of the free surface liquid menace being realized, good use will be made of such tables, especially by officers on small vessels.

DANGER OF FILLING BALLAST TANKS AT SEA

Conditions may arise on a cutter, as the result of a heavy deck load carried or from the consumption of large quantities of fuel and water on a long tow, to tempt the filling of a tank with salt water for ballast. This would be all right if the tank could be instantaneously filled, but the time required to fill it completely full may allow the stability to be lowered too markedly from the effect of free surface liquid.

That cutters do, through force of circumstances, sometimes approach an unstable condition is verified by the officers attached to the *Snohomish*, who reported that their vessel nearly capsized in crossing the Columbia River entrance. Their fuel had been reduced to 50 tons and water correspondingly low.

STRUCTURAL DAMAGE BY FREE SURFACE LIQUID

If a deep tank be not quite full, the water, lashing from side to side as the vessel rolls, is brought up, or "choked", in the corners below the tank top, and, as a result, it is not uncommon to find the rivets of the beam knees loosened or broken, and sometimes the shell rivets in the frames. For this reason the beam knees of deep tanks are made deeper than is usual for a lower deck, i. e., about 3 times instead of 2½ times the depth of the beam, and the shell-to-frame rivets are more closely spaced. If a fore-and-aft middle-line bulkhead is fitted it may be constructed no less substantially than the transverse bulkheads, for it may be exposed to the battering effect of free water. In many cases, when the connection at the top and bottom has been meager, the bulkhead has been swept down by the moving water. (From art. 221, Practical Shipbuilding, by Campbell Holms, vol. 1, by special permission of the publishers, Longmans, Green & Co.)

ROLLING OF VESSELS (see fig. 29)

114. This figure represents a wave motion approaching the ship from the left. WL represents the waterline before the wave reached the ship, and $W'L'$ the waterline just as the wave reaches the ship, before the ship has started its inclination from an upright position. Before the wave approached, position B was the center of buoyancy. As $W'L'$ becomes the new waterline the position of the center of buoyancy is shifted from B to B'. The slope of the side of the wave and the consequent movement to the left of the center of buoyancy will cause the vessel to roll to the right in its endeavor to remain perpendicular to the wave surface. Should the period of roll of the ship correspond to the time required for each wave to move a wave length to the right, it is seen that each inclination of roll of the ship would continue to become greater and greater until finally the ship would roll over. There are two things, however, which prevent this: (*a*) The friction of the water on the ship's sides; (*b*) the angle of roll can increase only with a consequent increase in period, with a consequent break-up of synchronism between the period of the wave and the roll of the ship. In other words the amplitude of the rolling increases until the ship is requiring for each roll a greater period of time than the normal period of the waves. Another factor is that waves seldom follow at constant intervals. Means for the prevention of the rolling of ships are: Bilge keels, antirolling tanks, gyro-stabilizers, moving weights upward and outward, adjustable fins,

and two tanks on either side of the ship with an arrangement to control the flow of water between them. In the gyroscope system, which makes use of the gyroscopic properties of a rotating wheel, a pilot gyro controls a precession motor which in turn controls the precession of the main gyro about the athwartship axis. The resultant reaction of the precession is opposition to the heeling movement. The resistance offered by the gyro to rotation of its axis dampens the rolling of the vessel in which it is installed. Antirolling tanks usually consist of large tanks on either side of the ship, connected by a pipe at the bottom and by an air passage, regulated by a valve, at the top. One tank is filled along with the connecting bottom pipe. The air valve is then adjusted so that when the vessel rolls the motion of the water is one-fourth period behind the roll of the vessel. Considerable use is made of antirolling tanks, especially on German vessels, including two of their large liners. Adjustable fins are a Japanese installation. Fins, which are mounted on the ends of shafts, the inboard ends of which are geared together, project downward and outward through the skin of the ship, at the turn of the bilges. A gyro-controlled steering engine rotates the shafts so that the leading edges of the fins on the side moving down are turned up and the leading edges of those on the side moving up are turned down. Alongside the dock and in shallow water the fins are retracted within the hull. They are about 60 percent effective in reducing roll.

The radius of gyration is the effective radius of inertia of a vessel with respect to its center of oscillation. It greatly affects the period of roll and is controlled by the type of the beam of a vessel.

If: T=the time of a single oscillation or period of roll

GM=metacentric height (transverse)

g=acceleration of gravity 32.18

K=the radius of gyration above the longitudinal axis

through the center of gravity, in feet

$$T=.554\sqrt{\frac{K^2}{gM}}$$

The value of the radius of gyration used is that of a similar vessel already known.

The rolling of vessels is dependent upon their metacentric heights, displacements, and their radius of gyration.

RADIUS OF GYRATION

115. Its value is so largely dependent upon the type and beam of the ship as to be practically beyond the control of the designer. Nevertheless, the winging of weights whenever possible is of assistance in increasing its value and so increasing the period of roll.

While, as above stated, the value of the radius of gyration is not readily controllable, a fairly definite knowledge of its probable value for various types and sizes of ship is possible, and is of considerable importance.

The following table has been prepared in order to show the relationships existing between the several factors affecting the periods of roll of representative types and sizes of ship:

Type	Displacement	Beam	Draft	Radius of gyration	Approximate value GM designed condition	Period of roll seconds[1]
	Tons	*Feet*	*Feet*	*Feet*	*Feet*	
Tankers, colliers, miscellaneous cargo vessels	5,000–20,000	40–65	19–28	13–25	2.0–3.0	10–14
Naval auxiliaries	5,000–12,000	40–60	20–26	13–23	2.5–3.5	9–12
Modern battleships	20,000–40,000	85–105	25–33	28–37	4.5–7.0	13–16
Fast passenger vessels	15,000–60,000	60–100	25–40	20–38	2.0–4.0	15–18
Destroyers	500–2,500	25–37	7–12	9–13	2.0–2.5	4–8
Yachts, power driven	75–1,000	15–30	4–11	5–10	1.5–2.0	4.5–8

[1] This is a double oscillation and is equal to $2T$ as used in the formula for unresisted rolling.

GYRO STABILIZER, DESCRIPTION OF

116. A stabilizer was built in 1931 by the Westinghouse Electric & Manufacturing Co., at South Philadelphia, Pa., to the order of the Sperry Gyroscope Co., of New York, for a foreign shipbuilder. The huge top, weighing 110,000 pounds, spins at a speed of 930 revolutions per minute within the stabilizer casing, spun by a built-in 200-horsepower motor. The gyro, precessed by an external electric motor of 75 horsepower, is designed to keep a 450-foot ship within 2° maximum roll. Almost an hour is required to get the 55-ton rotor up to its speed, and when power is cut off the rotor it will revolve of its own momentum for more than 2 hours. (Professional Notes, United States Naval Institute Proceedings, May 1931, by special permission.)

NOTE.—The superliner *Conte de Savoia* has three stabilizers.

PITCHING

117. Pitching is caused by the movement of the center of buoyancy in a fore-and-aft direction, which results from the longitudinal slope of the waves.

MOMENT OF INERTIA

118.

$$BM=\frac{\text{moment of inertia of } L\ W\ L \text{ plane}}{\text{volume of displacement in cubic feet}}=\frac{I}{V}$$

(where BM equals the distance from the center of buoyancy to the metacenter). The moment of inertia is the measure of the tendency possessed by the area of the water plane of any floating body to remain motionless. It applies only to the area of the waterline plane at which the craft is floating.

By definition the moment of inertia of an elementary mass about a plane or axis is the product of the elementary mass times the square of its distance from the reference plane or axis. The moment of inertia of a body or area about a plane or axis is the sum of the moments of inertia of all its elements about the reference plane or axis. If the body is of small uniform thickness and is of uniform density (such as the waterplane) its moment of inertia is computed by treating the waterplane as an area. The transverse metacentric height, *GM*, and also *BM* are concerned with the moment of inertia of the waterplane about the longitudinal fore-and-aft middle line of the ship through the center of gravity. This radius of the waterplane about the middle line equals the radius of gyration of the waterplane. The moment of inertia of an area distant from the center of gravity is much greater than it would be for the same area were it massed near the center of gravity. The moment of inertia equals the sum of the force necessary to stop or move a body. It is always the weight of the body times the square of its distance about the axis under consideration.

To obtain the moment of inertia of the load waterplane, the plane is divided up into equal-sized small areas and the distance their centers of gravity are from the longitudinal (fore-and-aft) axis, or line through the center of gravity of the vessel, are measured. Then the sum of all the products of each small area times the square of its distance from the axis equals the moment of inertia of the plane about this longitudinal axis. Use is made of this calculation to determine *BM* from the relation $BM=\frac{I}{V}$.

For a rectangular shaped waterline, considering a transverse inclination, the moment of inertia equals

$$\frac{\text{width}^3\times\text{length of waterline}}{12}$$

For *LWL* waterplanes of other than rectangular shapes, for transverse inclinations, the moment of inertia equals width^3×length×coefficient, or, in general the moment of inertia equals $Cof\times L\times B^3$.

The moment of inertia about the *vertical axis* through the center of gravity of a vessel is the weight of every component part of the vessel times the square of its distance from the vertical axis. This computation indicates the readiness with which a vessel answers the helm. The greater the moment of inertia, the slower the boat will turn and gain angular velocity. It is therefore desirable to concentrate weights near the vertical axis which passes through the center of gravity.

RESISTANCE TO SHIP'S PROPULSION

119. The resistance to a ship in motion is made up of (*a*) air resistance, (*b*) friction against water, (*c*) streamline (which is caused by compressing and diverting lines of water out of their normal position or path), (*d*) waves, and (*e*) eddies. As a result of resistance bow waves consume one-half of the ship's power for high-speed ships. The stern wave would be similar to the bow wave were it not for the fact that the water being disturbed from passage of the ship, the stern wave becomes a resultant of the bow and the primal stern wave. Eddy resistance is due to the formation of eddies behind the more or less blunt stern post or strut. For example, the resistance of an exposed gun on a submarine under water reduces its speed 2 knots. Skin resistance is frictional. The bow wave, stern wave, and streamline resistance are due to pressure. Skin resistance is 70 to 80 percent of the total resistance. Total propulsive resistance is measured in a model basin with dynamometers. With the same horsepower 1 propeller will give a higher efficiency than 2 propellers.

TACTICAL DIAMETER (see Glossary)

120. The tactical diameter of a vessel depends on (*a*) speed, (*b*) rudder angle, (*c*) area of rudder, (*d*) draft, (*e*) form of under body, (*f*) length of ship, (*g*) distribution of weights, (*h*) tonnage, and (*i*) shape of rudder.

The distance from the bow of a ship to her pivoting point, when the rudder is put over, is approximately one-third the length of the vessel from the bow. The exact location of the pivoting point will depend on the shape of the profile of the underwater body. For example, if the forefoot is cut away, as in an ice breaker, the pivoting point will be further aft than it would be in a vessel with a deep forefoot, and the deadwood forward of the propeller cut away.

Four effects are produced on a ship in motion when the rudder is put hard over, namely (*a*) slows down, (*b*) vessel turns, (*c*) vessel heels inward at first and later may heel outward, and (*d*) vessel moves bodily sideways, outboard.

Tactical diameters (approximate):	*Yards*
Mojave class	350
Lake-type cutters	300
165-foot patrol boats	200
Escanaba class	165
328-foot cutters	---

MOMENT TO ALTER TRIM

121. It is the weight required to effect a change in trim of 1 inch:

$$w\times d=\frac{W\times GM}{12L}\text{ (in foot tons)}$$

w=weight moved in tons
d=distance in feet
W=displacement in tons
GM=metacentric height (longitudinal) in feet
L=length of vessel in feet

(I. e., moment to change trim 1 inch (as determined from longitudinal inclinations)

$$\text{equals } \frac{\text{displacement in tons} \times \text{longitudinal } GM}{\text{vessel's length on } LWL \times 12}.$$

Change in G by movement of weights

$$\text{equals } \frac{\text{weight moved} \times \text{distance moved in feet}}{\text{displacement in tons}}.$$

When a ship changes trim 1 inch, she is inclined, relative to her original position, an angle whose tangent is one-twelfth foot divided by the length of the waterline in feet. The tangent of this angle is also the distance longitudinally that the center of gravity is considered as moving, divided by the longitudinal metacentric height.

Correction to displacement for 1 foot trim by the stern

122. When a ship is trimmed 1 foot by the stern the shape of the water-line changes on account of the difference between the form of the molded surface at the forward and after ends. Displacements are calculated for the water line corresponding to drafts with the ship on an even keel. The correction to displacement when down by the stern is as follows:

$$\frac{12\,Td}{L}$$

T = tons per inch immersion

L = length of water line in feet

d = distance the center of gravity of the load waterplane is aft of amidships, in feet.

When the center of gravity is aft of amidships, the correction is additive, and when the center of gravity is forward of amidships, the correction is subtractive.

The stability of a hull is not apt to suffer from athwartship weaknesses, but mainly from damage to hull resulting from hogging or sagging. Structural strains are due to weather and sea, propulsion thrusts and local strain from weights, such as machinery. Seaworthiness depends upon (*a*) stability, (*b*) buoyancy, (*c*) strength, and (*d*) endurance. Stability depends upon the underwater shape of the body, distribution of the underwater shape and distribution of all weights on board. To protect initial stability all compartments must be subdivided as much as possible.

As is commonly known, buoyancy of water is measured by the weight of the water displaced by the body. Buoyancy force is always the same as the weight of the ship. A 10,000-ton ship with a GZ or righting arm of 4 inches has $10{,}000 \times 1/3' = 3{,}333$ foot-pounds righting moment. Reserve buoyancy is the floating power contained between the load waterplane and the upper deck.

CENTER OF FLOATATION

123. The center of floatation is of value in making longitudinal stability calculations. It is the center of gravity of the waterplane at which the vessel is floating. The plane of floatation is the plane formed with the surface of the water and the sides of the ship.

IMMERSION, TONS PER INCH

124. Tons-per-inch immersion equals the number of tons required to sink a vessel 1 inch at a given draft. This varies with the different drafts of a ship on account of the irregular shape of the hull. The curve of tons-per-inch immersion is a curve representing at various drafts the tons of displacement per inch of depth of hull at that draft.

The rule for finding the tons-per-inch immersion is as follows: Let A equal the area of the waterplane at any draft. A times 1/12 equals the volume in cubic feet of a layer 1 inch thick at the draft of the waterplane. Tons-per-inch immersion for salt water for any draft $= \frac{A}{420}$; for fresh water $= \frac{A}{432}$ (35 cubic feet of salt water to a ton; 36 for fresh water).

EFFECT MOVING WEIGHTS HAVE ON CENTER OF GRAVITY

125. (1) *Suppose the weight is raised.*—The distance that the center of gravity of the vessel is raised will be found by multiplying the weight, in tons, by the distance moved, in feet, and dividing the result by the total weight of displacement, in tons.

Example.—A weight of 60 tons was raised from the hold and placed on the deck of a steamer at a distance of 20 feet above its original position.

The steamer had a displacement of 2,000 tons. Find the distance the center of gravity was raised:

$$\frac{\text{Weight} \times \text{distance}}{\text{Displacement}} = \frac{60 \times 20}{2{,}000} = 0.6 \text{ feet.}$$

(2) *The weight is removed.*—In this case multiply the weight, in tons, by its distance, in feet, from the center of gravity of the ship, and divide the product by the displacement, in tons, after the weight was removed.

Example.—A weight of 60 tons 10 feet below the center of gravity of a ship of 2,000-tons displacement was removed. How much was the center of gravity raised?

$$\frac{\text{Weight} \times \text{distance}}{\text{Displacement} - \text{weight}} = \frac{60 \times 10}{2{,}000 - 60} = 0.3 \text{ feet.}$$

(3) *Adding a weight.*—Multiply the added weight, in tons, by its distance in feet from the center of gravity of the vessel and divide by the new displacement, in tons.

Example.—A weight of 60 tons was placed on board a steamer, with an original displacement of 2,000 tons, 10 feet below her center of gravity. Find the distance the center of gravity was lowered.

$$\frac{\text{Weight} \times \text{distance}}{\text{Displacement} + \text{weight}} = \frac{60 \times 10}{2{,}000 + 60} = 0.29 \text{ feet.}$$

(4) *Moving a weight athwartships.*—Multiply the weight, in tons, by the distance, in feet, and divide by displacement, in tons.

Example.—A weight of 40 tons at the center of the upper deck was moved 10 feet to starboard. The steamer had a displacement of 2,000 tons. Find the distance her center of gravity was moved.

$$\frac{\text{Weight}\times\text{distance}}{\text{Displacement}}=\frac{40\times10}{2{,}000}=0.2 \text{ feet to starboard.}$$

(5) *Moving a weight in two directions.*—The new position of the center of gravity can be found by using (1) and (4).

Example.—In a vessel of 8,000-tons displacement, 200 tons of coal were shifted so its center of gravity moved 18 feet transversely and 4 feet 6 inches vertically. Find the new position of the center of gravity.

By (1) the center of gravity will move vertically

$$\frac{200\times4.5}{8{,}000}=0.11 \text{ feet.}$$

By (4) the center of gravity will move horizontally

$$\frac{200\times18}{8{,}000}=0.45 \text{ feet.}$$

INITIAL STABILITY

126. In figures 1 (*a*), (*b*), and (*c*), WOW_1 is the *emerged* wedge and L_1OL the *immersed* wedge. For inclinations up to 10° or 12°, WL and W_1L_1 intersect at O on the centerline, but for large inclinations the point of the intersection moves to the side of the centerline to which the vessel is inclined. The position of M is practically fixed for all inclinations up to 10° or 12°. Hence, it is seen that in determining the *initial stability* inclinations of not more than 10° should be used.

INCLINING EXPERIMENT

127. *To determine the position of the center of gravity:*

(1) The experiment is to be conducted before taking on a load or outfit.

(2) All tanks for liquid should preferably be empty; if not empty, then completely filled so that there will be no free surface.

(3) The weight and vertical position of water in boilers and machinery at the time of the experiment is to be ascertained and included in the report of weights.

(4) An accurate record of the consumable and removable weights is to be made, which is to include officers, crew, and their effects. Careful record should be made of the various stores, spare parts, ammunition, cargo, and fuel. The weights are to be given and the calculations by compartments or by frame numbers and decks stated.

(5) Anchors should be housed with the chains and hauled taut or lashed.

(6) All weights which might shift under small inclinations should be secured.

(7) The location and position of all boats noted and recorded; preferably boats should be in their sea stowage positions.

(8) Coal in bunkers should be trimmed.

(9) The character, amount, and location of all ballast, whether fixed or movable, should be recorded.

(10) Bilges and other places where liquids may collect should be drained dry.

(11) All foreign weights, dunnage, workmen's tools, and yard equipment should, as far as practicable, be removed from the ship. Those not removed should be carefully recorded.

(12) The crew should be confined to the midship line and preferably all that can be spared should be sent ashore.

(13) It is important that the vessel be inclined in still water or under conditions approximating thereto.

Builders furnish data on the height of the metacenter and the center of buoyancy above the keel. In order to obtain the height of the center of gravity above the keel, it is necessary to carry out the inclining experiment. It is obtained by moving across the upper deck a weight of known amount. The ship must be floating freely, alongside the dock or in a drydock, with lines slacked. (See figs. 6 and 2*d*.) W equals the displacement of the ship including the weight to be moved; w equals the weight which is to be shifted across the deck; d equals the distance weight is moved; equals the heel angle (the angle the vessel heels when weight is moved) whose tangent is $\frac{GG'}{GM}$. G equals the center of gravity of vessel and weight after the weight is moved from one side of the vessel to the other side. M equals the metacenter corresponding to the displacement W. As the weight is shifted across the deck the plum bob, which is suspended from point P, moves from Q to R, figure 6. The distance from Q to R is carefully measured. Angles of inclination up to 10 degrees only are used. The operation is repeated several times and the distance QR carefully checked. GG' is determined by the application of moments. Thus $GG'\times W$ equals $w\times d$ or GG' equals $\frac{w\times d}{W}$. (PG' and MB being parallel, angle RPG equals BMG). $\frac{GG'}{GM}$ is also the tangent of θ the angle of inclination caused by moving the weight, the angle MGG' being a right angle. PQ, MQ, θ and QR are known values.

$$W\times GG'=w\times d$$

$$GG'=GM \text{ tangent } \theta=\frac{w\times d}{W}$$

$$\text{(i. e.) } GM \text{ tangent } \theta=\frac{w\times d}{W}.$$

$$GM=\frac{w\times d}{W\times \text{tangent}\,\theta}.$$

Tangent θ also equals $\frac{QR}{PQ}$ both of which are known

If the water is brackish, multiply W, the displacement (in long tons), by the density of the water. Builders' data give the height of M above the base line. Hence the height of G above the base line is now easily found.

STABILITY STUDY

Loss of British Steamship *Vestris*

[From notes compiled by the Liverpool Chamber of Commerce as the result of the court of inquiry]

128. The British steamship *Vestris*, a 10,000-ton-burden vessel, sailed from New York at 3:45 p. m., November 10, 1928. At about 2:30 p. m., November 12, she foundered with a loss of life of 68 passengers, over one-half of whom were women, and 44 of the crew, out of a total of 128 passengers and 197 crew. Briefly, the following events occurred.

November 11.—At 2 a. m., vessel took on a starboard list of several degrees. About 9 a. m., ash ejector line or its flapper valve fractured, allowing entry of large quantities of sea water. During the day a northeast gale developed. At 12 noon the vessel refused to steer. Engines were stopped and she drifted in the trough of the sea. At 7:30 p. m., two particularly heavy seas struck the ship and put her over nearly on her beam ends. She recovered slowly to a list of about 20°. At this point wing tanks numbered 2, 4, and 5, starboard, were pumped out, the result being, instead of righting the ship she heeled more than ever as the result of the tons of free surface liquid left in the partly filled tanks, (there being no wing suctions). At this point the list to starboard became about 28°.

November 12.—Water entered between decks, which did not find its way below. As the vessel heeled more and more, water entered poorly calked half-doors and through portholes which could not be tightened on account of accumulated paint on the screw threads. An SOS was sent out at about 9 a. m. Lowering of the port boats was practically impossible owing to the heavy list to starboard, and the starboard decks being flooded prevented passengers from getting into the starboard boats. The vessel turned over at about 2:30 p. m.

Lessons from the Loss of British Steamship "Vestris"

129. The serious and salient feature of the *Vestris* and most other disasters is that once water finds access to the ship the whole problem of stability changes instantly. Stability calculations are based explicitly on the assumption that the vessel remains intact. When this fundamental basis is impaired it becomes not a question of *GM's* or righting arms, but one of "boats and davits."

If the list be suddenly caused by free liquid in the ship, and in a reasonable time the pumps do not minimize it, nothing else will.

Officers should make a careful study of the effect of free liquid in a ship, because it is the most dangerous element figuring in stability today, and they should obtain a thorough appreciation of what free liquid implies.

For instance, a ship 470 feet long carries oil fuel in her double bottom no. 2 tank from forward and has a capacity of 400 tons. When this tank is one-quarter full, that is, when it contains 100 tons and has a free surface, the effect is exactly equivalent to placing this weight in the ship at a height of 56 feet above the keel. From this it will be realized what the effect must be of water getting into an empty hold affording such an extensive scope for free surface.

When carrying water ballast, it is most essential to see that no free surface exists in any of the tanks, and sometimes this is more difficult than is imagined, because there is the danger of air locks, which may mislead the officer and give him the impression that they are full when actually they are not. In the case of Diesel ships and oil-burning ones, the oil-fuel tanks can never be assumed to be full. Theoretically they can, but in practice they cannot. A shipmaster, therefore, when estimating his GM must not fail to assume that his oil tanks are slack and assure himself that his ballast tanks, if containing water, are absolutely full.

After the *Titanic* disaster it will be recollected how experts affirmed that if this ship had only had side bunkers, or an inner skin, she would never have sunk. Perhaps she would not, from the particular nature of her accident. Inner skins, therefore, became a sine qua non for all new passenger ships, and many vessels on the stocks had side bunkers installed with watertight doors. Then came the *Empress of Ireland* disaster, a totally different kind of mishap from the *Titanic*, for she capsized, instead of sinking by the head, and it became apparent that water must not be confined to a watertight compartment on one side, but must have free access to the other side. So out came the inner skins, and the ships which on the stocks had had watertight side bunkers fitted had the watertight doors removed.

Quantitative knowledge of a ship's stability prior to sailing is becoming more and more essential, not because captains from their wide experience are unable to "feel" if their ships are stable or not, but because they may be faced with some contingency when their subsequent action would have to be fortified by actual knowledge and not by impression only. For instance, a ship might have a GM of 1.5 feet, a perfectly satisfactory amount, and certain circum-

stances might call for filling or emptying a deep tank, the free surface of which reduced the *GM* by 2 feet 6 inches. Here it would obviously be better for the captain to know his stability in actual figures, or otherwise his ship would take a serious list during the operations of filling and emptying the tank.

Stability is a wide and important subject, but it reduces itself to a persistent watch upon the center of gravity of the ship, and if captains and officers will cultivate the habit of resolving all such matters as added weight, shifting of weights, removal of weights, and free surfaces in tanks, into terms of effect upon the vertical position of the center of gravity, there will never be any need for restrictive and incidentally anomalous legislation upon the subject.

The pumping of tanks at sea was a dubious method of righting a ship. (This refers to the pumping out of the starboard wing tanks, which having no wing suctions left a large amount of free surface liquid, which was one of the main causes of the loss of the vessel.)

It would, disregarding the free surface resulting therefrom, tend to right the ship but make the ship more tender. However, the free surface liquid made it dangerous. When they had trouble with the ash ejector, and with water getting into the ship, and the combined effect of that and the wind producing the loss of the ship, it is possible that instead of pumping out a tank the master could have filled one on the opposite side (i. e., counterflood to right the ship). A pump was taken off the bilges and put on to something which was no good—the pumping out of the wing tanks. That had some influence on the loss. Water in the bilges also contributed to the listing.

FINDINGS OF THE COURT OF INQUIRY

130. The following are the main contributory causes of the loss of the vessel, and the loss of life. (1) Overloading of the vessel beyond her loadline 6 to 7 inches. (2) Tender condition of the ship. (3) Insufficient margin of stability, and reserve of buoyancy. (4) Heavy weather, high wind and sea, causing the vessel to list to starboard. (5) Leaks from starboard ash ejector, "booby" hatch on shelter deck, and half-doors on upper deck. (6) Upper deck hatches in starboard shelter deck bunker and cross-alleyway not being battened down soon enough in some cases, and not being battened down at all in other cases. (7) Water finding its way into lower bunkers, saturating the coal, causing list and probably preventing pumps from working efficiently. (8) The scuppers becoming, after a certain angle of list was reached, a means of incursion of water into the upper deck, which, in the *Vestris* (being a shelter-deck vessel), was also the weather deck. These scuppers not being stopped or plugged when the vessel listed gave ready access of the sea to the upper deck, and so reduced the margin of stability. (9) Wing suctions not fitted in ballast tanks.

It is possible and very probable that free surface water existed in some or all of the double-bottom tanks.

The engineroom bulkhead gave way without shearing rivets. It was 14 years old and badly deteriorated.

The International Conference of Naval Architects in 1914 recommended a cut-off valve be installed inboard of the outlet valve on ash ejectors, sanitary lines, etc., to prevent flooding in case of failure of the flapper valves to operate.

CHAPTER II

MATERIALS USED IN CONSTRUCTION OF COAST GUARD CUTTERS

201. Cutters now in service have steel hulls. Steel plates, forgings, castings, shapes, rivets, and welding are fabricated into the ship. Cast steel and forged steel, also a combination of the two, are used for stems in Coast Guard cutters. The stern frames, stern tubes, struts, spectacle frames, machinery beds, hawse pipes, chain pipes, bitts, anchors, gun mounts, windlass barrels, wildcats, etc., are cast steel.

Hull plating is made by the rolling out of steel to the required thickness. Mild steel of high tensile strength is used. Plating is also used for inner bottoms, decks, bulkheads, trunks, floors, web frames, girders, etc. (See arts. 208, 322.)

Shapes are such members used in ships as channel bars, I-beams, Z-bars, T-bars, angle bars, etc. They are rolled to the particular cross section. (Fig. 126.) Wrought iron is used where ductility and strength are essential, as for anchor chains, steering-gear chains, etc. (See art. 207.)

Genuine wrought iron is now used for salt water piping. Brass and copper is also used for salt-water piping. The modern practice on cutters is to fit in salt-water lines, adjacent to composition valves, an 18-inch length of cast iron, rubber-lined piping, completely insulated from valve and pipe line. Such an arrangement acts as a corrosion-prevention measure.

Manganese bronze is used for propeller blades and hubs. (See art. 221.)

Copper is used for fresh- and salt-water piping, for exhaust piping and where the bends are complicated, as it is easy to work.

Monel metal and stainless steels are used for sinks, etc.

IRON PLATING

202. Iron plating is less corrosive than steel. For this reason it is sometimes used for tank-top plating and for floors under boilers, to minimize the rapid corrosion incident to the moist heat in such regions.

STEEL PLATES, TYPES OF

203. Flat plates are gaged by pounds per square foot; a steel plate 1 foot square and 1 inch thick weighs 40.8 pounds, but is usually called a 40-pound plate. Similarly half-inch plates are called 20-pound, and quarter-inch plates, 10-pound plates, etc.

Universal plates are flat plates of standard sizes over 6 inches wide, or rather, plates of the various commercial sizes.

Checkered plates are used for floor plates in engine rooms and firerooms.

Chafing plates are used under anchor chains where the chain runs over a wooden deck, the top side of the plating being checkered.

Corrugated plates (having one corrugation running lengthwise) are used for fenders on the sides of craft like a coal barge.

Flats are flat plates of various sizes up to 6 inches wide inclusive, and are used for seam straps, liners, tie plates, margin pieces, etc.

Rounds are round bars and rods up to 7 inches in diameter.

MANUFACTURE AND PROPERTIES OF IRON AND STEEL

Pig Iron

204. Pig iron, obtained by melting iron ores in a blast furnace, is used in its natural state, or somewhat refined, for castings. It contains 2.5 to 4.5 percent of carbon, and slight amounts of phosphorus, manganese, and sulphur.

Sulphur and phosphorus are harmful, and specifications usually limit the amount of these ingredients in the finished article. Silica is often present. It does no harm in small quantities, and increases fluidity, facilitating casting.

Cast Iron

205. Cast iron is brittle and weak under tension, but has good compressive strength. It machines well, but cannot be forged, bent, or welded, except by acetylene welding. Quickly cooled cast iron, called chilled iron, is extremely hard. The hardness can be estimated by the color, chilled iron being white, while soft cast iron is gray, softness corresponding to darkness of color.

Castings

206. Castings are rendered malleable by annealing in oxides, which results in partial decarburization.

Malleable cast iron is not brittle, can be bent slightly but cannot be forged or welded.

Wrought Iron

207. Wrought iron is made by removing the impurities in the pig iron. The process, called puddling, consists of melting the iron in the presence of oxides. The oxides unite with the impurities to form a slag which has a lower melting point than the iron. The mass is then cooled to a pasty state, in which condition it is rolled and worked to squeeze the slag out. A thin film of slag remains, giving the finished product a fibrous or laminated appearance.

Wrought iron is tough, ductile, and has good tensile strength. Its laminated structure makes it weak under compression. It can be welded, forged, or rolled. It should be worked freely so that the fibers will lay in the direction of the stress in the finished piece.

Mild Steel

208. Mild steel resembles wrought iron in composition, but contains up to one-tenth of 1 percent of carbon. It is made by burning out the impurities in pig iron and then adding the desired amount of carbon. From a liquid stage it is poured into molds and then rolled into plates and bars. It has good strength in tension and compression, is ductile, and can be cast, rolled, drawn, sheared, or punched. (See art. 322.)

Machine Steel

209. Machine steel contains more carbon than mild steel, up to 0.7 percent. It is harder and stronger than mild steel. It can be worked in the same manner.

Mild and machine steels have largely displaced wrought iron in modern manufacture.

High Carbon Steel

210. High carbon steel, 0.7 to 2.2 percent carbon, is harder and stronger than machine steel, but more brittle. It does not weld or cast well. Steel containing 0.8 carbon or more can be hardened by heating beyond the critical point and quenching. It can then be softened to any desired degree by reheating to the appropriate temperature.

Iron and steel are alloyed with manganese, chromium, nickel, tungsten, vanadium, and molybdenum, or a combination of these, to gain properties desired for special uses.

Defects in Ingots

211. Certain defects in the finished steel are caused during the solidification of the ingot and are known as pipes, blow-holes, and segregation. Pipes are cavities in the top and center of the ingot caused by the uneven cooling of the exterior and the interior of the metal. The outer walls and the top cool first, forming a crust; when the interior becomes hard there is not enough material to fill the entire volume within the crust and a cavity results. Blow-holes are holes due to the gasses that have developed and are dissolved in the steel. Segregation is the name given to nonuniform composition of steel, usually indicated by a porous or spongy mass in the central upper portion of the ingot. These defects cause cracks and weak streaks in the finished steel and should be checked as soon as possible. Another defect is known as ingotism—it is caused by the formation of large crystals in the steel. Large crystals adhere to one another less strongly than small ones, and ingots in which ingotism develops are therefore not as sound and strong as those in which it is not present.

ALLOY STEELS

Tungsten Steel

212. Combinations of metals with each other are called alloys. Carbon also affects the qualities of the alloys of steel commonly called alloy steels, made by adding other elements to give them special properties. One of the most important of these elements is tungsten, and steels in which the principal properties are due to this element are known as tungsten steels.

Manganese Steel

213. Among the varieties of steels, the hardest and toughest is manganese steel. Manganese steel is practically nonmagnetic. In shipbuilding it is used for propellers and many other purposes.

Nickel Steel

214. Nickel steel is readily worked cold or hot. It is largely used for guns and engine and propeller shafts, and for structural purposes in which great strength and lightness are required, and in which high cost is not prohibitive. Nickel steel is especially valuable because it offers a much greater resistance to corrosive influences than does carbon steel.

Chrome Steel

215. When a small percentage of chromium is added to steel in the crucible process, the product is a steel having great hardness and toughness.

Nickel-Chrome Steel

216. Alloy steels made with more than one alloying element are rapidly coming into use. In such alloys each element added to the steel imparts its individual effect to the finished product.

Stainless Steel

217. A form of steel that is commonly known as stainless steel, or rustless steel, may be produced by using a high percentage of chromium in the alloy.

MISCELLANEOUS ALLOYS

Brass

218. Brass is an alloy of copper and zinc. The zinc promotes solidity and makes the metal cast better than

would copper alone. Cast brass is weak and low in ductility and malleability. It can be improved by either hot or cold working, or by annealing. The strongest brass is produced by making the alloy with 40-percent zinc. The maximum ductility is obtained with about 25-percent zinc.

Bronze

219. Bronze is an alloy of copper and tin. Tin increases the fluidity of molten copper and the tensile strength of the castings but decreases its ductility. Bronzes generally are very useful alloys. They are harder, denser, and stronger than copper and do not oxidize so easily. Their strength is increased by cold working just as that of brass.

Aluminum-Brass

220. Aluminum-brass is a copper-zinc alloy containing up to 3 percent of aluminum. It is used for castings that must be particularly free from blowholes and have a smooth surface.

Manganese Bronze

221. Manganese bronze is the name given to an alloy that really is brass as it only contains a trace of tin.

Phosphor Bronze

222. Phosphor bronze is an alloy of copper and tin and a very small percentage of phosphorus. Phosphorus increases the strength, ductility, and solidity of castings.

Bell Metal

223. Bell metal contains 78-percent copper and 22-percent tin. It is hard and brittle and is therefore used for the casting of bells.

Copper-Nickel Alloy (Monel Metal)

224. Copper-nickel alloy (Monel metal) contains 67-percent nickel, 28-percent copper, and 5 percent of other elements, chiefly iron and manganese. In appearance and physical properties it closely resembles pure nickel. It is white, malleable, and ductile, both hot and cold, and noncorrodible. Another alloy of copper and nickel containing from 3-to 5-percent nickel is used in the manufacture of projectiles and for steam boiler tubes.

ALUMINUM ALLOYS

Aluminum-Bronze

225. Aluminum-bronze is made by adding from 2- to 12-percent aluminum to copper. This alloy is remarkable for its strength, malleability, and ductility.

Aluminum-Copper

226. Aluminum-copper alloys are one of the most commonly used aluminum alloys. One in common use consists of 92-percent aluminum and 8-percent copper. It is not exceptionally strong but it resists vibration well and is very uniform in quality.

Aluminum-Manganese

227. This alloy is more resistant to salt water and cheaper than duraluminum. It is the most useful of the rolled alloys where the higher strength of duraluminum is not required. It is now used for motorboat canopies, divisional bulkheads, joiner doors, file cases, shelving, and bins. (Navy No. 47–A–4 in sheets.)

Aluminum-Zinc

228. Aluminum-zinc alloys are largely used for castings in which flexibility and extreme lightness are not essential.

ALUMINUM ALLOYS, NAVY

Class 1

229. Manganese is used in this alloy which was developed by the Naval Gun Factory. In this alloy manganese is added in small percentages which increase the physical properties and corrosion resistance of the aluminum. Castings are less difficult to make as there is a high solidification shrinkage. It is used for electrical equipment, for fire-control systems, and junction boxes.

Class 2

230. This is known as the 5-percent silicon alloy, which has the maximum resistance to salt water corrosion. Silicon greatly increases the fluidity of aluminum and enables the casting of intricate shapes. It is used in the manufacture of watertight covers for ventilation systems; airport and lens frames well above the water lines; and bedplates for motors and pumps.

Class 4

231. This is the strongest of the naval aluminum alloys; but it is not equal to class 2 alloy in resisting salt water corrosion. It is used in the manufacture of blast covers for airports, ladder treads for companion ladders, bedplates, and hand wheels.

Duralumin

232. Duralumin is an alloy of aluminum with from 3 to 5 percent of copper, 0.3 to 0.6 percent manganese, and a trace of chromium. This is the trade name of the Bausch Machine Tool Co.; No. 175 of the Aluminum Company of America. Navy Specification Nos. 44–A–2 for tubes; 46–A–4 for shapes; 47–A–3 for sheets; and is known in the Federal Standard Stock Catalog as aluminum-copper-magnesium-manganese. This metal must be heat treated to obtain maximum strength but can be cold worked. It is ductile, stronger than cast iron in castings and has the strength approximately that of mild steel in shapes

and plates. The physical properties vary according to cross section and shape. Physical properties (depending on thickness):

	Shapes	Rods and bars
Tensile strength.....pounds per square inch..	50,000	45,000–60,000
Yield point.....pounds per square inch..	25,000	20,000–33,000
Elongation in 2 inches.....percent..	16	25–12

This alloy is used in airship construction, for furniture, file cases, etc.

MAGNESITE COMPOSITIONS

233. Magnesite compositions or cements have been used for years as substitutes for deck planking, or covering, on steel decks. They are generally used in compartments, washrooms, lavatories, etc. Whereas the cost is less, such coverings frequently crack, disintegrate, and pull away from the metal and thereby cause serious corrosion in the deck plating. Magnesite compositions are composed of magnesium chloride, magnesium oxide, a color pigment, and sawdust and are applied in the same manner as cement.

STRENGTH OF MATERIALS

234. When a beam is deformed the internal forces or stresses fail to equal the external ones. The internal stresses vary for different parts of the cross-section of the beam. Considering a horizontal beam bent downward at both ends, it follows that the upper fibers of the beam are in tension and the lower ones in compression. Fibers near the upper surface are stretched and those near the lower surface compressed or shortened. At the point where the horizontal fibers are neither lengthened or shortened, is located the neutral axis. The neutral axis is located by taking moments of various sections of a beam about a reference axis. Adding the moments together and dividing by the total of the areas of the sections dealt with gives the distance of the neutral axis from the reference axis.

RADIUS OF GYRATION

235. *Moment of inertia* (art. 118) is obtained by dividing a section or area into a large number of very small areas and multiplying each minute area by the square of its distance from the axis about which it moves, or rotates, the summation of the results being the moment of inertia. The mean value of all of these distances of the very small minute areas from the axis, is called the *radius of gyration*. (See art. 114–115.)

This subject is of interest in its relation to strength of materials. Briefly, in computing the strength of a column or of a beam, if r equals the radius of gyration, then r^2 equals the moment of inertia (MI) divided by the area (A) of a section, where r is the radius of gyration of any section with respect to the neutral axis through the center of gravity of area A. $r^2=\frac{MI}{A}$

(The radius of gyration of a ship as a whole is the effective radius of inertia of the ship with respect to its center of oscillation, i. e., the radius at which the mass is considered concentrated.)

SECTION MODULUS

236. The section modulus of a section under transverse stress or the stress to which a beam is subjected under a load that tends to bend it is the moment about the neutral axis of such a portion of the section that if its area is multiplied by the extreme fiber stress, the resisting moment of this portion will equal the resisting moment of the variable stress in the actual section, from the neutral axis to the extreme fibers. (See figure 30.)

$ABCD$ is a section of a rectangular beam. EF represents the neutral axis which passes through the center of gravity. GH is a line situated at the edge of the section and represents the position of the extreme fibers. Then $\frac{d}{2}$ is the distance from the extreme fiber to the neutral axis. The stress on the fibers on the neutral axis is zero, but it gradually increases until the edge of the section is reached, where it is the maximum. As long as the area is uniform the stress varies with the distance of the fiber from the neutral axis.

Draw the diagonals AC and BD; the shaded portions ABO and DCO represent the area that, if considered as having a uniform stress equal to the stress in the extreme fibers of the section, offers the same resistance as the entire section having the variable stress. Then the moment of this shaded portion about the neutral axis gives the section modulus of the beam. The combined area of the shaded portions is equal to $\frac{bd}{2}$, and the lever arm, which is the distance from the center of gravity of each section to the neutral axis, is $\frac{d}{3}$. The moment therefore, is

$$\frac{bd}{2}\times\frac{d}{3}=\frac{bd^2}{6},$$

and the section modulus for a rectangular beam may be expressed by the formula

$$S=\frac{bd^2}{6}$$

in which S=section modulus;

d=depth of beam, in inches;

b=breadth, or width, of beam, in inches.

Also $S=MI$ divided by the distance from the neutral axis to the farthest edge of the section.

SIZE OF ANCHOR CHAINS (By Lt. D. R. Simonson, U. S. C. G.)

237. Chain cable sizes for Coast Guard cutters are in accordance with the American Bureau of Shipping rules, which tabulate the chain and anchor sizes against an equipment-tonnage number. This number is based on displacement, freeboard, and amount of superstructure as follows:

$$\text{Tonnage under freeboard deck} = \frac{L \times B \times D \times C}{100}$$

where L = Length of vessel.

B = Breadth of vessel.

D = Depth of vessel to freeboard deck.

C = Coefficient of displacement.

Additional for superstructures on freeboard deck =

$$\frac{l \times b \times d \times 0.75}{F}$$

where l = Length of superstructure.

b = Breadth of superstructure.

d = Mean height of between decks.

F = 150, lower superstructure; 200, next tier; and 250, for higher tiers.

Lloyd's Rules contain similar tables based on equipment numerals estimated in about the same manner as the American Bureau equipment tonnage.

LUMBER, SEASONING OF

238. The seasoning required for lumber should be specified. The following governs the usual inspection of lumber.

239. *Green.*—Wood which is practically in the same moisture condition as when cut from live timber; no shrinkage shall have taken place.

240. *Air-dried.*—Wood that has reached a moisture content which is in equilibrium with the average condition of the atmosphere, without exposure to artificial heating. One-inch oak generally requires from 1 to 1½ years to air-dry thoroughly.

241. *Kiln-dried.*—Wood that has been dried in a kiln or by artificial heat to a moisture content below 10 percent. A written statement may be required from the contractor showing the length of time and the process used in drying the wood.

242. *Special manufacture.*—In the inspection of manufactured timber, such as cypress, white cedar, or oak plank, the material as a whole must be fully up to the grade specified.

LUMBER, DEFECTS IN

243. Defects in lumber are knots, knot-holes, splits, checks, wane, dote, rot, rotten streaks, pin- and worm-holes, dog, nigger, or picaroon holes, pitch pockets, solid pitch, shakes of any description, stained heart, loose or rotten heart, sap, sap stain, chipped, loose or torn grain, and imperfect manufacture.

YELLOW PINE DECKING

244. Yellow pine decking to be of the best quality must be fine-grained, longleaf, yellow pine from Gulf ports that has not been tapped; to be in lengths of 16 feet and up, averaging at least 24 feet, to be well manufactured and sawed fair and full to the sizes given. Seasoning as specified. To be all heart and edge grain, and free from the defects noted in the preceding paragraph. In square decking one face, and in other decking one wide face, must be absolutely clear and must show edge grain its entire length. The underside of pieces may have perfectly sound tight knots. *Edge grain* admits no piece in which the angle of the grain exceeds 45° from the vertical at any point.

LUMBER, KINDS

245. Two general groups of lumber are used in the service. They are hardwoods and pines and evergreens. Among the hardwoods are ash, beech, birch, oak, maple, hickory, poplar, and mahogany. Besides numerous pines the evergreens mostly used are spruce, hemlock, cedar, and cypress.

White Pine

246. White pine is a light, soft, straight-grained wood, slightly yellow in color; not very strong. It is good for pattern making, plugs, wedges, and interior finishing.

Douglas Fir (Oregon Pine)

247. Douglas fir, also called Oregon pine, is an excellent lumber for structural purposes, and on the Pacific coast it is used for the same class of work as the hard pines are used on the Eastern coast.

Spruce

248. Spruce is a strong, tough wood used for piles, submerged cribs, cofferdams, etc. Spruce poles are used for spars.

White Cedar

249. White cedar is a soft, fine-grained, durable wood; not very strong or tough. It is excellent for planking of small boats.

HARDWOODS

Ash

250. There are three kinds of ash: white, red, and black. White ash is most generally used in the service for such work as thwarts, benches, gratings, stretchers, ladders, tables, and in such places as are scrubbed instead of painted.

White Oak

251. White oak is one of the many kinds of oak used in the service. It is hard and tough, cross-

grained, very strong, and of a light yellowish-brown color. It is used where strength is necessary, as for small boat framing, chafing, battens, capping, and for furniture, etc.

Mahogany

252. Mahogany is a hard close-grained wood which takes a high polish. In color it is a deep rich red. It is easily worked and used in joiner, cabinet, and furniture work. It is excellent for making turned patterns.

Teak

253. Teak is a very heavy strong wood of yellow or brown color, straight and even grained. It is excellent material for decks, railings, deck and hatch margins, gun foundations, etc.

Lignum-vitae

254. Lignum-vitae is an excellent, hard, close-grained oily wood, dark brown in color. It is used for making clump blocks, sheaves for blocks, and as lining for outboard shaft bearings which are water lubricated.

CHAPTER III

SHIPBUILDING

DISPLACEMENT (fig. 2) (Archimedes principle)

301. A floating body displaces its own weight of water; or inversely, the weight of the water displaced or set aside by a floating body equals the weight of the body. Thus the displacement of a ship is the weight of the ship and the load it carries. It is expressed in long tons of 2 240 pounds. This is determined by dividing the volume of the underwater body in cubic feet by 35 for sea water, or by dividing it by 36 for fresh water.

302. The *dead weight* is the weight of the cargo, fuel, reserve feed water for boilers, drinking water, stores, passengers, and crew, and is always the difference between the displacement and the weight of the ship including the weight of the propelling machinery. It is the number of tons of stores, fuel and cargo, etc., that can be carried without exceeding the designed draft.

303. *Tonnage* is expressed in tons based on volumetric measurements, 100 cubic feet to the long ton of 2,240 pounds.

304. *Gross tonnage* is the measure of the entire internal capacity of the whole ship. It is the volume of the ship below the main deck in cubic feet divided by 100.

305. *Net tonnage* is the gross tonnage less the spaces occupied by officers and crew with effects, navigation spaces, and propelling spaces. It is a measure of the passenger and cargo-carrying space and is obtained by dividing this volume in cubic feet by 100.

306. *Standard displacement* is the displacement of the ship complete, fully manned, engined and equipped ready for sea, including all armaments and ammunition, equipment, outfit, provisions, and fresh water for crew, stores and implements of every kind carried that are intended for war purposes, but without fuel or reserve feed water on board. *Standard displacement* is so defined in the Reduction of Armaments Treaty.

307. *Displacement, normal,* is the displacement of a ship ready for service, water in boilers, all personnel with effects on board, normal fuel, ammunition and stores and reserve feed water. It does not include water in trimming tanks or double bottoms other than reserve feed.

PLANS (see Fig. 15)

308. The three plans of a vessel are as follows: (*a*) is called the half-breadth or water-line plan; (*b*) is the sheer or profile plan; (*c*) body plan. On all three plans the centerline is designated, *CL*.

Three series of planes are used to provide working line drawings of the ship: (1) Water line, (2) stations, (3) buttocks. (Fig. 15.)

Water lines (marked *WL*, fig. 15) are obtained by the passing of planes parallel to the designer's water line. In the sheer or profile plan the intersections of these planes with the ship's sides show as straight lines parallel to the base line. In the half-breadth plan the intersections of these planes with the shell show as curves, which have the greatest curvature near the bow and stern of the ship. In the body and midship section plan these planes show as horizontal lines parallel to the base line and their outer limits are in the shell. The zero water line is the one at the base line, the other water line being numbered numerically upward from the zero one.

Stations (numbered 1–10, fig. 15) are athwartship planes passed at regular intervals perpendicular to the water line planes and to the longitudinal vertical center-line plane of the ship. Starting at the forward perpendicular these planes are numbered in rotation aft. There are usually 20 to 40 such planes. In the sheer or profile plan they appear at straight lines perpendicular to the base line and water lines. In the half-breadth plan they appear as athwartship lines perpendicular to the longitudinal center line and the buttock lines. In the body plan their outboard limits are at the shell of the ship and show the exact curvature of the ship's side plating at the station in question.

Buttocks (see fig. 15).—By passing a series of planes perpendicular to the water-line planes and to the station planes and parallel to the longitudinal vertical center-line plane, buttocks are formed. In the sheer or profile plan their intersection with the shell shows as a curved line. On the midship section or body plan these intersections show as vertical lines parallel to the longitudinal vertical center-line plane and in the half-breadth plan the intersections show as lines parallel to the longitudinal center line.

Usually a fourth series of planes is used, namely one perpendicular to the surface of the shell wherever they cut it. This makes these planes, which are called *diagonals*, perpendicular to the planes of the stations. They are inclined to the waterline planes and to the buttock planes.

It is readily seen that the sheer plan shows the true shape of the buttocks; the half-breadth plan the true shape of the waterlines and the body plan the true shape of the stations.

The half-breadth plan shows the deck lines as curves, the stations as athwartship straight lines, the buttocks as fore-and-aft straight lines, the diagonals as curved lines and the waterlines as curves.

The sheer plan is a side view profile or elevation, looking at the ship from a distance. It shows the keel line in true shape, the waterlines as horizontal lines parallel to the base line, the buttocks as curved lines, the stem, stern, and deck lines in true shape; the stations as straight lines perpendicular to the base line.

The body plan shows the two half transverse elevation sections, the right side as observed from the bow and the left side as seen from the stern. It shows the details of the cross sections, curves of the deck lines, the waterlines as straight lines perpendicular to the vertical centerline, the bow, the buttocks as vertical lines parallel to the vertical centerline and the diagonals as straight lines perpendicular to the skin of the ship where they intersect it. The widest section is the midship one.

The principal plans or drawings of a vessel are: 1, Midship section; 2, half-breadth; 3, inboard profile; 4, outboard profile; 5, stem; 6, sternpost; 7, rudder; 8, struts; 9, deck; 10, hold; 11, inner bottom; 12, stations or cross sections; 13, shell expansion; 14, bulkheads; 15, plating; 16, piping; 17, engines, boilers, etc. The midship section is also termed the dead flat. It divides the ship into the fore and after body.

The "forward perpendicular" (figs. 1, 15, 22) is the line perpendicular to the base line intersecting the contour of the stem at the designer's waterline. The "after perpendicular" is the line perpendicular to the base line at the point of intersection of the contour of the stern frame and the designer's waterline. The "length between perpendiculars" is the distance between these two. Except in cases where there is a drag the base line is usually along the upper edge of the flat plate keel.

THE SCRIVE BOARD

309. When a vessel has been laid off, either upon the mold loft floor or upon paper, the lines are transferred to the scrive board. Briefly, this consists of a number of seasoned deals, secured edge to edge by clamps at the back, the edges being close-jointed, and the area of the board large enough to receive a copy of the body plan to *full* size. Sometimes two boards are prepared for each vessel, one showing the two sides of the fore body, and the other showing the two sides of the after body. Some shipyards draw both sides of the body on the one board; the lines of the two overlapping each other. For convenience in adjusting the frames, reverse-frames, and floors, and setting off the rivets upon them, marks are made at different lengths in each body plan showing the breadths of the frames drawn upon the opposite body.

The scrive board should show the outer edges of frame angles, the inner edges and upper boundaries of floor plates, the landing edges of shell plating, the lines of the upper parts of the beams at the outer edges of the frames, the middle lines of keelsons and side stringers, the position of ribbands for holding together the frames in their proper locations, the several waterlines by which the vessel was faired, the bow and buttock lines used for the same purpose, the girders or longitudinal frames at each transverse section, and the base and middle lines of the vessel.

These lines are scratched into the surface of the board, different colors being used to distinguish the lines.

FRAMING

In shipbuilding practice there are two commonly used systems of framing, the transverse system, figure 11, and the Isherwood, or longitudinal system (fig. 21). Coast Guard cutters up to and including the lake type cutters have transverse framing (fig. 68, 74 (a)). The 328-foot cutters will have more of a longitudinal construction.

TRANSVERSE SYSTEM FRAMES

310. Transverse framing is shown in figure 27. It makes use of frames that run athwartship or transversely. There are a large number of closely spaced frames (for cutters 24 inches apart) which are connected by brackets to the beams. Longitudinal strength comes from the shell plating, decks, and keel structure, with one or more intercostal side keelsons or stringers worked intercostally and with continuous plates or angles along the reverse frame bars. Transverse bulkheads also add strength in this system.

Web or deep frames (figs. 21, 72) are frequently used in connection with the side stringers in order to provide for maximum stowage or to make up for beams that are omitted in areas such as over boiler rooms. The term "deep" frame is the same as "web" frames; however, preference is given to the term "web" frame. They are simply transverse frames which by the addition of a plate are deeper than the regular frames.

ISHERWOOD SYSTEM

311. In the Isherwood system of framing a vessel has closely spaced, light, longitudinal frames with heavy deep transverse web frames located at widespread intervals, forming a complete belt around the ship so as to give the necessary stiffness to the longitudinal frames. Structurally, the Isherwood system of framing is stronger than the transverse framing system in resisting hogging or sagging in a long vessel, such as an oil tanker. However, in a vessel for which the ratio of length to beam is not so great, the ten-

dency to hog or sag is not so great, hence the slight increase in strength gained by use of the Isherwood system is not so important as it would be in a long tanker with a lower length to beam ratio.

In regard to cargo capacity, for general cargo vessels carrying cargo in large boxes, the Isherwood system would have a smaller carrying capacity for a given space than the same vessel framed with transverse frames. The reason is that the web frames in the Isherwood system are spaced from 10 to 12 feet apart and are deeper than the web frames used in the transverse system of framing, so that they would project into the cargo space more and in that way reduce the available clear space for the stowage of packages. For vessels which carry bulk cargo, such as oil, grain, coal, or ore, and in which the cargo can be distributed around the web frames, the Isherwood system is ideal and is used extensively for the construction of oil tankers and for freighters on the Great Lakes.

The Isherwood system is slightly lighter in construction, and this saving in weight results in an increase in the deadweight carrying capacity of a cargo vessel and also in a slight saving in the cost of construction.

The frames are slotted around the outer edges to provide for continuous longitudinal stiffeners which are fitted at the deck, along the sides, the bottom, and under the tank top.

In the Isherwood system the inner bottom usually extends to the skin of the ship; whereas, in the transverse system the double bottom usually ends at the lower turn of the bilge, in a margin plate to which the side frames are bracketed.

The total advantages of the Isherwood system are, besides an increase in the longitudinal strength, a greater carrying capacity for bulk cargo, freedom from stanchions in holds, and reduction of the shell plating permitted because of the increased fore-and-aft strength of the members.

LONGITUDINAL CONSTRUCTION (Fig. 21)

312. In the days of wooden-vessel construction it was practically impossible to provide sufficient longitudinal strength to avoid hogging or sagging.

The *Great Eastern* was the first iron vessel to make use of a longitudinal system of framing. This vessel had very few transverse frames, with all continuous longitudinals. This required numerous athwartship bulkheads. She had a complete inner skin extending up to the lower deck.

In steel ships transverse frames, forming as they do continuous ribs transversely around the body of the ship, provide adequate athwartship stiffness. For vessels where the length of beam ratio is not so great as in cutters up to 250 feet in length, by the addition of shell plating, a vertical keel, one or more bottom keelsons and side stringers the necessary longitudinal strength is provided.

In the longitudinal system many transverse web frames take the place of a much larger number of ordinary transverse frames in the ratio of one web frame to about six ordinary frames. The longitudinals are usually continuous between transverse bulkheads, at which points they are cut and heavily bracketed, the web frames being slotted or notched to provide for the continuous longitudinals passing through them. The deck supports are augmented by light longitudinals which are continuous from bulkhead to bulkhead through deep athwartship girders which are lateral extensions of the frames under the decks.

This type of construction does away with the side stringers, which in conjunction with the few web frames in the shorter cutters along with the shell plating give the necessary fore-and-aft strength.

In some systems of longitudinal construction longitudinals are not only cut and bracketed to the transverse bulkheads but also at each transverse web frame.

The usual plan in longitudinal construction is to run at least one longitudinal inside of each strake of shell and deck plating. The 328-foot cutters will have 19 longitudinals, in conjunction with 24 web frames.

The web frames are cut at tank margin plates and a connection to the tank top is provided by heavy tiebars.

The double bottom in this system is quite like that of the transverse system, an intermediate floor being usually fitted between the floors which are extensions of the web frames. These additional floors provide floors at approximately a 6-foot interval, and provide support for the longitudinals between transverses and a means of connecting the frames between the shell plating and tank top. The cellular checkerboard type, double bottom formed, provides ample drydocking bottom strength. To provide for the tendency in docking for the upper parts of the floors to pull away from the vertical keel, the upper angles of the floors are made continuous between the longitudinals on either side of the keel, as they pass continuous across the vertical keel. Frequently full-depth side girders are substituted for one or more side longitudinals.

Floors are frequently placed 33 percent closer under the propelling machinery.

The longitudinal system tends to reduce the vessel's weight. Welding also has the same desirable effect. In the 328-foot cutters a high percentage of the ship's fastenings excepting shell plating will be welded.

Welding also does away with calking, punching, and much fitting work. A large saving in weight accrues from the fact that overlapped welded joints are 2 to 3 inches in breadth whereas 5 and 10 inches is common for riveted joints. With butted joints there is still a greater saving. Numerous flanges and connecting an-

gle bars may be dispensed with where welding instead of riveting is employed. (See art. 345.)

As the art of welding improves and it becomes possible to verify the soundness of welds the next step will be to build our ships welded throughout.

Longitudinal weakness is most apt to occur in the upper hull region. A small increase in strength members there gives more longitudinal strength than heavier reinforcements in the lower regions of the vessel.

SHIP CONSTRUCTION

313. The two-deck vessel shown in Figure 11 has web frames (no. 10), in combination with ordinary frames (no. 29). The *Mojave*, *Escanaba*, and the lake-type cutters have a preponderance of ordinary transverse frames, the *Mojave* class has 5 web frames, the *Escanaba* class 6, and the lake type 7 web frames. Frames are usually from 18 to 36 inches apart. In cutters ordinary frames are 24 inches apart, and above the main deck alternate frames are usually omitted. In destroyers the frames are 21 inches apart. The strength of any vessel is mainly dependent on the strength of the transverse framing. This may be accomplished in three ways: By making the transverse frames deeper and stronger; i. e., *deep framing;* by inserting web frames in place of every sixth to tenth frame; by increasing the number and dimensions of the longitudinals and stringers which give longitudinal strength to the vessel. The longitudinal strength of a vessel is mainly dependent upon the top and bottom structural members.

The vertical floors shown in figure 11 support the inner bottom and are important transverse strength members. As shown, the side girders or side keelsons, extend parallel to the center keelson and are intercostal between the floors. The floors are shown continuous between the center keelson and the margin plate. Side stringers are usually intercostal between web frames, being laid along the inside edge of the reverse frame. Web frames ordinarily extend only to the main deck. Beams are connected to frames by brackets and are usually run between alternate frames; i. e., at approximately 48-inch intervals.

ELEMENTS OF BLUEPRINT READING (Fig. 126)

314. In constructing a working drawing of almost any nature, conventional methods are employed to indicate various materials, shapes, and processes.

Figure 1 of figure 126 shows a side view and cross section of various forms of structural steel, known as "shapes." These shapes are used in the frames of modern iron and steel structures. The relative dimensions of the beams vary, depending on the purpose they are to serve. The top pieces show a side view and two methods of indicating the end of a wooden beam.

Figure 2 shows several methods of indicating what is known as breaks. When a piece of rod, pipe, or beam is of uniform shape and size for a considerable distance, a great deal of space may be saved by taking a piece out of the center and bringing the ends closely together. The dimensions and shape of the broken ends indicate the cross-sectional size and shape of the piece omitted. The dimension for the length always means the length of the whole unbroken piece.

Figure 2 (*a*) shows a wooden beam broken, and (*b*) and (*c*) indicate a break in a metal beam or plate. Pipes, cylinders, etc., are usually shown broken as in (*d*), although the method shown in (*e*) is sometimes used. A round rod is shown with a break in (*f*), and in (*g*) is a similar rod with a piece removed and the ends brought together. Breaks in rectangular pieces are sometimes shown as in (*h*). Usually breaks are indicated by section lines, but in small or narrow pieces they are shown solid. It will be noticed that the breaks usually indicate the shape of the transverse section of the piece.

The symbols shown in figure 3 are Osborne's code of conventional signs for structural rivets. An open circle represents a shop rivet, or a rivet that is to be driven in the shop. A solid circle represents an open hole into which a rivet is to be driven at the scene of erection. The solid circles are the size of the rivet holes, and the open circles are the size of the rivet heads. A diagonal cross indicates that the head is to be countersunk, and chipped off flush with the surrounding material. The position of the diagonals on the circles, whether inside, outside, or both, indicates the side of the material into which the rivet head is to be countersunk. This side may be the far side, near side, or both sides. When rivets are to be countersunk but not chipped, diagonals cross the rivet head in only one direction, the number of diagonals indicating to what height the head of the rivet is to be flattened. Hence, one diagonal means that the maximum height of the rivet head is to be one-eighth inch after flattening. Two diagonals indicate that the rivet head is to be one-fourth inch high. Three diagonals indicate that the head is to be flattened to a height of three-eighths inch.

GENERAL PROCEDURE IN BUILDING A CUTTER

315. The shipbuilding plant is furnished with design line drawings, such as figure 39, contract plans, and a book of detailed specifications. From these, detail plans are prepared and submitted to Coast Guard headquarters for approval. Lines are layed off and faired on the mold loft floor, figure 75. Usually the body plan, figure 15, is layed off in full size. Other line drawings are expanded on a glass

or marble slab. These enable the taking off of templates, figure 75, which are used in marking the various scantlings for preparation prior to fabrication into the ship.

The flat keel plate connected by butt straps, figure 59 (a), is first laid on the keel blocks of the building ways. It is dished at its forward and after extremities. The flat plate keel is faired when laid on the keel blocks by means of the center-of-keel marks or by means of a transit. The vertical keel, figures 56, 62, is next added on top of the flat plate keel. It consists of a heavy vertical keel plate, the outer angles (on either side of the base of the vertical keel), and the inner angles (on either side of the top of the vertical keel). The keel runs from stem to stern frame. (See fig. 13, arts. 350, 351.)

Next is added the bottom plating and the transverse framing and floors within the double bottom space, figures 58, 59 (a). Transverse bulkheads are usually next erected, figures 59, 60, then margin plates, figure 63, side frames, side plating, figure 74 (a), inner bottom plating, longitudinal bulkheads, beams, pillars, stanchions, stem, stern frame, breasthooks, panting members, stringers, and stringer plates, tieplates, bounding bars, superstructure, deckhouses, machinery, etc. (See figs. 57 to 118, inclusive.) (For details refer to arts. 352–387, inclusive.)

A sufficient amount of the structure of a cutter should be erected concurrently to ensure that all adjacent parts are properly placed and faired. If at any time it is found, during erection, that bolting, figure 114, or riveting of any part is being done prematurely and it appears that adjacent structural parts cannot be properly matched, a sufficient amount of the structure should be loosened and reset to rectify the discrepancy. In doing this, neither undue drifting nor working in place by means of heating should be allowed.

Installation of auxiliaries, piping, wiring, laying of wood decks, interior fitting out, painting, outfitting, etc., occur after the cutter is launched. Usually the launching takes place when the vessel is about 40 percent complete.

TRIALS

Numerous dock and builder's underway trials are held. Prior to acceptance a board of officers makes the trial trip and carefully checks to see that the specifications in all respects have been rigidly complied with. A squad of observers is necessary to observe and record data during the trial trip. After a preliminary acceptance and when up to all requirements, the cutter is accepted and delivered to the Government. Usually a certain payment to the builders is held up until after an extended shakedown cruise of sufficient duration to develop any weaknesses or failures in performance. For trial details see chapter on *Inspection*.

BOLTING UP (figs. 64, 114)

316. During the progress of erection, structural parts should be securely fastened together by a sufficient number of service bolts to bring all faying surfaces in a metal-to-metal contact. Riveting should not be permitted until the proper number of bolts are in place and set up, or until the proper position of the parts affected is ascertained and they are sufficiently bolted to maintain their position and fit during the riveting.

To save labor and to expedite the work, fitters are inclined to use a fewer number of bolts than is desirable for the assurance of thoroughly close work. Any joint which cannot be made tight by bolting should be examined for burrs, chips, reamings, etc., which if found, must be removed. All buckles or lumps should be faired out before riveting.

Particular care must be taken in bolting up, to see that the edges of plates and butts of angles in strapped joints are brought together to a complete fit.

LINERS (figs. 11, 14)

317. The fit of the liners and the rivet holes in them require particular attention. Liners are often defective, due to being too short, or they may have an imperfect taper which will result in sharp depressions and lumps in the shell plating. The frame liners should so fill the void or vacancy between the frames and shell that a thin-bladed testing knife may not be inserted. In bad work the rivet shanks may be encountered with the knife blade in which case if left the rivets, when subjected to stress, are apt to loosen and admit water.

The rivet holes in the liners must be punched no larger than those in the frames. Often this is disregarded in order to minimize the effect of the noncoincidence of the holes, and to permit the free entry of the rivets, but the soundness of the rivets in such a case is greatly prejudiced. All liners should be of such thickness as not to require supplementary filling slips.

FAIRING

318. If any of the bulkheads (fig. 51), stern framing, deckhouses, or other parts of the structure are assembled and riveted before incorporation in the ship structure, extra attention must be given to checking the work in erection and to shoring and ribbanding (figs. 52, 60, 82), in order to have the assembled parts, when placed, fit neatly without buckling or distortion.

If the vessel's framework and its various parts were prepared with absolute precision, the fairing of the framework, when erected and put together, would be a simple affair, but in ordinary shipyard practice there are many sources of error, resulting in discrepancies, so that when adjusting the various parts, some discreet compromises have to be made.

When the frames are faired they must be plumb transversely and the center of the beam must be exactly over the center of the keel, and they must not lean forward or aft. The operation of fairing the frames to meet these requirements is termed "horning the frames." No special effort is made to fair them until a considerable number have been erected.

As the various frames and bulkheads are erected, their upright condition is checked by plumb lines suspended from the centers of the beams and angles, which should fall over the center of the keel.

The shell angles of the frames should lie close to the ribbands. If only the toe touches, the frames must be twisted in such a manner as to also bring the heels close to provide a metal-to-metal contact with the shell plating. Care in this respect is particularly necessary in the case of deep frames.

The decks and bulkheads should be faired up with ribbands before riveting, as often between beams and stiffeners bulges or hollows will be present. All shell and deck plating should be required to be rerolled to remove irregularities, and all fairing carried out before any riveting is commenced.

The surface of the upper-deck beams is usually faired immediately after the fairing of the frames, for which purpose fore-and-aft ribbands should be fixed on the upper surface, one on either side of the hatches. In the absence of pillars, the beams should be supported by shores which are placed with their heads under the beams, planks being introduced as required to distribute their supporting effect. The beam positions should be checked by means of battens from the mold loft, giving the height of each beam above the keel, etc.

When the central parts of the beams have been adjusted and faired, their ends at the sides must receive attention. The tops of the frames are never quite fair and tapered liners of varying thickness must be introduced between them and the sheer strake. Also a large number of the beam ends will be found to be above or below a fair sheer line and must be corrected at this time, though as ordinarily is the case the beams may not be faired until the deck stringer plate is fitted on their ends. The upper flanges of the deck beams (the top flanges follow the sheer line) must be in full contact with the deck plating.

The upper-deck waterway bar and stringer plate angle must be fair longitudinally, otherwise the sheer strake, the most conspicuous part of the hull, would be unfair. It is necessary, therefore, that this part of the fairing be given special attention.

If the floors have been adequately made and faired the shell surface in way thereof must also be fair, provided the tank top surface is fair. Small discrepancies, however, are unavoidable here and where they occur the fairness of the shell surface should have precedence over that of the tank top, irregularities in the latter being unimportant in comparison with the former. It is essential that the margin plate shell angle be fair with the surface of the contiguous tank frames, otherwise it will show as a ridge or depression on the outside plating. In some cases through carelessness in fitting, the line of the margin plate is closely discernable from the outside of the vessel.

SHELL PLATING

319. Connections at the upper and lower sides of plates are called seams and at the ends, butts. A lapped joint is where one plate extends over the one next to it. A strapped joint is one where the two plates butt together with their edges close together and flush, the two adjacent plate edges being covered by an inside butt strap or plate, one-half of which is over each of the connected plates. A double-strapped joint has such a strap plate both inside and outside of the butts of the connecting plates. Joints are single, double, treble, quadruple, etc., according to whether they have 1, 2, 3, or 4, etc., rows of rivets. (See fig. 14.) Edge laps are shown at (*a*) and (*b*). At (*a*) the plate is joggled. At (*b*) it is a plain lap. At (*c*) is shown strips which have the width of the beam flange and the thickness of the under-deck plate to fill in the space between the underneath or *in* plates. Joints at (*d*) and (*e*) are joggled butt laps. At (*h*) and (*j*) are shown tapped fillers or liners; in joints (*d*) and (*e*) these fill up the opening that otherwise would be left between the end of the plate (*f*) and the joint where plate (*g*) leaves the lower level (*f*) and passes over the end of the plate (*g*). At (*k*) is shown a butt strap placed underneath the joint. At (*i*) is shown a scarphed lap; the lap of plate (*n*) is set or bent upward and that of plate (*m*) sets downward so that when the parts of the plates back of the laps are in line, the laps touch each other for their full width. There is a wedge-shaped piece cut out of the underside of the plate, shown dotted in small figure (*b*). The width of the narrow edge lap is shown by (*cd*). By cutting out the dotted section at (*cd*) as the result of being bent downward, it can project below and to the right of the plate (*p*). The feather edge (*cd*) will be in the position (*abc*) and lie flat on plate (*p*) as shown in (*b*). This type lap requires no filler. The position of plate (*m*), after (*cd*) has been cut out and the plate bent, is shown in (*c*)

BUTTS, SHIFTING OF (figs. 11, 14, 21)

320. The relative weakness of a butt connection, as compared with the remainder of the strake, makes it necessary to arrange butts of plating so as to minimize this weakness. The shell plating of a vessel is butted about midway between the frames in order to obtain space for fitting the butt straps, which are secured to the inside surface. The lengths of the plates are multiples of the frame spacing. The use of long plates helps in the location of a satisfactory arrangement of butts. Plates usually cover

from 7 to 10 frames. Another reason for shifting butts is to equalize the strength of the vessel so that no one section will be stronger than another. (See art. 366.)

FLUSH PLATING

321. Flush plating gives a smooth outer surface hull and provides a better appearance above the waterline for cutters than raised and sunken strakes. In some types of construction with flush plating the edge or seam straps are continuous, and in other types fitted in short lengths between frames. In the one case no liners are required between the plates and the frames, and in the other case, the whole of the frames have to be linered. Continuous straps are to be preferred in vessels such as cutters and yachts, for by the other method there is always danger of leaks where the plate edges cut across the frames. The flush system requires a greater number of rivets, as the butt straps are double the width of the ordinary plate laps and have twice the number of rivets in them. In flush plating, when well fabricated, much support is given to resist sheering stresses on the rivets. However, the work of fitting such plating is difficult, and it too often happens that the joints are closed by filling in with the calking tool.

IN-AND-OUT OR RAISED AND SUNKEN SYSTEM (figs. 11, 19, 21)

322. In this system both edges of the plate are lapped either over or under those of the adjoining plates. The strake with its edges on top of those of the adjoining strake is called a raised strake; one with the edges underneath, a sunken strake. A raised strake will not contact with the frame bar unless special provision is made. There are three ways of providing for this: (*a*) By inserting a liner between the plate and the frame bar; (*b*) by offsetting the laps of the plate, i. e., joggling the laps; (*c*) by offsetting the frame bar, i. e., joggling the frame bar. The raised and sunken system is generally used on the underwater parts of the hull.

Most Coast Guard cutters are constructed with flush shell plating above the waterline and in-and-out plating for the underbody.

The thickness of shell plating, which is determined by mathematical calculation, is dependent for a large part upon the type of construction used. Its function, in addition to adequate skin protection against the inward pressure of the sea, is to provide the necessary rigidity and longitudinal strength. The shell plating and the deck plating are the main providers of longitudinal strength. In cutters, by virtue of their hazardous occupation in assisting vessels, the bottom plating must be strong enough to resist contact with the bottom without a tendency to assume a washboard profile between frames. A guide to shell plating thickness is that found adequate on similar vessels. Shell plating on cutters is of the mild steel type with a tensile strength of 55,000 to 60,000 pounds per square inch. See table B, in the front of this book, for weights of strakes of plating for the various type of cutters. (See art. 366.)

MILL SCALE

323. When steel plates leave the mills they are covered by a black oxide scale. If this is left on the plating it will be broken through in places and galvanic action, promoted by sea water, will occur between the oxide scale and the steel. All steel must be well cleaned and free from mill scale before red lead, etc., is applied. To obtain this, it is customary to defer the painting of all parts of a new hull until just before the launching, or to require that all hull steel shall be allowed to stand without paint as long as possible so that the natural process of corrosion will cause the scale to drop off, or loosen it so that it may readily be removed by hammer blows. More often the painting of the outside of a new hull is deferred until after the launching, so that the short period of unrestrained rusting (the rusting is expedited by the water) may effect a thorough removal of the scale. In this case the ship is docked 2 or 3 months after launching, just before the trials, when the metal will be found comparatively free from mill scale.

By the pickling method, new steel plates are immersed on end in a bath of 1 part of hydrochloric acid to 19 parts of pure water for half an hour or more and then washed with an alkaline water and scrubbed with wire brushes. Another method is by the sand blast. It produces an absolutely clean metallic surface.

JOINTS (fig. 16)

324. The strength of a *riveted joint* depends on (*a*) the number of rows of rivets, (*b*) kind of material in the rivets and in the plating, (*c*) diameter of the rivets relative to the thickness of the plates, (*d*) distance the rows of rivets are from the edge of the plate and the distance between rows, (*e*) workmanship.

The strength of a *welded joint* depends on (*a*) material of welding rod, (*b*) width of weld parallel to plane of the pieces joined, (*c*) thickness of weld perpendicular to the plates joined, (*d*) whether or not the plates joined are in a horizontal or vertical plane, (*e*) method of making the weld and skill of the welder.

Joints are classified as follows: (*a*) Oiltight, (*b*) watertight, (*c*) nonwatertight.

Oiltight joints are made by calking both edges, closer spacing of rivets in welding, and use of oil stops if necessary.

Watertight joints are made by (*a*) close spacing of rivets, (*b*) calking, (*c*) stopwaters, (*d*) continuous welding.

In ship construction, plating is laid in three different ways as regards the kind of joints in the seams,

namely, (*a*) flush, figure 22, (*b*) clinker, (*c*) raised and sunken, also called in and out, figures 11, 107. Connection between 2 pieces of shell plating is made by 2 kinds of joints, butt and lap, and deck plating is usually joggled.

The advantages of welded joints are (*a*) lightness, (*b*) saves rivet holes, (*c*) strength may be calculated, (*d*) plate may be replaced more readily.

Tack welding means intermittent and noncontinuous welding. It is used for nonwatertight work, and frequently as a preliminary to continuous welding in new work.

STERN FRAMES (figs. 20, 22, 57, 91)

325. The stern post on a sailing vessel, or a side-wheel-paddle steamer, is practically a vertical continuation of the bar keel as it forms, in these vessels, a stiffening member for the shell plating and it is also fitted with gudgeons to form bearings for the rudder pintles.

In single-screw vessels, the stern post becomes more elaborate and massive and is usually called a stern frame and sometimes a propeller frame. It consists of two posts, the outer, or rudder post (sometimes referred to as stern post) by which the rudder is supported, and the inner one, the body, or propeller post. They are united above by the arch or bridge and below by the sole piece. The propeller shaft passes through the propeller post, which is enlarged or bossed to receive it, and the stern tube which carries the propeller shaft bearings. The propeller works in the aperture between the two posts. The rudder is usually fitted with pintles which work in bearings fitted in gudgeons which project from the after side of the rudder post.

The stern frame serves to support the propeller and rudder and also ties the after ends of the shell plating and transom frame together rigidly. The stern frame must therefore be made quite massive and stiff in order to insure that the propeller shaft will be rigidly supported. (See art. 353.)

CANT AND TRANSOM FRAMES (figs. 17, 61, 94)

326. Cant frames are frames in the forward and after sections of a vessel that do not set square to the keel. Transom frames are deep floor-like vertical athwartship frames which fasten to the top of the propeller and stern posts to form the transom or counter of vessels. (See art. 359.)

SPECTACLE FRAMES (fig. 38)

327. Spectacle frames are installed where it is desired to eliminate shaft struts for twin-screw vessels. They are shaped like the contour of the rim of eyeglasses and the shell plating is shaped around the frame so as to form a streamline base around the shaft. They are installed just forward of the propeller screws (within the skin of the ship).

In single-screw vessels and in the center screw of triple-screw vessels, the propeller shaft passes through a bearing which is part of the stern tube. The stern tube passes through and is secured to the boss in the propeller post of the stern frame casting. In twin- or quadruple-screw vessels, each shaft revolves in a bearing in a stern tube. Each stern tube may be installed in a boss on the hull which is located at the point where the shaft comes out of the skin of the ship. Farther aft, the shaft may be provided with struts to carry the bearing which are necessary to support the shafting and the weight of the propeller outside the hull, as in the case of the 100-foot and 125-foot Coast Guard patrol boats. Or in another type of construction the stern tube may be connected to a spectacle frame which is installed just forward of the wing screws within the skin of the ship so that the propeller weight is carried in the stern tube bearing, which is housed in the spectacle frame. Forward of the spectacle frame, the shell plating and framing is a stream-lined boss around the shaft, so that the shaft is no more exposed than in a single-screw vessel. This latter arrangement eliminates the need for shaft struts, but is more expensive to construct due to the difficulty in shaping the plating to form the boss around the shafting.

STEMS OF CUTTERS

328. The stems of Coast Guard vessels are not all cast steel, nor all forged steel. The type used generally depends on the method of connecting the shell and to the amount of curvature in the forefoot A cast steel stem is used where the stem is broad, as in the forefoot in some cutters, in which case it is necessary to have flanges on the stem to which the shell plating is connected. A stem, which must have flanges and considerable curvature, is much cheaper to construct if made of cast steel than if forged from steel bar. In cases where the lines of a vessel are such that the two sides of the shell plating at the bow will come close together at the stem, as in the cutter *Shawnee*, a forged steel stem is used. The following cutters have been built with all-forged steel stems: *Escanaba*, *Northland*, *Ossipee*, and *Tallapoosa*. Sometimes a combination of forged steel and cast steel is used, in which the section including the forefoot is made of cast steel and the straight section of the stem above the water line is of forged steel and connected to the cast section of the stem by a scarped joint, figure 54. Examples of this type of stem construction are the *Tampa* class and the *Itasca* class cutters (art. 352).

RUDDERS (figs. 20, 22, 92, 93)

329. A rudder should be large enough to control a vessel at slow speeds, and also large enough to control the vessel without use of a large amount of rudder.

A description of the rudder installed on a lake-type cutter will be found in the article headed "Detailed Description of the Construction of Lake Type Coast Guard Cutters" (art. 386). Also, the brief description of the 165-foot patrol boats contains a description of their twin rudders (art. 392).

Balanced rudders (fig. 20 (*a*), 40), have approximately two-fifths to one-third of their area forward of their axis. The 328-foot cutters will be equipped with balanced rudders. The advantages of a balanced rudder are: (*a*) Less power is necessary to put the rudder over, (*b*) the balancing portion gives to the rudder the power to quickly right itself when the pressure on the steering wheel is released.

The maximum rudder angle used is 35° to 36°. Lake-type cutters are adjusted for 35° with rudder stops at 38°. The rudder, when put over, causes the ship to turn, to move sideways and outward, heel first inward and then probably outward and to slow down. Rudders are usually carried on the rudder post by the pintles which seat in gudgeon bearings. In order to actuate the rudder, there is secured to the upper end of the rudder stock a yoke, in two parts, which are keyed together around the stock. (See *steering gear.*)

The 165-foot patrol boats have two rudders of the twin streamline type; all other cutters have but one rudder.

DECKS

330. Upper decks on cutters are invariably cambered (fig. 23), i. e., the beams rounded up or arched in an athwartship direction for the purpose of draining off water to the waterways. The camber is expressed in inches as compared to the greatest molded breadth of the vessel in feet as 10¼ inches in 40 feet for lake-type cutters. It is the distance at the midpoint of the beam from the cord of the arch to the top of the beam.

Deck Planking, How to Lay (figs. 11, 31, 102)

The butts of two adjoining fore-and-aft planks must land on a beam. Butts falling on the same beam should be at least three planks apart, butts in contiguous planks should not be closer than 5 feet, those in alternate strakes should not be less than 4 feet apart and those on adjacent beams should have at least 1 plank between them. Decay invariably starts in the butt region. The calking becomes loosened by the fore-and-aft straining of the vessel and by shrinkage. The presence of the galvanized iron bolt in sodden wood hastens the deterioration. Holes bored in the planks are frequently torn elliptical shaped, or not at right angles to the surface. Such planks should be rejected.

In laying planking on metal decks one priming coat of red lead should first be applied to the upper surface of the deck plating. After this has thoroughly dried, a thick, heavy red lead paint is applied to the deck as each plank is being laid to fill efficiently all interstices between deck planking and plating underneath. Where exposed, the underside of the planking is covered with priming coats of white lead in oil during the process of laying the planking, and before completion is painted the same color as the metal work in the vicinity. During the laying of the planking the upper surface should be thoroughly protected by a thick coat of crude turpentine, cheap grade of Georgia pitch, or other approved material, well sprinkled with sawdust, and renewed as often as necessary to maintain a thoroughly efficient protection. After final planing, the upper surface of the planking is cleaned where necessary.

In order that the holding-down bolts will not pass too near the ends of the planks, a piece of plating of the same width as the plank, and about three times the width of the beam, is inserted between the planking and the beam, and the holding-down bolts in the ends of the planking are fastened to this inserted plate, called a "tie plate", figure 31. Three or four basing strakes should be left between each butt. The bolts should not be less than 4 inches from the planking ends. One-half-inch galvanized bolts, with flat heads and square necks, are usually used for fastenings. A hemp grommet, white-leaded, is placed around the head of each bolt. The bolt head sinks 1 inch below the upper surface of the plank and wooden plugs or dowels steeped in white lead are driven in on top of the bolt to fill the hole in the plank. They should be 1½ inches deep for 3-inch planks. The plugs are of the same material as the planking and are inserted with the grain of the wood running parallel to that of the planks. A grommet is also placed around the bolt just above the washer. Butts and seams are calked with 1 thread of cotton and 3 of oakum and payed with 1 inch of marine glue.

On Coast Guard vessels 3-inch deck planking is used and in most cases is yellow pine or Douglas fir, with margin planks around the deck houses and at the side of the deck of teak, yellow pine, or Douglas fir. On superstructure and bridge decks thinner planking is used, usually about 2 inches. On yachts, teak is frequently used for all deck planking but is more expensive than yellow pine or Douglas fir. (See art. 368.)

RIVETING

Arrangement of holes (figs. 16, 48 (a), 78)

331. Chain riveting is used generally where two or more rows of rivets are required in plating butts and seams. For seam riveting and single butt strap riveting the distance from center to center of rows for chain rivets should not be less than 2½ diameters. In double butt straps and butt laps, where chain riveted, the distance between centers of rows should not be less than 3 diameters.

(*a*) *Zigzag riveting.*—In zigzag riveting of plates, straps, and shapes generally the distances between the centers of rows should not be less than the following:

Spacing of rivet diameters

Rivets:	*Spacing diameters between rows*
For 3½ in rows	1½
For 4 in rows	1¾
For 4½ in rows	1⅞
For 5 in rows	1⅞
For 5½ in rows	2
For 6 in rows	2

(*b*) *Distance of holes from edge.*—Centers of holes should not be less than 1⅝ times the diameter from the edges of plates or shapes.

(*c*) *Spacing of holes in same rows.*—The size of the holes, the spacing of the holes in rows, and the rows from the edge and from each other are important matters, and all require checking carefully. The spacing of the holes in the same row depends upon the service; if watertight, the spacing varies from 3½ to 5; oiltight, 3½ to 4; and nonwatertight, 6 to 8 diameters, according to plan.

Unfair holes

Unfair holes, i. e., where the holes of two faying surfaces are not concentric, are most prejudicial to good riveting as such rivets offer but little resistance to straining of the joint. In good work, there should be no holes so noncoincident as not to permit being faired by moderate reaming. Drifting by means of the drift pin is not permitted.

If in any one part, there should be a considerable number of unfair holes, say 5 percent, that part should be rejected. No corrective means, such as welding or working under heat of such plate, or shape, should be allowed except on definite authorization.

Method of driving

The method of driving depends upon the type of vessel, the character of the work, the place where the riveting is done, and the contractor's facilities. The method is immaterial provided that the results are satisfactory, except that in oiltight work, all rivets, as far as practicable, should be power driven. Where rivets are driven by power, the holding-on also should be by power.

Rivets should be driven as soon as possible after being brought to the proper heat. All riveting should bring the parts together so closely that the thinnest testing knife blade cannot be inserted between the faying surfaces.

For pneumatic riveting, the air pressure available at the hose should be maintained at about 95 to 100 pounds per square inch. Pneumatic riveters should be of sufficient size to properly drive the rivets before a black heat develops in order that the points may be trimmed while yet a dull red. When riveting is done by pressure devices—bull riveting—the pressure should not be released until the rivet has cooled to a black heat. In ordinary pneumatic, or hand riveting, each blow of the rivet hammer must be backed up by means of a suitable holding-on device.

Riveting in oiltight work

Care must be taken that all riveting in oiltight work is perfectly sound because the fluid carried in the tanks is particularly trying on the rivets, due to the bursting pressure which takes place on the plating. The pressure being conveyed to the framing through the rivets, places them in tensional stress, tending to pull off their heads and points, elongate, and slacken them. (See art. 372–374.)

Inspection and test of riveting

Rivets are tested by holding the forefinger against one side of the rivet head, and striking the other a side blow with a small testing hammer. If the rivet is tight and solid, the finger will not be sensible to the blow, but if not perfectly tight a jar will be felt, and the hammer will not rebound sharply.

Wherever found, rivets, which are loose, burned, with slack or eccentric points, cracked or eccentric heads, or with the heads lacking full contact with the surface, must be condemned, cut out, and replaced. Defective rivets should not be removed by burning except upon specific authorization.

PREPARATION OF METAL PLATE, ETC., FAYING SURFACES

332. The faying surfaces of nonwatertight work should be given a protective coating of red lead paint, freshly mixed, except in drinking water, fuel oil, and lubricating oil tanks. Faying surfaces in oil compartments are to be painted with a mixture of pine tar and shellac or other approved mixture such as "Olomel." All faying surfaces must be scrupulously cleaned before assembly.

USE OF RED LEAD GUN

333. In inaccessible places, or where stop waters or oil stops have been inadvertently omitted, the only expedient is to introduce, by means of the red lead gun, red lead putty, or other approved material. In oiltight work a compound impervious to oil must be used by means of the gun. However, it should not be permitted to make good defective material or workmanship, but only where unavoidable. The used of the red lead gun is generally the sign of poor workmanship and its use should be avoided as much as possible. Other means of stopping leaks, such as shellac, cement, etc., should never be permitted.

Holes drilled for the insertion of the gun must be threaded and closed with steel tap bolts or rivets firmly screwed into place and made tight. Tap rivets, where used, should be flush with the adjacent surface.

BOSOM PIECES

334. Bosom pieces are short pieces of angle bar used as connecting members or butt straps for two adjoining angle bars. The bosom flange projects in the same direction as those of the angle bars it connects and it is fitted in the bosom between the flanges of the angle bars it joins.

When bosom pieces are required as in connections of angles, care must be taken to see that their heels are removed to secure a proper calk in watertight and oiltight work, or that bars with rounded heels are used.

PILLARS (figs. 24, 116)

335. Care should be observed that the holes to take the heels and heads of pillars are good holes, that the surfaces fit closely, and that the pillars bear on the beams. (See art. 361.)

The holes in the beams to take the pillars must be placed well up near the neutral axis because, when subjected to excessive forces, the lower edge is liable to break through at these holes.

BEAM BRACKETS AND KNEES (figs. 32, 74 (a), 79)

336. As the rivets binding the beam brackets to the frames are the medium through which the stresses affecting the one are conveyed to the other, they must be given most careful attention. To provide for a proper joint the holes should be drilled in place. The two faying surfaces of the beam brackets must be bound together intimately to aid the rivets in resisting the various stresses.

LAMINATIONS

337. Plates, especially iron ones often contain laminations, which are loosely cohering layers, and very objectionable, for water or moisture will get between the layers and set up corrosion. As rust has from 4 to 6 times more bulk than the iron from which it is formed, it may burst the layers apart, as the formation of rust scale between the layers becomes thicker and thicker.

Laminations often occur in steel plates and each bar and plate should be examined for laminations as it goes into the structure. They may escape detection unless they are looked for in the freshly made countersinks.

CALKING AND CHIPPING

338. Calking is necessary along the edges of plates in watertight, oiltight, or airtight compartments. No attempt should be made to calk where rivets are not spaced for such tight work or where plating is less than $\frac{3}{16}$-inch. First, the fuller tool is used. It is round nosed and slightly bent near the end. The lower edge of the top plate, the thickness of the fuller is driven down hard on the bottom plate. Next, the straight-faced calking tool, also bent near the end with a flat face at bottom, is used to bring the angular corner or edge in direct line with the seam; the curve near the end of this tool prevents it from cutting the lower plate. The object of this tool is to set the metal of the upper plate hard down on the lower plate. Care should be taken not to drive this tool too hard which will raise the edge of the upper plate thereby loosening the surrounding calking.

In calking a watertight surface such as a bulkhead it should insofar as possible be done from one side, that opposite the stiffeners. In some cases it is desirable that the heel of the bar on one side and the toe of the bar on the other side be calked.

Butt calking is accomplished by the same operation upon both upper edges of the butt. Calking is not done until the compartment is nearly ready for testing for tightness, or at least until all riveting and chipping has been done. Chipping is necessary in places to remove burrs and smooth up surfaces.

Calking requires conscientious care, and if not well done, the fault is usually that the joints were not properly closed in the first instance. The calking is finally tested by hydrostatic pressure, or air pressure, and any surface which is properly calked should be equally tight, whether the pressure is against the calked or uncalked side. (See inspection chapter.)

In a well-calked joint, the shoulder should be deep, rather than high, for a high shoulder separates the plates. In butt calking the edges may be too far apart, when the calkers will sometimes endeavor to fit in strips of iron for calking purposes, which is not allowable. The watertightness of a butted joint depends largely on the calking, for the edges of the two plates even when carefully planed and fitted rarely fit with perfect watertightness at all points. Butt calking is not as efficient as lap or edge calking and it is more liable to pull apart.

STOP WATERS AND OIL STOPS

339. The use of soft packing as a substitute for calking should be confined to joints which cannot be readily or properly calked; or as an auxiliary to the calking, in places where, through inaccessibility, the calking being difficult to perform, is not entirely reliable.

Stop waters should not be used to make good defective workmanship or materials nor where the best practice requires metal-to-metal contact. They should be used in general, only where nonwatertight members pass through watertight members for the purpose of preventing leakage from one side of the watertight member to the other, and should be permitted only where unavoidable.

Flange-to-flange joints for all systems should be made with trunk board, saturated with a mixture of 20 parts wax and 10 parts varnish, or with trunk board dipped in water just before being fitted in position, the immersion not to exceed 15 seconds.

OILTIGHT WORK

340. Oil stops may be used in seams, laps, staplings, etc., where necessary to secure oiltightness. Oil stops for heavier than 7½-pound plate may be lampwicking or canvas, soaked in a mixture of pine tar and shellac. For material of 7½ pounds and less, oil stops should be made of 10-ounce canvas soaked in a mixture of pine tar and shellac.

Oiltight work of a vessel's structure, including inner and outer bottom plating and tanks, should be made with two layers of no. 10 canvas saturated with a mixture of 97¼ parts of pine tar and 2¾ parts shellac, or with trunk board dipped in water just before being placed in position, the immersion not to exceed 15 seconds.

Gaskets for oiltight manholes and hatches, which are secured by dogs, should in general be of square-braided flax, treated with wax and tallow. Gaskets for oiltight joints of bolted manholes, etc., should be of trunk board, treated with wax and varnish.

WATERTIGHT WORK

341. All flange-to-flange joints of water systems should be made up with 1/16-inch gum, with one insertion of cloth. Flanges of joints connected to watertight bulkheads and floors, to metal decks, to outside plating, and to inner bottom plating, or other parts of the structure, should be laid up with two layers of no. 10 canvas soaked in raw linseed oil and painted with thick white lead. Through bolts for joints should be packed under the head of the bolt, and also the washer for the nut with grommets of lampwick or hemp, thoroughly soaked in red lead for watertight work. Washers in all cases should be fitted under nuts and where required under both head of bolt and nut.

LIMBER AND AIR HOLES

342. Limber holes are punched above the floor-frame angles, and vary in size from 2 to 4 inches. Their purpose is to permit bilge water to flow to suctions. Because they are punched above the lower or frame angles, it is necessary to provide supplementary drain holes about 1 inch by 2 inches through both the floor and lower angles unless the bottom is cemented in to the height of the limber holes.

Air holes are also punched near the upper limits of tanks to permit air to find its way out when tanks are filled or pumped out, thus allowing a free flow of liquid from cell to cell and prevent air locks which would result in a tank not being fully emptied or filled (i. e., free surface liquid).

The upper parts of floors and longitudinals are also so perforated, and frequently liners fitted below the outer strakes of the tank top plating are omitted for the same purpose.

LIGHTENING HOLES

343. Lightening holes are holes cut out of any member such as a floor, longitudinal or the deep plate in a web frame, where very little loss of strength will occur. Such holes not only reduce the weight but also often serve as access holes, such as in floors and bottom longitudinals (fig. 21).

HATCHES

344. In constructing a hatch on a deck it is necessary to cut deck beams or use shorter beams called "half beams." The inner ends of the half beams are connected by angle clips to a fore-and-aft bar member called a "carling", which is similar to the beam.

Doubling plates, on which the raised vertical sides of the hatch called "coamings" are seated, are worked around all such openings in decks to compensate for the loss of structural strength due to the opening. (See fig. 104, arts. 378–381.)

WELDING

345. Cutter building practice in the past has been to permit welding on clips, bins, lockers, pockets, racks, shelves, and fittings throughout the ship, on tanks which were not part of the ship's structure, on foundations which were not subjected to violent shock or vibration, on steel or wrought-iron piping systems where required by the detailed specifications, and on bulkheads, decks, deck houses, flats, and partitions that did not contribute to the longitudinal or transverse strength of the ship as a whole. Welding work has been so improved in recent years that the 328-foot cutters will be welded nearly throughout, with the exception of shell plating.

On repair work, welding may be used for remedying defects due to accidents or deterioration, subject to the parts when repaired being satisfactory in strength and tightness.

Unless specifically authorized welding should not be allowed on malleable iron, or in combination with riveted joints, except where welding is intended for tightness only.

In general, welding is not applicable to mast and rigging fittings, especially those involved in the handling of weights. The shell and strength decks are subject to vibration and repeated alternations of stresses during ordinary service at sea, therefore any welding to these parts should be treated with great caution.

Inspection should be made after welding for the purpose of checking the penetration, surface appearance, contour, continuity, and thickness of welds. Should inspection or test indicate an unsound weld it should be cut out and rewelded. All welding in oil and watertight work should be calked as necessary to obtain watertightness.

MODEL BASINS AND SHIP TRIAL RUNS

346. In order to obtain data on the propulsive resistence of a ship which is to be built, models of the ship, usually about 20 feet long, are constructed and subjected to towing tests in the model basin. Resistances are measured by means of a dynamometer towed by a suspended carriage which is operated electrically. Wave-making apparatus is a part of the basin equipment. One of the best equipped model basins is located at the Washington Navy Yard.

The following extracts on this subject are from a paper read by Commander Harold E. Saunders (CC), U. S. N., before the Society of Naval Architects and Marine Engineers, and are used by special permission of that society:

"The fundamental endeavor of a model basin is to predict accurately the performance of ships and the effects of variables on this performance. Whether these aims are fully realized depends upon the accuracy of self-propulsion model tests in indicating full-scale performance, and on the corresponding reproduction of the effects of variables from model to full-scale. While the latter is more nearly true for moderate-speed vessels, there are added complications for high-speed vessels, especially in the reproduction of effects of variables in the full scale. Excluding instrumental and observational errors, discrepancies in predicted results and full-scale performance continue to manifest themselves. The primary measurements are revolutions, speed, and power. The secondary measurements—the necessary complement to the above—are displacement, force and direction of the apparent wind, ship's heading, and amount of rudder movement and trim. Lastly, the trial may be conducted by the 1-run, 2-run, or 3-run method, though there has been considerable discussion relative to the advantages of each method."

FULL-SCALE OR SHIP'S TRIAL RUN TESTS

370. "These tests, when sufficiently extensive and carefully conducted, will furnish data very nearly as accurate as can be obtained with model tests under laboratory conditions. To insure this accuracy, corrections for all tangible sources of error must be applied to the observed data. Such trials emphasize the necessity for measuring thrust. Making possible a more complete analysis of propeller performance, and more important, it supplies the only means for analyzing hull performance.

"Frictional resistance is still, perhaps, the most elusive and uncertain element in the conversion of model test data to the predicted full-scale performance, due to the use of a factor, loosely termed "roughness allowance" governed by judgment and experience to compensate for ultimate variations in hull surface conditions. For purposes of analysis and comparison with model prediction, it should be possible to measure ship speeds through the water consistently to within ½ of 1 percent.

"Variations between models, which are supposed to be identical in every respect, indicate the difficulties confronting experimenters who are frequently called upon to determine the effect of small changes in ship's forms or their appendages by means of model tests. The induced drag, even at small rudder angles, is appreciable and definite even though it may be small." (See inspection chapter.)

DRAFT DIAGRAMS (fig. 15 (b))

348. On destroyers an additional set of draft marks is placed abreast the lowest projection of the keel, skeg, rudder, or tips of propeller blades if they project below the base line. The displacement of a vessel may be obtained from the "displacement and other curves" if the mean draft is known. As external marks and internal gages are not, in general, equidistant from the middle perpendicular, an arithmetic mean will not give a true draft if the vessel has trim. To facilitate the determination of the mean draft and the readings of the displacement from the observed drafts, a "draft diagram" is furnished the vessel. From this sheet the mean draft and corresponding displacement can be obtained by drawing a straight line through the points corresponding to the forward and after drafts and middle perpendicular shown on the diagram. The displacement generally requires a correction for any trim of the vessel; trim being the difference between the drafts forward and aft, and the correction in displacement for trim given on the draft diagram is for the trim with reference to the length between the forward and after perpendiculars of the vessel. The trim determined from the external draft marks will be in general sufficiently accurate. Draft marks for navigational purposes are arabic numerals; those for calculative purposes are roman numerals.

TO FIND THE AMOUNT OF FUEL TAKEN BY CHANGE OF DRAFT

349. Subtract mean draft before fueling from mean draft after fueling. The product of this remainder in inches, multiplied by the tons per inch immersion, will give the number of tons of fuel. The mean tons per inch immersion is taken for the mean of the mean draft before fueling and that after fueling.

DETAILED DESCRIPTION OF THE CONSTRUCTION OF LAKE-TYPE COAST GUARD CUTTERS

(Structurally one type of cutter differs little from that of another. The following has been general Coast Guard practice.) (See tables I and II in front of book.)

FLAT KEEL AND RIDER PLATE (figs. 56, 59 (a), 73)

350. The flat keel for the midship portion is 28.1-pound plate, 42 inches wide.[1] It is dished for about 60 feet abaft the forefoot and for about half that length forward of the stern frame. The keel plate butts are planed and fitted metal to metal, with butt straps on the inside. The flat keel plate is double riveted to the stem and sternpost with through rivets and tap rivets. The rider plate is heaviest in its midship portion. It is continuous wherever practicable and wherever intercostal especial attention is given to the maintenance of continuous strength—by heavy fastenings to watertight and oiltight bulkheads, etc. In the way of the single bottom it is angle clipped on top of the floor reverse frame angle. (See art. 315.)

VERTICAL KEEL (figs. 56, 59)

351. The vertical keel (20.4-pound plate) extends from frame no. 8 to no. 96 and has a general depth for its main portion and special depths at the after end of the engineroom and forward end of the shaft alley, as shown on the plans. At bulkheads the vertical keel is cut and heavily bracketed to them or its depth changed. Its outer and inner angles (i. e., the outer angles are at its base connection to the keel, and the inner angles at its upper extremity) are double, and have bosom pieces fitted wherever they butt. However, they are maintained as continuous as possible. A portion of the vertical keel is watertight, and in way of fuel oil tanks the longitudinal centerline watertight bulkhead forms the vertical keel. The vertical keel butts are fitted with double-butt straps, treble riveted. Only necessary access and limber holes are cut in the vertical keel; also smaller drain holes are located close to the bosom of the outer angles, just above the flat keel, none of course being placed where the vertical keel is worked watertight.

STEM (figs. 54, 57)

352. The stem is a rolled steel bar or steel casting to the contour shown on the plans. It extends from the top of the bulwark downward and aft to a sufficient distance to receive the outside plating for which purpose it is rabbeted. The stem is rounded on the forward side and scarphs of ample length are worked as necessary. The flat keel is warped around the stem at the forefoot. Shell plating is double riveted to the stem. (See art. 328.)

STERN FRAME (fig. 91)

353. The stern frame is a steel casting with design and connections to insure ample strength and with a propeller well sufficiently large for the removal of the propeller without drawing the tail shaft when portable parts of the streamline structure of the rudder post are removed. An Oertz type streamline rudder, developed in connection with the propeller post, rudder post, and rudder is fitted. The propeller post has a boss for the stern tube, and a strong heelpiece extending forward and connecting to the keel. A well-proportioned solepiece connects the propeller and rudder post at their bottom extremities and they are united above by an arch or bridge. A tapered horn which attaches to the transom floorplate is worked over the rudder post. Outside plating is double riveted to the stern frame. The rudder post has stops to prevent a rudder swing of more than 38°. Gudgeons are bushed with lignum vitae, bored one thirty-second inch larger than the pintles.

FLOORS (figs. 58, 63) (see art. 325)

354. Floors are of 15.3-pound plate throughout except the transom floor which is 20.4-pound plate. In general the floors are the depth of the vertical keel at its throat. They extend horizontally between the port and starboard margin plates which are located near the turn of the bilges. Depth of the floors is increased (deep floors) to suit special conditions in peak tanks, double bottoms, etc., and certain floors are oiltight or watertight, as noted on the plans. Floors are continuous on each side of the vertical keel except in the way of oiltight fore-and-aft bulkheads in the boiler room double bottom oil tanks. They connect to the vertical keel by T-bars and double angles. Access holes, or lightening holes, are worked as necessary to provide access to all parts of the ship structure. Limber holes, drain holes, and air holes are punched as necessary.

FRAMES AND REVERSE FRAMES (figs. 58, 68, 78)

355. Frames are 18-pound channel bars lapped onto the floors or bracketed to the inner bottom, depending on their location. In way of oiltight floors frames are heavier channels. Frames stand square to the base line and are spaced 24 inches below the main deck and 48 inches above it. Even-numbered frames run to the upper deck stringer, being continuous, with staple work or welded collars at the watertight berth and main decks. The other frames extend to the main deck, watertightness of decks being maintained as described above. In the way of fuel-oil tanks all frames are intercostal at the main deck and at the fore-and-aft bulkheads. Where channel frames are lapped on floors the outer flange is suitably cut away for lapping. Frames are cut and bracketed to the inner bottom by brackets turned on the inner edge and connected by double-riveted tees. In way of the double bottom gusset plates are worked on web frames and on other frames to suit special conditions. In the boiler room large brackets are fitted at every frame in way of the berth-deck stringer. Diagonal strut angle braces, bracketed at ends and extending from main deck beams to the frames at the stringer,

[1] 1-inch steel plate weighs 40.8 pounds per square foot.

are worked on every third frame. Reverse frames extend across the tops of the floors and are continuous on each side of the vertical keel except in fuel-oil tanks where they are cut at fore-and-aft bulkheads. Reverse-frame angle bars are single except in inner bottoms, where they are double.

WEB FRAMES (figs. 21, 72)

356. Seven web frames 15.3 inches deep are worked at specified frames and extend from the inner bottom to the main deck. The web is lapped on the back of the regular frame with suitable connections at its ends. They have face angles double the required width.

LONGITUDINALS (figs. 60, 63)

357. Longitudinals of 15.3-pound plate are worked about 7 feet out from and on each side of the vertical keel. The longitudinals are intercostal whereas the inner angles are continuous and double. Clips connect the intercostal plates to the floors. The longitudinal and shaft alley bulkheads are arranged as sections of the longitudinals for continuity of strength. Suitable access holes are cut in the longitudinal under the engine and boiler space.

STRINGERS (figs. 74, 81)

358. A side stringer of a continuous channel bar is secured by a single clip (angle bar) to the inner flange of each frame, port and starboard. They run longitudinally below the berth deck. The stringers extend along each side of the vessel from a breasthook at the stem and stern, thus forming panting stringers in the bow and stern regions. A side stringer is run at the berth-deck level in the boiler space and merges into the engine room flat. Between berth and main decks a panting stringer, consisting of a continuous channel bar clipping to the frame channel, extends from the breasthook at the stem and the desired distance aft, then commences again in the after body and runs aft to the crutch at the stern. Midway between main and upper decks a panting stringer of similar construction likewise extends from the breasthooks at the stem and stern.

BREASTHOOKS AND CANT FRAMING (figs. 17, 18, 61, 94)

359. A breasthook of 15.3-pound plate is worked in the bow in way of the side stringers and panting stringers. Cant frames (figs. 17, 61, 94) at the bow and stern are 18-pound channel bars, and fastened with suitable bracket plates to the transom and deck. In developing details of cant framing care is taken to clear the steering gear. The radial deck beams on cant frames are the same size and material as the upper deck beams. (See art. 326.)

BILGE KEELS (fig. 99)

360. Bilge keels are fitted, extending from frame no. 42 to no. 76. At their ends they are reduced with an easy taper. They consist of a 14½-inch T-bar plate with a double half-round bar on the outer edge. The plate connects to the T bar by riveting and each of its butts are fitted with double riveted straps. The T bars have watertight riveting in the shell flanges and the edges are calked. The flanges are cut at butts of shell plating as necessary, and are worked without butt straps. The bilge keel T bar is welded to the shell plating in the way of oil tanks.

DECK PILLARS AND GIRDERS (figs. 22, 24, 65, 116)

361. Deck pillars and girders are worked generally in two rows. Pillars are largest in the holds and reduce in size as the work that is required of them lessens. They are made of extra strong steel pipe. Deck girders, which are longitudinals running fore-and-aft, consist of angles and reverse angles worked below the deck beams. Girders are clipped to the beams and bracketed to the bulkheads. Upper-deck girders have an added intercostal plate clipped to the underside of the deck plating where the span is more than a limited amount. Where encroachment on headroom is not objectionable, equivalent Z-bar girders are fitted as approved. Bulkheads taking the place of girders, or a line of pillars, are suitably stiffened. Pillars in the boiler and engine rooms have extra strong pipe worked in conjunction with girders consisting of continuous channels with a face angle. Where berth-deck beams are increased in depth in the engine room, channel girders are likewise increased in depth to correspond. Where pillars are not located directly under the girders suitable stiffening bars are worked at their upper extremity. Girders and pillars are worked to provide support for decks, platforms, windlass, gypsy, compass platform, steering gear, and towing bitt foundations, etc.

INNER BOTTOM (fig. 24)

362. The inner bottom extends the full length of the boiler and engine spaces and over other portions as shown on plans. It is worked oiltight over the cofferdam frames and watertight elsewhere. The inner bottom extends outboard to the margin plates on each side. It is worked intercostal between athwartship bulkheads. The plating is 20.4-pound plate with double riveted butts and seams. Wing bilge wells are arranged outboard in the inner bottom plating at desired locations. These wells are formed of plates and angles within the inner bottom just inboard of the margin plate. Access holes are cut in the margin plate in the way of the wells to permit drainage to the suction and for cleaning. Suitable flat bar bearers are provided to take the boiler pan carrying the fire bricks of the boiler.

BERTH DECK STRUCTURE (fig. 97(a))

363. The berth-deck channel-bar beams are worked without camber and spaced on every frame. Brackets

connect the beams to the frames and to stiffeners on fore-and-aft bulkheads. Beams are cut and carlings are worked at hatches. Berth deck plating is worked flush on top. Coamings and other stiffeners at the edges of the flat are worked as required. Except where noted, the berth deck is watertight throughout, with double riveted butt and single riveted seam straps, butts and seams calked. Bounding angles are of required weights. Where frames are not cut, watertightness is secured by stapling or welded collars. A watertight coaming is worked around the refrigerator compartments.

MAIN DECK STRUCTURE (fig. 85)

364. The main-deck beams, channel-bar type, are worked without camber on every frame, and are fitted with brackets to the frames. Carlings and short fore-and-afters, in general, are the same size as the deck beams. The main deck has its heaviest plating over oil tanks and is worked oiltight. Lighter plate is worked watertight elsewhere. Deck plating, except over oil tanks, is flush on top with double riveted butt and single riveted seam straps. Over oil tanks, lapped seams and butts are double riveted. All butts and seams are calked. The main deck bounding angles are stapled watertight around frames, or welded collars are used. Forward of the steering gear an angle coaming is fitted to confine oil leakage. Similar coamings are fitted around the coffee urn and scuttle butt.

UPPER DECK STRUCTURE (fig. 81)

365. The upper deck beams are of 6 by 3½-inch by 15.3-pound channels, cambered. They are worked only on even numbered frames, except for special conditions near bow and stern and at ends of deck houses. Beams are cut and carlings and coamings are worked at the hatches and other openings. Special stiffening is added in way of foundations. The upper deck stringer plates are heavier in the midship area and reduced in size at the ends. Around hatches and deck houses, along the centerline and elsewhere as necessary to stiffen the deck, especially on account of gun thrust, diagonal and fore-and-aft deck tie plates are fitted. Stringers, tieplates, and plating on this deck are worked flush on top to avoid scoring of the planking. In general, they have double-riveted butts and single riveted seams, with the straps or laps on the under side. Butts of the stringer plates for the half length amidships are treble riveted. Enclosure angles, intercostal between frames, are fitted as seam straps to stiffen the deck. Deck plates are increased in thickness, or double plates fitted as necessary in way of guns, boat davits, windlass, capstan, etc., and suitable deck ties worked to distribute the stress. Special stiffening and framing is worked in the way of the stack. The upper deck stringer angle is heavier in the amidship area and reduced at the ends. It is fitted with bosom straps at butts 12 inches in width and widened locally in the way of deck ventilators. On the inner side of the waterway is fitted a strong waterway bar. The bounding angles at hatch and house coamings are of sufficient size to allow calking of the top edge of the vertical leg above the wood decking. The deck plating and angles are worked in as long lengths as practicable and butts properly shifted with outside plating.

OUTSIDE PLATING (figs. 22, 71)

366. Outside hull plating is worked on the in-and-out strake system and above the waterline is of the flush type and arranged about as shown on the midship section. For thickness of the various strakes of plating refer to table II. All plates are in as long lengths as practicable, with butts about midway between frames. Butts in adjacent strakes are shifted not less than 2 frame spaces; in alternate strakes not less than 1 frame space. Garboard butts are kept well clear of butts in the keel plate, with a shift of at least 2 frames on opposite sides. Butts of the sheer strake are shifted not less than 2 frames from adjacent deck stringer butts. Plating below the waterline strake has lapped butts. All butts are treble riveted. All seams have double-chain riveted laps. Plates are double riveted to the stem and stern post. Plating at and above the waterline being of the flush type requires butt straps on the inner side of the shell. Straps of the inner strakes are worked the whole width of the plates and for outer strakes worked between edges of adjacent plates. Shell plating seams and butts are riveted watertight except in way of fuel-oil tanks and cofferdam, where riveting is oiltight. Doubling plates to provide for chafe are worked in way of anchors and chain cables, extending from sheer to keel and a distance aft from the stem. Doubling plates have the same thickness as adjacent plating and below the waterline are worked on the outside of the inner strakes and on the inside of the outer strakes. Care is taken to avoid weakness in the shell by staggering the ends of the doubling plates. Lozenge-shaped bulkhead liners are worked on the outside strakes in way of water and oiltight bulkheads and floors and between certain frames, to maintain the strength of the outside plating. In laying out strake edges, seams are kept clear of airports and other openings, and are arranged with due regard to the design location of bilge keels as shown on *lines*. Pad eyes for handling the propeller, gangway ladders, painting stages, etc., are fitted. A molding of desired size, solid half round, with watertight riveting and edges calked, is fitted at the gunwale and on the bulwark forward, as indicated on the profile plan. (See art. 319, 322.)

BULWARKS (fig. 111)

367. Steel bulwarks having a vertical height above the sheer strake as indicated in the profile plan, including the brass chafing strip, are worked at the

frame folds over and forms a support for the canvas canopy fitted around the companion.

BOILER- AND ENGINE-ROOM HATCHES

381. Quadrants are provided for opening the boiler-room hatch covers at convenient angles. Suitable lifting gear is provided to operate the engine-room hatch covers from the upper gratings. Twelve-inch deadlights are fitted in the covers. Cowl and louver ventilator trunks are installed for the boiler and engine rooms.

HAWSE PIPES AND CHAIN PIPES (figs. 71, 98)

382. There are two cast-steel hawse pipes, designed to snugly stow the stockless anchors. The pipes have a minimum thickness of 1¼ inches with 1¾ inches at bolsters, which are well rounded to reduce chafe on the chain. Flanges are worked connecting them to the outside plating and the deck. A portable slotted plate cover is fitted closely over the top of each hawse pipe, dogs and bolts being fitted for securing. Chain pipes, extending from the windlass bedplate to the chain lockers are 12 inches in diameter and three-eighths inch thick, with well rounded bolsters at the top and bottom. The tops of the chain pipes are arranged practically watertight by means of heavy metal covers.

BITTS AND CHOCKS (figs. 96, 97, 111)

383. A pair of cast steel towing bitts are fitted on the upper deck aft, and four standard mooring bitts are located on each side. They are securely tied to the steel decking and the ship's structure. There are 6 chocks of the open shell type, 4 of the same type except closed, and 6 bulwark chocks. These chocks are of cast steel with well-rounded chafing surfaces.

ZINC PROTECTORS

384. Zinc protectors one-half inch thick are fitted on outside plating below the waterline at sea connections and on the stern frame, such as: (1) sea valves below the waterline, (2) where there are any brass or composition valves or nonferrous metals, (3) stern post, (4) rudder, (5) stern frame, (6) skeg. Also mild steel protectors in the form of doublers on the outside of the shell are fitted snugly against the protecting lips of the sea chests. These zinc and steel protectors are fastened by studs and nuts and are embedded in red lead.

NAME, DRAFT FIGURES AND LABELS (figs. 110, 111)

385. The ship's name is placed on the stern in block letters. Letters are of cast composition finished smooth, gilded with gold leaf and are fastened with brass screws. Draft figures at the bow and stern are Arabic numerals 6 inches high. The bottom of each figure shows the height above the bottom of the keel. The outline of each figure is center-punched or scored. Engraved brass name plates with letters filled with black enamel or lacquer are fitted to show compartment numbers or names, occasional beam numbers, bulkhead numbers, center line, level line, water lines, valves, deck plates, directions for operation, etc.

RUDDER (figs. 22, 92, 93)

386. The rudder is a double plate, Oertz streamline, cast steel frame type. It has a 10-inch stock and is of especially robust construction, it being designed with a view to the possibility of the rudder taking the bottom when the vessel is maneuvered in confined waters. It has a heavy flange to connect with the stock by means of six fitted bolts. Especial attention is given to stream line shape in way of the palm. Composition bushed cast steel bearings are fitted. The rudder is held by a collar in halves, slightly scored into the stock above the crosshead. A portable tiller is provided with suitable stowage.

STEERING GEAR (figs. 22, 117)

387. The electric-hydraulic steering gear, installed aft on the main deck in the steering gear compartment, has four hydraulic rams which operate a double jaw, balanced tiller, or crosshead and which is keyed to the rudder stock or arranged with a jaw clutch. The steering gear is operated by a single, continuous running motor driven pump equipment capable of operating the rudder throughout its range at the specified speeds of the vessel, without exceeding an oil pressure of 1,000 pounds per square inch. The steering gear is capable of putting the rudder from hard-over to hard-over in 30 seconds with the vessel at full speed. Automatic stops and a pressure safety device are provided. The gear is adjusted for a maximum rudder angle of 35° and is so constructed that no damage will occur if it goes against the stops, which are placed at 38°. The hydraulic rams are mounted on a cast steel bedplate carried on a structural foundation. Hand steering is accomplished by means of a worm and quadrant, which is so designed that when operated by hand gear the rudder stock will be entirely free from the crosshead rams. Positive lubrication is provided. (See art. 389.)

THE ESCANABA TYPE

388. The general data pertaining to this type of cutter may be found in tables I and II in the front of this book. The general plan of construction closely follows that of the lake-type cutters.

The rudder is of the double-plate, cast steel frame type of especially robust construction. The forged steel rudder stock has a minimum diameter of 8½ inches and extends to the upper deck, with the upper end squared to take the tiller. A watertight trunk, designed to allow the removal of the rudder stock or the rudder complete, while the ship is afloat, is installed just abaft the rudder post.

This type has a flat keel 40 inches wide of 20.4-pound plate. The two side keelsons are located on each side of the center keelson (vertical keel) 6 and 12 feet therefrom.

A side stringer is run at the berth deck level.

In the bow and stern regions a panting stringer is run between the berth and main decks.

Breasthooks are worked forward in way of the side and panting stringers.

The outside plating is worked on the in-and-out strake system.

A heavy belt of ice plating extends well downward from the top edge of the water-line strake.

Chafing strips are fitted at the edge of the plating in way of the anchors.

Bilge keels are located on each side about 34 feet in extent between frames 28 and 45.

Linotile is used as a deck covering in place of linoleum.

There are two stockless type, 2,275-pound anchors. The chains are 1⅜ inches stud-link and of 105 fathoms each.

STEERING GEAR (figs. 22, 117)

389. Modern cutters are equipped with electric hydraulic steering gears. The designs vary between the 2- and 4-ram types. When four rams are used the diametrically opposite rams, i. e., port forward and starboard after rams and starboard forward and port after rams, work in conjunction. The *Mojave* type utilize a telemotor for control between the bridge and the steering engine room. The *Escanaba* class have a system of control and follow-up levers between the bridge and the rudder crosshead, connecting to the oil pump, which keeps the rams in synchronism with the steering wheel. A trick wheel, built up of hard wood with hand grips, 66 inches in diameter, is located in the steering engine compartment. Hand steering is effected by means of gears from this wheel connecting to a duplicate oil pump, which is interchangeable with the main power-plant oil pump, and which is piped to a double three-way valve in the power line. The double three-way throw-over valve and removable pin provide for changing from the main power-plant oil pump to the similar hang-gear pump. Other items of equipment are pressure piping, fittings, relief, stop, and check valves, filling pump, strainers, pressure gauges and a shuttle valve for pumping the system.

Oil pressure is admitted simultaneously in the two diametrically opposite rams. Whenever a heavy sea strikes the rudder a spring-loaded bypass valve opens and allows oil to flow in the opposite rams, thus allowing the rudder to give, or slip away, and then return to its original position.

A "tell tale", operated either mechanically or electrically, transmits the rudder angle to the bridge where it is shown by a short arm pivoted over a graduated arc.

Cast-steel cylinders are bolted to a structural-steel frame which is tied to the transom frame, in which is provided a rudder stock bearing and rudder post thrust bearing. This bearing takes the weight of the rudder, rudder post and crosshead assembly. The crosshead is cast steel, split in two halves athwartships and bolted together.

The rudder may be put over from hardover to hardover in 20 seconds, with the vessel going full speed ahead.

OPERATION OF THE ESCANABA TYPE GEAR

A movement aft of the three-way control lever will open the valve for power operation, while a forward movement will open the valve for hand operation. With the steering-gear pump control and steering wheel all on dead center and the three-way valve opened for power drive, start the electric motor. This will idle the northern pump on neutral but will not transmit movement to the rams. A part turn of either the steering wheel on the bridge or trick wheel in the steering engine room will put the pump on stroke, forcing oil into one pair of cylinders to give movement to the rams. The steering gear is designed to move the rudder and steer the ship to starboard with a starboard movement of either steering wheel, when facing forward.

In changing over from power to hand steering, it is only necessary to push the three-way valve control lever forward and remove the pin from the control lever. In changing back to power drive bring the steering gear in position to insert the pull pin and shift the three-way valve lever aft.

A shuttle valve is located across the pipe lines in the purging system to permit the oil under pressure to pass out of the system and return to the tank bedplate when the needle valve is open.

The motor is a 115-volt, 7½-horsepower, 1,150–1,200 revolutions per minute, compound wound.

The usual ram pressure is approximately 300 pounds per square inch, but during ice-breaking operations the pressure goes up as high as 1,400 pounds per square inch.

VARIABLE DELIVERY PISTON PUMP (NORTHERN) (fig. 123)

390. This pump provides oil pressure for the steering rams of the *Escanaba* type cutters. It operates as follows: The multicylinder rotor is mounted on ball bearings, part 3, and is driven by the shaft 23. The radial cylinder bores of this rotor engage piston units consisting of a piston body 15 and a piston sleeve 11, held in place on the piston body by the nut 10. This piston body carries needle bearing 16 mounting a crosshead pin 14, which in turn mounts the piston through the bearing shoe 13. This bearing shoe rides against the floating ring 19 which is mounted on the ball bearings 4. These ball bearings are used in two slide cast-

ings 5 capable of longitudinal movement from left to right.

The inner end of the cylinder bore communicates with ports on the valve 2, which is housed in the pipe connection cover 1.

Looking at the cross section *AA* when the slide castings 5 are in the central position, the floating ring 19 is concentric with the valve 2 and a cylinder rotor 9, so that there is no movement of the pistons in the cylinders and there is no flow through the pump. When the slide castings are pulled to the right by means of the connection shown at the right-hand side of section *AA*, then with a clockwise rotation of the pump the pistons will be moved out of the cylinders as they rotate through the upper half of a single rotation, sucking oil in through the upper ports of valve 2, and once they have passed the horizontal center line, the pistons will again descend into the cylinder caused by the eccentricity of the floating ring 19 so that the oil that was sucked into the cylinder on the upper half of the stroke will be discharged into the central valve on the lower half of the stroke, thence out through the pipe connection cover through the hydraulic system.

The amount of the discharge will, of course, be proportional to the amount the floating ring is shifted away from the rotor center, and it can be readily understood that if the floating ring was shifted to the left instead of the right, the flow through the pump would be reversed.

MACHINERY DATA, CUTTER ESCANABA (by Lieut. M. T. Braswell, U. S. C. G.)

391. The main propelling unit and a majority of the engine-room auxiliary equipment for the *Escanaba* was manufactured by the De Laval Steam Turbine Co. of Trenton, N. J.

The designed shaft horsepower for the main unit was 1,500 at a speed of 140 revolutions per minute, which corresponds to 7,000 revolutions per minute, of the main turbine. The normal steam conditions are 300 pounds per square inch, initial pressure, 200° F. superheat, and at a 27½-inch vacuum. During operation the turbine has developed up to 1,940 shaft horsepower, and operated very satisfactorily for a considerable period of time. The unique features of the design and construction are that the turbine develops 100 percent astern power and the second stage ahead blading was so installed that the upper section of the second stage buckets form the astern element. Ahead and astern steam chests are combined in a horizontally split circular casing which is located within the center of the main casing, its web forms the dividing wall between the stage compartments; this casing, together with the nozzle plates bolted to it, is the only part of the turbine proper that is subjected to the high-temperature steam, it is entirely separate from the main casing and is supported therein so that it can expand in any direction.

The rotor is of the built-up type in which the bucket wheel elements of each stage and their respective shaft ends are turned from solid forgings. The two sections were machined with the utmost precision and care and then they were balanced individually with the buckets in place before they were assembled.

The turbine thrust bearing is of the Kingsbury type and is mounted in the forward bearing bracket of the turbine for maintaining the axial setting of the rotor with respect to the stationary blading.

The reduction gear unit is of the built-up double-helical type; the high-speed pinion turns at 7,000 revolutions per minute, second reduction 1,100, and the bull gear at 140 revolutions per minute. The gear case is of light welded-steel construction and has an inner pan and oil sump with the lubricating-oil pump suctions attached thereto. The first reduction pinion is connected to the turbine shaft through a flexible coupling of the claw type. A quill shaft and flexible-coupling construction is used for the connections between the first-reduction gears and the second-reduction pinions, the couplings are of the rubber-bushing type. The quill-shaft flexible-coupling combination allows the necessary flexibility that is required for the equal distribution of the load among the several gears and at the same time makes the unit more compact.

A Kingsbury 17-inch equalizing thrust bearing is used for the main thrust, it is mounted on the forward end of the reduction-gear base.

The two boilers installed on board the *Escanaba* were manufactured by the Babcock & Wilcox Boiler Co. These boilers are of the convention three-register type used on board recently built cutters. The only departure from the usual conditions as experienced on the other new vessels of the service is that the safety valves are set at 340 pounds per square inch steam pressure, and the usual underway steam pressure on the boilers is 325 pounds per square inch. The steam pressure in port is 275 pounds per square inch.

The heating surface is 2,463 square feet, the superheater heating surface is 222 square feet, and the furnace volume is 264 cubic feet, for each boiler.

The superheaters are of the interdeck type and steam must be passing through them at all times when there is a fire under the boiler. The steam for auxiliary use is led from the superheater and through a coil of piping in the boiler steam drum and then to the auxiliary steam line, this permits reduction of the steam temperature for auxiliary use.

Experience has proven that distilled water makes for better operation and is just as economical as using dock water for boiler purposes, and for the past year

nothing but distilled water has been used in the boilers of the *Escanaba*. (See art. 393, propelling machinery, lake type cutters.)

165-FOOT PATROL BOATS (fig. 44; tables I and II)

392. Following is a brief description of the 165-foot patrol boats. Beam, molded, is 25 feet 3 inches; depth, molded, 13 feet 2 inches; displacement, 300 tons; mean draft, 7 feet ½ inch and maximum 8 feet 6 inches; block coefficient 0.378; total shaft horsepower, 1,340; two 6-cylinder, 4-cycle Diesel engines. Frames and beams are the bulb-angle type. Side plating, 12.8 pounds (per square foot) for one-half the length, and 10 pounds at ends. The keel plate is 18 pounds, the sheer strake 12.8 pounds for one-half its length and 15.3 pounds near the ends. There are 6 watertight bulkheads and 2 oil-tight, all of which extend from keel to the weather deck. Included in the transverse framing are 5 web frames. The galley has an aluminum tile laid on a steel deck. Boats carried are: Two dories, length 19 feet, and two surfboats, length 19 feet 3 inches. The two bower patent anchors weigh 900 pounds each. A Hyde windlass, operated by a 7½-horsepower motor, ½-inch anchor chain, and an electric hydraulic steering gear which changes from electric to hand-steering automatically, are provided. There are twin screws with twin rudders. The after end of each propeller hub is supported by a Goodrich rubber cutlass bearing which is located in a boss on the forward side of each rudder post. The main stern tube bearings in the propeller post are of babbitt metal, oil lubricated. The intermediate shaft bearings are of the Goodrich cutlass type. The twin rudders have 5-inch stocks and are of the streamline, watertight, double plated, cast-steel frame or plate type. They are of especially robust construction and of sufficient thickness to completely house the cast-steel frame. The rudders have two pintles which are about 2½ inches in diameter with brass sleeves ¼ inch thick. A cast-steel combined bearing and stuffing box, with composition gland in halves, is fitted at the outside plating for each rudder stock; cast-steel composition bushed bearings are fitted at the top of the transom, so arranged as to take the weight of the rudder. Floating disks are provided at the top bearings with flanges on the latter so the disks may run in grease. Each rudder is carried by a collar in halves scored into the stock. The tactical diameter at 6 knots is about 200 yards. The maximum cruising radius is 3,200 miles. Full speed is 17.5 knots and most economical speed 12 knots.

SHIPBUILDING, UNITED STATES COAST GUARD PRACTICE

393. Requirements for Coast Guard vessels are reliability and good maneuvering qualities, speed, adequate towing ability, unusual stability and seaworthiness, economical and large cruising radius, minimum draft, ability to break ice, combatant armament, watertight subdivision, including double bottoms, and equipped with salvage and demolition gear. Design and construction practice have therefore been a compromise between naval and the best commercial practice, the lines of the ship being a compromise between fineness for speed and fullness for buoyancy. A pronounced flare forward provides for a maximum dry ship. The flush upper deck does away with the flooding menace and danger to personnel on deck ever present in the older tyes from the wells which frequently were deluged with tons of surging water and also does away with the inconveniences incident to well deck construction.

The lake-type cutters have a full-load displacement of 2,000 tons which provides for 335 tons of fuel oil, 151 tons of fresh water, and 60 tons of ammunition and stores.

Anchors and chains are unusually heavy and gypsys are provided capable of heaving in towing hawsers, boats, and planes. One of the important newer missions of the service will be to assist aviation wherever the lanes pass over the water. Clear decks are provided for carrying planes. The 328-foot cutters will carry in addition to a superstructure housing two seaplanes a large reserve gasoline supply for refueling planes.

The following paragraphs under this heading are from Typical Vessels and Boats of the Coast Guard, by Capt. R. B. Adams, engineer in chief, and Constructor F. A. Hunnewell, superintendent of construction and repair, in the United States Naval Institute Proceedings, May 1929:

"Modern bridge equipment consists of the following: Steering wheel, gyro repeaters, gyro course recorder, magnetic compass, engine telegraphs, propeller-shaft counter, rudder-angle indicator, bell and whistle pulls, telephones for ship and fire control, voice tubes for conning ship, return sound tube from engine room, fathometer instruments, electric-log recorder, clear-view screen, running light panel, megaphone stowage, chart board with hooded light, chart shelves on wings of bridge, radio compass, high-intensity and incandescent searchlight controls, night-signal keys, receptacles for binoculars, mountings for clock, barometer and thermometer, signal rockets and fire extinguishers, clinometer, and hand operated mechanical siren. On the compass platform, which forms the top of the wheelhouse, supplementary devices consist of standard compass, conning tube, gyro repeater; fire-control station with range finder, range keeper, spotter's station and telephones; signal-flag stowage, and other minor conveniences.

"The propelling machinery in the lake class of cutters is the turbo-electric type. A central-power-station scheme was introduced for the first time on board ship with the realization of main-turbine efficiency in meet-

ing practically all power requirements. Two Babcock & Wilcox marine-type water-tube boilers, designed to operate at 250 pounds pressure with 250° of superheat, and under either forced or natural draft, are installed. These boilers are fitted with all modern attachments, including feed-water regulators to automatically maintain the boiler water at a determined constant level. The propulsion unit consists of a steam turbine direct connected to an alternating-current generator, with a synchronous motor secured to the propeller shaft. The turbine is designed for 3,600 revolutions per minute at full speed, with an output of 2,500 kilowatts at 2,300 volts from the generator. The vessel has a single screw and the synchronous motor will deliver 2,000 horsepower to the shaft at 163.5 revolutions per minute. Most of the auxiliaries, including the windlass and the deck gypsy, are motor driven, and the principal auxiliaries take power from the main generating set through a transformer when the frequency of that set is in excess of 40 cycles; that is, when the propelling machinery is operating from two-thirds to full speed. At lower speeds, the power for auxiliaries is supplied by an auxiliary three-unit set designed for these ships. This set consists of a steam turbine, a direct-current generator and an alternating-current generator. In maneuvering the ship, or when the frequency of the main set is variable, this three-unit set is turbine driven; when the vessel settles down to a certain speed, with the frequency of the main generator over 40 cycles, the auxiliary alternating-current generator is synchronized with the main generating set, the turbine is cut out and the auxiliary generator becomes a motor taking on the three-unit drive, and the principal auxiliaries take current from the main generator. If, and when, the frequency of the main generator drops below 40 cycles, the steam turbine of the three-unit set automatically picks up the load, the alternating-current motor again becomes a generator, and the auxiliary set furnishes power for the auxiliaries. In actual service experience, this automatic drive has performed satisfactorily and the central-power-plant scheme has proven its value. (See art. 391, Machinery, *Escanaba*.)

"The Coast Guard cutter *Northland*, built by the Newport News Shipbuilding & Drydock Co. and commissioned in May 1927, is a novel vessel to which the above general description applies, but in addition it has special characteristics not embodied in a regular cruising cutter. The *Northland* was designed for service in Alaskan waters and the Arctic Ocean and possible ice pressure on the hull was a vitally important matter. By special construction from below the bilges to well above the waterline, the *Northland* has extraordinary resistance to crushing by the ice. The stiffeners on the numerous athwartship bulkheads run horizontally instead of vertically, and with the lower-deck beams stiffen the plating of the bulkheads and decks, and thus provide integral parts of a strut effect. These strong members to resist compression, with deep webs on every frame and heavy outside plating, riveted and welded in the seams and butts, all combine to make the hull a homogeneous structure with a consistent strength to avoid local points of weakness. The bow of the *Northland* is cut away in the typical contour of an ice breaker and the commanding officer reports that during the Arctic cruise of 1928, the behavior of the *Northland* in the ice was even better than anticipated.

"The *Northland* has Diesel electric-propelling machinery.

"The *Northland* has also a considerable sail spread which will not be used under ordinary conditions but may be of value should the propeller be damaged by the ice. While moderate in speed, this vessel otherwise has all the characteristics of a cruising cutter, very special hull construction, and masts and sails, and the vessel as a whole is even more unique than the Coast Guard usually develops. It is hoped the *Northland* will have a long and useful life, under the strenuous operating conditions she is likely to encounter, and will make as good a record as the historic cutter *Bear* whose place she takes.

"The duty of the Coast Guard to combat smuggling which, for a time, was increasing, brought about the necessity of new designs for offshore and inshore patrol boats. A typical offshore patrol boat has unusual sea-keeping abilities and cruising radius and moderate speed although there is now a tendency to provide increased speed in this class of boats. Boats already in service are about 125 feet long, 24 feet beam, 9 feet draft, 250 tons full-load displacement, with a speed of about 11 knots, obtained by two 150-horsepower Diesel engines. These boats are entirely successful for the purpose intended, but in future designs the higher speed may be obtained at some sacrifice to other qualities and cruising radius.

"As regards small boats for Coast Guard station use, there have been developed boats of unique design with certain characteristics not usually found in small craft. The 36-foot motor lifeboat is self-righting and self-bailing and its behavior under severe conditions of wind and sea has permitted gratifying records of accomplishment. A smaller boat, the motor self-bailing surfboat, is not self-righting but is self-bailing and has proven indispensable for use at Coast Guard stations. Boats of this class have also been employed on miscellaneous duty by the Coast Guard and the Navy, and officers who used these boats in salvage work on submarines write in the highest terms of their availability under bad sea conditions."

CHAPTER IV

DAMAGE CONTROL

401. In order to impress younger officers with the necessity of continually being on their guard to prevent damage to their vessel and to cause them to think about the steps that should be taken to cope with damage and the saving of life, several actual cases of strandings of cutters will follow. The list of such accidents over a period of years includes the following: Lost, *Perry, Tahoma, Mohawk, Tampa, McCulloch;* stranded or damaged from striking, *Winona, Windom, Pamlico, Manning, Acushnet, Tuscarora, Bear, Shaw,* and three other destroyers. It is safe to say that before a vessel is in service 15 years, the odds are 9 to 1, that it will have touched the ground one or more times. Is any further argument necessary to urge eternal vigilance. To quote a senior officer, "You can save a vessel by care a million times; you can lose her only once." Probably a higher percentage of accidents to cutters have occured in Alaskan waters than in any other area. A former captain in the service, now a retired commodore, remarked that an officer assigned to duty on a vessel in Alaskan waters was practically worthless for his first cruise. Another officer who made 10 long cruises in the North remarked that the longer he piloted in those waters the less faith he had in his ability. He mentioned that he had been ice locked and the vessel all but crushed several times—at one stretch they remained held in Bering Sea ice for 24 days. He also stated that the peculiar weather conditions there made land falls never the same twice and I observed him search 3 days for St. Lawrence Island—no sights or radio bearings being available, and land to be made out in any distant clouds if you just look long enough and strain your eyes.

The merchant service has experienced their share of fatalities. The writer made a check of the vessels that had been on the Alaska run between 1900 and 1910 and found that 80 percent of them had been lost or had suffered severe damage by stranding. Liners and large cargo vessels have time and again sunk, even right alongside their piers. The American Line liner steamship *St. Paul* turned turtle at her berth in New York in 1918. One of the commonest causes of alongside the dock sinkings is the careless leaving of port holes near the waterline open. An added load, improper filling of tanks, or roughened water does the rest. Sea valves become inoperative or are carelessly left open or carry away when corroded. Numerous vessels have capsized in drydock and the cause is invariably traced to the moving of weights on board, consumption of liquid tonnage, etc. Collision at sea takes the greatest toll of all.

Not only must the Coast Guard officer consider damage to vessels as the result of collision or grounding, but also damage control in battle, from accidents and fire. In peace time, especially during foggy weather, the possibility of damage should be ever in mind and a trained organization kept properly equipped *ready* to act immediately in such emergencies. Watertight doors, port holes, and openings in watertight decks should be kept closed in foggy weather. True, no two cases are alike, but there are numerous general remedies for the preservation of the buoyancy of a cutter, as follows: (*a*) Pumping affected compartments; (*b*) sluicing of damaged compartments to areas that can be pumped; (*c*) pumping out of surrounding compartments to give more buoyancy in damaged sector; (*d*) shoring up of weakened members; (*e*) repair of damage, if possible; (*f*) counterflooding compartments diametrically opposite in order to bring vessel back to the best possible trim and even keel; (*g*) plugging or calking of watertight doors, decks, bulkheads, and hatches; (*h*) relieve, plug, or repair damaged electrical circuits, telegraphs, voice tubes, piping, etc.; (*i*) close all manholes and openings, ventilation ducts, etc., in vicinity of the leak; (*j*) make a careful examination of all compartments adjoining the damaged one to search out leaks.

Familiarity with the details of the ship is an absolute essential to the successful dealing with damage control. The perforation of bulkheads and decks by ventilating pipes, voice tubes, etc., makes it necessary that great care be exercised to see that water does not make its way through the injured to adjacent compartments. Drainage systems are often damaged, great caution is required in operating the suction valves of the main drain.

Ordinarily a watertight bulkhead or deck will hold, even though it leaks, unless it has been damaged structurally.

The drilling of small holes in watertight bulkheads, decks, etc., and then allowing them to remain nonwatertight or failure to replace deteriorated gaskets and faulty dogs is a flagrant neglect of duty.

The transfer of oil or water in counterflooding and the use of collision mats, backed by the shoring of bulkheads, plating or decks, pumping out and the stop-

page of leaks are the most common methods of damage control. *Counterflooding* is very important. The pumping out of wing tanks which cannot be pumped dry with resultant free surface liquid is frequently a dangerous procedure.

When a bilged compartment is in free communication with the exterior water, it may be considered as a part subtracted out of the ship at the waterline. A compartment fully flooded (with no free surface) is considered as so much dead weight. Its effect upon the vessel may be easily computed by locating its center of gravity and by simple formula find how much the added weight changes the position of the center of gravity of the vessel. However, if a compartment is flooded but not wholly, which presents free surface liquid, a material upsetting moment results. Such a condition is the most dangerous to be dealt with in bilging problems. In this case it will doubtless prove most desirable to completely fill the compartment, even by increasing the draft of the ship, if such procedure is possible.

In addition to collision mats, the following items will come in handy to check the inflow of water: Wooden wedges, various shaped wooden plugs covered by canvas and sheet lead, shoring timbers, calking tools and materials, and emergency mats made up of mattresses, blankets, etc. Auxiliary lighting such as flashlights lanterns, etc., should be kept available.

During war time, arrangements should be made for the closing of all openings, including watertight doors, and for the shutting down of ventilation systems in case of gas attack. Several men, in addition to the carpenter, should be trained in taking compartment soundings and be able to do so without electric lights.

Flooding of the vessel as a result of damage causes the following changes: (*a*) Vessel lists, (*b*) change of trim, (*c*) mean draft increases. If the damage allows water to enter the boiler or machinery spaces a complete breakdown may result.

NEW VESSEL—DAMAGE CONTROL

402. In order to counteract that wellbeing feeling so often prevalent, "Oh! everything is all right—nothing will happen", and to impress the fact that even a new vessel does have occasions to exercise damage control, the following account, generously furnished by the Italian Line, in keeping with a request, concerning the maiden voyage of their splendid liner the steamship *Conte di Savoia*, is given. It should be realized that passenger vessels desire to release no information which may have the least deterent reaction on passenger travel and that this information is furnished for official use of Coast Guard personnel only.

While on her maiden voyage, the steamship *Conte di Savoia*, a few days before arriving in New York, an intake valve located at the ship's side suddenly fractured, causing the partial flooding of the dynamo room which contains two 850-kilowatt Diesel-driven generators mounted on the tank top and four turbo-driven generators fitted at a higher elevation. The valve in question is the inlet for the circulating water of the turbo generators' auxiliary condenser. The sudden burst of water caused a slight list and the 2 turbogenerators and the 1 Diesel generator located on the lower side, together with their cables and wiring, experienced considerable damage.

The inflow of water was temporarily stopped by inserting a wooden plug and rag packing from the outside, after which a cement box, reinforced with metal was hastily built around the damaged valve in the dynamo room.

The body of the valve in question was of cast iron and has since been substituted with others of extra heavy steel. The fractured valve was of the stop-lift check type, heavily loaded with a lead weight and it is thought that the constant hammering may be accountable for the damage.

To illustrate the forceful, original, and intelligent handling of an emergency, the following incident is related:

DAMAGE CONTROL—FLOODING (By Commander F. A. Zeusler, U. S. C. G.)

403. As far as the *Snohomish* incident is concerned, I was rather dubious whether this action would save the ship. In this connection I wish to state that the vessel was somewhat different in trim than now, for at that time the wardroom ports were still above water, it being possible at times to open them for air. With that in mind I should be pleased to relate the incident with reference to that near accident. The *Snohomish* had left Seattle with stores of all kinds, including some lumber, which was secured on the fantail. Just about the time we arrived off Port Angeles, an SOS was received. A southwest gale was blowing, making a rather nasty slop in the Straits. When we were off Waadah Island, Neah Bay, the *Snohomish* dipped three times in the heavy seas that were running. Our speed, I should judge, was about 12 knots. On the second dip and rebound the fantail took a sea, which cast adrift all lumber and the grating. One piece of lumber was caught between the bitts and after freeing port on the starboard side and with the third dip filled up everything aft, the planks jamming the freeing port and holding the water on deck. The *Snohomish* took a 30° list. The starboard rail from the fantail to the break of the forecastle was approximately 1 foot under water. We tried to right her by left full rudder, full speed, getting wind and sea on the starboard bow, but of no avail. We attempted to swing out the port boats, but could not. As a last resort I received permission to force open the starboard wardroom door. As soon as that door was open there was a rush of water filling the wardroom waist high with water, the

magazine flooded, drained into the bilge, and was pumped out by the bilge pump. The ship righted itself instantly. We proceeded into Neah Bay and restowed what was left and went to sea. I for one would not recommend this procedure, except as a last resort, but I felt it was the only possible way in which we could right the vessel under existing conditions.

MANNING—DAMAGE CONTROL (By Commander J. C. Cantwell (retired) U. S. C. G.)

404. (An account of the grounding of the cutter *Manning* on an uncharted pinnacle rock in Prince William Sound, Alaska, and the measures taken to repair the damage sustained to such an extent as would make it possible to proceed to Valdez, Alaska, after she had been floated from the rock by the tide, where a cement inner bottom was put in the vessel while in the water, and of her subsequent safe passage to Seattle, Wash., under her own steam.)

In order that a study of the problems confronting the officers of the *Manning* at the time of the accident may be made, the following facts are recited.

The *Manning* was what is known as a composite-built ship, having a steel frame with a wooden plank sheathing covering the lower part of the hull and extending upward to a distance of about 3 feet above the waterline.

At the time she struck the rock she was proceeding at a rate of about 11 knots per hour.

When she stopped, she lifted about 3 feet out of the water and careened about 30° to port.

The rock was situated about 2½ miles from the nearest land, uninhabited.

There was a minimum depth of 45 fathoms in the immediate vicinity of the rock.

The weather was clear, the sea smooth, and the tide was just turning to flood. The range of tides in this locality is an average of 12 feet from mean low water to mean high water.

The adjacent shores are all too steep and there are no flat beaches upon which to place a vessel if that had been deemed advisable after she had been freed from the rock.

In the position the vessel lay, it was impossible to lower the starboard boats, thus reducing the number of boats to be used for embarkation purposes.

In addition to the regular ship's company there were on board about 50 Japanese sealers who were being taken to Valdez for trial for illicit sealing.

It was estimated that there would be an interval of about 2 hours from the time the vessel grounded to that when she would be water-borne by the incoming tide. In other words, whatever was done to prevent the ship from sinking when she lifted from the rock must be accomplished within 2 hours.

An examination of the hull in the wake of the damaged portion disclosed the fact that the bottom planking had been stripped, broken, and splintered and the bilge strake plating forced up between the I-beams for a longitudinal distance of about 30 feet and a lateral distance of about 6 feet on the starboard side and to a less extent in the same area on the port side, under the fireroom space. The hull had been pierced in many places and the water entered so freely that it was seen at once that unless something could be done to check the inflow of water the pumps could not control it and the ship would sink when she lifted from the rock.

With these conditions confronting us, the following things had to be accomplished in the space of 2 hours if the ship was to be saved from sinking:

(*a*) Repair the damaged section of the hull sufficiently to enable us to proceed to Valdez, 60 miles distant, the nearest point where any other repairs could be made.

(*b*) Land the prisoners, both from the standpoint of humanity and also to provide more space in the boats for the ship's company in case of the necessity of abandoning ship.

(*c*) Secure all records, instruments, etc., and see that each boat was properly supplied with food and water to last until we could reach Valdez in case of necessity.

(*d*) Get collision mat in place.

(*e*) Make a raft to support the members of the ship's company in the event the ship would sink before we could get the starboard boats out, or the port boats used in landing the Japanese would not be able to make the round trip to shore in time to render assistance.

With reference to (*a*), Chief Engineer W. E. Maccoun requested that everybody who could be spared from deck be sent below to assist in the work of making a stop-water over the damaged portion of the hull. This was done. Under his directions everything available in the way of material which could be thrown into the spaces between the floors in the wake of the damage was collected and packed into the spaces as tightly as possible. Then the floor boards of the coal bunkers were torn up and sawed into lengths made to fit fore-and-aft between the floors and wedged into place under the reverse frame angles. For this purpose bedding, oakum, waste, clothing, ashes, cinders, and anything else that could be used were packed into the spaces, and so well was the job done that when the ship floated off the rock, Maccoun reported to the commanding officer that the pumps could hold her afloat if we proceeded slowly.

With reference to (*b*), the prisoners were mustered in the port gangway and the port boats lowered into the water. There were four boats available, whaleboat, sailing launch, otter boat, and dinghy. Under perfect control and with no confusion the Japanese were embarked in these boats and in charge of six members of the crew were landed on an island about

2½ miles from the ship. They were left there with a supply of food and water, the usual emergency kit in each boat being put on shore for their use in case of necessity. The boats then returned to the ship, the six men pulling one boat and towing the others and arrived back at the ship in about an hour and three-quarters, a few minutes before she floated from the rock.

With reference to (*c*), the navigating officer, Lt. W. H. Shea, secured all the ship's records, charts of the region, instruments, etc., and placed them in the starboard boats, and saw that each boat was properly supplied with food and water for emergencies and reported their condition to the commanding officer.

With reference to (*d*) Lieutenant Joynes, the executive officer, assisted by the boatswain and others available, stripped the boat davits of their strongbacks and with these as frames and with the addition of oars, boat-water breakers, and life preservers, constructed two rafts and had them raised on the rails aft in a position where they would float clear in case of the sinking of the ship. This work was well done and might have been the means of saving the ship's company in the event of there being a shortage of boats.

With reference to (*e*), to get the collision mat overboard and in place amidships, it was necessary to put the mat over the bow and work it aft by means of the hauling lines, but it could not be gotten in place over the damaged portion of the hull until the vessel floated. Difficulty was experienced in sinking the mat owing to the fact that the mat was thrummed with manila yarns and these were so buoyant that the mat would not sink until it had become thoroughly waterlogged. In order to overcome this difficulty it is suggested that in all cases the lower edge of the mat should either be weighted with spare grate bars, small anchors, or sounding leads, or else the roping on the lower edge of the mat should be leaded. If this idea had been carried out at the time, no difficulty would have been had in sinking the mat. However, this was a matter that did not occur to us until it was too late to be acted upon and in consequence, we had considerable trouble in handling the mat to best advantage. These suggestions are included in these remarks simply as a guide for any future operation in placing a collision mat over a damaged portion of the hull of a ship below the waterline. In spite of the difficulty referred to, the mat was finally placed in position over that portion of the hull which had sustained the greatest damage and undoubtedly was of material assistance in checking the inflow of water when the ship floated.

After the ship floated, an interval of half an hour was spent in ascertaining whether the repairs which had been made were of such character as to warrant proceeding, and at the end of this period the chief engineer reported that in his opinion we could safely proceed at half speed to our port of destination, Valdez. Thereupon the boats were dispatched for the Japanese prisoners and upon their return to the ship we steamed ahead slowly and arrived safely at Valdez, a distance of about 60 miles, in about 8 hours. The prisoners were turned over to the custody of the deputy marshal at that place and we then sought a place where the ship could be anchored in safety while the major repairs, hereafter described, could be undertaken. Fortunately we had on a former occasion visited in small boats a small cove located near Fort Liscom on Valdez Bay, and as it was the only place known on the bay where the water was shoal enough to at least prevent the vessel from sinking out of sight in case our attempts to repair the hull should prove unsuccessful, we cast off from the wharf at Valdez and steamed across the bay for this cove. Arriving at the entrance it at first seemed impossible to maneuver the vessel through the narrow entrance, but this was finally accomplished and she was brought to anchor in about 6 fathoms, the tide being about one-half flood.

So ended the first phase of the matter of repairs to the ship. It is only just to say that except for the admirable discipline displayed by all hands, which includes the Japanese prisoners, the freedom from anything approaching panic or hysteria, the quiet, efficient, and prompt obedience to every order as it was issued, was what saved the ship. Without such coordination of effort it is probable that she would have sunk in deep water when she floated from the rock, with a possible loss of many of her personnel.

After the *Manning* had been brought into Swansport (the local name of the cove near Fort Liscom) and anchored, a further examination of the damaged portion of the hull was made and it was decided that an attempt should be made to remove the temporary repairs and replace the material with a solid cement inner bottom. Fortunately for the purposes of carrying out this plan, there was available at Valdez a large quantity of cement and sand which had been imported for the use of the Valdez Yukon Railway, a project which was later abandoned, but the material for construction had been left in storage at Valdez. Permission to use as much of this as might be necessary was readily obtained and this enabled us to go ahead with the work without further delay.

The plan of operations was unique. There had been no precedent in the history of salvaging a damaged ship while in the water by the method which was now being tried, but under the skillful guidance and superintendence of Chief Engineer Maccoun the temporary stop-water was removed by section and replaced by cement rubble, completely filling up the spaces between the floors of the damaged portion of the hull until the whole area had been covered. Before the cement hardened the lengths of floor boards were again

wedged under the upper floor angles and the job was completed.

It took about 2 weeks to finish the work, and after an interval of 10 days to allow the cement to harden, the vessel was taken out of the cove and headed down the bay to where she could be exposed to the action of the sea, in order to ascertain whether or not the cement bottom would stand up under the ordinary conditions of cruising in open water. After a day's observation, no weakening or breaking down of the filling having developed, we returned to port and notified the Department by telegraph that the repairs were completed and that we awaited further orders. A reply was received stating that if in the judgment of the commanding officer the vessel could safely be brought to Seattle, to proceed to that port either direct or by way of the island passages of Alaska. If an escort was desired a vessel would be dispatched to act in that capacity. The Department was notified that no escort was deemed necessary and we thereupon left for Seattle under our own steam and arrived there safely without mishap of any kind, and placed the ship in drydock at Quartermaster Harbor.

While it is true that every officer and man attached to the *Manning* at this time acquitted himself in a way to earn the admiration and respect of the commanding officer, it is only just to say that the chief responsibility for the adoption of a plan of ooperations and the successful issue of these plans was borne by Chief Engineer Maccoun, and it is now as it was at that time my considered opinion that his actions throughout are without parallel in the annals of this or any other service. I consider that he is entitled to the credit for having saved the ship and possibly the entire command from death. In this respect I do not ask for any personal recognition of any particular display of ingenuity, performance of duty, or courage under most extraordinary circumstances, as none is due, but I do think that every other officer and man of the command at that time deserves to be always remembered and respected by his fellow officers and shipmates as having performed the duties assigned him in a manner most satisfactory and in accordance with the best traditions of the Service. The officers attached to the *Manning* at the time of the accident were: Capt. J. C. Cantwell, commanding; First Lt. W. W. Joynes, executive officer; Chief Engineer W. E. Maccoun; Second Lt. W. H. Shea, navigating officer; Lts. Austin and Rideout, watch officers; and G. W. David, assistant engineer.

The following remarks are added by Capt. (E) W. E. Maccoun:

"There was considerable water entering the ship where the planking was splintered at various places in the fireroom bilges. In order to stop the flow of water so that the concrete between floors would not wash out before hardening, cement was placed in gunny sacks, the sacks about three-fourths filled, so that the cement could squash as desired in the sack, and the mouth of the sack closed. The sacks thus prepared were laid flat on the bottom planking between the floors where the water was entering and where the planking was broken upwards and splintered. Pieces of 3 by 12-inch planking were sawed to go fore and aft between the floors and placed on top of the sacks. These blocks were shored down from the reverse bars so as to stop the leaks. The bilges of damaged sections were then filled with concrete, care being taken that the concrete was packed under the flange of the reverse bar on each floor so that the cement block would be held down. At the location of the worst break in the hull planking a piece of ½-inch sheet steel was bolted over the top of the floor bars before filling the section with concrete and packing it under the backing plate.

"It is desired to state that all the work of fitting the blocks and shores to keep the bags of cement against the leaks was performed personally by Mr. Penner, the able warrant carpenter of the *Manning*, and that Mr. Penner should have received credit for proper execution of the most difficult part of the work.

"On the run to Seattle the vessel only proceeded a short distance by the inside passage when it was necessary to go outside on account of foggy weather."

THE LOSS OF THE TAHOMA (Figs. 121, 122)

405. The following story of the loss of the cutter *Tahoma* by stranding on an uncharted reef on the south side of the Aleutian Islands, Alaska, in latitude 51°53′ N., and longitude 175°53′ E., on September 20, 1914, is included in this treatise mainly because of the graphic lesson it carries which cannot fail to impress officers to be on their constant guard for the unexpected emergency to arise and to better be able to deal with such untoward happenings when they are finally met. If the article will urge officers even to keep their boats and boat equipment in first-class condition, the space devoted to the case will not be wasted. However, the moral of the occurrence goes much deeper than that.

Extracts are quoted from the account as recorded by the commanding officer of the ill-fated cutter, Capt. R. O. Crisp, now a retired commodore.

"We were sitting in my cabin the night before we left Unalaska on the last voyage, when the United States deputy marshal asked me what my rule was in the navigation of Alaskan waters. I replied that I had only one rule and that was to be *careful*. Asking me if there was anything more, I replied that it was necessary to be *still more careful*.

"The vessel took a departure from Dog Cape and headed down for Amchitka on course ESE. * * * At about 9 p. m., I felt the vessel graze the bottom. I knew that feeling, because I remembered how we went ashore while drifting off the northeast end of St. Paul Island on the *McCulloch* in 1906. I grabbed

my cap, and rushed up the steps leading to the spar deck, but before I got to the deck I heard the backing signals to the engine, and immediately afterward heard the most dreadful and agonizing sounds as the ship hurled herself on the reef. Imagine all the windows in the Woolworth Building breaking out at once and falling to the street, with a fearful crash. That is what it sounded like to me. The call of the boatswain: 'All hands prepare to abandon ship', I heard above all of this din. I could hardly walk the decks; the pounding and jumping of the ship swaying me from side to side. However, I kept my wits about me, and knowing that the sea was smooth and there was no wind, I at once countermanded the order for the boats. * * * I gave hurried directions that the boats be lowered to the rail only, outfitted there, griped in, and then to await further orders.

"The engines were backing full speed; the way of the ship was stopped; the *Tahoma* was jumping about on the pinnacle rocks like a pea on a hot griddle, and no land in sight nearby. I gave orders to turn on the searchlight to see what we had struck. It lasted long enough for me to see the sea covered with kelp, and note a small breaker (hardly a breaker, but a wash over the reef) * * *. Soundings showed that the ship was reef-locked. Soon the pounding of the vessel fractured the supports of the searchlight and put it out of commission. The main steam-pipe in the engine room pulled loose from the bulkhead flange, causing a bad leak and I feared if further efforts were made to release the vessel it would pull out altogether and scald the engineer's force to death. The rudder was disabled, with both hand and steam gear out of commission. Water gained rapidly in all compartments and all pumps were broken but the circulator. On account of the broken feed pump water could not be put in the boiler fast enough to provide more than slow speed."

"I want to say in passing that had we passed this spot in daylight, the officer of the deck and the quartermaster on watch would have certainly seen the kelp, which shows like a black patch on the sea. And furthermore, had the coal not been short, and our speed limited we would have safely passed these reefs in daylight.

"The *Tahoma* took the bottom with her starboard waist in water, her spar deck listed 45°, her stem down and near the water, and her poop high in the air. * * * I now saw that the case was hopeless, and that it was not possible to release the *Tahoma* from this nest of pinnacle rocks on which she had crashed. When the vessel first took the reef, an SOS was sent out containing her position, with the further information that if I found it necessary to abandon her that we would proceed to a rendezvous in MacDonald Bay in Agattu Island about 120 miles away. My reason for not attempting to reach Buldir was because of the fact that it was 30 miles or more off; that the chart reported tide bores to the south of it; that it was a very small island; that in the conditions then prevailing we might row or sail past it into the Bering Sea and get lost there. My reason for assigning MacDonald Bay as the rendezvous, was because of the islands of Attu and Agattu, stretching across the western course, presented a side of from 20 to 30 miles to steer for, and I knew of no dangers on that course as we had just come that way.

"Meanwhile, other radiograms were sent out to the patrol commander at Unalaska, and we received in reply messages from him. In one of them he stated that the Japanese steamship *Tacoma Maru*, was only a few miles away from us and that he had communicated with her, asking her assistance. Also, that he had communicated with other ships at or near Unalaska, and had asked their assistance. The water continued to rise rapidly and it was about midnight that the fires had to be drawn. * * * Had there been a good rise of the tide at our position, perhaps the *Tahoma* might have been floated before she filled with water. But what to do then? Our pumps' foundations were broken, and we could not keep the ship free, and she would have sunk in deep water if we took her off the reef. A word or two about this reef which was uncharted. It was about a mile in diameter, and we struck the middle of it. At daylight the next morning, I observed kelp all around the ship for a distance of at least a quarter of a mile. Seeing was very poor, a light fog and mist being around the ship. * * * I want to say that had there been a storm on when the *Tahoma* struck the reef, not a soul would have lived to tell the tale.

"The sea still continued calm and there was no wind. We were waiting the arrival of the *Tacoma Maru* which I believed would arrive some time in the afternoon. Our effects had been placed on deck and on the bridge, where we hoped they would be easy of access to the rescuing ship; the boats were fully provisioned and supplied for abandoning ship; every thing that I could do or that had been suggested had been done and we now awaited rescue. But it was not to be. I learned sometime afterward that the *Tacoma Maru*, was indeed on her way to Japan along the great circle route, but that in getting the SOS, her master feared it was a "ruse de guerre" on the part of a German war squadron then, as he supposed, somewhere in the Pacific. Meanwhile the ship continued to fill with water and fearing that she would roll on her side, I called a muster of the officers and the crew and told them that I was going to abandon the ship in our boats, but that we would hang on to the *Tahoma* until the last possible minute as I was expecting the Japanese steamer to come to our assistance shortly. I bade them all to be of good cheer, and to get ready for the boats, every man, woman, and child on board knowing exactly where his or her boat was. All of the boats were then lowered and made

fast with their painters to a small hawser payed out over the stern, with a long spar attached at right angles by a span. I, as commanding officer, as customary, was the last person to leave the ship. The boats laid in this position for perhaps an hour, but I had noticed that not only had the ship rolled over on her side, her spar deck being at a slant of 20°, but that the wind and sea were increasing, and several breakers appeared on the reef.

"I turned to Mr. Molloy, whose boat was alongside of mine, and said: 'Mr. Molloy, I do not like the looks of the weather. We have got to get away from here and that quickly. See how the breakers are increasing on the reef, and we can't afford to stay a minute longer on this reef.' He at once agreed with me and I told him to give the order to shove off and to make the best of our way to MacDonald Bay, keeping together if that were possible. We shoved off, but I waited a minute or so to take a man from another of our boats which appeared to be crowded. I saw the ensign from the *Tahoma's* taffrail flagstaff; saluted it for the last time and got out the oars. We had considerable difficulty in rowing across the reef, and avoiding the breakers, our oars being caught frequently in the kelp floating on the surface. Finally we got off as it was growing dark, and I observed several of our boats making sail. However, when my boat got off the reef, I found it not possible to make the course of WNW. ½ W. by sail, and turned the men to the oars. They pulled lustily all night long, and I was considerably encouraged to find that the wind did not increase from a gentle breeze. It was the coming of a sudden storm that I most feared for the safety of my crew in those small boats. Coming off the reef under the conditions I have mentioned, separated most of the boats, but three of them managed to keep together, as I afterward learned. I steered the boat by a small boat compass fastened in the cockpit. * * *

"I did not sleep at all that night, nor had I slept the night before, nor did I sleep while in the gig, excepting for a nap hastily snatched the night before we were picked up. At daylight on the following morning, someone suggested that we have some crackers and water, which had been stowed under the supervision of the ship's carpenter, Mr. Russell, in the cockpit aft with a chronometer and a chart of that region to navigate by. Accordingly the canvas flap was lifted, but to my surprise there I saw two of the ship's rifles stowed right under the compass. Here then was the reason that we could not make sail the afternoon before when I had tried to do so. I sent the rifles forward, the boat being headed in the same general direction as before. I noted that there was a difference in the compass readings of about 40° or more and that instead of being headed for Agattu island we had been steering down toward Honolulu. This had to be rectified. I made a quick estimate of the southing we had made and altered the course to northwest in order to get back on the line to MacDonald Bay. This was much to be regretted and explains why my boat did not make the land as did all of the others, but was picked up at sea. But I have noticed that when a small calamity follows a big one, that you do not rail at it, but accept it as a matter of course. * * *

"We had breakfast and I was pleased to note that among our stores of hardtack and water, my steward had added some canned Swiss milk, which I thought at that time was the best milk I ever tasted. * * * During the 5 days and 5 nights the gig was at sea, considerable good weather was experienced. At times it was necessary to heave to riding to a drogue made up of boat spars and canvas with an oil bag made fast to the painter. It was necessary to bail a great deal. * * * The albatross, and the gulls seemed to know of our peril, and wheeling about us looked down with the idea of making a meal soon. Our situation was full of peril. I did not know but the next wave would swamp the gig. I looked for my revolver not intending to drown if I could help it, but I had sent it in the bow with the rifles. Thick weather and weather of low visibility without the aid of sights made the searching of land a severe trial." * * *

Their rescue was effected about 10 miles off Agattu Island by the Steamship *Cordova*, Capt. Thomas Moore, which had proceeded in answer to the SOS the great distance from Nome, Alaska. * * *

"I took a look and sure enough I made out a steamer's light. A rocket was at once fired into the air, then another as the steamer did not answer at once. Finally her searchlight was thrown high in the heavens, and we knew that we were saved. Every one now took this as a matter of course and while we congratulated each other there was no hilarity or boisterous manifestations. We hauled in the sea anchor, hoisted sail with our lantern at the mast-head and ran down to the steamer, which had altered her course and was standing for us. One of the men said: "Captain, can we have some more water now?" They had been on short allowance for several days. They broached the water keg and all hands had all they wanted." * * * As the *Cordova* approached MacDonald Bay, soon one of my boats appeared. It was the dinghy with about eight men in her of our crew. The coxswain in charge told me that our whale boat was on the south side of Agattu, with Lieutenant Scammell and about 14 men. I asked him how he knew this. He said that a party from the whaleboat had walked overland the day before, to see if any of our boats had landed there, and told him. Hoisting in the dinghy, we got underway, and steamed around Dog Cape, a distance of 30 miles, more or less, and in the afternoon, picked up Lieutenant Scammell's party. He had narrowly missed going by Agattu Island, but had seen the land in time.

"After passing through Agaitu Pass, on one of the small Alaid Islands bright flames at night directed us to Lieutenant Hutson's party in the sailing launch."

The executive officer, Lieutenant Molloy, Lieutenant Yeandle, and men in the other boat and the large dory; in all, about 40 persons were found by the Coast and Geodetic Survey steamer *Patterson* after the *Cordova* was forced to Akutan owing to fuel oil shortage.

The commanding officer had been ordered upon his return eastward to proceed on the south side of the Aleutian chain. *This was at the time unusual.* No blame was attached to the vessel's loss.

Commander S. S. Yeandle, in speaking of the *Tahoma* wreck, which occurred from stranding on the south side of the Aleutian chain to the westward of Unalaska, Alaska, says: "The outstanding thing in connection with the loss of the *Tahoma* was the searchlight standards snapping with the shock of impact. The generators were fastened to the ship's frames and were immediately thrown out of line. I believe this is bad practice in our ships."

DAMAGE TO THE HERNDON

406. Commander C. G. Roemer, who was in command of the Coast Guard destroyer *Herndon* when she was in a severe collision in a fog with the steamship *Lemuel Burrowes*, states: "We were struck on the port bow and torn wide open for a distance of about 25 feet, and were kept afloat by the watertight bulkhead separating the 2 firerooms. All parts of the *Herndon* forward of this bulkhead were flooded and consequently *if the bulkhead door had not been closed, or was in poor condition*, the sea water would have entered the after fireroom, destroyed her buoyancy, and caused her to sink. Everyone kept his head, which I believe is the main thing at such a time. One small watertight door in proper working condition saved scores of lives and a valuable ship."

APPLICABILITY OF THE "GENERAL PRUDENTIAL RULE" (By Capt. H. H. Wolf (R.), U. S. C. G.)

407. "Experience of practice ship *Chase*, spring of 1897. Lesson: Applicability of the 'general prudential rule' in rules of the road where there is any doubt as to the proper lookout on a crossing vessel over which you have the right-of-way.

"The *Chase* was heading offshore off the Carolina coast in the midwatch, close hauled on the port tack. A sailing vessel was sighted coming down wind three or four points on the *Chase's* port bow. Flares were burned to warn the approaching vessel, the *Chase* holding her course until it was apparent that the vessel, which was also holding her course, would cut the *Chase* down, when the officer-of-the-deck luffed sharply to bring her bow in contact with that of the other vessel. The collision occurred with the stem of the *Chase* crashing into the stranger's bow at about the starboard cathead. The *Chase* was badly wrecked forward, and lost some top hamper, but remained afloat and by good seamanship was sailed to Charleston Harbor 3 days later. Ineffective or no lookout on the approaching vessel was probably responsible for her failure to give way as provided by the rules."

FLOODING OF THE KICKAPOO (By Capt. R. C. Weightman, U. S. C. G.)

408. A case of damage control I can recall being concerned with occurred on the *Kickapoo*. The main hold filled up with water from a leaking sea valve and there was no suction in the compartment. We drilled a couple of inch holes through the forward bulkhead, letting the water run into the next compartment, where the ship's pump could work on it.

FLOODING—SNOHOMISH

409. On an occasion observed by the writer, the *Snohomish* was brought out of a precarious situation. During a storm off the coast of Washington the commanding and engineering officers were called during the mid-watch with the announcement that the engine and firerooms were flooded and the vessel in danger of sinking. A quick survey disclosed that as the result of the ash hopper cover cracking, sea water entered through the ash-ejector line (see steamship *Vestris* case), had flooded up to the point that the fires under the boilers were nearly out and steam pressure was practically nil. A rocky lee shore lay 2 miles away. Owing to the stormy sea and motion of the vessel, it was realized that to put the collision mat in place over the ash-ejector outlet in the hull, where the water was entering, would be only a last resort. A cone-shaped wooden plug, its widest diameter somewhat larger than the ash-ejector outlet, was built up by means of canvas and sheet lead. A volunteer, Chief Boatswain's Mate Niels Eliason, wearing a life jacket, went over the side on a life line secured below his shoulders. By heroic work in the slashing seaway he finally succeeded in inserting the jury plug in the outlet, at which time a second man drove it home with a maul. The bilge drain lines of the engine and fire rooms being clogged with fine coal, it was necessary to use all hands on a bucket line to free the ship of water. Steam was regained and ashes hove by man power. Investigation disclosed that the engineer watch had grossly erred in failing to notify the engineer officer that an emergency had arisen, instead of vainly attempting to correct conditions until they got beyond his control. Had the chief petty officer of the watch notified his seniors in time it is reasonable to assume that a jury cover, or lid, could have been rigged for the ash hopper, shoring it from the deck overhead, or a large ball of oakum been driven from inboard into the orifice of the ash discharge line.

DANGER IN ASSISTING STRANDED VESSELS

409 (a). To impress officers of the deck with their grave responsibilities for the safety of vessels, two experiences, both of which occurred when assisting stranded vessels, are cited.

In the first case the cutter was made fast alongside a large freighter which was ashore forward with bow compartments punctured by jagged rocks. Between operations and during a period of awaiting another high water, the commanding officer was obtaining some much needed rest. Suddenly with a swing of the tide the freighter's stern swung around, as she pivoted on the rocks forward, and the cutter was forced on the rocks alongside. The commanding officer was immediately notified, and having previously studied the soundings of the operations area, he promptly backed the cutter off before the tide fell away. Had he been uncertain of local soundings or had a delay incident to the passing of a dip rope been required, the cutter would, as the result of a big fall in tide, have been stranded.

The other case occurred when the commanding officer, in between efforts to pull a large freighter off the beach, cautioned and warned the officer-of-the-deck to keep an especial lookout to see that a change in the cutter's position swinging with the tide did not allow the 12-inch line, which ran from the stern of the cutter to the freighter, to slacken and get in the wheel. In spite of the precaution, the line was allowed to get in the wheel and only by arduous and prompt work was it cleared.

Steel towing hawsers, at least when not used in connection with a towing engine, are of questionable value. In using them in slacking out and taking in on the line, men's lives are constantly in danger. An incident occurred on a cutter which will carry its own point—a large passenger and freight vessel, the *Lurline*, was ashore in Puget Sound. In order to be able to "jump" on the tow line, two parts of the wire hawser were run from the towing bitts of the cutter to the stern of the *Lurline* and as a matter of expediency, owing to the nearness of high water, the bight was made fast to the cutter's towing bitts. In order to hold the cutter's bow up to the tide the starboard anchor had been planted well ahead. As the tide changed the cutter was caught with the strong current on the beam and given such a deep list that hacksaws were about to be brought into play to cut the lines when the stranded vessel finally answered the request to let go both ends of the wire hawser.

FIRE ON AMMEN

410. A case of damage at sea observed was on the destroyer *Ammen*. The fuel-oil line burst at a point near the firebox. Flames so quickly spread that the fire room force were obliged to flee without being able to shut off the fuel pumps which forced oil, under high pressure, out on the floor plates. The entire fireroom was very soon a raging furnace and by the time the fire alarm was sounded the main deck plates, immediately over the fire room, were red hot. Either the deck remote-control steam-smothering valves had not been worked as often as required, or else the heat caused them to jam. With 1,200-gallon tanks of fuel oil on each side of the fireroom, the situation was serious. All life boats were nested in the danger area. The red-hot decks and the condition of the sea militated against lowering the boats. The fireroom had been promptly sealed up and efforts were continued to flood it by steam. The crew was divided up, one-half by the two life rafts on either side of the bridge and the other half by the two rafts near the stern. The fireroom oil tanks were momentarily expected to blow up. The destroyer was well off shore, a moderate sea running, and the sea water cold. One of the steam valves was finally gotten into action. For the next 20 minutes, with intermittent explosion of accumulated oil in the bilges, all hands were on the anxious seat. When finally the fire was smothered out it was found that all fittings had been burned off the boilers and the steel gratings and ladders had been warped into all sorts of shapes. Had the destroyer been equipped with a hose connection, which could have been run from the after fireroom, to induce foamite or steam into the fire area, the situation could have been better controlled. The intermittent explosions of oil in the bilges prevented stack covers from being kept on. In spite of the fireroom being closed up tightly, sufficient oxygen was thus available to promote combustion.

FLOODING

411. In the case of a ship flooded as the result of damage, there is a transfer of the center of buoyancy from the initial position below the waterline to a higher position of equal volume above the waterline There is a greater loss in the metacentric height during the early stages of the flooding, as the result of free surface liquid, than when the maximum flooding is reached. Thus a maximum list is usually observed during the early period of flooding, which will decrease gradually as the bilged compartments fill completely. If there were ample initial stability and sufficient GM remains, the vessel will practically right itself; if not, counterflooding must be carried out. If, after maximum flooding, the ship does not at least retain a neutral metacentric height, she will capsize. During the period of flooding she may have even had negative GM, but that condition existed for a very short period. Counterflooding will correct negative GM to positive, but it is apt to be disastrous if attemped after maximum flooding.

In the case where the flooding is in a compartment which extends from one side to the other, less initial

GM is usually required than when there is unsymmetrical transverse flooding. Most cutters are provided with a comparatively high initial stability, or a *GM* great enough to provide a safe margin. Scant attention has been paid to the mathematical calculations pertaining to flooding for the reason that it is rarely possible to determine the exact extent of the damage and data relating thereto. A relative degree of safety is all that can ordinarily be sought.

It is most necessary for officers to acquaint themselves with the intimate details of a ship such as lead of pipe lines, and to supervise frequent working of steam smothering valves to insure that they do not freeze shut from lack of use, etc. Thought should be given to the method it would be necessary to employ in augmenting bilge suctions or a means to employ in the case of blocking or failure of drain lines. Portable steam hose should be accessible for replacing a smothering line which fails to operate and tools should be at hand to permit the cutting of a hole in bulkheads to enable the introduction of a smothering line into a sealed compartment on fire, or for draining a flooded compartment into another one which can be pumped out.

It is hard to believe, but it is a fact, that bilge suctions have been known to be so corroded through that they proved inoperative in case of emergency. The writer witnessed an actual case on a cutter.

COFFERDAM

412. To enable a cutter to proceed to a yard after receiving severe damage to a plate, not too far below the waterline, a cofferdam (fig. 124) may be constructed of sufficient size to enable a man to work inside it, after the water is pumped out. A large box with an open top and the side next to the ship open is constructed with its three inner edges which contact the ship conforming to the shape of the hull of that sector. A diver may obtain the exact curve or lines on wooden battens, or they may be obtained from the ship's plans. The upper end must extend above the waterline. The inner or bearing edges of the box are padded with canvas and oakum. The box, of strong construction, is calked tight with oakum or cotton and the outside seams are covered with heavy canvas, well soaked with paint. The cofferdam is then weighted and lowered into place where it is held in place by hogging lines and guys. As the water is pumped the force of the surrounding water pressure will gradually seat the cofferdam snugly against the ship's side. The box may be greatly assisted in working into place by reeving lines from the inner edges of the box through improvised hooks installed by a diver. Sawdust spread in the water outside of the cofferdam will, as it is forced into the crevices by the outside pressure, lodge and swell so as to prevent leaks.

COLLISION DRILL VARIATION (By Capt. Thomas Molloy, U. S. C. G.)

413. I have varied the collision drill on board ship to the extent of having the mat placed at different parts of the ship. Sometimes the mat was passed at the bow and then hauled along aft to amidships and even to the stern. This I believe good practice, no two placings of the mat to be near the same section of the ship. It is surprising how expert the crew can get in handling the collision mat clear of the many boats and other fixtures along the deck. It is also advisable to have two collision mats, one forward and one aft, and both used in every collision drill.

WATERTIGHTNESS

414. When a vessel leaves the builders' yard it can safely be assumed that every part of the watertight structure is, for all practical purposes, watertight. In an old ship it is a different story. Reliance is placed on the watertight subdivision to localize the flooding, losing the buoyancy of one or more compartments, rather than freeing the ship of water altogether. But assume that one of the bulkheads bounding this area is in the following condition: A voice-tube lead has been changed, and the original 4-inch hole was not blanked. A hatch stanchion stowage was also removed, and the four bolt holes remain. Various small leaks in the structure, doors, and vents will bring the total area to about 15 square inches. Further assuming a mean head of only 10 feet, water will enter at a rate of over 1,000 gallons per minute. This is rather a bad case, but it is not impossible, nor unheard of, as it should be. * * * A case is recorded where magazine spaces were flooded intentionally to prevent fire spreading to powder; the watertight integrity proved so poor that the flooding had to be discontinued to avoid serious consequences. (From Watertightness, by H. W. Pierce, former lieutenant (C. C.), U. S. Navy, in Naval Institute Proceedings, March 1931, by special permission.)

FORMULA FOR CALCULATING LEAKS

415. The quantity of water which will flow through a given orifice is expressed by—

$$Q=kAv=kA\sqrt{2gH}$$

in which—

k=coefficient of discharge
A=area of hole
H=static head
g=acceleration due to gravity

Example.—Using a coefficient of 0.9, and a head of 9 feet, and a hole 1 square foot in area; the quantity of water is found to be 9,500 gallons, per minute, or, in terms comparable with the displacement of ships, at the rate of 2,200 tons per hour. If this 1-foot hole is 25 feet below the water line, the rate will be found to

be 3,700 tons per hour. (Watertightness, by H. W. Pierce.)

WATERTIGHT DOORS

416. A watertight door dog is not an easy matter to fit and make tight without working unduly hard. However, it is no easy matter to polish one in place. On how many ships are these dogs frequently removed for cleaning, and how many times are they replaced with sufficient care and skill to make sure that every part is in place and reasonably tight? Are all drop bolts on hatches and watertight covers in place? Regardless of the condition of a rubber gasket, doors will not be remotely tight unless the knife edge is both clean and true. The easiest way to clean a knife edge is to use emery cloth, the coarser the quicker, but the result is usually a wavy edge after a short time. Frequent chalk tests on doors selected at random will indicate this condition. The knife edge is rubbed with chalk, and the door closed and dogs set up by hand as it would be in an emergency or regular use. On opening, the chalk transfer on the rubber gives a rough check on the efficiency of the door. And it frequently tells an interesting story. (Watertightness, by H. W. Pierce.)

FIRE DAMAGE CONTROL (By Capt. R. W. Dempwolf, U. S. C. G.)

417. In 1906, one of the large Luckenbach freighters came into the port of San Juan, P. R., with no. 4 hold on fire. The hold was filled with general cargo. The ship's crew were unable to control or put out the fire. While attached to the *Algonquin* and in temporary command, we proceeded alongside the *Luckenbach* and put out the fire in the hold by the following method. The ship's carpenter cut a 4-inch hole through the wooden deck and through the steel plating underneath the wooden deck in order that the *Algonquin's* fire hose could be placed through the hole and no. 4 hold flooded with water. By this simple method the hold was flooded and the fire put out in less than 2 hours' time.

THETIS IN THE ARCTIC—JURY REPAIRS INCIDENT TO DAMAGED RUDDERSTOCK (By Commander Le Roy Reinburg, U. S. C. G.)

418. I can cite an instance where the old *Thetis*, when I was aboard her in the Arctic, struck an iceberg, ran partly up on it, and then, in sliding back, struck her stern on another berg, causing the rudderstock to split. Of course, we could do very little with the rudderstock, but, through the ingenuity of those on board, wire tiller ropes were run from the steering engine over each quarter to the monkey tiller on the rudder. By this means, the *Thetis* was steered from a point off Wainwright, Alaska, back to Seattle, without any further damage. While stopping at Unalaska she was able to take on board 243 shipwrecked persons and transport them to Seattle. When this jury rig was completed, the helmsman at the wheel had no difficulty whatever in steering the ship, for the steering engine could be used the same as before and no inconvenience noted.

EMERGENCY DIVING APPARATUS (By Commander E. A. Coffin, U. S. C. G.)

419. The Coast Guard destroyer *Terry*, preparatory to sailing, in testing the engines had the misfortune to entangle the propeller in a steel cable which held a camel alongside. No diving suit being available, by the aid of a short length of hose with a funnel inserted in one end, the carpenter's mate, by placing the other end in his mouth maneuvered with his head about 4 feet under water. With a hack saw he got adrift the outer strands and then a relief worker, using the funnel apparatus, with the aid of a bolt cutter severed the cable. It was necessary to exercise care in loosening the steel cable for the reason that the camel was held under water by the shortened cable and would surge violently when released.

PRACTICAL CASES OF EMERGENT REPAIRS (By Commander J. E. Stika, U. S. C. G.)

420. The *Tuscarora* was ashore on a gently shoaling beach, boulder strewn, so that some rocks stuck through her bottom into the main hold to the extent of having started the seams by shearing the rivets. The crew filled the opened seams with burlap from the outside, using long poles from boats. The engineer's force installed a steam syphon in the manifold and pumped until the inside of the opened seams could be reached. Next soft pine wedges were driven into the opened seams to further stop the larger leaks. Then as most of the water was being kept out, reinforced concrete was worked over the damaged shell and split two-by-fours between frames through the limber and lightening holes in floors. The entire bilge was filled with cement and the whole covered with hatch covers over mattresses and then shored up to the overhead. Some pumping was necessary during the operation but the hydraulic cement set and the ship was floated, whereupon she operated under her own power until reaching drydock some hundreds of miles away.

The *Seneca's* scupper casting near the waterline in the engine room rusted through. Built a wood box around the faulty fitting and filled it with cement over wire winding. After it set, removed the wood. It was such a good job that the repair officer at the New York Navy Yard did not renew the fitting.

The *Seneca's* shell plating under the counter (between outside plating and cabin bathroom deck) rusted through. Closed it in with planking and filled the entire frame section with cement. This also was such a good piece of work that the Coast Guard representative at the New York Navy Yard would not touch it.

Seneca's wood weather deck leaking in many places. Calked where possible, also graving pieces. Then wet down several times a day so that entire deck remained reasonably tight.

The steel deck under the towing bitts of the *Roc* rusted out. Covered with wood and made somewhat watertight with roofing pitch. Did same to steering engine room deck to keep oil and condensed steam from running into wardroom.

Twisted the *Ossipee's* rudder stock (breaking ice in narrow channels) so that only 6° left rudder was possible. Disconnected the steering engine and steered by using relieving tackles on deck until arrival in port. Then disconnected quadrant, cut new offset keyway, replaced quadrant and completed winter cruising. (Rudder stock was renewed during summer.)

The *Ossipee* was allowed to lie on the bottom during falling tides while working in the St. Croix River, breaking ice. When the tide rose sufficiently resumed ice breaking and towing of coal schooners—several weeks' work—as several schooners were towed to St. Stephen (opposite Calais) during that one ice-bound winter. The main condenser would develop impaired circulation due to fish, sawdust left over from lumber milling days, and other foreign matter, being drawn into the tubes; connected wrecking pump and forced foreign matter out.

On the *Unalga* in southeastern Alaska during the winter of 1916–17 installed a wooden plug from the outside into the ash ejector discharge as the elbow there had erroded away. Also had a plug in bottom of the ship where a steam kelp clearing pipe to a strainer had rusted away.

Also had a boat smash in her bilge when gripes gave way during an iced-up period. All running rigging carried away by ice during the same icing up, also aerial; salvaged the wire after getting into Yakutat; restrung aerial after ice melted away.

The following case is related by Lt. Comdr. John Trebes, U. S. C. G.:

421. Shortly after the armistice of the World War, Mine Squadron 1 of the United States Atlantic Fleet was en route to Hampton Roads with homeward-bound pennants flying, having completed the task of laying 60,000 mines in the North Sea between Scotland and Norway.

A few minutes after dinner on Christmas Day, 1918, on the Grand Banks, the leading ship of the column was struck by a British freighter. As first lieutenant and head of the construction and repair department, I proceeded to my station at the scene of the collision. The port wing of the bridge was cut away; the second deck showed a mass of bent and broken piping with steam escaping in great volume; on the fourth deck the shell plating was pierced, and bent for a space of nine frames, with butt straps broken and rivets sheared off. The repair party reported promptly with tools, hammocks, mattresses, shores, etc., and after several hours' work, the inflow of water was effectively stopped. Constant drill under war conditions in the North Sea on this large mine layer had developed excellence on the part of the repair party; too much stress cannot be laid on using foresight in preparing for the unexpected emergency, which somehow, always happens.

SOFT PATCH (By Lt. Comdr. L. W. Perkins, U. S. C. G.)

422. In September 1926 when the *Seneca* was proceeding to Florida from New York for flood-relief duty, a leak developed in the hull, presumably under the athwartships coal bunker, which was then filled to full capacity with 90 tons of coal. Accordingly, the work incident to removing the coal was started. Shores were driven down in the center of the coal resting against the center longitudinal braces. The starboard side of the bunker was then cleared to the flooring. Upon removal of the flooring the leak was located about 3 feet from the keel and proved to be a hole caused by a defective plate. A soft pine plug was driven through the plating which only curled back and made the hole larger. An outside patch was made up by threading an 8-inch bolt throughout its length. A plate of ½-inch stock about 5 inches square was placed on this bolt and over that 5 layers of canvas smeared with white lead. This was hauled into place as follows: A bellyband was rigged under the ship, while a line weighted with a marlin spike was dropped through the hole in the hull. By carrying one end of the bellyband clear around the ship to the location of the other end, a loop was formed which, when hauled up to the rail, brought up the line attached to the marlin spike. The patch bolt was then thrown overboard and hauled into place. Four more layers of canvas and white lead were put on inside, then another piece of 5-inch square plating and finally the nut, which when set up, made an absolutely watertight patch. While the arrangement was very satisfactory in stopping the leak, an additional safeguard of a cement form was placed over the hole. Subsequently when the vessel was docked for repair it was found that this patch had proven entirely watertight.

FLOATING OF STOVE-IN VESSEL (By Lt. Comdr. L. W. Perkins, U. S. C. G.)

423. While on seal patrol with the *Unaiga*, April 1927, a halibut vessel was found stranded in Shakan Inlet, Alaska. Due to the extreme tides, the vessel had, at low tide, fallen on her beam ends with the hull punctured on a large pinnacle rock. Removal of all cargo did not provide for floating of the vessel at high tide due to the weight of the engine. Accordingly, 24 oil drums were borrowed from the Shakan cannery which were lashed to the hull of the vessel at low tide, which provided enough buoyancy to float the vessel at high tide and to clear the pinnacle.

The vessel was then hauled ashore on a sandy beach, where the hull could be repaired during low water.

COLLISION MAT (By Lt. Comdr. L. W. Perkins, U. S. C. G.)

424. After the ramming of the *Tallapoosa* by the *Malta Maru* in the Gulf of Mexico, September 11, 1923, the collision mat was rigged over the hole in the hull which was from the waterline to 4 feet below it, and the vessel was maneuvered approximately 110 miles with apparently no leakage.

TO ENCLOSE BROKEN AIRPORT OR OTHER OPENING FROM INSIDE (by Lt. Comdr. A. G. Hall, U. S. C. G.)

425. When it is necessary to close a broken airport or other opening from the inside, such a leak stopper as is shown in figure 47 (A) can be used. It is composed of a long threaded bolt, onto which are inserted the following parts in turn: A bar or strongback, which is inserted through the opening; a solid rubber disk; a circular wooden disk; a large washer; and a following-up nut to set the disks up tight on the inside.

When openings are ragged or so formed that the rubber disk is of no value, it can be left off and the wooden disk set up tight, after which its edges can be calked with oakum. All cutters should carry some such equipment for emergency.

LEAKY RIVETS (by Lt. Comdr. A. G. Hall, U. S. C. G.)

Leaky rivets may be stopped by opening bags of dry sawdust in contact with rivet heads. The sawdust will be drawn into the cracks and swell and may stop the leak temporarily. Bags may be placed under the ship's bottom by means of lines and opened by a slip hitch.

Leaks may be stopped by use of a hogging line with bundles of oakum made fast with split yarn every 18 inches, or blankets secured on a hogging line by corners and hauled under the bottom in vicinity of the leak.

QUICK HARDENING CEMENT WHICH SETS IN FIVE MINUTES; A MARVELOUS AID FOR DAMAGE CONTROL (by Machinist W. C. Dryden, U. S. C. G.)

426. "While cleaning bilges in the *Seminole*, a rivet came entirely out, leaving a ⅞-inch hole in the vessel's bottom 13 feet below the water line.

"A double handful of dry cement was mixed with one handful of sal soda, a tablespoonful of salt, and water. Hot water was used in working it into a stiff cement. It was then placed on a small board; the board was turned over and pressed over the hole in the bottom. The chief machinist's mate stood on the board for about 5 minutes, during which time the cement fully hardened. The patch remained intact until the next regular docking period.

"When using hydraulic cement in this manner it is necessary to work fast, as the mixture will become stone hard in a very few minutes. It acts quite like plaster of paris."

Of course, in the above instance a wooden plug could no doubt have been driven in, but the main thing is that there is such a quick-setting cement that may be used in damage cases. It is interesting to note that such a rivet hole 13 feet below the waterline would admit nearly 5,000 gallons of water per hour.

HOOK BOLT

427. Hook bolts, as shown in figure 47D, are used for securing plate patches. They are especially useful for securing to joggled edges of plates.

TUMBLER BOLT

428. A tumbler bolt, such as that shown in figure 47, leak stopper B, is used for securing patches in plating. It is of similar construction to the Colome's patent leak stopper, a description of which follows:

LEAK STOPPER, COLOME'S PATENT

429. This apparatus is composed of a steel rod, threaded on the inner part of its length. At its outer end there is pivoted an iron bar with one end slightly heavier than the other, so that when the rod is held in a horizontal position after being inserted through the ship's side the heavier end of the bar, as the result of the tumbler bolt, will drop down allowing it to stand in a vertical position, thus forming a strongback. An oval-shaped piece of sheet iron, each side of which is covered with a thick felt, followed by a conical-shaped bag filled with cellulose both with circular holes in their centers, is fitted over the bar on the inside of the ship and followed up by a large washer which is set up by a hand nut engaging the threads of the bar.

TOGGLE BOLT

430. A toggle bolt is shown in figure 47, leak stopper C. These toggle bolts can be used in securing a temporary patch or to replace a leaky rivet. A washer and grommet are inserted on the bolt and followed by a set-up nut.

BULB FRAME BAR AND CLAMP

431. In order to eliminate long shores in bracing damaged plating, a bar and clamp, similar to that shown in figure 47E can be used to good advantage for wedging a patch or support between the bar and the ship's shell or deck plating.

REPAIR METHOD APPLICABLE AT A DISTANCE FROM A YARD (by J. J. Dirschel, C. C. M., U. S. C. G.)

432. The U. S. S. *Philip*, destroyer, had a badly damaged plate in the bow. The berth deck was

flooded to a depth of about 3 feet, a free surface in communication with the exterior water. The ship came into the repair base, but was unable to go on the ways for replacing the strake. Temporary repairs were made in the following manner so that the ship could proceed without delay: Working in the 3 feet of water the damaged plate was removed, a template was made, and the rivet holes marked on it. From the template a plate was obtained from the yard. The under-water part of the plate with strips of thin sheet lead inserted between the seams was bolted in place by hand. A red-lead canvas water stop was inserted between the plate laps of the upper section of the plate which was cold driven riveted. The repair was made in such an efficient manner that the ship was not put on the ways until its regular drydocking period.

NOTE.—It is believed that cutters, at least on duty in Alaskan waters, should be equipped with an acetylene torch for dealing with emergent repairs and in working on wrecks. Normal requirements of cutters involve a considerable amount of brazing work and welding and much time and delay due to removal of parts can be saved as well as marked economy. The cost of a complete acetylene welding and burning outfit is in the neighborhood of $100.

EMERGENCY DRILLS

433. A good opportunity to test the efficiency of the carpenter's force to act quickly and efficiently in an emergency follows: At an opportune time during a collision drill or general quarters, if there is a badly cracked port-hole lens aboard the ship which needs replacing, and renewals are on hand, the lens can be knocked out by a blow and the battle port removed. Then send word to the carpenter or carpenter's mate, as the case may be, that a port lens and battle port have been carried away and the ship is taking water, and see how long it takes to satisfactorily cope with the emergency.

It is suggested that the monotony of emergency drills be varied by the simulation of certain damages as follows: The shoring up of a bulkhead or deck, combatting an oil fire in a compartment by smothering and cutting off all sources of oxygen, discussion of methods to rig a jury rudder, discussion by officers of pipe-line arrangement, drains, suctions, and counterflooding, division discussions of different kinds of fires and how to deal with them, warning men to use only tetrachloride, foamite, lux, and carbon dioxide on electrical fires and the danger of a stream of water or use of the acid-soda-type extinguisher, etc. A good time to work all smothering valves on board, in order to keep them free, is at each fire drill.

THE NEED FOR WRECKING PUMPS (By Lt. Comdr. John W. Kelliher, U. S. C. G.)

434. Too little attention has been paid to the need for efficient wrecking pumps of adequate size in our smaller service craft. My experience has been that there are times when such a device is indispensable. In the autumn of 1924, the *Unalga* towed a fishing vessel into Juneau. The leaks got so bad that it became necessary to bring her alongside the *Unalga* and put the suction hose of the wrecking pump into her bilges to keep her free of water. Although the craft was a poor affair, it represented the whole wealth of the owners and 2 or 3 days alongside the *Unalga* enabled them to raise a little money for her repair, otherwise she would have been beached and perhaps have become a total loss.

In the summer of 1934, during S. R. B. P., schedule, the *Yamacraw* at Fort Pond Bay, was ordered to the assistance of the *Galatea* which had a sinking fisherman in tow west of Moriches Buoy. The *Galatea* was overhauled 4 miles south of Fire Island light. The fisherman, the *Polaris*, was badly down by the head and there were 4 or 5 men from the *Galatea* bailing with buckets. The *Yamacraw's* suction hose was all rigged, the *Galatea* put her alongside and in about 15 minutes from the time we encountered them the craft was free of water. However, it was necessary to keep pumping to keep her from filling. The leaks could not be reached. It was too far to New York and we couldn't get into Fire Island Inlet. The assistance of the *AB–14* at that place was requested in the belief that she had a large pump on board, but when she arrived we found there was no suction pump on board. The *Yamacraw* pumped the *Polaris* dry, cast her off and let the *AB–14* make a run for it. We heard them report later that they had made it all right. The *Galatea* had pulled the *Polaris* off the beach only to find that she was about to sink on them. They had 2 eductors going and furnished 4 or more men for a period of 10 hours to bail to keep the *Polaris* afloat. One good gas- or electric-driven reciprocating suction pump and 100 feet of good 2-inch suction hose would have filled the bill. The only small Coast Guard vessel in that vicinity should be equipped to render all possible aid as there are a vast number of small fishing vessels operating in that area. If the *Galatea* had been so equipped, the salvage of that tiny craft would have been a matter of routine. The method used by the *Galatea* to keep the *Polaris* afloat was remarkably well done but in this day and age of mechanical contrivances, it seems a travesty on efficiency, because of the limitation of design and equipment, we should have to resort to a method in vogue probably among the Phoenicians before the Pyramids were built.

A FIREROOM FIRE (By Lt. Comdr. John W. Kelliher, U. S. C. G.)

435. During the summer of 1925, while engineer officer of the *Roe*, I had to fight an oil fire in no. 2 fireroom, while the destroyer was alongside the oil dock at Melville, R. I. It started from a small accumulation of oil in the drip pans under the burners of no. 4 boiler, the only one steaming. There was so

little oil in the drip pans that it relatively quickly burned out. Flames burst up through the two open hatches with clouds of black smoke. We closed all hatches, blower covers, put on stack covers, secured the deck steam valves, but all this appeared to do little good as the deck commenced to warp and the paint burn off. We had foamite apparatus, but here's the rub—it was impossible to get to it in the burning fireroom. Having the impression that there was a burst oil line I secured the auxiliary steam stop to prevent pumping further oil into the fireroom. There was not sufficient hose on the foamite apparatus in the dead fireroom to reach over the deck to the burning fireroom. Securing the steam prevented the use of a powerful stream of salt water. The heat under the deck was intense. Finally, I decided to take the fresh-water hose from the dock and opened the midship hatch just enough to admit the hose, directing the stream toward that part of the fireroom where the flames had been seen through the deadlight in the hatch on the theory that the intense heat of the metal parts in the proximity of the flame would cause the fresh water to flash into steam upon contact and have a smothering effect. It was successful for the flames immediately subsided though there is still a doubt as to whether they would not have ceased soon anyhow due to lack of air and the consumption of the oil that was burning. It was afterward found that the fire was confined to the drip pans which were not full and the capacity of which were but 3 gallons. There was no loose oil around the fireroom or in the bilges. The points to be stressed are these: First, the rapidity with which it all happened; second the impossibility of using the oil-fire fighting apparatus, because of the character of the installation; third, the lack of auxiliary fire-fighting apparatus. It was afterward discovered that the water tender, at the moment the oil flashed into flames thought first of closing the master valve on the fuel-oil line and continued at that until his shoes caught fire and had to escape. If we had had some heavily charged bottles of CO_2 gas on deck with discharge pipes leading into the fireroom we could have put the fire out instantly.

As soon as it was determined that the flames had died, I donned the only device we had in the way of a gas mask and with a reduced stream from the hose playing on me descended onto the fireroom floor plates where I only had time for a hasty glance because the mask was strangling me. This worse than futile thing that I wore could easily have put me out. I was gasping for breath by the time I emerged from the fireroom. I could not have touched any valve even if I had found it desirable without searing my hands, everything was so hot. Smoke masks and asbestos gloves should be in the fire-fighting equipment of every vessel.

DAMPERS FOR SMOKESTACKS (By Lt. Comdr. John W. Kelliher, U. S. C. G.)

436. In connection with oil fires in the fireroom let me call attention to the absolute necessity for dampers in stacks. If nothing is done about closing off the stack where a fire starts, the natural draft causes the flames from the fireroom to enter the boiler and go out the stack, whereas the idea is to cause a complete stagnation of all draft by battening everything down. The rigging of a stack cover in place is a slow job and might be of doubtful value because the heat might burn the fabric. But a steel damper in the stack that could be worked from the upper gratings or somewhere on the upper deck would completely shut off any possibility of draft at that point.

SHORING BULKHEADS

437. In emergencies it may become necessary to shore up bulkheads. The general principle should be adopted of bracing all shores against material running at right angles to the structure to be supported. It is not advisable to brace one bulkhead by shoring up another, or one deck by shoring to another unless there are supporting structures in the way of the shoring so as to distribute the load. In general a bulkhead should be shored to a deck or vice versa. (See figs. 35 and 36.)

AIRPORT LENSE AND BATTLE PORT CARRY AWAY

437(a). During bad weather off Cape Hatteras a port-hole lense shattered and the battle port carried away on the Coast Guard destroyer *Shaw*. Mattresses were braced in place by men. On hand to cope with just such an emergency were rubber discs, one-fourth inch thick, cut to port hole size and a solid wooden disc cut to fit within the retaining ring. A rubber disc was inserted under the lense frame and dogged down. The wooden disc was placed and the warped battle port shored in place against it. This procedure requiring 17 minutes. Several tons of sea water had meanwhile poured into the commissary hold, rising to a height of about 4 feet. When an attempt was made to operate the valve in the manifold the stem sheared off at the bonnet. It was necessary for men to work under water to remove the nuts from the valve holding the bonnet to enable the pump to gain suction.

IN GENERAL

438. A word of caution may not go amiss. Whenever damage control fails, or the damage is too severe to control, it should always be borne in mind that unless there are sufficient reasons to the contrary, every effort should be made to beach the ship. A vessel even lying on the rocks has more potential value than a sunken one. One exception of course is

that during a storm a rocky lee shore is no haven, and that the lives of those on board are of first consideration. Not infrequently vessels have been abandoned too soon and later found safely afloat.

The writer observed the *North Bend*, a large sailing vessel, go ashore on Columbia River bar, after a tow line parted. The crew of the *North Bend* were preparing to jump overboard in the heavy surf, which would undoubtedly have been the cause of the loss of several lives when the cool heads of the crew from the Cape Disappointment Coast Guard station called out warnings to the men to remain aboard ship. Two hours later when the tide ebbed the men were able to step on the sandy beach as they left their vessel's side. In connection with the *North Bend* loss it is mentioned that the Coast Guard station power boat from Cape Disappointment, after running the line to the sailing vessel, was upended by the surf and capsized. A. Rimer, late chief boatswain (L) suffered internal injuries and had several ribs broken. All of the boat crew, with the aid of their life jackets, were washed ashore. During the operations the *Snohomish* was anchored in breaking surf with the engines turning over ahead as required. Pitching heavily it was indeed a problem to keep the lines out of the wheel during the process of their running.

GAS ATTACKS, PREPARATION FOR

439. The greatest danger at the beginning of another war, wherein gas is used, will come from panic which may follow if information is not diligently spread, and preparations made for protection. Each person on the ship should be given most comprehensive instructions in its details. Teachings so outlined should be simple in form, progressive, and inscribe learning by so doing. Methods should be simple and brief but effective. A thorough understanding should be acquired of the protection afforded by mask, canister, clothing, gasproof spaces, filtered ventilation, and contamination removal. The cost of training appliances is prohibitive but the theory of their use can be promulgated.

Chemical agents are classified as vesicants, lung irritants, lachrymators, or toxic smokes according to the effect they have on human beings. The application they have to war at sea can be summarized by the various possible ways of projection. Substantial methods of gas release are by bombs, torpedoes, cylinders fixed on decks of submarines, toxic smokes from stacks of fast vessels, and spray from tanks attached to racks on aircraft. Gas from submarines will be the lung-irritant type released in clouds by the vessels approaching submerged at night. Toxic smokes from fast-moving vessels, such as destroyers and cruisers, will be loosed as a screen for the opposing ship to pass through. Gas from aircraft will be of the vesicant type, sprayed by fast planes that approach under clouds, or under cover of a screen made by other aircraft. Of these various methods, the two that show the easiest and most effective application are by submarine and by airplane.

GAS, TYPES OF

440. A detailed list of chemical-warfare agents would form a very lengthy work. A few examples of what may be used are the following: (*a*) Screening smokes such as white phosphorus in the form of heavy white fog, smoke candles giving off white or gray smoke, dense black smoke from the incomplete combustion of fuel oil as used by destroyers; (*b*) incendiary agents such as white phosphorus which ignites spontaneously in the air, slow-burning powders having high oxygen content, oils and inflammable liquids which are sprayed on the object to be ignited; (*c*) irritants and lethal agents such as—

Chlorine, greenish-yellow, heavier-than-air, pungent, and suffocating gas. This goes into solution in the lungs forming hydrochloric acid. In high concentrations it may cause quick death by choking. It is a nonpersistent gas leaving no traces.

Phosgene (carbonyl chloride), used in liquid or gaseous form; it is colorless but has a distinctive odor—like that of new-mown hay. The victim may be unaware of the fact that he has been gassed and continue working for as long as 48 hours, when he is suddenly stricken and dies. The patient literally dies of drowning. Phosgene is many more times toxic than chlorine. It is also nonpersistent and easily neutralized.

Chlorpicrin, like chlorine in its action but stronger.

Chloracetophenone (CN) is a solid crystalline substance at ordinary temperatures, but gives off copious fumes in hot weather, and is very persistent. It is either thrown out as a cloud of finely divided particles by an explosion, or is dissolved in highly volatile liquids which act as carriers. The eyes are extremely sensitive to CN; the action is immediate; tears begin to flow; and because of acute pains it is impossible to keep the eyes open. CN is nonpoisonous, acting only as an irritant.

Brombenzyl cyanide (CA) is much like CN, but much more positive in its action.

Diphenylamine chlorarsine (DM) is a toxic smoke, differing from gases in being a cloud of very finely divided particles so small that the ordinary gas mask is easily penetrable by them. It arises in a yellowish cloud, causing burning of the mouth and throat, and later acute nausea and vomiting. It is scattered by an explosive or volatilized by steady heating. It is nonpoisonous, and is called a sternutator, or sneeze gas.

Lewisite (*beta chlorvinyldichlorarsine*) is a liquid under ordinary temperatures, giving off poisonous fumes. In small concentrations it has a somewhat pleasant odor, like the odor of geraniums. Higher concentrations cause a burning sensation in the nose and throat. Lewisite is a powerful vesicant agent

and respiratory irritant. It has somewhat the same action as mustard gas, but acts as a vesicant in from 4 to 6 hours, whereas mustard requires from 20 to 24 hours. Lewisite is more easily broken down than mustard gas, becoming hydrolized in the presence of water.

Mustard gas (beta-beta-prime dichlordiethyl sulphide), like Lewisite in many ways, it under ordinary conditions is a stable liquid. It is one of the most persistent gases known, impregnating wood and clinging to metal; in an open field exposed to the weather and the wind it lingers for about a week. It is one of the most toxic agents, the liquid acts as a vesicant agent, giving chemical burns that later suppurate, the vapor also enters the lungs and burns the tissues. It has a pungent odor, somewhat like mustard, but after the first few whiffs, the sense of smell is attacked and deadened, and the victim is oblivious to the fact that he is being gassed. Its action is delayed, however, for about 24 hours, and hence it must be used a like time before an attack. The seaman facing this gas works under a greater handicap than a soldier, for the latter may leave the mustardized area, whereas the former cannot abandon his ship.

GAS DEFENSE ABOARD SHIP

441. In time of war every man aboard ship should be furnished with a gas mask fitted to his needs with an impregnated garment of reasonable efficacy and comfort. Men should be permanently stationed at the fire plugs on the exposed decks to wet down the decks on the approach of hostile aircraft, thereby reducing the danger from incendiary agents and removing mechanically at least a part of the liquid mustard which may fall. They should be supplied with bins of neutralizing agent, with buckets to distribute it to the various gun positions immediately after a sprinkling attack, where it might be scattered on deck like sand. A system of reliefs for the exposed guns' crews should be provided; these reliefs to be in protected positions below the superstructure deck within reach of the exposed stations. On a large ship at least two separate demustardizing stations, with chlorine chambers and facilities for bathing, getting rid of contaminated clothing, and donning fresh clothing should be provided. All men in exposed stations should have gas masks and protective coveralls.

All closed compartments containing battle stations should have seals for all entering ducts and pipes so that they may be made gastight. Reliance is to be placed on air-renewal apparatus and air-purifying chambers in the ventilating ducts. In the engine and fire rooms distant controls from gastight booths will afford the best protection. Of course in the event of war special apparatus will be installed, but in the meantime the introduction of simulated gas attacks would break up the monotony of general quarters and gun drills. (Abridged from The Application of Chemical Agents to Naval Warfare, by Lt. N. A. Draim (CC), U. S. N., in U. S. Naval Institute Proceedings, December 1928, by special permission.)

CHAPTER V

CARE AND PRESERVATION

In general

A ship, like a chain, is no better than its weakest link. Following are some of the commonly neglected things which will lower the ship's efficiency and even jeopardize its safety.

MANIFOLDS, SLUICE VALVES, MAGAZINE FLOOD VALVES, STEAM-SMOTHERING VALVES, ETC.

501. Seats and disks pitted or marred; frozen valve stems, sheared-off valve stems, disconnected operating gear, frozen knuckles of operating gear to valves, painted, corroded, or improper adjustment of operating valves on deck. Handy billy pump out of order or not functioning properly. Not tested weekly. Dogs and knife-edges not in good condition. Watertight door, porthole, and other safety gaskets in poor condition. Lack of knowledge of location of piping, fire mains, flooding valves, drainage system, etc.

The instructions relative to cutting and drilling the flanges of bulkhead stiffeners, and the webs of beams and bulkhead stiffeners are: "Where necessary in fitting piping systems, electrical leads, etc., under plated decks, holes may be cut in the webs of the beams above the middle line. The size of the holes is limited to a diameter equal to one-fourth of the depth of the beam, provided that not more than one horizontal row be cut in one beam and that the reduction of the web area in a horizontal section shall not exceed 40 percent in any 1 foot of length. The holes may be cut as close to the upper flange as practicable. No holes shall be cut in the lower flange of the deck beams. Any holes cut in the webs shall not be located closer than 3 feet to pillar attachments."

The instructions about cutting holes in watertight bulkheads and decks are as follows: "Holes or openings for any purpose whatsoever, except those shown or indicated by plans or specifications, shall not be cut in any watertight bulkhead or deck without the approval of Headquarters."

When the *Vestris* heeled deeply just prior to her loss in 1928, screw threads on porthole dogs bore such a heavy layer of paint that the passengers were unable to close them and stop the water flowing into their rooms.

CARE OF BOATS AND EQUIPMENT

502. Conversations with officers who have abandoned ship in lifeboats would be a good thing for some officers to impress them with the necessity of careful inspections and the proper maintenance of lifeboats and their equipment. Some of our officers have been forced to live in such boats for a period of days and then use the equipment on deserted islands until picked up. Equipment has a habit of disappearing from boats and boat boxes. In spite of their being kept locked, such articles as fish hooks, sounding leads, kerosene, matches, leak-patching material, etc., are frequently missing from the boat boxes and the equipment is allowed to rust and deteriorate. Emergency rations frequently receive scant attention and are permitted to become unpalatable. Men are not always required to place them in the boats at drill, and even do not know where they are stowed. Frequently water beakers do not contain fresh water or are in a leaky condition. Lanterns sometimes are not kept burning in lifeboats. Too many boats are damaged in their cradles, during bad weather, from failure to see them properly secured.

A WORD TO YOUNG OFFICERS

503. Senior officers frequently note a tendency on the part of some young officers to let their departments slide. Too much is taken for granted—a willingness is displayed to ride on the shoulders of their junior assistants. Unless the officer knows, for instance, say, the details of the windlass operation, sooner or later by virtue of changing conditions a new man will have to operate it. Unless he is properly supervised an anchor and chain may be lost, the windlass wrecked, and even the ship itself stranded. Another important detail officers sometimes fail to familiarize themselves with is the manner in which the shift is made from power to hand steering. Officers are found who do not know how to effectively remove the air from the steering gear telemotor lines, and inspecting officers frequently find junior officers who do not know how to flood the magazines.

CARE OF HULL

504. The regulations require that a steel or iron unsheated ship shall never be attached to the moorings

or chains in use by a ship sheathed with copper or yellow metal, nor moored alongside the latter. No loose articles of copper or bronze, filings of same, or rust scale, shall be allowed to rest in immediate contact with the iron or steel; and leaden pipes, strainers, and other such parts in the bilges shall be kept in good condition.

CORROSION

505. Particular attention shall be given to the following: (*a*) corrosion at waterline, under transoms, below air ports in behind ceiling, engineroom and fireroom bilges, chain lockers, lower sections of bulkheads, void spaces where water may accumulate, and the underwater exterior of the vessel, including valves, propellers, rudders, and all other fittings that are accessible; (*b*) all parts of the topsides and inner hull; (*c*) the efficiency of all hand pumps, testing them frequently for pumping the bilges and for fire-drill purposes; (*d*) all compartments, making frequent inspection of them; (*e*) keeping on hand a sufficient quantity of cement, composition, and paint for use in preventing corrosion. When places showing corrosion are detected they should be carefully scaled, dried, and coated with anticorrosive material; (*f*) the surface of coal bunkers shall be kept free from scale and corrosion and properly painted. They shall be painted every 6 months if necessary; (*g*) the rubber gaskets of watertight doors, manholes, hatches, air ports, etc., shall not be painted, greased, or oiled.

The recurrence of corrosion in any particular locality or compartment shall be followed by special investigation to determine its cause and the remedy to apply. Unusual cases shall be subject of special reports to Headquarters, enumerating the extent and character of the corrosion, the cause or causes as far as determined, and the remedies applied.

CORROSION OF ALUMINUM

506. Corrosion has been the great drawback to the use of aluminum aboard ship. As regards method of installation on shipboard, there are three important cautions:

(1) Do not install aluminum where it will be in continuous contact with salt water.

(2) Do not install aluminum in metal-to-metal contact with copper alloys; suitable insulating materials should be used.

(3) Do not install aluminum adjacent to wood which is continually exposed to dampness from the intermittent presence of sea water.

DOORS, WATERTIGHT

507. When setting up dogs on watertight doors, hatches, etc., a dog on the opposite side from the hinges first should be set up with sufficient pressure to hold the door, hatch, etc., closed. Two dogs should then be set up on the hinge side; after which all the dogs should be set up evenly to insure a bearing all around. When loosening dogs, those dogs nearest the hinges should be loosened first; this prevents the door from springing and makes it easier to operate the remaining dogs.

AIR PORTS

508. Particular care should be taken in setting up dogs on air ports, the necessary tightening being obtained by setting up a little on one after the other successively, as in the case of watertight doors, until all are down firmly. This will prevent breaking of the glass lens when the ship is working in a seaway or when the port is hit by a heavy sea.

FRESH-WATER TANKS

508(a). The use of cement wash in water tanks has been discontinued. The interiors of all water tanks, including culinary, drinking, and feed water, should, after a thorough cleaning, be painted with two coats of metallic brown, Navy formula 26.

CALKING RIVETS IN OILTIGHT WORK

509. Should any attempt be made to calk rivets in oiltight work, the calking should be done very lightly, as the force of heavy blows on the rivets is likely to result in more leakage. Shellac, not red lead, should be applied over leaky oil seams or rivets. A spark caused by calking, in the presence of gas in a partly filled oil tank, will cause an explosion (art. 338).

KEEP VALVES CLOSED WHEN NOT IN USE

510. It is advisable that drainage valves not actually in use be kept closed so that they may be effective in preserving the watertight subdivision at all times. Valves should be operated frequently to insure that they are ready for service.

FREEZING WEATHER

511. During freezing weather the fire hydrants on weather decks should be protected, and in very cold weather the fire main should be drained to below the cut-out valves, after which the valves may be closed and the fire main kept in service. Make sure that fire hose, after use in freezing weather, is well drained.

DECK STOWAGE OF HAWSERS

512. Hawsers and lines secured on deck when under way may break loose during darkness and foul propellers. Deck stowage is bad practice. In assisting vessels there is ever the danger of getting lines into the wheel; in spite of precautions *it does happen.*

NEVER SMOKE IN A MOTORBOAT, AND REQUIRE RIGID OBSERVANCE OF THIS RULE

Fittings

513. All portable fittings such as boat davits, anchor davits, life lines and awning stanchions, etc., should when overhauled have working parts thoroughly cleaned of rust and paint, and be well slushed

with heavy grease, such as albany grease and graphite mixed, or tallow and white lead. Such fittings should be overhauled every 3 months if possible, and by all means in less than 6 months. Care must be taken to protect the decks by old canvas to keep any grease from staining the decks. Frequently boat-davit sockets are provided with petcocks at the bottom for draining off any water that may accumulate. Most davits are fitted with alemite or similar attachments for forced bearing lubrication.

GALVANIC ACTION IN PIPING

514. Galvanic action has been found to exist in any case where brass or copper pipes have connections with iron piping in a system through which salt water flows. The effect of the galvanic action is to eat away places in the brass and copper piping and to eat away entirely iron nipples where screwed directly into brass or copper piping. Galvanic action has also been noticeable in continuous lines of brass and copper pipe where no direct iron connections are made. This is believed to be due to lack of insulation between the pipe and the surrounding structural work of the ship, which is iron or steel. All brass and copper pipe and steel tubing was formerly well tinned or lead-lined inside when used for salt water service.

Genuine wrought iron is now used on cutters for salt-water piping. The modern practice on cutters is to fit in salt-water lines, adjacent to composition valves, an 18-inch length of cast iron, rubber-lined piping, completely insulated from valve and pipe line. Such an arrangement prevents corrosion.

RUDDER HEAD PACKING

515. In setting up on the rudder stuffing box, care should be taken not to set it up so tight that the packing will pinch and cut the rudder head shaft. It is best to set up a little at a time, watching the leak; if it decreases considerably, set up a little more, but this gland should never be set up extremely hard, especially while the ship is under way. It is better to allow a slight leak than to take chances on having the rudder head freeze in the box. Sometimes when packing is old and hard, setting up on the stuffing box has very little perceptible effect. In this case it would be well to slack out the gland as far as possible, allowing it to leak freely for half an hour or so; this will allow the old packing to expand, absorb water, and loosen up some, after which the gland should be set up as instructed above.

VALVES, SEA

516. All sea valves should be operated weekly with the wrenches from the respective deck plates. In this operation, valves which are habitually kept open should not be entirely closed on account of bruising the disk of the valve against shell formation, etc., that might be on the seat. A mark should be made on the indicator which will show when the valve is within about one-quarter inch of the seat. The operating mechanism should be kept well lubricated, and where the transmitting rods, universal joints, gears, etc., are located or pass through storerooms, much care should be taken in stowing such places, in order to keep the devices clear so they may operate freely.

Whenever a ship is in drydock, all sea valves and other openings in the ship's bottom, upon which no work is being done, should be closed overnight.

VOICE TUBES

517. Elbows in voice tube lines have practically no acoustical disadvantage. A sharp bend or turn, or even a complete reversal of direction of the line does not introduce appreciable inefficiency in a voice tube. Frequent requests for elimination of elbows are submitted owing to an erroneous notion as to their effect. The loss in the intensity of sound transmitted through voice tubes is due to four principal causes: (1) from friction in the tube; (2) from yielding of the material from which the tubing is made, in other words, panting; (3) from loss of energy due to sudden expansion or contraction of the area of the tube; (4) from leakage or open outlets. The tubes should be kept free from water, cinders, dirt, waste, and soft, porous materials. The third and fourth causes are introduced by having too many outlets on the one main line; a closed outlet becomes equivalent to a sudden expansion or contraction. By means of compressed air it can be readily determined whether the tube is clear of obstructions.

STUFFING TUBES

518. Water-tightness is obtained where piping such as water, steam, air conduits, and voice tubes pass through watertight members, such as bulkheads and decks, by the use of stuffing tubes with lock nuts and washers. It is necessary to insulate voice tubes at the hangers and where passing through holes in order to avoid metal-to-metal contact.

WHITEWASH

519. Whitewash, shellac, or similar compositions shall never be applied to any metal portion of a vessel except that shellac may be used on leaky oil-tank rivets and seams.

WOODEN DECK, RECALKING

520. First reef out the old marine glue from the seams. Drive down the old calking, fill any soft places by driving in new oakum until the seams are about the same depth, and have a solid foundation. If there is a space for another thread of oakum, calk it and repay the seams with marine glue. It is a waste of money and effort to use a poor grade of marine glue.

INSPECTING WOOD DECKS

521. Use a knife blade to test the seams of calked wood decks, and to prove the existence of dry rot,

which is usually first evident at butts of planking, around steel foundations or bounding angles, and in hot areas. If the knife blade sinks easily through the seam composition and the oakum, the calking is not good, and the deck should be hardened down, recalked, or repaid. The existence of white spots along the seams where the marine glue or putty is missing will frequently mean a leaky deck, and the underside of the wood, or steel on which the wood is laid, should be examined for leaks or rust streaks. Look for scale between the stringer plates and the wood laid on them. Bulging down of stringer plates or bulging up of the wood are often reliable signs of scale that cannot otherwise be detected. (From The Art of Bilge Diving, by Capt. C. W. Fisher (C. C.), United States Navy, Naval Institute Proceedings, June 1933, by special permission.) (Arts. 330, 368.)

INSPECTING TILE OR CEMENT DECK COVERING

522. Sound tile and cement with the testing hammer. Use light blows and let the hammer bounce. A hollow sound or a marked variation in sound over different areas will indicate the probability there is not a good bond between the tile or the cement and the steel beneath. Examine the edges of cement and tile. Rust stains or the pulling away of the cement or tile from steel boundaries almost invariably means leaks. Broken or stained tiling by no means indicates the necessity for renewal. Although the appearance may not be good, it is a waste of money to renew unless leaks exist that will cause deterioration of the structure beneath. (From The Art of Bilge Diving, by Capt. C. W. Fisher (C. C.), United States Navy, Naval Institute Proceedings, June 1933, by special permission.)

DENTS; HOW TO REMOVE FROM OUTSIDE PLATING

523. If the dent is very deep, a hole should be drilled in the center for a drawbolt, which is extended through a heavy strong back or bar and placed across the concave side of the dent. While the drawbolt is being tightened up, the dent should be driven out by hammering from the convex side. It is sometimes necessary to heat the plate at the dent, which may be done with a blowtorch. Small dents may sometimes be forced out with a jack or driven out with hammers.

DRYDOCKING (see also Bottom paints elsewhere in this chapter)

524. In drydocking a vessel the following precautions should be taken: (*a*) All sea valves closed and so report, (*b*) on even keel, (*c*) a trim of not over 1 foot for every 100 feet of length, (*d*) no free surface liquid in large amounts (tanks full or empty), (*e*) sufficient men to handle lines, taking emergencies into consideration, (*f*) the engine secured, (*g*) while in dock shift no weights (this includes water and oil), (*h*) lead fire hose aboard. In undocking the following precautions should be taken: (*a*) All valves closed and man guarding each, (*b*) air ports and other openings closed.

Docking once a year for examination, cleaning, and painting of bottom will be authorized, if practicable, for all vessels in fresh water and for vessels in salt water with wooden hulls completely protected by metal sheathing. Docking twice a year will be authorized, if practicable, for steel or iron vessels in salt water.

When a steel or iron vessel is hauled out to have the bottom cleaned and painted, care should be taken that no paint adhering firmly to the bottom is disturbed; only the marine growth and foul accumulations, rust, and blistered paint should be removed. Fresh paint must not be applied until the bottom has been thoroughly cleaned and dried. Places showing corrosion are to be carefully scaled, dried, and properly coated with a coat of American process zinc oxide in spirits of gum turpentine prior to the application of the anticorrosive paint. The frequent recurrence of corrosion in any particular area should be followed by investigation to determine the cause and best remedy possible. Examination should be made of all outboard valves, propellers, shafts, tubes, rudder, and underwater fittings. Zincs should be renewed as necessary. The necessary structural repairs should be made. Leaky seams and rivets should be tightened up.

While in dock all sea valves are overhauled. Packing in the rudderhead stuffing box is examined and renewed if necessary. Plating of hull and rudder is examined and all underwater riveting and calking examined and defects remedied. *No valves or other openings in the hull below the water line are to be left open over night while in dock.* When the ship is ready to be undocked, all the sea valves are closed and men stationed by them until the ship is afloat, to watch for defects. Should any leaks appear they should be reported at once so that, if necessary, the flooding of the dock may be discontinued, the water pumped down, and defects made good. While in dock in order to guard against altering stability, no considerable change should be made in the distribution or amount of weight on board, such as taking off or putting on large quantities of fuel or water, or shifting ammunition, coal, or fuel from one space to another; and no such change should be made without first obtaining the approval of the officer responsible for the ship while in dock.

If upon drydocking a first-class cutter it is found that the lignumvitae in the stern tube has worn sufficiently to give a clearance up to 0.15 inch it does not necessarily need rewooding. The Coast Guard has no exact table of maximum allowable clearance, but usually follows the table given in Manual of Engineering Instructions for the Navy, chapter 29, which for a

10-inch shaft gives a clearance of 0.185 inch, at which the bearing should be rewooded. However, seven thirty-seconds inch would not be considered excessive if it were necessary, due to lack of time, to postpone the rewooding to some future date. In other words, to say that a shaft requires rewooding at 0.185 inch or seven thirty-seconds inch clearance is not a definite requirement, but more a matter of personal judgment.

When the ship is ready for undocking, all loose material that will float should either be removed from the dock or else secured to prevent its floating around while the dock is being flooded. A floating object will sometimes lodge under the flat of the bottom of the ship when the dock is being flooded, where it will remain after the ship is afloat, being held there by the pressure of the water, and be of consequent damage to the propellers, etc.

ZINC PROTECTORS, ORIGIN OF

525. The following extract from Brande's Dictionary (1844) will give an idea of the problem of hull protection as understood a century ago:

"*Sheathing.*—The covering laid on the ship's bottom to defend it from worms. Sheets of thin copper nailed on with copper nails constitutes, at present, the sheathing of all the better kinds of vessels. Lead has been used; and large-headed iron nails, called scupper nails are still used for the same purpose on the bottoms of old hulks, piles, etc. Zinc and different compositions have been proposed as substitutes for copper; and Sir Humphrey Davy ingeniously suggested the application of pieces of zinc or iron upon different parts of the copper surface, which by the action of the sea water render the latter metal electronegative, and capable therefore of resisting the oxidizing and corrosive agencies of the substances held in solution. These pieces of iron or zinc so applied have been properly called protectors; but by occasioning the precipitation of earthy matters on the copper, while they effectually protect it, they render its surface favorable to the adhesion of weeds and barnacles, etc., and sometimes to such an extent as to interfere with the passage of the ship through the water; upon such grounds, Sir Humphrey's valuable suggestion has been neglected. When vessels are laid up in dock the protectors are in successful use. Sheathing formerly was composed of thin fir boards."

ZINC, MILD STEEL, AND COPPER-ALLOY PROTECTORS

526. Ship deterioration results mainly from rust and electrolysis. Once rust of steel starts the rust oxide formed hastens the oxidation of the metal. The presence of even a small amount of moisture especially in the presence of heat greatly increases the rate of deterioration. Salt water, being slightly acid, greatly accelerates rusting. Electrolysis is the resultant action between two dissimilar metals in the presence of an acid. Salt water acts as the electrolyte. The metal which is electropositive to the other is wasted away. Electrolytic action also occurs between two pieces of the same metal which vary a small degree in composition. Steel is electropositive to most metals.

For many years zinc plates have been used as a preventative for electrolytic action. More recent practice also includes the use of underwater hull protectors of very mild steel, which are electropositive to the structural steel. Also around sea chests and propellers copper-alloy margins are fitted next to the shell plating. The zinc oxide in underwater body paint also acts as protector of the steel body.

BOILER GALVANIC ACTION

527. To prevent galvanic action in a boiler, zinc plates are installed inside. They should have as good a metallic connection with the steel as possible. In addition to preventing electrolysis, they take up oxygen more readily than steel, thus preventing corrosion.

ANCHOR-CHAIN CARE

528. Anchor chains, except those parts required to be painted white, or light gray, are required by regulations to be kept coated with black asphaltum varnish, Navy formula 27. Galvanized chains shall not be painted but regalvanized when the coat is worn. Every 6 months, and also each time the vessel is in drydock, if practicable, swivels and detachable links should be lubricated with white lead and tallow.

LAUNDRY MACHINERY

529. Examination of laundry equipment on various cutters reveals that when the washing machines stand unused they are partially filled with water or they are left with the washer doors closed. It is essential that these machines be drained and ventilated whenever they stand unused. The presence of water or the lack of ventilation softens the cylinder wood thereby causing splinters to break loose during the process of washing and work into the clothing.

LINOLEUM

530. Headquarters proposes to discontinue the use of linoleum on steel decks owing to reports and observations of excessive corrosion taking place under this type of deck covering. The fabric back of the linoleum acts as a wick thereby drawing moisture under the covering by capillary attraction. Moisture once between the linoleum and steel deck soon softens the waterproof cement and corrodes the steel. While the affected areas are sometimes indicated by blisters, bulges, or curling up of the edges, it is suggested that close inspection be maintained of all linoleum-covered decks. Where the bond between the linoleum and steel deck is broken in toilets, washrooms, stores, or over large areas of spaces occupied by enlisted personnel, the covering should be removed to the bare steel and the deck painted black, gray, aluminum, or

white with the walking areas protected by all-rubber mats or runners. Where large areas are affected in officers' and warrant officers' quarters, the practice of laying Linotile no. 130 surf green with Dolfinite cement in place of the linoleum, should be followed. When the bond is broken only in the way of radiators, the deck covering may be cut back and the exposed steel deck cleaned and painted to match the linoleum, or with a color that will harmonize with the surrounding paint work.

Extended investigation has shown that shellac, as the result of the alcohol dissolving the binder, disintegrates and eventually ruins linoleum. For cleaning and sanitation, all crew spaces, passageways, etc., should be clamped down as necessary with lukewarm fresh water to which has been added soap powder and about two tablespoons of creosote to the gallon of water. About every 3 months, the linoleum should be rubbed with linseed oil to which has been added a small amount of drier. The linoleum should be dry before the oil is applied, the oil is then rubbed in well and any superfluous oil wiped off. For brightening up linoleum preservative stain may be obtained from the Norfolk Navy Yard. Linoleum seams should at all times be kept filled with seam cement to prevent water getting underneath. This seam cement may be obtained from the Norfolk and Mare Island Navy Yards.

PREPARING FUEL-OIL TANKS FOR ENTERING

531. Whenever a fuel-oil tank is to be entered or any work is to be done on it requiring heated rivets, hammering, etc., or any open lights other than gas-proof electric lights used, or whenever such work is to be done in the vicinity of open tanks or pipes, all such tanks and pipes shall be cleared of vapor and all traces of oil removed. First pump out all oil gases. Then to remove the oil that is adhering to the side of the tank steam it out from 6 to 12 hours. Guard against overheating adjacent compartments such as magazines and storerooms. After thorough ventilation by artificial means, and when a test shows the air in the tanks to be free of gas fumes (or gas masks may be worn), men who must be in communication with men on deck, wash out the tanks with hot salt water, and then the tank is pumped out. The tank will then be given a second steaming out of at least 4 hours. After again thoroughly ventilating by artificial means the tank men will be sent into it to scrape and wipe it clean of oil and sediment. Repeat the above operation until no trace of oil remains. From 2 to 3 hours after the final cleaning of the tank, chemical analysis shall be made of samples of air from the tank to ascertain whether or not it is safe for men to work in it and for hot rivets to be used. In the above cleaning operation whenever it is necessary to send a man in the tank he will be equipped with a line around him and attended so he may be hauled out if necessary. Forced suction ventilation, with the blowers well located *outside* the tank, will be provided at all times when men are working in a fuel-oil tank. Suitable fire-extinguishing apparatus should be maintained in vicinity of the tank. It must be kept in mind that fuel-oil gases present a great danger as they are highly explosive and readily ignited. The men guarding men inside fuel-oil tanks should always be provided with gas masks for emergencies. (See page 38 of Glossary.)

FUELING; CARE OF OIL TANKS

532. To provide for the expansion of oil when warmed, the regulations require that fuel-oil tanks shall not be filled to more than 95 percent of their capacity. Great difference of levels in adjacent oil tanks must be avoided to prevent needless strain on bulkheads. When filling tanks, men are stationed at the source of supply, at the tank to sound, and at the ship's cut-off valve to act in case of failure to close the valve on the source of supply. In filling tanks they require careful watching to prevent overflow and leaks, and should such leaks develop the loading must at once cease and steps shall be taken to stop the leaks without generating excessive heat or causing sparks. Time and again on vessels in the service, as the result of careless oiling supervision, living quarters on board have been flooded with oil—sometimes several feet deep. Combined ventilators and air escapes extending above decks shall always be open and clear, and the wire gauze protectors shall be kept intact. The regulations particularly require that fuel-oil tanks and surrounding structure remain intact as installed. No attachments whatever shall be made to decks or plating forming a boundary of a tank. Attention is called to article 2054, Regulations Fuel-Oil Safety Precautions.

It is necessary that fuel-oil tanks be protected against corrosion, as they form an integral part of the ship's structure. Inspections should be made annually to see whether or not the beams and undersides of the deck are properly covered with oil, which is the best possible protection. By means of the ship's pumps the compartment can be filled above the ordinary maximum of 95 percent capacity, and then allowed to drain back to normal level. If not discovered, air locks frequently prevent a tank being properly filled.

DOUBLE BOTTOMS; CLEANING; PRECAUTIONARY MEASURES

533. When about to examine, clean, or paint double bottoms, the following precautionary measures are required. They must first be opened and well ventilated by artificial suction ventilation. The purity of the air is then tested before entering. Except in the case of freshly painted compartments and those wherein fuel oil, gasoline, or other similar gas-generating oils or liquids have been stowed, the air is tested

by burning a candle on the bottom for at least 5 minutes. Working parties inside shall always maintain communication with someone outside (who should be provided with a gas mask for emergencies). They also take with them a lighted candle, except in the case of freshly painted compartments and those wherein fuel oil, etc., mentioned above have been stowed. The men inside the double bottom are instructed to withdraw should the candle begin to burn dimly. Artificial ventilation shall be maintained while working in or painting double bottoms. Naked lights shall not be used in compartments wherein fuel oils, gasoline, or other similar gas-generating oils or liquids have been stowed.

It should be borne in mind that constant alertness is necessary to discover unusual conditions and situations. Gas fumes may have penetrated a space, believed to be clear, by following some pipe line through a faulty hook-up, through a corroded seam, plate, or rivet, or other uncommon source. Now that gasoline will be carried in large tanks, its highly volatile gas will have to be watched to keep it from wandering.

PAINTING

534. The frequent sound of chipping hammers and the sight of splotches of red lead is not always an indication of a well-kept ship. It may be a public advertisement to the contrary. The wear on painted surfaces that are kept clean by scrubbing and properly sanded between coats, will be of longer duration and will remain smooth and free from cracks longer, if the paint is properly mixed and applied. Rust and corrosion are usually the result of cracked and scaling paint. The cause of cracked and scaling paint is in most instances the direct result of dirt covered with fresh coats of paint or the failure to completely remove rust and dry the surface before painting.

While it is recognized that the many emergent duties performed by the service increase the problem of painting ship, much can be done in good weather at sea to keep the deck and superstructure fittings in good condition, and the outside hull painting can be done according to plan during the most suitable season, and, above all, done carefully and thoroughly. Thirty days for the conditioning and painting of the outside of an average cutter is probably a minimum period.

When to paint and when not to is a common-sense problem. When to apply the second coat of either paint or varnish is easily determined by a simple test. Most paints and varnishes in good drying weather will harden in about 48 hours after they have dried or set. However, there are so many factors entering that it is impossible to determine the exact time required for drying. Time of the year, surface condition, kind of wood or metal, paint or mixture and how applied are all to be considered.

Test.—Let the paint or the varnish dry until it is hard enough to sandpaper with no. 0 or no. ½ sandpaper without dragging or rolling up under the paper. If it will stand this test the second or third coats may be applied without regard to the time element.

PREPARATION

535. A most thorough inspection of the compartment or section of the ship to be painted should be made by the officer responsible, assisted by the chief petty officer, who will have charge of the working detail. All defective paint or rust spots, especially the smaller ones that are apt to be overlooked, should be carefully marked. These spots should then be cleaned down to bright metal and given at least one prescribed protective coating and allowed to dry. If the touch-up paint is not of the color of the finishing coats, the spots should be given a second coat with the finishing color and allowed to dry, before the scrubbing and cleaning operations are started. If this is properly attended to the touched-up spots will not show through and the finished coat will have a uniform color. Painted wood surfaces should be treated in a like manner. Varnished wood surfaces, unless in good condition, should never be recoated. The old coatings should be completely removed with varnish remover and the surfaces prepared as in new work.[1]

PROTECTION AND CARE

536. Frequent cleaning is the best preservative that can be recommended for painted surfaces, whether interior or exterior. Paints should be washed or scrubbed with fresh water and any soap that is free from potash, lye, and other paint solvents. Care should be taken to prevent soapsuds from running or splashing on sections not included in the painting schedule. Oils and grease may be removed with spirits of turpentine or petroleum. This in turn should be thoroughly washed off and wiped dry. All varnished surfaces whether wood or metal should be washed off with fresh water to remove the accumulation of sea-water salts. Dried-out sea-water salts are especially destructive to varnish. Strong soapsuds if permitted to remain on white paint work will turn it yellow and similarly damage any painted surface. All soap should be washed off.

BOTTOM, PAINTING OF,

537. Repainting the bottom and boot-topping while in drydock presents some problems which are not usually given the thought and attention their importance merit; that is, the proposal for docking the ship very often omits a proviso for drawing and dropping the blocks, so that the hull may be cleaned and

[1] When 25 percent of a painted surface is considered to be poor, that section or area of paint should be completely removed and repainted.

painted under them. A docking company will always make a record of the first docking and any subsequent docking will place the ship in as nearly the same position as possible. This may mean that the hull will have a number of places on the bottom and keel plating that will not receive attention for a long period, and may cause leaky rivets or the renewing of a section of plating. The bottom, whether wood or iron, should be thoroughly cleaned and dried before repainting. After the bottom is clean and dry it should be inspected again before painting to make sure that the white or milk colored scale that adheres to the paint under the barnacles has been removed. If this is not done the scale will loosen and fall off shortly after being painted, leaving the bottom without protection.

PAINT BRUSH, USE OF

538. In painting, the first operation is to work the brush into the paint so that the paint is on every fiber. This can be done in two ways. The better method consists of dipping the brush in the paint until about one-half the length of the fibers are submerged and then slightly rotating the brush by holding the handle of the brush between the palms of the two hands and sliding one hand past the other, then working the brush against the inner edge of the can. Another method is to dip the brush in the paint and then work the brush against the edge of the can or on a board until it is thoroughly worked into the paint. A good painter will take care to take just enough paint on his brush to proceed with the work without dripping paint from the brush and without causing the paint to run after it is applied. If he is painting a sufficiently large surface he will cross his work, that is, he will cover a portion of the area with strokes in one direction and finish with strokes perpendicular to the first strokes. He will leave the surface with no brush marks showing and with all parts of the surface covered.

PAINTS USED IN COAST GUARD

539. Colors and kinds of paints used on Coast Guard cutters are as follows:

	White hulls	Black hulls	Gray hulls
Anchors	Outside white no. 6.	Outside black no. 13.	Light gray no. 5.
Boat davits	Spar no. 7	Spar no. 7	Do.
Waterways	Black boot top no. 3.	Black boot top no. 3.	Red boot top no. 2.
Windlass	Spar no. 7	Spar no. 7	Light gray no. 5.
Swinging booms and strongbacks.	Varnished	Varnished	Varnished.
Exposed parts of wire standing rigging.	Light gray no. 5.	Light gray no. 5.	Light gray no. 5.
Holds	Inside white no. 27.	Inside white no. 27.	Inside white no. 27
Bunkers and bilges.	Red lead no. 9.	Red lead no. 9.	Red lead no. 9.
Fuel oil bulkhead boundary in bilges.	Inside white no. 27.	Inside white no. 27.	Inside white no. 27.

Outside hulls above the water line should be painted not oftener than 3 times a year except under unusual conditions. Deckhouses should be painted once a year. Both should be touched up from time to time to give a complete, dry, hard coat.

PRECAUTIONS FOR PAINTERS

540. Lead poisoning produces indigestion, colic, diseases of the heart, lungs, and kidneys; also paralysis, and may cause blindness. Lead may enter the system through the mouth or by inhaling through the nose, or through the skin by absorption. The following precautions will be advisable: (1) Require some type of respiratory mask be worn by men working in compartments containing lead-laden dust; (2) a full meal with plenty of milk should be eaten before going to work; (3) avoid eating or drinking in a compartment containing lead-laden dust; (4) alcohol in any form should be abstained from, as it greatly increases the danger and severity of lead poisoning; (5) the hands should always be washed with a brush and the face with hot water and soap and the mouth rinsed and the finger nails cleaned immediately after stopping work and before eating; (6) a bath should be taken after finishing work followed by a change into clean clothing; (7) the compartment must be kept well ventilated; (8) smoking and chewing tobacco or chewing gum while at work must be avoided; (9) gloves should be worn during the process of handling, grinding, or mixing lead paints.

CARE OF PAINT BRUSHES

541. A set of brushes should be kept for each kind of paint. After use, the paint, varnish, etc., should be thoroughly rubbed out of the brushes and the brushes then placed in the liquid best suited to keep the bristles from becoming hard. Brushes should never be set on end of the bristles in liquid, this will turn up the ends in such a way that good work cannot be done with them again. They should be suspended with about three-fourths of the bristles in the liquid; one good method by which this may be done is by boring a hole through the handle of the brush, through which a rod is run and with the ends resting on or near the top of the vessel containing the liquid. When it is not convenient to hang brushes by their handles, if the bristles are wrapped in paper, they may be stood on end in the liquid, because the paper stiffens the mass of the bristles so that they do not bend out of shape. A small hole should be torn in the center of the lower end of the paper after it is tightly wrapped around the brush to permit the liquid to permeate the bristles. If it is desired to keep the brushes a long time without using them, this is decidedly the best method. Paint brushes wrapped in paper and placed with ends in water will keep for 6 months and be in excellent condition when required for use again.

Brushes used in oil paints should always be kept in water, and brushes used in varnish should be kept in

a mixture of raw linseed oil and varnish; brushes used in shellac and shipbottom paint should be kept in shellac or alcohol. The latter type brush should be of the type having bristles set in vulcanized rubber. It has been found to be good practice to have a snug fitting cover for brush tanks in which shellac brushes are kept; by keeping the tank closed it prohibits the alcohol in the shellac from evaporating too rapidly. When varnish brushes are to be stowed away for a long time without using, they should be thoroughly washed out with petroleum spirits or turpentine, and then with warm water and soap, carefully removing all the varnish from the bristles. Shake and fluff the bristles out in order to permit them to dry. The same practice may be applied to shellac brushes, using alcohol to wash them out. After using lacquer brushes wash them out in lacquer thinner.

DETERIORATION OF NEW PAINT BRUSHES

542. It has been found that paint and varnish brushes, in every way satisfactory at the time of inspection and delivery, will later shed bristles to a very objectionable extent. This shedding of bristles has been found to be due to the drying out of handles while in stock. In such cases steps should be taken to tighten the handles before issue. This may be accomplished by wetting the end of the wooden handle inside of the bristles with a teaspoonful of water, inverting the brush, and allowing about half an hour for the handle to swell. The brushes may be immersed in water up to the ferrule top for 24 hours.

Brushes that are very hard and dry can be softened by suspending the bristles about 10 hours in a solution of 1 part soda and 3 parts water; this solution must be kept warm, but not too hot, as this will spoil the bristles; a temperature which the hand can bear will be about right. After this clean with warm water and soap, and finally clean with spirits of turpentine or benzine.

USE OF READY-MIXED PAINTS

543. All ready-mixed paints must be thoroughly stirred in cans or drums, before using, in order to insure that the paint has proper body and to prevent waste of the residue left in the drums. The containers in which paint is kept should be carefully protected from the air.

CLEANING SURFACES

544. All steel and iron work which is to be painted or cemented should be carefully and thoroughly scraped, scaled, and cleaned down to bare surface, and should be thoroughly dry before the paint, cement, or bituminous composition is applied. In no case should the paint or other coatings be applied over damp, oily, or greasy surfaces, or other foreign substances. On thin plating, structural work or fittings, old paint and rust must necessarily be removed by means of scrapers and wire brushes. Except in unusual circumstances scaling hammers are not to be used. On galvanized plating, neither scaling hammers nor steel scrapers should be used. Before painting galvanized surfaces, the surface requires cleaning with ammonia, vinegar, or with a solution containing 4 ounces of copper acetate or copper chloride to 1 gallon of water in order to secure firm adherence of the paint. The preparation of the painted surface of metal work for repainting by ship's force entails scrubbing it with soap and fresh water, using burlap, canvas, or scrubbing brushes. Where old paint is lumpy or thick, fine sand may be used with soap, but under no circumstances should steel brushes or scrapers be used unless the whole surface is to be cleaned. Rough spots may be smoothed down with fine sandpaper.

PREPARING SURFACE FOR BITUMINOUS COMPOSITION

545. In preparing surfaces for bituminous compositions it is necessary that special care be taken to clean the metal so that it is entirely free of all rust, scale, or grease. Where the scale is heavy, pneumatic hammers should be used, but in all cases the rust must be removed even to the extent of using sandpaper and fine steel wire brushes. The last operation should be to dust off the surface with a fine hair duster, thus removing all the fine dust. In bilges, where considerable grease has been standing, it is necessary after scaling to cut and clean the grease by scrubbing with gasoline. (The rules governing the use of gasoline below decks in small stoppered containers should be rigidly adhered to.) After this the necessary cleaning with sandpaper, wire brush, and duster should be accomplished. The bituminous solution should be applied no longer than 1 hour after the space has been inspected and passed as ready.

"FAT" PAINT

546. Paint becomes "fat" if left too long exposed to the air in an open pot, and is unfit for use. It may be reclaimed, if it has not stood too long, by removing the fatty oil and paint skins from the top, and thinning with turpentine and linseed oil.

DON'T USE TURPENTINE FOR CLEANING HANDS

547. Turpentine should not be used to clean paint from the hands. This will cause what is known as "drop wrist." Oil paints should be removed from the hands with warm water and soap or with linseed oil if necessary.

PUTTY STICKING TO HANDS

548. Before handling putty the man should coat his hands with soap suds or raw linseed oil. This will prevent the putty from sticking to the hands.

BAD PRACTICE OF WATERING RED LEAD

549. Sometimes a quantity of water is added to a drum of red lead, the popular belief being that it makes the paint easier to work, etc. Introduction of water greatly impairs the properties or red lead paint and this practice of adding water should never be allowed.

OIL PAINTS

550. Paint made with boiled linseed oil will dry in 24 hours or about one-fifth the time necessary for paint made with raw linseed oil. The use of driers with raw linseed oil will cause these paints to dry as quickly as if boiled oil were used and in modern practice the general use of boiled oil has been discontinued except for special work, such as paint for confined spaces, etc.

LINSEED OIL

551. This oil is important for the reason that it is the most important of all drying oils. Other drying oils are used in combination with gum resins and linseed oil. Raw linseed oil is obtained from crushing flaxseed. It is one of the best vehicles used in paints, inasmuch, as it adds greatly to the durability of the paint. Paints mixed with it for covering wood surfaces, by virtue of the penetration of the oil, provide a most durable covering. Such paint mixed too thick will oxidize and the powdered pigment wash off rapidly. Boiled linseed oil is a product obtained by heating raw linseed oil to over 100° C. (350° F.), until part of the glutinous ingredients in the oil have thickened, and while the oil is boiling lead and manganese oxides are added which give the oil greater drying qualities. It drys rapidly, forming a hard glossy film which is durable and water resistant. Boiled oil is heavier in body and darker in color than the raw oil and will dry with less absorption of oxygen from the atmosphere. This makes it adaptable for use in paints used in confined spaces. It is well to keep in mind that 1 gallon of oil applied to the surface of a compartment will require all the oxygen in 65 feet of air to dry it; such rarification of oxygen in the atmosphere, unless guarded against, will cause headaches. There is also some toxic effect to the turpentine in the paint.

DRIER, JAPAN

552. Driers are used to speed up the oxidation of the linseed oil. Excessive use of driers burns up the linseed oil to such an extent that the otherwise protective film becomes nonelastic or entirely breaks down, thus permitting the paint to disintegrate or fall off in particles. It is a good rule never to add more than 2 gills of drier of the grades commonly in use or one-half gill of drier of excellent quality japan drier to a gallon of paint.

VOLATILE OILS

553. The most extensively used volatile oils are turpentine and petroleum spirits (turpentine substitute). In general an excellent grade of petroleum spirits is a very satisfactory substitute for turpentine. Turpentine is obtained by distillation of pine-tree sap. Its high oxidizing characteristic causes paints and varnishes to dry rapidly. Petroleum spirits is produced from Pennsylvania or Texas crude oil. The functions of both these oils is to thin paints so that they can be more readily applied. Since they are volatile they pass out of the paint soon after being applied and do not add anything to the durability or life of the paint film. The objection to using gasoline, etc., for thinning is that they vaporize so rapidly the oil in the film does not have a chance to fill up the spaces which were occupied by the volatile oil. This results in numerous small holes being formed in the film.

FLAT PAINTS

554. Flat paints contain a large proportion of turpentine or petroleum spirits. Such paints are used where they will not be exposed to the weather because when the spirit film is dry it contains nothing but the pigments with only a sufficient amount of drying oil to hold the pigments to the surface to which the paint is applied. If such paints are applied to exposed surfaces they will soon wash off. Flat paints also are used in spaces where it is desired to avoid the reflection of light as occurs when a glossy surface paint is applied.

DIFFERENCE BETWEEN PAINT AND VARNISH, ETC.

555. Paint is a combination of oil and pigments. Varnish is a combination of oils, gums, and resins. Shellac is the exudation deposited by the lac bug; it is soluble in alcohol in the proportion of 2½ pounds of gum shallac to 1 gallon of alcohol. The lac deposit is also used in lacquers and in some varnishes. Stains are a combination of coloring pigments and oils. Prepared paints are preferable to those made on board ship for the reasons, first, that most paints require a grinding process in paint mills in order to thoroughly mix the pigments with the oils and to break up or grind finer the particles of pigment, and secondly, because of the necessity of maintaining standard colors.

WHITE LEAD AND WHITE ZINC

556. White lead is a chemical product of metallic lead, being composed usually of 3 parts of carbonate of lead and 1 part of hydrate of lead. White zinc is the oxide of zinc. It is found that lead will not give as white a finished surface as zinc, but it is more opaque. White zinc is much more durable than white

lead; however, it requires more coats than white lead to cover a dark background. White lead drys somewhat softer and, when exposed to the elements, will eventually become chalky with a flat appearance resembling whitewash, and will rub off easily when touched by the hand. White zinc in drying becomes very hard, showing that the weakness of white lead is the strength of white zinc and vice versa. It is for this reason that the mixture of lead and zinc makes such a good combination. Flat white for inside work is usually made of white zinc entirely as a base.

RED LEAD

557. Red lead is a lead tetroxide produced by heating litharge in air at about 480° C. (700° F.). The commercial varieties usually contain from 6 to 12 percent of free litharge. Red lead exerts a strong drying action on linseed oil. Unless it is mixed up ready for use, in sealed cans, red lead should not be mixed in advance of use because it becomes hard and unfit for use in a short time. It acts somewhat like plaster of paris or cement. The addition of dry silica helps to prevent the hardening and is used in ready-mixed red lead. Putty made by adding red lead to it makes an excellent cement for pipe flanges and other watertight joints.

VARNISH

558. Spar varnish and coach varnish are used for work exposed to the weather. For inside work copal, hard oil finish, and other interior varnishes are used. Spar varnish is pale in color, very rapid drying, water resisting, elastic, and durable.

CORK PAINT

559. Cork paint is pulverized cork held onto the surface by a sizing over which paint is applied in the usual manner. It is applied only to such interior surfaces as living quarters, storerooms, magazines, etc., which are directly exposed to chilling by conduction through metal from the action of wind or water, or where sweating would occur due to the opposite extremes in temperature.

BOTTOM PAINTS, NAVY

560. The Navy Department reports that it has found that the ship-bottom paints containing coal tar and rosin, formulas nos. 14 RB and 15 RB and the improved formulas nos. 14 RC and 15 RC, do not deteriorate rapidly on exposure to air; it is *important*, however, that these paints be given ample time to dry before the vessel is undocked. Anticorrosive paint should be allowed a minimum of 8 hours to dry before the antifouling paint is applied; the antifouling paint should be allowed a minimum of 6 hours to dry before the vessel is placed in the water. All proposals relating to drydocking steel vessels should specifically state the requirements as to drying time and that the ship-bottom paint will be supplied by the Government.

BOTTOM PAINTS, COMMERCIAL

561. Anticorrosive paint (bottom paint) is usually made from metallic zinc, zinc oxide, pine tar, turpentine, shellac, and alcohol. It serves to insulate the metal in the antifouling paint from the steel plating to prevent electrolysis and corrosion. By virtue of its constituents it is a very rapid drying paint. This paint serves as a base for antifouling paint.

Antifouling paint contains poisonous substances such as copper, mercuric oxide, cyanide, etc., to prevent marine growth. It exfoliates, thus producing new surfaces at intervals.

Boot-topping paint is usually a mixture of zinc oxide, lampblack, and special varnish. It resists the alternate wind and water exposures. Oil paint would last only a few days under such trying conditions. Use Navy no. 2 for black hulls, no. 3 for white and gray hulls.

ASPHALT SOLUTIONS

562. A viscous asphalt solution in mineral spirits or turpentine substitute is applied as a priming coat for bituminous cements and enamels. The enamel is applied hot.

ALUMINUM PAINT

563. This paint has good heat-resisting qualities. When applied to iron it is only slightly effected by a dull red heat. It is one of the most durable of paints, the pigment being very prone to oxidize. It is equally good for priming or finishing coats. Except when used as a heat-proof paint it should be prepared in the proportion of 2 pounds of aluminum powder to 1 gallon of mixing varnish. (See Navy formula 49.)

SMOKESTACK PAINT

564. This paint is usually made of zinc oxide, white lead, litharge, and damar varnish thinned with kerosene and drier added. It is very good in the presence of high temperatures. (Spar color, Navy formula no. 8; light gray, Navy formula no. 10.)

CHINA WOOD OIL

565. This is an oil derived from the tung bug. It is quite viscous and dries rapidly, producing a hard film with an opaque surface. After heating it is used as a base for waterproof varnishes.

POPPY SEED OIL

566. This oil is next best in quality to linseed oil. It is light in color, spreads freely, and dries rapidly. It does not darken easily.

NAME PLATES AND LIFE BUOYS NOT TO BE PAINTED

567. The regulations provide that care shall be taken to leave unpainted name plates and metallic or Franklin life buoys and to allow them to assume a dull or natural oxidized color.

APEXIOR

568. Apexior is the trade name of certain special paints manufactured by the Dampney Co. of America. The two grades usually used in the service are Nos. 1 and 3.

Apexior No. 1 is a gray-black liquid, similar in consistency and appearance to a paint, for use on surfaces exposed to steam and hot water. It is applied to readily accessible surfaces, such as the interior of boiler drums, to turbine rotors and casings. It is applied by hand with an ordinary paint brush. On surfaces inaccessible to a hand brush, such as the internal-tube surfaces of water-tube boilers, Apexior is applied by revolving brushes attached to the end of the tube cleaner in place of the cutting head. It dries in a few hours and the boiler or turbine can then be put back into regular service. The average effective life of each application is about 1 year. It will adhere for long periods of time and will stop old pitting and corrosion and prevent new. It is also applied to induction pipes, evaporators, and other types of marine power-plant equipment where conditions of *wet heat* exist.

Apexior No. 3 is primarily an anticorrosive and no antifouling properties are claimed for it. Where fouling is anticipated it is recommended that a standard brand of antifouling paint be applied over Apexior No. 3. This will not lessen the anticorrosion value of the Apexior. It has been used on the stern portions of some merchant vessels alone or applied first and then a cost of antifouling added. It is designed to protect the plates and its resistance to marine growths is purely secondary. It has given good results when applied to propeller blades, boiler fronts, condensers, etc. It has been substituted for zinc plates on underwater surfaces where electrolytic action takes place.

SPRAY RUSTPROOFING

569. A process known as "Spray-Sherardizing" or "Spray Rustproofing" has been developed in recent years. This process consists in spraying zinc dust on structural steel surfaces after erection is complete. It is stated to be suitable for coating ships, bridges, and steel framework of buildings. The first step in the process is to clean the surface to be treated by means of steel brushes to remove all dirt, rust, old paint, etc. A coating of bright-green bitumen-base paint is then applied by means of an ordinary paint sprayer, and when this has dried to the tacky stage, zinc dust is sprayed on, employing a pressure of a few pounds per square inch only. The bright-green tint of the paint forms a contrast with the gray color of the zinc dust, and the operator can be sure he has covered the entire surface. The zinc adheres firmly to the layer of paint, and the whole becomes finger-dry in about 2 hours. After complete hardening, a tenacious and durable protective coating is obtained. Here again, owing to the fact that the zinc is electropositive to the underlying metal, rust does not spread beneath the coating, as may occur in the case of some paints after exposure. The process is said to be no more expensive than painting, and the resultant coating is said to be 2 or 3 times as durable as ordinary paint. As the pressure is low, the face and hands of the operator need not be specially protected; moreover, unskilled labor may be employed in the spraying operation. (Professional Notes, U. S. Naval Institute Proceedings, July 1931, by special permission.)

TO KILL KNOTS

570. All knots should be "killed" before painting, otherwise the sap will exude. Cover them with fresh slaked lime for 24 hours, then scrape the lime off and apply a coat of red lead and white lead mixed with glue size. Rub down with pumice stone when dry and paint.

LEAD DUST

571. The British Lead Paint Act, 1926, enacted to prevent lead poisoning, includes the following precautions that should apply aboard ship as well as ashore: (a) Lead paint should never be applied in the form of a spray on inside work; (b) no surface containing lead should be rubbed down or scraped by a *dry* process.

CANVAS, REGULATIONS REGARDING PAINTING OF

572. Regulations require that canvas outfits, including all boat covers, awnings, weather cloths, miscellaneous covers, etc. (except mast coats and fixed portions of the bridge-rail weather cloths previously painted), shall not be painted but such articles left bright for scrubbing.

To waterproof canvas that has already been painted and canvas-cover decks use paint mixed with raw linseed oil that is boiled with beeswax for 2 hours (12 ounces beeswax to 1 gallon raw linseed oil).

MOISTURE RESISTING GLUE

573. One pound glue, 1 pound black resin, ¼ pound red ochre; mixed with the least practicable quantity of water.

PUTTY

574. Well dried and sifted whiting, 14 pounds, and 1 quart boiled linseed oil well mixed, let stand for 3 days and work up again before using.

DO NOT PAINT

575. No-Oxide, creosote, and cement surfaces should never be painted.

TO RUB UP WOODWORK

576. The oak and hardwoods so much used in furniture often take on a dark stained appearance. A

fine cleaner is made by adding one-half pint of turpentine to one-half pint of boiled linseed oil. This will remove all dirt but will not polish. Use plain boiled linseed oil to polish.

PAINTING (By Lt. Comdr. M. O'Neill, U. S. C. G.)

577. I sincerely hope that you have given much space to Care and Preservation, particularly in regard to preparation of surfaces for painting and in regard to the mixing and application of paints. As you probably know the practice most common in our service is to scrub the ship's side, for example, with a solution of our famous "soogy" water and then apply a coat of paint that has been mixed to the consistency of soft putty. I asked one of our oldtime boatswains once why his paint was so thick, and he informed me that by having it thick only one coat need be applied In other words, a satisfactory and finished job was sacrificed in order to save a few hours' labor.

We are in danger of becoming known as a "paint-slapping" service, and I think it is frequently due: First, to an inferior grade of paints furnished to the ships; secondly, to the method for preparing the surface for painting; and thirdly, to the application of the paint. In other words, we strive to keep our ships looking as well as possible and achieve what we believe to be satisfaction in this respect by placing on a new coat of paint.

A large percentage of commissioned officers, warrant officers, and enlisted men seem to know very little about the application of "old-fashioned" red lead as a rust preventer. I have seen this preservative applied too thickly, allowed insufficient time to dry, and then covered with a coat of gray or deck paint with the result that not only labor but much paint as well was wasted.

SPONTANEOUS COMBUSTION

578. Canvas used for deck protection, while painting equipment or bulkheads, is often carelessly rolled up and stowed in the paint locker until it is required for another job. Waste or rags used for wiping up paints and oils while painting or about the leaky drums in the paint locker are also often rolled into a ball and thrown into a corner. This canvas, waste, or rags becomes impregnated with easily oxidized oils and in certain circumstances ignition may occur without the application of any external sources of heat. Poor and defective ventilation will furnish sufficient air to support combustion without removing the resultant heat fast enough to maintain the temperature below the ignition point. That is, oxidation, proceeding slowly at first, may cause heat to accumulate until ultimately the temperature is raised to the "ignition point", when inflammation occurs. The spontaneous firing of hay-ricks and piles of finely divided coal is the result of similar causes.

MOTOR BOAT FIRES

579. Practically all motor boat fires are caused by gasoline accumulation in the bilges. This results in the presence of an explosive mixture of gasoline vapor and air, particularly in cold weather when condensation of gas in the intake pipe is increased. Bilges in addition to pumping should be washed out frequently. It is believed that many motor boat fires start from a cigarette rather than from the usual alibi "an electrical spark."

GASOLINE

580. The low limit of gasoline occurs when but 1.4 percent of the mixture is gasoline vapor. One cubic inch of gasoline completely vaporized will render a space of 9 cubic feet highly explosive. The vapor may travel along a current of air for a considerable distance and then be ignited. Gasoline vapor is heavier than air and will be found near the floor first. A prolific cause of gasoline explosions is the existence of static or frictional electricity and subsequent sparking due to difference in potential between two metallic objects which are adjacent but not in actual physical contact. Gasoline passing through a hose generates electricity, and if the nozzle at the discharge end is not in contact with the metal of the receiving container the electricity may be stored up in the nozzle and ultimately discharge to the container with a spark. In order to avoid danger from sparking, actual physical contact must be made between the metals of the two containers when transferring gasoline from one to another.

Gasoline should not be used for cleaning or other purposes in inclosed spaces unless unavoidable, in which case small stoppered containers should be used. Contrary to the belief of some personnel, the gas fumes in an open bucket of gasoline are highly explosive and the gas vapor in a partly filled or empty drum or tank is veritable TNT.

The following impressive accident occurred on a cutter. A man returning at night from liberty carried a lighted lantern under the forecastle head to obtain his hammock. Someone had evidently been cleaning clothes in that part of the vessel and had left a bucket partly filled with gasoline near the spot where the unsuspecting man set his lantern down. The gasoline vapor was exploded by the lantern flame and threw burning gasoline all over him. He was frightfully burned. In his agony he jumped overboard. His suffering was most pitiful in its severity and after being rescued it required a day to transport him to the nearest hospital. The man suffered permanent loss of a vital organ of his body.

Pure air contains 21 percent oxygen. In order to put out a fire by reducing or depriving a compartment of oxygen it is necessary to remove 6 percent of the oxygen. The dilution may be effected by steam or any

other inert gas which will not support combustion. The three gases used for this purpose are carbon dioxide, sulphur dioxide, and funnel gas.

It must be kept in mind that after putting out flames by the dilution method that any glowing or red hot mass will flare up again if opened up too soon to allow the entrance of fresh air.

Steam smothering as a means of extinguishing fires is much less efficient than gas. Upon admission to a compartment it condenses on cold surfaces instead of driving out the air. This requires all parts to become hot before it acts and thus requires a long period to obtain results. Also steam striking red-hot surfaces where there is incandescent carbon, decomposes into gases which when mixed with air in the right proportion are explosive.

Funnel gas, the gas which is thrown off a vessel's smokestack, is an excellent one for extinguishing fires. In such a system a fan suction is used to collect the gas, after which it is cooled and washed.

The sulphur dioxide system produces gas from the burning of sulphur in an oven. It is also used for fumigation purposes.

EMERGENCY FIRE HOOD

581. The emergency fire hood is simply a large, loose bag (fitted with goggles) which, fitted closely around the neck, entraps a certain amount of fresh air which is breathed over and over. When this is vitiated, the wearer must seek fresh air. It affords protection against noxious atmospheres for a time not to exceed 5 minutes. A fire hood is in no manner as effective as a gas mask and is totally unsuitable for use at such times as ship fumigation or in the presence of poisonous gasses. No special instructions are required as to the use of such a hood, excepting that as much air as possible should be entrapped when putting the hood on. It should be understood that the oxygen entrapped in the bag will not last as long when the wearer is exercising as it would if he were at rest. Rapid breathing, due to excitement, will also exhaust the oxygen more rapidly than would be the case with a man of steady nerves.

A life line should always be attached to a man wearing the emergency fire hood when he is about to enter a dark or smoke filled compartment.

GAS MASK

582. The Navy has developed a type of gas mask known as the "Oxygen rescue breathing apparatus (Navy type)" which is especially designed for use aboard ship where a self-contained gas and smoke-proof apparatus of low breathing resistance is required. It is compact, of light weight, and will permit the wearer to pass through any space through which he can get his shoulders. It will also permit the wearer to do moderately hard work in irrespirable atmospheres for half an hour. The Navy has established a school at the New York Navy Yard to train personnel in the use of this apparatus and as to its construction, the method of wearing it, the system of circulation, and the source of the breathable air it supplies. For a full description of this mask, see chapter 28, Bureau of Construction and Repair Manual, United States Navy.

FIRE PRECAUTIONS

583. In the service frequently too little attention is paid to the care and servicing of fire extinguishers. One of the commonest offenses is this regard is the failure to recharge them annually or to keep them filled to capacity. Inspecting officers frequently find the tertachloride type inoperative from frozen plungers or clogged orifices. It should be kept in mind that tetrachloride is a nonconductor and may be used directly on electrical apparatus. CO_2 may also be used for electrical fires. Men should be cautioned to not play a stream of water or the acid-soda type extinguisher on such a fire.

The acid-soda type are often found with deteriorated hose connections and charges and with the nozzle stopped up. The simple test of blowing one's breath into the nozzle is effective. If the orifice is clogged no air goes into the hose and in this case the unmistakable rebound of the air is not felt. Accurate recharging is necessary. Cases have happened where an overcharge in an acid-soda type extinguisher has resulted in the extinguisher blowing up from excessive pressure when placed in use, and recently in Waterford, Conn., a man was so killed.

Accurate weighing twice a year of the CO_2 type extinguisher is necessary to insure that they are not less than 90 percent fully charged. In most CO_2 types if the valve has been opened at all, it cannot be closed and the extinguisher must then be recharged.

Record cards attached to each CO_2 extinguisher show the total weight when fully charged and should be carefully kept attached. Refill date cards are to be kept attached to all extinguishers.

Foam.—Two and one-half gallon, portable, hand type consists of a metal container filled with a solution (charge B) surrounding an inner cylinder containing aluminum sulphate (charge A). When the cylinder is inclined more than 45° from the vertical the cylinder cap is released, thus allowing the aluminum sulphate to mix with the foam solution. As this is a secret formula, the charges are simply ordered as charge A and charge B. However, there are other formulas that may be found in the Navy Construction and Repair Manual.

FIRE-FIGHTING APPARATUS

(By Lt. Comdr. John W. Kelliher.)

584. "Now that the service has practically an oil-burning fleet we should have the latest apparatus for fire-fighting. Except in the cases of the 75-foot patrol boats the fuel fire-fighting apparatus is in the fireroom and quite inaccessible in emergencies. Oil

fires are so hot, so rapid in their spread that they drive the personnel away and then what use is a device in a compartment you are unable to enter. They should be located somewhere else and should consist of an adequate bank of CO_2 bottles so connected that they can discharge into the fire-room and engine room. Their discharge can be conducted about the ship and directed to advantage. Another point that is greatly neglected is this matter of gas masks, asbestos gloves, etc. We go through a fire drill and put it in the log and for all practical purposes it all ends there. The hose is led out on the top side, the first and last water is timed and everybody seems satisfied. Whoever heard of a serious fire on the top-side where it is in plain sight? Fires occur in the most unlikely places, many times quite inaccessible, and always accompanied by great volumes of blinding, acrid smoke. Many times due to the peculiar drafts through passages, etc., it is impossible to tell where the fire is located. Men do not readily carry a hose down a ladder into thick smoke and delay ensues. Gas masks should be provided so that those carrying the hose can see where they are going and locate the fire. A burning waste basket will cause enough smoke to make it appear to be a fire of some size. To point out a recent example, it is my profound belief that if there had been a sufficiency of efficient gas masks and the fire bill had designated certain personnel to use them, it would have been possible for the crew of the *Morro Castle* to have awakened and led to comparative safety dozens of passengers who perished because they could not see to escape. Gas masks for the fire and engine room personnel would have made it possible for them to remain at their posts longer."

BOILER CLEANING

585. Regulations provide that each boiler on a cruising cutter shall be cleaned as soon after 700 hours' use as practicable, the steaming time to be computed as follows: For each hour the boiler is in use while the vessel is underway (or standing by when not lying at dock or anchored) full time shall be charged, and for each hour that it is used while the vessel is not underway, for running the principal auxiliaries, such as the dynamo, evaporator, etc., one-tenth hour shall be charged. When steam is being used only for heating purposes or for running the sanitary pump no time shall be charged. Each boiler shall be cleaned once every 3 months regardless of steaming hours. In special cases where the operating conditions are not good, the boilers should be opened at more frequent intervals and examined to ascertain their condition and cleaned if necessary.

Boilers of inshore patrol cutters, harbor cutters, and harbor launches shall be cleaned once every 2 months.

PLACING VESSELS OUT OF COMMISSION

586. The Coast Guard regulations covering the placing of vessels out of commission are quoted below:

"When a vessel is ordered out of commission the following procedure relative to the care of the machinery, shall be observed:

"The steel and iron bright work of the engine shall be well cleaned and covered with white lead and tallow, or other suitable substance. All packing should be removed from rods. All rods and the interiors of all steam cylinders and valve chests shall be thoroughly cleaned and covered with a mixture of graphite and vaseline.

"Bearings shall be well oiled, and the holes plugged with waste and tallow. The engines shall be turned, and the pistons and valves brought to rest on well-lubricated surfaces. The water cylinders and channel ways of all pumps and condensers shall be drained and cleaned.

"The boilers shall be washed out with fresh water.

"Furnaces, back connections, tube sheets, and the interiors of boiler tubes in Scotch boilers shall be coated with heavy black oil. The top of the smokestacks shall be suitably covered.

"The pipes to gages shall be disconnected for drainage, and oil cups shall be removed, cleaned, marked with tags giving the name of the ship and the location of each pipe and cup, and stored. When a vessel is laid up in a cold climate, suitable provision shall be taken to prevent the freezing of the sea-valve boxes and stern tube. The sea valves shall be closed and properly secured. The storerooms shall be cleaned and locked.

"A record shall be kept detailing all steps taken during the operation of laying up the machinery and boilers, and stating where each removed part is stored. A copy of this record shall be left in a safe place on the vessel where it can readily be found and the original sent to headquarters.

"Telemotor system of steering gear to be drained. Fidleys to be covered to exclude rain and snow. Voice tubes with outlets exposed to be covered to exclude moisture. Spars, blocks, staffs unshipped and stowed. Ladders, sounding platforms, etc., to be unshipped and stowed. Metallic smokestack covers fitted. Keys properly tagged and turned over to custodian after everything is locked up. Furniture protected with light covers of muslin, if left aboard."

The Bureau of Construction and Repair Manual, United States Navy, outlines the procedure to be carried out in laying up electrical machinery. Extracts follow:

"Electrical machinery should be removed if it can be taken out of the ship readily without great expense. The building where it is stored ashore should be heated so that the air may be maintained at a suffi-

ciently low relative humidity to prevent deterioration of the machinery. Such machinery as remains on board will be covered by canvas or other suitable covering that is practically dust and water proof. Covers should be lashed securely in all cases. Several connections to controlling appliances should be broken and carefully tagged so as to prevent unauthorized operation. Such periodic inspections and tests will be made as will insure the good condition of all such material whether aboard or ashore.

"Remove armature and field coils from frames. Wire brush and clean frames, pole pieces, and shafts. Remove all sediment and dust, then coat armatures, coils, frames, and pole pieces with a black air-drying varnish. Lightly coat the armature shaft with rust-preventative compound. Reassemble.

"Commutators should be thoroughly cleaned and laid up dry. Oil in no form should be used on the commutator. Either cover the commutator with oilcloth, or with varnished cambric tape, or enclose same with generator cover tightly lashed.

"Cast-iron grid rheostats should be thoroughly cleaned and coated with rust-preventative compound.

"The bottoms of vessels placed out of commission should be protected with the usual 2 coats of anticorrosive paints and 1 coat of antifouling paint. Boot-topping paint should not be applied to the region between the light and load water lines of decommissioned vessels. The oil paint used on the ship's sides should be carried down 1 foot below the actual water line.

"In order to reduce to the minimum possible galvanic action between the bronze propellers and the steel of the hulls, propeller blades of ships out of commission should be painted with 2 coats of anticorrosive and 1 coat of antifouling paint.

"When placing a vessel out of commission, the exterior painting of the ship shall be in good condition and all bare or rusted spots shall be thoroughly cleaned and coated with red lead. Bare steel plate on weather decks shall be given a complete coat of deck paint and touched up as necessary to insure a thorough protective coating. The paintwork on the interior of the hull shall be examined thoroughly and interior surfaces shall be thoroughly dried when the vessel is placed out of commission. All bare or rusted spots shall be cleaned thoroughly and coated with red lead. All hatches, ventilating openings, air ports, shutters, doors, or other openings shall be closed and thoroughly sealed against the weather. Old tarpaulins or canvas should be used to close such openings. Hatches and doors not required for access may be permanently sealed. It is expected that before a vessel is placed out of commission all compartments, lockers, bins, refrigerating and other spaces will have been thoroughly cleaned and all paint work put in a suitable state of preservation.

"Wood decks that are exposed to the weather shall be given a thin coat of crude turpentine and well coated with sawdust. Canvas decks shall be well painted.

"All water tanks, both for feed and potable water, also peak tanks, shall be completely drained and dried out. All valves shall be seated and handwheels securely locked. All vent valves shall be closed or vents sealed against the weather. All bare spots should be touched up after making sure that the surface is thoroughly dry. Dry unslaked lime, in lumps as large as possible, stowed loose, and not greater than 1½ inches in depth, in shallow iron containers (2 pounds per 100 cubic feet volume of tanks) shall be placed inside each tank other than fuel-oil tanks.

"Fixed ballast, as necessary to be added before water tanks and ballast tanks are emptied.

"The water piping, valves, and fixtures are to be thoroughly drained by drains or by breaking joints at the lowest points of the lines, or wherever a pocket is formed that is not suitably drained. Remake any broken joints with new gaskets, tagging them so that when pressure is again applied to the line these joints may be noted. Record should be kept on all joints broken. Outboard valves to be locked and boxed with sawdust, straw, or other suitable insulating material to prevent freezing.

"Unslaked lime in approximately the same proportions as noted for water tanks to be placed in the storerooms and other spaces which will be normally kept closed while the vessel is out of commission.

"Bilges to be thoroughly dried and protective coatings in good condition.

"Oil tanks shall be pumped out as far as practicable and all water removed. The oil coating will act as an excellent preservative, provided no water is present. Valves should be seated and handwheels locked. All manhole covers should be made tight and securely closed. Vents to be left fully opened.

"Special precautions should be taken to guard against fire or explosion. Care should be taken that wire gauze protectors in the vents are intact, and immediate vicinity of such vents guarded against sparks or flame. Warning signs should be posted near vents warning against sparks or open flame. A man shall never be allowed to enter such a tank until the required clearing of fuel oil and gasses is carried out."

The preparation of a fuel-oil tank for entering is described in article 531 and on page 38 of Glossary.

CHAPTER VI

FORMULAS AND PROBLEMS

601.

(*a*) Propeller slip $=\dfrac{\text{speed of propeller}-\text{speed of advance}}{\text{speed of propeller}}$

(*b*) Displacement in tons $=\dfrac{\text{volume of underwater body in cubic ft.}}{35}$

(Divide by 36 if fresh water.)

(*c*) Brackish water density effect on displacement $=$ Displacement in tons $\times$ density

(*d*) Tonnage (in tons) $=\dfrac{\text{Internal capacity of vessel in cubic feet}}{100}$

(*e*) Gross tonnage $=\dfrac{\text{Volume of ship below main deck in cubic feet}}{100}$

(*f*) Net tonnage $=\dfrac{\text{Volume of cargo space in cubic feet}}{100}$

(*g*) 1 cubic foot salt water weighs 64 pounds.
1 cubic foot fresh water weight 62.4 pounds.
1 long ton salt water=35 cubic feet.
1 long ton fresh water=36 cubic feet.
1 gallon fresh water weighs 8.35 pounds.

(*h*) difference in draft from salt to fresh water $=\dfrac{\text{Displacement in tons}}{35\times\text{mean tons per inch for draft range dealt with}}$

(For fresh water to salt water divide by 36 instead of 35.)

(*i*) Distance center of gravity moves in feet $=\dfrac{\text{Weight moved in tons}\times\text{distance moved in feet}}{\text{displacement in tons}}$

Difference in draft salt water to brackish $=\dfrac{\text{Displacement in tons}\left(\dfrac{36}{d'}-35\right)}{35\times\text{mean tons per inch of range}}$

where d'=density of brackish water

(*j*) Moment of stability (statical) $=$ Displacement in tons $\times$ lever arm GZ

Moment of stability for inclinations $=$ Displacement $\times$ GM sine θ

where θ is the angle of transverse inclination.

(*k*) In salt water; tons per inch immersion or the weight required to increase or decrease draft 1″ $=\dfrac{\text{area load water plane}}{420}$

(For fresh water÷432.)

(*l*) Salt water density=1.026
Fresh water density=1.

(*m*) Inclining experiment

$GM=\dfrac{\text{weight moved in tons}\times\text{distance moved in feet}}{\text{displacement in tons}\times\text{tangent angle of inclination}}$

$\left(\text{The tangent}=\dfrac{\text{length of plumb bob}}{\text{distance it moves athwartships}}\right)$

(*n*) Moment to change trim 1 inch (in foot-tons) $=\dfrac{(\text{Displacement in tons})\times(\text{Longitudinal metacentric height})}{12\times\text{length of vessel in feet}}$

(*o*) (Moment of an area about an axis) $=$ area $\times$ distance its center of gravity is from the axis

(*p*) *MI* or moment of inertia of area (as L. W. L.) $=$ Divide the area into very small areas. Obtain the summation of all the areas multiplied by the square of the distance each area is from the axis under consideration.

(*q*) $BM=\dfrac{\text{Moment of inertia of load water plane}}{\text{Displacement in cubic feet}}$

$$BM=\frac{I}{V}$$

(*r*) Period of roll

$$T=0.554\sqrt{\frac{K^2}{GM}}$$

Where T=the period of roll from one side to the other in seconds. K is the radius of gyration about the longitudinal axis through G, and GM the transverse metacentric height in feet.

(*s*) (Transverse *MI* of a waterplane) $=K\times B^3\times L$

Where B=greatest breadth
K=coefficient of fineness of water line
L=length of vessel

Coefficient of fineness:
Circle=1/16
Rectangle=1/12
Triangle=1/18

(*t*) Area of ship's bottom $=15.5\sqrt{W\times L}$
W=displacement in tons
L=length of water line in feet.

(*u*) Righting moment=Displacement in tons $\times$ righting arm (GZ) in feet.

Block coefficient $=\dfrac{V}{LBD}$

V=volume of displacement
LBD=length, beam, and draft.

(*v*) Prismatic coefficient $=\dfrac{\text{Displacement in tons}\times 35}{\text{Area midship section}\times\text{length}}$

(*w*) Center of buoyancy below $LWL=\frac{1}{2}\left(\dfrac{d}{2}+\dfrac{V}{A}\right)$

d=mean draft (to top of keel) in feet
V=volume of displacement to LWL, in cubic feet
A=area of LWL, in square feet

(*x*) *To compute irregularly shaped areas, such as water planes.*—Simpson's first rule for even number of spaces. Odd number of ordinates.

$$\text{Area}=\frac{h}{3}(y_0+{}^4y_1+{}^2y_2+{}^4y_3+{}^2y_4+{}^4y_5+{}^2y_6+{}^4y_7+y_8)$$

$$\text{Area}=\frac{h}{3}(y_0+{}^4y_1+{}^2y_2+{}^4y_3+{}^2y_4+\cdots\cdots{}^4y_{n-1}+y_n)$$

h is the common interval between ordinates.

(*y*) *Trapezoidal rule.*

$$\text{Area}=h(\tfrac{1}{2}y_0+y_1+y_2+y_3+y_4+y_5+y_6+y_7+\tfrac{1}{2}y_8)$$

$$\text{Area}=h(\tfrac{1}{2}y_0+y_1+y_2+\cdots\cdots\cdots\cdots\cdots y_{n-1}+\tfrac{1}{2}y_n)$$

Problem.—Required the amount of linoleum necessary to renew a section of deck having ordinates at a common distance apart of 2.5 feet; the length of the ordinates being 3.5, 4.7, 5.6, 6.3, 7.0, 7.5, and 7.9 feet. Using the trapezoidal rule compute how many square feet of linoleum are required.

Area $=2.5\ (1.75+4.7+5.6+6.3+7.0+7.5+3.9=2.5$ (36.8) or 92.0 square feet of linoleum.

(*z*) *Computing volume of a vessel and changing it to tons displacement.*—By Simpson's rule compute areas of equally spaced planes. Then perform another Simpson's rule calculation using the areas as ordinates. Nine feet between ordinates of planes and 9 feet between planes.

Ordinate	Multiplier	*f* (a)	Ordinate	Multiplier	*f* (a)
$y_0=8$	1	8	$y_6=14$	2	28
$y_1=12$	4	48	$y_7=12$	4	48
$y_2=14$	2	28	$y_8=8$	1	8
$y_3=15$	4	60			
$y_4=16$	2	32	Σ		320
$y_5=15$	4	60			

(The system of planes passed through the vessel may be either transverse stations or fore-and-aft longitudinal planes.)

$A=\frac{9}{3}\times320=960$ square feet, the total area of plane A.

Similarly the areas of the other planes were computed with the following results:

[$B=900$, $C=880$, $D=860$, $E=820$, $F=740$, $G=410$]

Waterplanes	Areas	Simpson's multiplier	*f* (V)
A	960	1	960
B	900	4	3,600
C	880	2	1,760
D	860	4	3,440
E	820	2	1,640
F	740	4	2,960
G	410	1	410
Σ			14,770

$V=\frac{9}{3}\times14{,}770=44{,}310$ cubic feet.

To reduce the above cubical displacements of a ship to tons displacement, divide by 35 for salt water and 36 for fresh water.

602. *To find the vertical position of the center of buoyancy.*—

An approximate method of finding the vertical position of the center of buoyancy, when a vessel is floating at or near her load draft: Measure down from the waterline, a distance equal to between 0.4 to 0.45 of the mean draft taken to the top of the keel. The transverse position will ordinarily coincide with the fore-and-aft middle line.

A more accurate method is to divide the ship into equally spaced waterplanes. Calculate the area of each plane by Simpson's rule. Then proceed as in obtaining the volume displacement (i. e.), using the areas as ordinates perform another Simpson's rule calculation to obtain the products as shown in the column headed *f* (V). (See art. 601 (*z*).) Next multiply each of the amounts in the *f* (V) column by the respective distances of their waterplanes from the top of the keel (levers). The sum of the moments obtained divided by the sum of the products of the areas gives the height of the center of buoyancy above the keel.

603. (1) Find the moment of inertia of the load waterplane and then compute the location of the transverse metacenter of a vessel of 100 tons displacement, whose half ordinates spaced 9 feet apart are: 0, 2.5, 6, 9, 11, 12, 10, 7, 5, 2, and 0.5 feet (in salt water).

Number of ordinates	One-half ordinates	Cubes of one-half ordinates	Simpson's multiplier	Moments
1	0	0	1	0
2	2.5	15.62	4	62.48
3	6.0	216.00	2	432.00
4	9.0	729.00	4	2,916.00
5	11.0	1,331.00	2	2,662.00
6	12.0	1,728.00	4	6,912.00
7	10.0	1,000.00	2	2,000.00
8	7.0	343.00	4	1,372.00
9	5.0	125.00	2	250.00
10	2.0	8.00	4	32.00
11	.5	.12	1	.12
⅓ of cubes				3)16,638.60
⅓ common interval				5,546.23
M I of ½ plane				16,638.6 2
Moment of inertia of load waterplane				33,277.2

$BM=\frac{I}{V}=\frac{33{,}277.2}{100\times35}=9.5$ feet.

(2) The *areas* of transverse stations in square feet of a vessel are 0, 31, 66, 111, 163, 221, 281, 338, 385, 420, 428, 416, 387, 342, 288, 218, 170, 113, 61, 22, and 0. Distance between stations, 11.6 feet. Find the volume by Simpson's multipliers.—1,478 tons.

(3) *Problem.*—A wind force of 20 tons is exerted on a sail 50 feet above the deck of a vessel. What is the opposing force for a 2,000-ton vessel?

Solution.—$20\times50=1{,}000$, the wind's heeling moment.

The righting moment equals 2,000 times GZ, which also equals the heeling moment, 1,000.

$1{,}000\div2{,}000=0.5$ foot, the righting arm which is the opposing force to the capsizing or heeling moment.

(4) *Problem.*—9,000-ton ship with the righting arm, $GZ=4$ inches. What is the righting moment?

Solution.—$9{,}000\times\frac{1}{3}=3{,}000$ foot-tons.

(5) *Problem.*—A weight of 84 tons moved transversely 10 feet causes a 5° inclination. If the displacement is 2,000 tons, what is the metacentric height GM?

Solution.— GM = weight × its distance ÷ displacement × tangent $\theta=\frac{84\times10}{2{,}000\times0.0875}=4.8$ feet.

(6) *Problem.*—A vessel of 2,000 tons has 100 tons of coal stowed in the bunkers, the center of gravity of the coal being 2 feet below the center of gravity of the vessel. During the voyage the coal is consumed. How much does this cause the center of gravity to rise?

Solution.—$100\times2\div1{,}900=0.105$ foot.

(NOTE.—It is necessary to deduct the 100 tons from the displacement.)

(7) *Problem.*—The half breadths of a frame are 0.8, 2.0, 4.9, 9.1, 13.7, 17.9, 21.3, 23.6, 25.1. The distance between the ordinates is 4 feet. Find the area of a section of the ship at this point, by Simpson's first rule.

Solution.—Area $=\frac{4}{3}(0.8+(4\times2.0)+(2\times4.9)+(4\times9.1)+(2\times13.7)+(4\times17.9)+(2\times21.3)+(4\times23.6)+(25.1)=\frac{4}{3}(316.1)$, or 421.47 square feet for half breadth, or 843 square feet for area of a section.

(8) *Problem.*—A ship of 12,000 tons displacement has a draft of 24 feet in salt water. Tons per inch immersion is 50.

How many inches does she sink at New Orleans where density of brackish water is 1.006?

Solution.—

$$d=\frac{\frac{12000(36-35)}{1.006}}{1750}=5.35 \text{ inches.}$$

(9) *Problem.*—

In salt water:

Given area of *L. W. L.* plane is 9,648 square feet.

Find tons per inch immersion, and if 400 tons of fuel were taken aboard what would be the increase in draft?

Solution.—

$$T=\frac{W}{420}=\frac{9648}{420}=22.97$$

$$\frac{400}{22.97}=17.40 \text{ inches increase in draft.}$$

(10) *Problem.*—A vessel's draft in salt water is 28 feet 4 inches, displacement 14,800 tons. Tons per inch immersion for fresh water and salt water in 75. Can she pass over a shoal of 28¼ feet after reaching fresh water if 105 tons of fuel are consumed before reaching it?

Solution.—

$$d=\frac{W}{35T}=\frac{14800-105}{2625}=5.6 \text{ inches.}$$

5.6 inches − 1.4 inches = 4.2 inches

$\left(\frac{105}{75}=1.4 \text{ inches}\right)$

28 feet 4 inches + 4.2 inches = 28 feet 8.2 inches

28 feet 8.2 inches − 28 feet 3 inches = 5.2 inches too great a draft to pass.

(11) *Problem.*—Before departing from fresh water a vessel's mean draft is 30 feet. Tons per inch immersion=100. Before sailing she took on fuel. After making a voyage, having consumed 300 tons of fuel and 100 tons of stores, and when in salt water her mean draft is 30 feet 5 inches and displacement 32,000 tons. How much fuel did she take on board before sailing and what will be her mean draft when this is consumed?

Solution.—

$$d=\frac{W}{36T}$$

$\frac{32000}{36}=8.89$ inches sinks deeper in fresh water.

$\frac{300}{100}=3$ inches deeper

8.89 inches + 3 inches = 11.89 inches +

30 feet 5 inches = 30 feet 16.89 inches

− 29 feet 11.00 inches[1]

17.89 inches

17.89 × 10 = 1,789 gallons.

Alternate solution.—

$\frac{1}{36}\times32000=888$ tons + 400 = 1,288 tons = 12.88 inche

30 feet 5 inches

\+ 12.88 inches 17.88 × 100 = 1,788 gallons

30 feet 17.88 inches

1789 − 300 = 1,489 tons fuel left

$\frac{1489}{100}=14.89$ inches

30 feet 5.00 inches

− 1 foot 2.88 inches

29 feet 2.12 inches draft when fuel is consumed.

(12) *Problem.*—Mean draft before fueling is 28 feet. After fueling it is 29 feet 8 inches. The tons per inch immersion for the range of drafts is 101.5. If oil density is 300 gallons per ton, how much fuel did she take?

Solution.—

29 feet 8 inches − 28 feet 00 inches = 1 foot 8 inches = 20 inches 20 × 101.5 = 2030 × 300 = 609,000 gallons.

(13) *Problem.*—In fresh water a vessel draws 14 feet 9 inches and corresponding displacement=7,800

[1]Deduct 100 tons for stores.

tons. Then takes on board 15 000 gallons water, 12,000 pounds meat, and 40,000 pounds stores, and 25 tons of ammunition. Tons per inch immersion=50.8 tons. Fresh water weighs 8.35 pounds per gallon. Give draft of the vessel after reaching salt water.

Solution.—

$15{,}000\times8.35=125{,}250+12{,}000+40{,}000=177{,}250$

$177{,}250\div2{,}240=79.13$ tons $+\ 25=104.13$ tons

$\frac{104.13}{50.8}=2.05$ inches deeper

$7{,}800+104.13=7{,}904.13$ tons

$d=\frac{W}{35T}=\frac{7904.13}{35\times50.8}=4.44$ inches up

4.44 inches − 2.05 inches down = 2.39 inches up

14 feet 9 inches
2.39 inches
14 feet 6.61 inches = draft in salt water

(14) *Problem.*—Took soundings in fresh water. After reaching salt water took on 65,000 gallons fuel oil. Soundings then were same as in fresh water (300 gallons oil per ton). What was the displacement after fueling?

Solution.—

$\frac{65{,}000}{300}=217$ tons

$\frac{217}{T}=$ change in draft

also $d=\frac{217}{T}=\frac{W}{35T}$

$W=7{,}595$

Displacement after fueling $=7{,}595+217=7{,}812$ tons.

(15) *Problem.*—A vessel's draft is 13 feet forward and 15 feet aft. Tons per inch immersion is 20. If a weight of 55 tons be placed over or under the center of floatation what will be the new draft?

Solution.—

$\frac{55}{20}=$ 2¾ inches. 13 feet + 2¾ inches = 13 feet 2¾ inches forward.

15 feet + 2¾ inches = 15 feet 2¾ inches aft.

(16) *Problem.*—A vessel of 14,000 tons has a metacentric height of 3½ feet. She is then inclined to an angle of 10°. What is her stability (statical) or tendency to return to the upright position?

Solution.—

Stability $=W\times GZ=W\times GM$ sine θ (sine 10 $=0.1736$)

$=14{,}000\times3.5\times$ sine $10°=8{,}506$ foot ton

(17) *Problem.*—A 5,000-ton vessel has a weight of 70 tons moved transversely on deck 30 feet. Find movement of center of gravity in both direction and amount.

Solution.—

$CG'=\frac{w\times d}{W}=\frac{70\times30}{5{,}000}=0.42$ foot transversely

(For additional problems of this nature see chapter on stability.)

(18) *Problem.*—Vessel of 4,000 tons. If 100 tons of coal are moved so that center of gravity of the coal moves 18 feet transversely and 4½ feet vertically, what will be the shift of the center of gravity of the vessel?

Solution.—*CG* moves horizontally $\frac{100\times18}{4{,}000}=0.45$ foot

CG moves vertically $\frac{100\times4\frac{1}{2}}{4{,}000}=0.11$ foot

(19) *Problem.*—The displacement of a Coast Guard cutter in sea water is 2,000 tons. The displacement per inch of immersion at water line is 15½ tons. Weight of sea water is 35 cubic feet per ton; of fresh water, 36 cubic feet per ton. The mean draft in sea water is 16 feet 3 inches. What will the mean draft of the vessel be in fresh water?

Solution.—A vessel floating at the same water line will displace one thirty-sixth less cubic feet in salt water than in fresh.

$\frac{2000}{36}=55.55$ tons. $2{,}000+55.55=2{,}055.55$ tons = Displacement in fresh water.

$\frac{35}{36}\times15.5=15.07$ tons per inch in fresh water.

$\frac{55.55}{15.07}=3.68$ inches.* Add the 3.7 inches to 16 feet 3 inches = 16 feet 6.7 inches (the mean draft of vessel in fresh water).

(20) *Problem.*—The cutter described in the above problem while in fresh water takes on board fuel oil of a density of 300 gallons per ton. After fueling, her mean draft in fresh water is 17 feet 10 inches. How many gallons of fuel did she take?

Solution.—17 feet 10 inches − 16 feet 6.7 inches = 15.3 inches.

$15.3\times15.07\times300=69{,}171.3$ gallons of oil.

(21) *Problem.*—The following data pertains to a first-class Coast Guard cutter: Length 250 feet; center of gravity of water-line plane aft of amidships, 4.5 feet; moment to change trim 1 inch, 175 tons; normal mean draft, 14 feet 6 inches; normal drag of keel, 24 inches. Vessel is aground (stem resting on ledge), 12 feet 6 inches. Approximately how many tons of fuel, stores, equipment, etc., must be moved from bow to stern to float vessel? (Assume the weight is moved from a point 10 feet abaft the stem to a point 10 feet forward of the stern.)

Solution.—The normal mean draft being 14 feet 6 inches, and the vessel having a normal drag of 24 inches, her normal drafts would be as follows: Forward, 13 feet 6 inches; amidships, 14 feet 6 inches; aft, 15 feet 6 inches. Being aground forward and drawing 12 feet 6 inches there, she will require a change of trim which is equivalent to 12 inches up, forward. If the center of gravity were exactly at the amidship point instead of being 4.5 feet abaft it, the stern being

* or $d=\frac{W}{35\ T}=\frac{2000}{35\times15\frac{1}{2}}=3.68$ inches d=difference of draft. W=weight of ship. T=tons per inch immersion.

depressed 12 inches would raise her bow 12 inches and float her. But on account of the center of gravity being 4.5 feet abaft midship point, the proportion is as follows: x : 12 inches=120.5 feet : 129.5 feet or x= 11.16 inches, which is the amount the stern will have to be depressed in order to raise the bow 12 inches.

By definition, trim is the difference between the draft at bow and stern, but *change of trim is equal to the sum of the change in drafts forward and aft.* Hence, the total change of trim is 12 inches forward, plus 11.16 inches aft, equals 23.16 inches.

$\frac{129.5\,x}{250}=12$ inches or $x=23.2$ inches $\frac{w\times 230}{175}=23.2$ $w=17.7$ tons.

or:

175 (tons)×23.16 gives a moment of 4053. But the weights are to be moved from 10 feet abaft the stem to 10 feet forward of the stern, which is 230 feet. Hence 230 times the weight necessary to be moved equals 4053; or the weight equals 17.61 tons.

(22) *Problem.*—The following data pertain to a first-class Coast Guard cutter: Length, 250 feet; center of gravity of water plane aft of amidship, 4.5 feet; moment to change trim 1 inch, 175 tons; mean draft, 14 feet 6 inches; normal drag of keel, 24 inches; displacement per inch immersion at average water line plane, 15½ tons. Under the above condition 100 tons of fuel oil are taken into the forward tanks and 100 tons in the after tanks. Assuming that the center of gravity of the oil taken on board forward is 50 feet from the stem and that the center of gravity of the oil taken on board aft is 40 feet from the stern, what will be the draft of the vessel forward and aft after fueling?

Solution.—14 feet 6 inches mean draft gives a draft forward of 13 feet 6 inches and aft 15 feet 6 inches there being a drag of the keel of 24 inches. The ship's mean draft by taking on board 200 tons of oil must go down $\frac{200\text{ tons}}{15.5}=12.9$ inches.

To consider the change of trim compare 100×80.5 feet (which is the 100 tons 80.5 feet abaft the center of gravity), with 100×79.5 feet (which is 100 tons forward of the center of gravity). The two lots of oil, from a viewpoint of trim only, reduce to the equivalent of 100 tons a distance of 1 foot abaft the center of gravity. Therefore, 100×1 foot equals 100 foot-pounds, the moment which will cause the change of trim.

$\frac{\text{moment } 100}{\text{moment } 175}$ equals 0.6 inch, change of trim (because it requires 175 tons for 1 inch). Since, by definition, the change in trim is equal to the sum of the changes of draft forward and aft, the 0.6 inch must be divided into 0.3 inch forward and 0.3 inch aft.

Aft	Forward
12.9 inches	12.9 inches
.3 inches	− .3 inches
15 feet 6.0 inches	
16 feet 7.2 inches draft aft.	12.6 inches
	13 feet 6.0 inches
	12.6 inches
	14 feet 6.6 inches forward draft.

(23). The *Sebago* has four oil tanks abreast between transverse bulkheads 41 and 50. The wing tanks are filled to approximately the same level but it is noticed that a difference in levels of the contiguous inboard tanks requires an equalization so that "great differences of levels in adjacent oil tanks shall be avoided to prevent needless strain on bulkheads" (Regs., art. 2053).

In equalizing the levels of the two inboard tanks, the net result has been to lower a weight of 15 tons of oil a vertical distance of 3 feet, causing at the same time an athwartship shift of the same weight a distance of 11 feet. If the displacement of the vessel is 1,950 tons and the metacentric height of the vessel before any shift of weights is 24 inches, the ship being initially upright, how many degrees of heel will result from this movement of oil? (Disregard any effect of free surface which effect remains approximately constant).

$\frac{\text{Wt.}\times\text{dist.}}{\text{disp.}}=\frac{15\times 3}{1950}=0.0231'=.28''$ down.

Also $\frac{15\times 11}{1950}=.0846'=1.02''$ transversely.

$\text{Tan}\,\theta=\frac{1.02}{24.28}=0.04201=2°24'.$

CHAPTER VII

ASSISTANCE

FLOATING STRANDED VESSELS

701. When possible soundings are taken, by means of small boats, in the vicinity of a stranded vessel.

In working on a strand there is frequently danger of the cutter grounding in an effort to approach close enough to the beach to reach it with the towline. In article 731 of this chapter Capt. T. M. Molloy outlines a method which will avoid going in too close to the shore.

In spite of the most painstaking precautions, lines are continually gotten into the propellers of assisting vessels. True, it is usually the unexpected thing happening which causes this; all the more the necessity of eternally being on guard against it. Some of the ways lines get in the wheel are: The hawser parts and the snap throws it into the wheel before the engines can be stopped; during the running of lines they are carried into the screw by current and sea, especially by backwash in surf; a quick change in the heading of either or both vessels may have the same effect; in between pulls while awaiting high tide, changing conditions will slew the line in the wheel, if left in place, unless carefully guarded against. Another condition which may throw the line in the wheel is that just as soon as the engines are stopped after pulling, the hawser sags materially. As the towline is let go by the vessel being towed, if soaking wet it will assume an up-and-down position if the water is deep, and is apt to foul the screw unless the cutter has gained some headway before this situation obtains. If the cutter puts her rudder hard over before the line is all in, the line may be thrown into the wheel.

While pulling on a stranded vessel with an anchor down, in an endeavor to hold the cutter's bow up to the current which is usually alongshore, if the current is strong there is grave danger, unless action is taken in time, that the anchor will drag and the cutter will be forced on the beach. This is a situation met with frequently. In working in currents which are strong, even with the aid of another craft to hold the cutter up to the current, frequently both vessels will be swung sideways in toward the beach. To hold on too long in such a case is fatal.

When anchored and pulling on a stranded vessel in the presence of heavy seas and surf, especially when their effect is directed against the cutter's side, as is the case when the stranded vessel is ashore on a spit which extends out normal to the shore, even if the anchor does hold, the chain is apt to snap. Such an accident resulted in the loss of a naval vessel on the west coast.

In pulling with an anchor down there is always danger, as the strand is released, of her charging into the assisting vessel before the latter can get up its anchor. The master of the vessel should invariably be cautioned in this regard; he can usually prevent this by stopping his engines or using them to check headway.

After a stranded vessel is floated, frequently there stilll remains the danger of both vessels stranding as an attempt is made to swing them in restricted, current-ridden waters; especially so when there is a sea in conjunction with the current, also with a sea athwartship to the current and in the case where the stranded vessel's rudder has been jammed hard over by the accident.

In running towlines, where they must be carried through surf to the strand, ship's boats are not infrequently capsized. It is therefore advisable, whenever possible under such conditions, to obtain the aid of a Coast Guard station power lifeboat to run the lines. To emphasize this point, it is mentioned that within recent years, at the entrance of Columbia River, on two occasions power lifeboats have been thrown end over end by the seas. Several years ago such a capsizing occurred there, resulting in the loss of a lifeboat crew. In that locality heavy seas meet an alongshore current in the breaker line, the seas being at right angles to the current.

Deep water in Puget Sound and along the Maine coast, etc., frequently prevents the assisting vessel from anchoring to hold its bow up to the current, while pulling on a strand. It is helpful to have an assisting vessel hold the cutter's bow up to the current, and in some instances this is the only way pulling may be effected.

Consider the case of a vessel in a seaway which has been driven close to the beach but still holding on with her anchors. The assisting vessel runs the hawser, sets taut all ready to go ahead. The helpless vessel either gets up her anchors or slips her cables. It is preferable for her to get up her anchors

whenever possible, for in the presence of seas, surf, and current, the minute she slips her cables the strain will be so abrupt and heavy on the towline that it is apt to part, and before further aid can be effected the vessel strands on the beach. If still provided with her ground tackle she may be able to get another hold on the bottom. Should weather conditions in such an instance be improving, and the vessel is not dragging much, it may be best to await more moderate seas before assisting further than setting taut on the towline and planting kedge anchors offshore.

TAKING IN TOW DISABLED VESSELS AT SEA

702. It is becoming a custom of the service to seldom lower a boat in getting a line aboard a disabled vessel at sea. The "towboat" fashion of directly passing the line aboard, floating a line by use of a can buoy, shooting a small line aboard, heaving a line aboard (a strong fishline may be weighted at the end with a bolt if the distance is great) or sending a small line aboard by means of a rocket are used. The large size brass-cannon Lyle gun has the advantage over the shoulder-line gun in that it will not only send over a larger line, which is strong enough to hold up under adverse sea conditions, but it will also shoot it a greater distance.

Capt. William T. Stromberg, in command of the *Algonquin*, was towing the *Bear* when heavy seas parted the towline. Shoulder-gun shot lines fired from both vessels invariably parted, as a result of the heavy seas, before the next-sized line could be run. The *Algonquin* circled the *Bear* with a long line trailing astern and buoyed up at the end; every effort to float it near enough to the *Bear* failed. Finally Captain Stromberg, in spite of smashing seas, approached the *Bear's* stern close enough with the *Algonquin* to heave a line aboard. This maneuver, owing to the wind and sea, required unlimited backbone and keen judgment. As the *Algonquin* was forced along by a high sea she was thrown too close to the *Bear's* stern for comfort.

A FEW LESS REVOLUTIONS

703. A senior officer was heard to make the following remark: "The hardest thing for young commanding officers to learn is not to attempt to tow too fast when assisting vessels." A few less revolutions will get the ship into port and save much grief running new lines or losing of the craft.

WRECKING PUMPS

704. Another important thing is to keep the wrecking pump and its special large hose lines at a high point of efficiency. When this apparatus is used the need is urgent. Deteriorated hose, missing gaskets, burred threads, etc., may be overlooked if frequent and thorough inspections are not made.

REMOVE MEN NOT REQUIRED ON DAMAGED VESSEL

705. Frequently too many persons are left aboard a damaged or leaking vessel which is being towed. Remove to the cutter all persons not required on board. Gales have the habit of breaking during the night; in case the craft sinks, the fewer persons to save under adverse conditions, the better.

WHEN RUDDER IS DAMAGED

706. Experience has demonstrated that craft, except large vessels, whose rudders are disabled, may be towed by a bridle. Make the two arms of the Y fast at the vessel's sides well back on the bow in the region of the bridge. As she shears off to one side the Y arm on that side tightens (the same amount that the other arm slackens) and hauls her head back. To tow a large vessel without a rudder ordinarily requires an assisting vessel which trails behind on a line to the stern of the disabled vessel. The trailing craft keeps the disabled vessel on her course by offering a drag on the desired quarter. When no assisting vessel is present to aid the cutter, and the vessel to be towed is without propelling power, either a jury rudder may be rigged on the disabled vessel, or some kind of a drag devised which may be regulated by guys, and towed astern. A weighted-down liferaft which has been made longer by the lashing on of timbers might prove of value. Capt. T. M. Molloy suggests trial be made with 1 or 2 small boats rigged as a drogue. If the ship being assisted has power, a lone cutter may trail on a line from her stern and steer her by veering from side to side. Other methods are given in articles in this chapter.

SMALL BOATS WORKING ALONGSIDE WRECKS

707. Authorities place much stress upon small boats keeping clear of wreckage when approaching disabled vessels in a seaway. This is especially true of sail craft. When approaching a vessel stranded near the shore, heavy undertow is to be guarded against. In the history of the service numerous brave boat crews have been lost under such conditions.

WEIGH CONDITIONS BEFORE RISKING BOAT CREWS IN TAKING MEN OFF WRECKS

708. Not infrequently a cutter answers a call to find the vessel ashore in boiling surf. The crew desires to be taken off. Frequently if they will remain quiet until low water they will be able to walk ashore. If conditions warrant, the commanding officer will ask the cooperation of the nearest Coast Guard station. If no station is within range he may well land, in the most sheltered place, the breeches buoy apparatus and then work from the shore. If this is impracticable, it may be advisable to adopt the following method: Unless thwarted by a strong current a *small* liferaft may be lowered on a line from the cutter at

anchor. A pulling boat or power boat may tow it to a point just outside the surf, well up to wind and current, and then allow it to drift in alongside the wreck. The small boat remains just outside the breakers to assist when the raft is pulled out far enough. Quantities of *oil* used by both vessels will greatly assist.

709. *Too frequently an offer is made to remove the crew from a stranded vessel during daylight hours under good sea conditions only to have the offer refused, and then when a gale springs up during the night frantic request for rescue is made.*

LIGHTENING OF STRANDED VESSELS

710. Cases have happened where a stranded vessel was so lightened by the removal of cargo, etc., to get it afloat, that it capsized when pulled off. One instance, which resulted in the loss of several lives and precipitated a controversy, was that of the German bark *Mimi* on the Oregon coast. The more frequent occurrence is to haul off a vessel only to find that pumps will not keep her afloat. In the absence of an underwriter representative or salvage aid, the average master looks to the commanding officer of the cutter for advice. The latter should make a careful examination, indicate emergent repairs, use of collision mats, etc., and guard against offering too hasty advice. Haste, however, is invariably necessary in order to get the vessel off before bad weather ensues.

SEMPER PARATUS

711. It should not be necessary to mention this but it is unfortunately the case that some officers do not keep in mind the crucial need of doing everything within their power to make the best possible record for the service. When ashore they do not maintain proper contact with their cutter and frequently it is delayed in answering a call or else goes out short-handed. Except in large ports, departure from the dock within half an hour after the receipt of an SOS should be made. During a tour of duty on the *Snohomish* such a record was maintained, and not once did an officer miss his ship. Recall the steamship *Republic* disaster, the fires on steamship *Berkshire*, steamship *Nika*, and on the steamship *Morro Castle*, and it is readily seen how a few minutes' delay may be disastrous. The marvelous record for rescues made by the *Kickapoo*, from burning vessels, while she was stationed at Cape May, is a good mark for cutters to emulate.

STRANDING OF THE PARAMITA

712. During May 1914 the American ship *Paramita* grounded in the vicinity of Lost Harbor, Akun Island, Alaska. The *Tahoma*, commanded by Capt. R. O. Crisp, and the *Unalga*, under the command of then Capt. H. G. Hamlet, made a heroic effort to save the stranded vessel. One series of gales followed another. Wrecking pumps were operated by both cutters as they lay alongside the wreck. It is interesting to note, from the official report, that heavy ground swells made it untenable to lie alongside the weather side of the *Paramita* at times. On one occasion it was necessary for the *Unalga* to anchor off the *Tahoma's* starboard quarter and run a line to the *Tahoma* to assist her in getting free from the weather side. On another occasion the *Unalga* held position off the weather side of the wreck, close to, riding to her port anchor and to a kedge off her port quarter.

A diver ascertained that there was severe damage in the region of the forefoot and that sand had piled high up around that sector of the wreck. It was impossible to haul her off into deep water in order to permit the passing of a collision mat. At the suggestion of Captain Hamlet it was decided to blow out the sand with jets hooked up to the fire mains of both cutters and then place a sail under the forefoot to act as a large collision mat. After the sand had been blown clear and all was in readiness for the placing of the mat, a heavy southwest gale broke and completed the wrecking of the *Paramita*. By means of small boats the cutters took off the wreck the 118 persons aboard.

NOTES ON ASSISTANCE BY CAPT. RANDOLPH RIDGELY, JR., U. S. C. G.

ALONGSHORE CURRENTS

713. Along all beaches, especially Jersey, Delaware, Maryland, and Virginia, there is usually a strong current running parallel to the beach during or after a gale, and when a heavy strain is taken on the hawser of an anchored cutter, being tied at both ends there is every probability that the anchor will be broken out and the cutter swept on the beach unless the hawser is let go or cut promptly.

STARTING AHEAD ON A TOW LINE AT SEA

714. After the hawser has been made fast and all is ready to start towing, the proper procedure is this: Inform the engine room that when "Ahead slow" is ordered the minimum number of revolutions to get way on vessel will be made; as strain is taken on hawser orders for increased revolutions will be given from the bridge by 'phone, such as "Increase revolutions 3 per minute", next order, probably "Increase speed 5 revolutions per minute", and so on until the maximum revolutions deemed proper by the officer-of-the-deck has been reached. To stop always takes the strain off the hawser and when the towing ship starts ahead again, the danger of parting the hawser will again become a probability unless the original procedure is undertaken. This takes time and often, due to impatience after a long period of preparation, the proper time and care is not taken in working up to proper towing speed.

NOTES ON ASSISTANCE BY CAPT. H. H. WOLF, U. S. C. G.

GETTING TOW LINE ON BOARD DISABLED VESSEL

715. Run in parallel to vessel, on her lee side, your port side to. With line out, when you back to check way, your stern is presented to vessel with towline trailing clear as you drift down wind, waiting for all to be made fast.

WHEN YOU HAVE TO ANCHOR IN PULLING ON STRAND

716. Instruct the vessel master not to start his engines when free, or if using them to stop immediately on floating, until you have your anchor. Such instructions are often disregarded by masters in the excitement of having the vessel come afloat, and you are likely to be run into by the hard backing vessel unless you can get your anchor in promptly. Have experienced this many times, and only hard racing of the windlass engine and dragging the final scope away from the position has averted collision.

If you would minimize your worries, use manila instead of wire for towing.

TOWING—OCEAN CURRENTS

717. With a heavy tow against the Gulf Stream or other ocean current of limited width, time can usually be saved by cutting across into the marginal waters, even though the course takes you away from destination and lengthens the distance considerably. This if the stream is moving near the velocity of your towing speed.

718. In taking a disabled vessel in tow at sea, the method above outlined by Capt. H. H. Wolf lends itself to all conditions. When the disabled vessel's port side is the lee side, placing the cutter on a parallel heading with its port side to her, means, of course, the two vessels are heading in the opposite direction. In this case naturally the cutter would proceed only far enough beyond the disabled vessel's bow so that as it backed it would present its stern within range of the bow of the assisted vessel. When the starboard side of the disabled vessel is the lee side, the cutter proceeds well up beyond her beam before backing and works with its stern under the starboard bow. In both cases the cutter is pointed for getting clear by going ahead. No matter which of the two vessels drifts to leeward the faster, the cutter by presenting her stern to the disabled vessel's bow can maintain a safe position by judicious backing and filling during the operation of placing the tow line on board.

The precaution of retaining about 20 fathoms of the hawser on board the cutter enables slacking away sufficiently to bring the two vessels in step.

ASSISTING VESSELS ON SHORE (By Capt. Wm. J. Wheeler, U. S. C. G.)

719. The proverb of the stitch in time which saves nine may usually be applied to a stranded vessel, and often this application may be expanded many hundred percent. If there is a substantial current along the shore at any stage of the tide, anchoring is usually necessary to hold position while running the hawser, and frequently it is necessary to pull with anchor down paying out chain if and when the stranded vessel is moved. If depth of water permits approaching close to the stranded craft, the problem of line running is simplified, and if conditions permit an approach sufficiently close for shooting a line, with or without anchoring, the task may be greatly facilitated and perhaps time saved.

Let us assume that there is a substantial rise and fall of tide, that the position of the stranded vessel is an exposed one, and that conditions justify Coast Guard operations. If anchoring is required, we would usually anchor sufficiently clear of the shoal to permit paying out approximately all our chain in the direction of the stranded craft. If boat work is foreseen, it is often highly advantageous to notify a nearby Goast Guard station while enroute, and have the power lifeboat or surfboat standing by to assist in running lines. The running line would be taken in the boat, and enough of the hawser to guarantee reaching the point of making fast aboard the stranded vessel. If a power winch is available aboard the stranded vessel, it may be used by leading the running line to it. Otherwise, sufficient man power must be made available to haul aboard and secure the hawser. With the hawser secured on the stranded craft, it should be hauled taut on the cutter with the winch, and chain paid out as the hawser is tautened and secured. The easy expedient of heaving in on the anchor chain will now bring further strain on the hawser, and guarantee that the stranded craft will not go higher on the shoal if tide rises, or if the swells lift her. Often keeping a strong strain on the hawser under these conditions will serve to move the stranded craft, at least to some extent, as swells roll in and the tide rises.

The time to begin pulling will depend somewhat on conditions. Care must be taken not to steam over the anchor if the water is too shoal for the ship's bottom to clear the anchor. Usually a start is made in pulling on the line from 2 to 3 hours before high water. Greatest care is necessary not to needlessly carry away the hawser or securing bitts. It is good practice to start pulling at slow speed to try out hawser and lashing, and gradually work up to the maximum number of revolutions that it is thought the hawser will stand, as the time of high water approaches. It must be borne in mind that a stranded

vessel may come off with a jump and the cutter should be in a position to steam clear and avoid collision.

Persistence is a great asset in this type of assistance work, and floating a stranded vessel on the first tide is the exception rather than the rule. To know when to stop pulling and wait for the next tide is very important. Often a hawser is needlessly parted by vain pulling after the tide has begun to fall.

A vessel may be moved a few feet each tide, and the task successfully completed after a number of days' effort, and stick-to-itiveness often accomplishes wonders.

On shoal coasts such as along the Virginia or North Carolina coasts cutters have often run 500 fathoms of line to reach a stranded craft. In such cases the use of station boats is highly expedient, and taking advantage of good weather is all important. The writer recalls from experience on the *Manning*, that they more than once succeeded in floating vessels high and dry on shore, when first efforts seemed like futile gestures.

The question of *interference with private enterprise* frequently enters into the case of a stranded vessel. If private assistance is not immediately available, the danger of delay and unfavorable weather, with possible resulting loss of the vessel, must always be borne in mind. In general, it would seem to be a safe doctrine that when in doubt, assistance will be given. The writer recalls a case of the *Carrabasset*, with the very efficient Boatswain Krestensen in command, on the North Carolina coast. A fisherman was stranded high on the beach in a most exposed location. The *Carrabasset* had run a line, with the assistance of station boats. Representatives of the owners had sent a power pump, with civilian shipyard personnel, to lighten the vessel by pumping her out. In spite of the protests of Boatswain Krestensen, the civilian force stopped work soon after nightfall, saying they were too tired to complete the task that night; although pumping her out would permit pulling at high water early next morning. The yard force insisted that delay of another day would do no appreciable harm. However, change in weather stopped operations for a number of days, and the result was the loss of the vessel.

A small vessel may be safely *dragged through the sand* without appreciable injury for an astounding distance. The writer recalls the case of a magnificent sailing yacht which grounded just north of Cape Hatteras, through error in judgment of the mate on watch. The yacht worked inshore until she was out of the water at low tide. The *Manning* arrived some 18 hours later, at which time the weather was calm. The *Manning* stood in until there was only a foot of water under her keel. Five hundred fathoms of hawser were run, in addition to paying out all the *Manning's* anchor chain. Careful pulling was begun some 3 hours before high water, and the yacht was worked off uninjured by high tide.

In the writer's experience, possible *objection from private enterprise* may often be obviated by communicating with the local representative of wrecking companies and towboat companies as soon as the call is received, to inquire if they are in a position to furnish immediate assistance. If their tug cannot reach the scene as quickly as can the nearest cutter, and the position of the stranded vessel would entail any degree of danger from delay, then surely the cutter should proceed at once. Another case is recalled on the North Carolina coast in the spring of 1933, when a large trawler was reported inshore and inside two bars near Pennys Hill Coast Guard Station. A dense fog prevailed, and the *Pontchartrain*, offshore, was proceeding full speed for the scene. The office of the Merritt-Chapman-Scott Corporation called up the division commander at his home and inquired whether or not this were a wrecking company task. The latter replied that strong easterly winds were predicted and that delay until the wrecking tug could arrive from New York would probably mean loss of the vessel. The wrecking company representative concurred in the opinion, and there was no further question.

The officer in charge of the Pennys Hill Station was directed to take his Lyle gun to the scene, with plenty of heavy charges, and when the *Pontchartrain* was expected to be some 10 miles off, he was directed to fire heavy charges at frequent intervals. The *Pontchartrain* reported hearing these explosions a number of miles and readily reached the spot. The time thus saved enabled the cutter to run some 400 fathoms of line, assisted by station boats, and she began pulling very soon thereafter, on a rising tide. The predicted easterly winds appeared with incoming swell very soon after the line was run, and this facilitated floating operations and the trawler was safely floated just before the swell became dangerous. Even the large cargo of fresh fish was saved in this case, when vessel and cargo would have probably been a total loss had operations been delayed a few hours.

In the writer's experience, the Coast Guard *telephone line* is invaluable in cases of stranding or grounding, especially if the division office and division commander's home can secure local connections. Naturally, messages to and from distant stations must often be relayed, but the delay is not great. Details and advice of station personnel of many years experience in the locality may be thus secured and most valuable time saved.

The *commercial telephone* is a far more potent source of information than is usually realized, especially in sparsely developed localities. A local telephone operator is also a compendium of latest news of a disaster or grounding, and this operator is usually

most willing to oblige along this line. The *collector of customs* or other official is also invariably a cheerful assistant in securing local information or advising how same may be secured.

In inside waters, such as the *Chesapeake Bay, North Carolina sounds and tributaries, and on the Gulf of Mexico*, fisherman and other small craft often ground in most isolated places, and their limited means frequently will not enable them to secure private assistance. The work that may be done by 75-foot patrol boats is often astonishing. For example, in the gale of August 1933, some 70 highly creditable cases of assisting small vessels occurred on Chesapeake Bay and tributaries. The attitude of private enterprise in this case may be judged from the fact that the president of the largest towboat company in Norfolk offered to lend *gratis* any hawsers, tackle, anchors, or other gear in his warehouse that might be needed for these assistance cases.

In the great majority of the above assistance cases, the stranded vessel represented the living not only of the masters and crews with their respective families, but also every vessel was an important thread in the financial fabric of the neighborhood. Assistance work of this kind requires utmost zeal and patience on the part of the crews of the assisting craft. In a large percentage of cases anchor must be planted in deep water, with small hawser attached, to be lead to the stranded craft and purchases rigged for laboriously hauling the vessel a few feet at a time on each succeeding high tide. This is strenuous work, and success requires much judgment on the part of the person in immediate charge. The expressions of gratitude received in the above cases certainly compensated for the time and labor bestowed on the work by the Coast Guard.

ASSISTANCE WORK AT SEA (By Capt. Wm. J. Wheeler, U. S. C. G.)

720. Taking in tow a disabled craft at sea, with reasonable expectancy of successfully bringing her to port, presupposes that the assisting vessel has efficient towing gear and efficient facilities for running hawser.

No commanding officer can afford to neglect an inspection, and, so far as practicable, a test of the towing and line running facilities of his vessel immediately after boarding her.

TOWING HAWSER

721. For a first-class cutter of the *Tampa* class or larger, a 12-inch oil laid manila hawser, 240 fathoms in length, is, in the writer's experience, indispensable. Naturally, this hawser must be specially made, but this only entails a certain amount of delay after the order is placed.

With such a hawser, one end should be spliced around a thimble of ample strength and fitted with a heavy shackle for securing the hawser to the anchor chain of the vessel being towed. In the writer's experience, 30 fathoms of anchor chain is none too much to pay out from the tow in the case of a large vessel being towed in heavy weather at sea. The purpose of this chain is to keep the towline from coming out of the water, in addition to giving added length to the towline. The writer recalls picking up with the *Tampa*, the freighter *M. S. Dollar*, out of fuel 300 miles out from Boston in the month of January, with northwest gales prevailing. The *M. S. Dollar* was a vessel of 13,000 tons displacement, fully laden with a cargo valued at 2½ million dollars. A line was fired to the *Dollar* with a shoulder gun, in spite of heavy weather; the new 240-fathom, 12-inch hawser was shackled to the anchor chain, 30 fathoms of chain were paid out and practically the entire length of hawser paid out aboard the *Tampa*. Northwest gales continued, but the vessel was brought in after 4 days of work. It was plain that the strength of the hawser was taxed to the limit in the swells, and probably a greater length of anchor chain should have been paid out.

Towing hawsers proportionately smaller may be supplied to smaller vessels, but provision should be made for not less than 240 fathoms of hawser for any vessel liable to be called upon to do substantial towing at sea.

RUNNING LINE

722. A 4-inch 4-strand running line, 120 fathoms in length has been found very convenient. However, coils of various sizes down to 12-thread, should be on board and immediately available for emergent use.

LINE-THROWING GUN

723. In the writer's experience, a line-throwing gun of the shoulder type, or other type conveniently portable, is indispensable for assistance work at sea. Routine practice with the line-throwing gun should invariably be carried out under varied conditions, to thoroughly acquaint the personnel with its use, possibilities, and limitations.

TAKING VESSEL IN TOW

724. A disabled vessel at sea usually takes a position with the wind and sea a trifle abaft the beam. In the writer's experience, the cutter usually approaches from astern, on a course parallel with the disabled craft and to windward. The line is fired from the stern or quarter of the cutter when opposite the bow of the drifting vessel. A number of lines should be immediately available for repeating the shot if the first line is not caught on board the drifting craft. When the projectile and line are secured on the drifting vessel, the end of the shot line of the cutter is immediately bent on to a larger line, probably a coil of 12-thread stuff, and this in turn is bent on to the running line or a shorter line if the distance involved is not great. The larger line is made fast to the hawser, which is sent over as quickly as possible. The bight of the hawser may be stopped to

the rail while the end is being shackled to the anchor chain aboard the disabled vessel.

On practically all cutters provision is made for clearing the after rail to give the hawser a chance to swing, and towing bitts are located as far forward of the rudder as practicable. Slushing the after rail with a mixture of tar and tallow will greatly reduce friction and deterioration of the line.

725. *If towing of schooners* seems likely to be involved, it may often be advisable to carry a wire pendant with an eye splice in each end of sufficient length to enable one end to be made fast aboard the schooner, while the other, shackled to the cutter's hawser, would extend beyond the bowsprit and headgear of the schooner.

A cutter of the *Tampa* class should carry additional smaller hawsers for smaller tow. Both a 10-inch and an 8-inch hawser would be recommended, each 200 fathoms long.

In the writer's experience, starting ahead on a tow line that has just been run or has been allowed to slack requires great care and patience, to avoid undue strain on hawser and bitts, before the tow is underway and straightened out on course. Beginning with the slowest possible speed, and stopping at intervals, until the vessel and tow are both on course, and then working up to higher speed very slowly is highly advisable.

DISABLED VESSEL WITHOUT RUDDER

726. Towing a vessel or derelict at sea *without steering power* is a very trying task, and in the writer's experience, increasing the length of the tow line is frequently the only way to keep the tow from charging here and there, without making either course or speed, and often with great danger of breaking the hawser.

In the case of assisting a steamer having power but unable to steer, the cutter not infrequently makes fast to the stern of the larger craft, permits her to steam ahead towing the cutter, which steers the larger craft by shifting her position from one quarter to the other, as necessary. This brings much strain on the towing line, and a bridle is often rigged from each of the bows of the cutter, or through each of the hawse pipes.

In the writer's experience, an additional 25 fathoms of hawser paid out will often cause a formerly unsteady and charging tow to take a comfortable position, usually on the quarter, and thereafter remain on the same bearing.

The writer recalls an extraordinary experience with a large Shipping Board steamer, the *Jacksonville*, that had lost her rudder entirely, some 200 miles from the Virginia Capes and on the other side of the Gulf Stream. After a partially successful experience in permitting the *Jacksonville* to tow the *Manning*, a head gale developed and the bridle carried away. The master of the *Jacksonville* suggested by radio that he be allowed to fill his forward trimming tank with sea water, put his vessel down by the head and thereafter try steaming into the gale. This experiment was tried, and succeeded beyond wildest expectation as long as the head gale lasted. The course was a zig-zag one; but the steamer crossed the Gulf Stream before the gale abated, and thereafter the *Manning* towed her at a moderate speed by bending on an additional hawser, and using 300 fathoms of tow line to keep the tow on the quarter.

ANCHORING AT SEA

727. The ground tackle of a cutter plays an important part in its efficiency. Assisting a stranded vessel may necessitate anchoring in a most exposed place until the line is run; thereafter it may often prove necessary to pull with anchor down, paying out chain as necessary, especially if there is a strong current. Usually the ground tackle, including windlass, of a cutter are appreciably heavier than are required by a merchant vessel of the same tonnage, and the chains are longer.

In the writer's experience the feasibility of *anchoring at sea* to hold position or ride out a gale is often underestimated. More than once the *Tampa* rode out at anchor, fresh gales, with seas to correspond, on the Grand Banks, in 35 fathoms of water; this without taking water aboard and without marked discomfort. Naturally all available chain was paid out, approximately 110 fathoms, and the anchor was lowered by backing on the windlass. On one occasion, in standing by the stranded British steamship *Thistlemore* on the outside of Cape Cod in a northeast gale and snowstorm, the *Tampa* anchored on the weather side of this much-dreaded cape, and there rode out a winter gale for some 36 hours, keeping her searchlight on the stranded vessel.

NOTE.—During the World War the *Mohawk* and another naval vessel maintained position throughout the winter stormy season at the entrance of Ambrose Channel, by anchoring or riding with anchor chain shackled to a mooring buoy. At times, during gales, the bridge wings dipped water; the rolling, while deep, was not violent. The *Bear* rode out many gales at anchor in the open roadstead off Nome, Alaska. Her old fashioned anchor was difficult to handle if she remained too long at anchor and was then forced to sea. On one occasion witnessed, after being put to sea, it was found impossible to place the anchor on the billboard. Only her rugged construction forward prevented damage by the charging anchor.

BOAT DRILLS (By Capt. Wm. J. Wheeler, U. S. C. G.)

728. A cutter's boats and boats' crews are said to be the best possible index to the general condition of the vessel and efficiency of her crew. Certainly the vessel's boats usually furnish the initial impression from which she is judged. In a service where practical boat efficiency is one of the most essential points, it is expedient to neglect nothing relating to the boats.

Since efficiency along any line is unattainable without real and active interest, if not enthusiasm, we must consider the problem of how to create interest in boats and their equipment, and how to promote zeal and possible rivalry among the different boats' crews. The solution will be found, to a considerable extent, in a proper example by the officers assigned to the various boats. Unless these are interested in their respective boats and crews, surely interest cannot be expected of the men. As division officers usually have, for most part, the same members of the crew in their boats that they have in their respective divisions, it should not be difficult for them to take active interest in the efficiency of their respective boats' crews, as well as interest in the equipment and upkeep of the boats.

Efficient drills, whatever their nature, promote discipline and general uplift among the men. Far more so is this the case when the men see prospective opportunity for real and practical use of the science or art taught by the drill. Existing conditions may tend to temporarily reduce the *relative* importance of boat drill, but conditions do not prevent this drill from being very important even at the present time. The Coast Guard is practically sure to have more or less arduous boat work both in war and in peace, and it is the writer's experience that no other drill is so productive of *esprit de corps*, and all around efficiency in the crew. The use of power boats and the fact that cutters now usually lay at a wharf when in port without routine running boats, makes it essential to give even added attention to boat drill. Not only should the deck force be first-class all-around boat men, but all on board ship should be able to acquit themselves at least *creditably* in the boats. Boat work is so inseparable from life aboard a cutter that usually the engineer force, galley force, and boys show no desire to evade reasonable boat practice. No member of the crew wants to appear awkward or lubberly in the boats or to have other members of the crew so appear. With our small crews, and, not infrequent calls for strenuous boat work, and with the ever present possibility of having to abandon ship, it is of the greatest practical expediency that every person be able to properly man a boat in emergency; this entirely apart from the aid such training renders to discipline aboard the vessel.

Usually assignment of members of crew to the various boats is to provide for abandoning ship, and this division must play a part in the boat efficiency of the vessel. Of course the details must largely depend on the number of officers attached to the vessel, the types of boats, and other circumstances. Usually, however, at least one officer is assigned to each boat of seaworthy size. A reasonable and impartial distribution of the members of the crew in the various boats is expected, and a coxswain or reliable seaman should be responsible, under the officer, for neatness and good order of boat and equipment. With reasonable encouragement, and assistance, when necessary, the coxswain usually displays zeal in the care of his boat. The required assistance should be given him, and all boat equipment called for by the regulations, or special circumstances of the case, should be provided and kept in the most shipshape order possible. No crew can take pride in an unsightly or poorly equipped boat. The entire complement, and not merely those assigned to oars on the boat bill, should be able to row well. In emergency all would be expected to take turns at the oars, and, furthermore, those lacking self-confidence or unfamiliar with boat work would surely become sources of serious danger.

Abandoning ship drill is required once a month, and surely an opportunity should be found, each time, to lower all boats fully equipped, and sufficient time should be devoted to the drill. Boat officers should carefully note the capacity of each man in the boat. Afterward, at weekly boat drills or other favorable times, those needing same should be given ample opportunity to work up along this line, regardless of the department of the vessel to which they may belong. At this drill, immediately after lowering, ample time should be taken to test out the handiness and probable seaworthiness of each boat, with complement and equipment for abandoning ship. This having been done, highly satisfactory results have been observed from removing the surplus gear and spending an hour drilling the various boats' crews, alternating them at the oars, and practicing alternately at oars and sails. With the usual frequent changes in complement of vessel, such method will give the boat officer a needed opportunity to become acquainted with the capacities of the various members of his crew and will show him who needs special boat drill.

This will also give an opportunity to work up a wholesome spirit of emulation among the various boats' crews that will prevent the drill from becoming tedious and will make it one of the buoyant and agreeable duties.

Boys from the various messes are, in the experience of the writer, especially benefitted by frequent boat drills, usually on afternoons, half at a time, in charge of the ex-officio master at arms or his assistant, these special boat drills may be carried out without difficulty or interference with the routine. The physical improvement, disciplinary uplift, and added interest and zeal resulting from these drills is very marked, this in a remarkably short time. Often added interest is created, and the drill made useful as well as instructive, by having the boys clear away and lower the boat and bring off their stores to the vessel, instead of having the men or a launch do this work.

In the writer's war zone experience in command of the *Seneca* he found himself in the beginning with a crew mostly without either sea or boat experience, and the opportunities for boat drills were limited. These scant opportunities were utilized so far as possible, and much criticism was to be heard, such as

"Can't get away from Coast Guard work, even though we are in the war zone and bent on taking life, not saving it."

Three times he was most thankful for this drill which had been considered so useless. Crews of torpedoed British sloop *Cowslip*, British freighter *Queen* (then flagship of convoy), and British collier *Wellington* were all picked up by the *Seneca*, with the enemy submarine in the immediate vicinity and in position to continue his deadly work. After the first experience a rectangular rope net was kept lashed to rail on either side amidships, so that stops could be cast off immediately and the net dropped to the water, so that practically an entire boat's crew could climb out at once. It would seem worth while for a seagoing cutter to have such net available for use on the lee side at sea. Old material, such as discarded boat falls, could be used for this purpose.

However, in spite of the importance of general boat knowledge throughout the vessel, it is necessary that the *deck force* further *specialize* in boat work. There must be, in each watch, a lifeboat's crew carefully drilled in its duties. While actually *required* by the regulations only once a month, *man overboard* drill is a highly essential and beneficial one, and there is no reason why it should not be held *frequently* when working circumstances permit. A profitable spirit of rivalry may be engendered by holding this drill every day for a number of successive days, with watch on duty, and noting the respective times taken for picking up buoy or object thrown overboard. When held in port, naturally a time for the alarm would be chosen when all were on board, as would be the case at sea.

We have heard the apparently plausible objection that too frequent man overboard drills are a needless risk to the boats' crews. We believe, on the contrary, that frequent drills promote the efficiency that eliminates the risk associated with infrequent drills or with the occasional necessity for lowering a boat in a seaway.

The practical points attending the lowering of a boat when underway at sea, or in other emergency, are numerous and varied. Only experience on each vessel, in the matter of equipment, and ample training for the crew can obviate the difficulties, if not serious dangers. We should try out, under conditions that are reasonable but varied, the most promising methods and appliances, adopting those giving best results. Practice will then give the crew the skill and confidence so essential to safety. Among essential points, there must always be provided steadying lines, usually traveling steadying lines, bow and stern, to prevent the boat being stove against the ship's side. One or more long vertical puddings, padded skids or similar appliance, should be slung over the ship's side. In addition to the sea painter forward, there should be a stern line aft to prevent undue fore and aft surging. Life lines from the boat span should be provided for each member of the crew lowered with the boat. The boat detaching gear, whatever its type, should be made reliable by suitable attention and frequent tests.

Life belts of suitable type should be provided for each member of an emergency boat's crew, and, in spite of well-known sailors' objection, they should be compelled to wear these belts whenever going into the boat with circumstances indicating that danger exists. In deciding the question of suitable type of life belt for boat use we are convinced that belt or jacket of kapok is the best adapted. A belt of this material is more comfortable to the wearer, adds warmth to the body, gives greater ease of movement, and does not bruise the body or hands. Two additional life belts, each seized to the middle of an extra long and well-stretched heaving line, should be part of the equipment of each emergency boat.

Efficient boats and boats' crews promote boat racing, both within a vessel's crew and with crews of other vessels. In our experience, this is highly beneficial to the personnel throughout, even though the material for the race may be partially unorganized. Not only is the monotony of routine relieved, and new interest aroused, but a wholesome spirit of rivalry and emulation is engendered, this along a line that is, with us, highly professional.

All reasonable support and encouragement should be given by the officers to conservative boat racing, each allying himself with his boat's crew or ship's crew, as the case may be. Indifference to one's own crew in a boat race, or the backing of a rival crew, is a form of disloyalty unworthy of a true seaman.

ASSISTANCE WORK (By Capt. W. H. Munter, U. S. C. G.)

729. I have never come across the following points in print, none the less I believe they are known to those who have had experience:

(*a*) Along sandy shores where strandings take place, it is useless to attempt to float a grounded vessel after full tide has been reached and the water level has become stationary at slack or at any time that the water's tide level is receding. The apparent reason for this is that the sand packs hard and loses its "life", as it were. With a rising tide, careful observation shows that the sands are "alive" with motion and that a condition exists similar to that of a spring bubbling up through sandy soil. This condition increases flotation and reduces friction to such an extent that a vessel may be drawn off a shoal even though she is "aground" in water of less depth than her draft at the time.

(*b*) Along the Atlantic seaboard a condition generally prevails which should be known to those engaged in salvage operations on stranded vessels on rocky as well as sandy shores. Easterly winds will always bring higher tides than winds from the western semicircle.

It will therefore often be well to await action on a salvage effort to float a vessel when weather indications predict a favorable shift of wind to the eastern semicircle in the near future rather than waste effort, labor, and unnecessary wear and tear to salvage gear. The heavier a northeaster, the higher the flood tides become on the Atlantic seaboard of the United States.

(*c*) Often there are times when derelicts and disabled vessels are taken in tow by vessels of the Coast Guard at sea. This has been done time and again by our officers under most unfavorable conditions as to wind and sea, day or night, clear or fog. The captain of the cutter will always assure to himself a greater degree of success in each case if before he begins actual operations to make a careful study of the effect of the current, wind, and sea on the drift of his vessel, in comparison with those factors effecting the drift of the vessel to be assisted. Having determined by actual experiment and study which vessel drifts more rapidly, their relative positions with reference to sea and wind, and the direction of drift each vessel takes, he can then plan how and when to pass his hawser with some degree of certainty of making a go of it the first attempt he makes.

(*d*) I have found it invariably to be true for all propeller ships regardless of size or type, that the best and most desirable position they can be made to take for the purpose of lowering boats or receiving a boat alongside is to allow the vessel to drift and take her own position. It is my experience that the best location for the lifeboat to hang is from a position forward of the athwartship middle line and just aft of the wing of the bridge. Also, the boat should be received alongside in this particular part of the ship because it offers the best lee and is the safest and most protected position afforded under all conditions except when a cross sea prevails at the time; in which case it would be impracticable to lower or receive a boat at all. The officer of the deck is thus in a superior position to control the operations from the bridge since he is able to get a better outlook on the sea and will have direct personal control of the management of the ship, as becomes necessary, for the situation at the time of lowering, receiving alongside, or hoisting a boat at sea.

(*e*) Locating a vessel at night at sea in poor visibility can often be accomplished with the use of searchlights when means of radio or direction finders are not available or inaccurately calibrated. This is especially true in cloudy weather. Either vessel or both sweep their searchlight on the clouds or sky overhead or along the horizon. Such signals have been seen under conditions when the vessels were obscured from sight of each other for distances up to 14 miles. If the vessel in distress sights the other, direction by compass is radioed to the assisting vessel. It is a simple matter for the other to make contact in any event.

Daylight contact between two vessels may be greatly aided by either or both vessels making heavy black smoke.

When a hard winter sets in and continued cold temperatures prevail, vessels in the Coast Guard are prevailed upon to perform an arduous and important duty in breaking ice to open channels and harbors to commerce. Caution and good judgment is called for in working the ship within narrow limits. Power is necessary to gather as much momentum as possible in the short distance available. Backing and filling is the only way to make progress under heavy ice-breaking conditions, whether the ice is hard and brittle or mushy or snow covered. The vessels most frequently work in shoal water. Under this condition the ship's momentum is harder to arrest than if the ship is in deep water. The headway continues for a much longer period of time under similar conditions as to speed over the ground. Another precaution is to be prepared to avoid having the vessel take a sheer by following a crack when breaking hard, brittle ice. To avoid this it is considered good practice to hit the ice from such an angle as to make the vessel take the sheer in the direction of the best water. This will always be to that side which offers the least resistance on that bow from the shock of the blow struck the ice by the vessel. This plan has in mind the idea of making progress slowly by chipping out sections rather than attempting progress by continued full power with speed. Another point is to break ice in channels and fairways at the precise time vessels intend to use them. The channel will remain open in severe weather for a short time only.

NEVER OVERLOOK AN OPPORTUNITY TO RENDER SERVICE (By Capt. P. W. Lauriat, U. S. C. G.)

730. The only suggestion that I can offer would be to never overlook an opportunity, no matter how small the chance to accomplish anything may appear to be. In my experience I have found that it is better to go 10 times and find that your services are not required than fail to start because it would appear almost hopeless to accomplish anything. I once brought in a steamer (while I was on the *Acushnet*), which had been abandoned by the crew as in a sinking condition when they were almost certain that it would not float more than a few hours. It was nearly 36 hours after they abandoned her before I found her. On another occasion I got two men from the rigging of a schooner sunk within sight of a Coast Guard station. The men were wrapped in the topsails and could not be seen from the shore. The station was unable to get its boat off from the beach on account of the ice and a frozen

engine. The men would have died if I had not taken them off before dark.

ASSISTING VESSEL ON LEE SHORE (By Capt. Thomas M. Molloy, U. S. C. G.)

731. A fine example of a lee shore is the east side of the Cape Cod Peninsula in winter time. Winter time is mentioned because of the frequency of northeast and northwest winds which blow almost directly onshore. Like most stretches of sand beach with a rather gradual slope, the section has its strong currents along the beach and for some distance out. Some time ago, a Navy submarine grounded there, that is in the section between Peaked Hill and Chatham. Very extensive operations by a salvage company were necessary to save the ship. A Clyde liner in the same situation was released after several weeks by a salvage company. These were comparatively large craft and the effect of the currents in further embedding them rendered the work in each case much more difficult. The first thing done by the salvagers was to lay out very heavy anchors to windward and place a heavy stress on them, meantime attempting to scour away some of the imprisoning sand. Usually, as in these cases, a Coast Guard cutter arrives early on the scene and attempts to haul the vessel into deep water on the theory that an early pull before the sand has settled and piled up further around the stranded craft might prove effective. Shallow water calls for the handling of great lengths of hawser the passing of which is made difficult by the sweep of the longshore current taking the hawser downstream in a great loop. As a rule, the cutter can do little in the cases of large vessels stranded. With small vessels ashore, it is different (fig. 120).

A small trawler went ashore about a mile or two south of Pamet River Coast Guard station. The *Cayuga* arrived and found the boat high and dry at low water, but completely surrounded by water and rolling in a basin which it had made, with a barrier of sand building up between it and the open water of the beach. The cutter sent a boat in with a 1,000-pound anchor and a good 8-inch hawser. There being no place on the fisherman to make fast the hawser, it was bighted around the latter and, the kedge having been planted directly to seaward about 60 fathoms, a strain was placed on it by means of tackles rigged on the fisherman. This was the first step. Another boat took in and made fast around the trawler, a 12-inch line or hawser, then proceeded toward the cutter, paying out line until there remained only sufficient to make fast to a line from the cutter; at which position the boat dropped anchor to hold position. A boat from the cutter with another 12-inch hawser, headed toward the anchored boat, paying out en route; both hawsers were joined at the anchored boat, which hauled up its anchor. The slack of the hawser, now nearly 300 fathoms long, was hauled in on the cutter which was anchored in 4 fathoms, drawing 16 feet itself. This depth is at low water and it is unsafe to anchor in less, because of the ridges of sand which roughly parallel the beach. It was found that a short distance inshore from the cutter there was 3 fathoms, and still further inshore there was 5 fathoms with other ridges nearer the beach. The cutter had down 90 fathoms of chain, part of which was hove in when taking up the slack of the hawser. The time of the year was February; the sea smooth with hardly any swell. The trawler came off while the sea was still smooth. However, within 24 hours, a strong northeast wind sprung up creating a heavy surf. It is because of the frequency of onshore winds that the use of the kedge is advised. It keeps the craft from going further up on the beach, and also with a heavy strain kept on the kedge line, this onshore swell or surf helps to haul the boat off.

Suggestions

1. Use the cutter's crew in making fast any lines on the stranded craft.
2. Plant a kedge with a line not less than 8 inches.
3. When two hawsers are to be joined, it is felt that it is less difficult to use the procedure mentioned above.
4. Do not trust absolutely the sounding on the chart, because there are constantly taking place, local shifts of sand which do not show the changed depth. Hence sound the vicinity of your anchorage.
5. Carefully protect your lines from chafe wherever such protection is needed. There will be a chafe of the hawser on the sandy bottom but that can hardly be guarded against unless the line is floated and that arrangement would use up valuable time.

The case mentioned was simple, but the use of the kedge is probably the most important part of it. When the kedge has been planted and under stress, should an onshore wind develop before the hawser from the cutter has been made fast, it will at least prevent the stranded vessel going higher up on the beach and may even haul the craft into deeper water. When the cutter starts to haul it should not take up its anchor, but steam with the anchor down in order to hold position in the longshore currents.

RUDDERLESS VESSEL

732. Having had to do with two cases of rudderless steamers on neither of which any effort was made to rig a jury steering arrangement, have given some thought to the subject. Have thought that one or two boat drogues could be used by shifting it or them from one side or the other towing astern. It is suggested that this be tried out on a patrol boat, it

might have results that would warrant further experiments.

PROTECTION OF TOW LINE (By Capt. Thomas M. Molloy, U. S. C. G.)

733. In all towing operations, it is of vital importance that the towing hawser be safeguarded against parting. If the tow be heavy, naturally the strongest hawser will be employed. This line must be protected from chafe. On the end made fast to the towed vessel the crew of the latter cannot be depended on to put on chafing gear to properly protect the line, hence they must shackle that end to their anchor chain if possible. In lieu of that, a wire pendant furnished by the cutter is necessary. But a heavy wire pendant has been known to break, while the 12-inch manila hawser remained intact; this very likely because the wire pendant was subjected to repeated blows at the lip of the towing chock of the towed vessel.

The writer has had good results from the following method: A 12-inch line was wormed with 21-thread stuff for a length of 50 feet in that portion of the line which would be in the vicinity of the stern. This worming is done carefully; then a parceling of old canvas, marled on, followed by serving of old boat falls, put on tightly, covered by a parceling of old canvas, marled on. When pressure is put on the hawser, naturally the latter stretches and contracts its diameter; therefore, to allow for this so that the chafing gear will not slip along the hawser, a good tight seizing is put on at each end of the chafing material; this can be quickly set up anew with the contraction of the hawser or another seizing at each end be put on next to the first seizing; this latter on the contracted hawser. When the above job is completed, it is slushed and then adjusted over the stern of the ship.

TOWLINE—GENERAL

734. It is necessary to keep the surface of the line where it works across the taffrail slushed continuously. On the *Sebago*, during a 2 weeks' tow of a large steamer, all available grease was used up and then quantities of lard substitute. On this long tow, as the result of gales, it was necessary to continue the turns of the hawser forward from the towing bitts and take turns around mooring bitts. The strain of the towing line was so heavy on the bitts that part of the strain was eased by a second line, made fast to the hawser just forward of the taffrail, and run parallel to it up over the towing bitts and then secured to mooring bitts. In spite of this the chafe from the towing bitts was very heavy and ruined the line for further use.

In a seaway the towline will surge violently from side to side, and it is necessary to keep foolhardy men, who are engaged in slushing the line, from being crushed. Even when lying flat on their backs, during the greasing operation, they are apt to have a hand or arm caught between the line and rail. At such times an alert officers' watch aft is indicated and at no time, even in smooth weather, should the watch aft be lessened.

NEW YORK DIVISION DISTRESS CONFERENCE—JANUARY 30, 1935

735. At this conference, which was called by Capt. William H. Shea, U. S. C. G., commander New York division, there were in attendance over 50 conferees of the Coast Guard, Navy, Army, Public Health Service, Bureau of Lighthouses, Weather Bureau, underwriters, steamship lines, Federal Radio Commission, Federal Communication System, shipping commissioner, radiotelegraph companies, and broadcast systems.

Capt. W. H. Shea addressed the conference, outlining Coast Guard operations. In part, he stated: "It is important to us that in sending any information regarding vessels in distress, as far as possible, the exact location of the vessel be given, the state of weather, the wind, and any pertinent information that might help us in establishing the position of the vessel with the least possible delay. The same thing applies to the location of a derelict. We are called upon to locate derelicts, and floating derelicts are 'mists of the night', so to speak. If we have proper information as to the state of the weather and the exact location of the derelict when sighted and the approximate drift, it will help us immensely in getting to the scene."

Capt. T. M. Molloy, U. S. C. G., also addressed the conference. He said in part, "Not over one-quarter of the applicants for lifeboat tickets pass our examinations at the barge office, and few of them have any idea of what should be done in an emergency. The first thing one would think to be a lifeboat man, a man ought to know how to handle an oar. The cases I have in mind seem to lead to the belief that the handling of an oar is not the most important thing. All seagoing 'skippers' should keep in mind the necessity of having their lifeboats remain in the vicinity of the position of the broadcast SOS and not try to make land in a locality where they have no idea of the conditions of the shore. The boats on most of the ships are unwieldy for an inexperienced man to work with an oar. If the shipping companies and 'skippers' would keep that in mind, about advising their people to stay in the vicinity, I think it would be far better than drifting away." Capt. W. H. Shea added: "Personally, I think that is a very good suggestion. When a ship's position is known, by keeping in that vicinity where various ships are responding to calls, there is more chance of rescuing them than by scattering and going to various points. Usually the boats will be overcrowded and they are not able to

row them properly and take care of them. A small boat at sea has wonderful seagoing properties, as you know. If you can keep her bailed out, she will remain afloat."

Mr. L. E. Brotzman, of the Weather Bureau, said in part, "Through the cooperation of the Navy Department, by radio, we distribute twice a day information relative to weather conditions. We provide maps of ocean and shore stations on which these reports can be plotted. We are taking part in an international program, which involves a survey of weather conditions over the entire world. When that program is functioning 100 percent it will consist of reports received from at least 1,000 ships. During the hurricane season we send out special broadcasts to ships within certain areas to forward reports at frequent intervals, in order to enable us to get a better plotting condition of the location of the hurricane."

DERELICTS (By Capt. William T. Stromberg, U. S. C. G.)

736. Searching out and destroying (or towing in) derelicts dangerous to navigation is one of the hardest and most interesting duties of the Coast Guard. Each officer should have a working knowledge of the "search problem." Due to the many factors and variations of each of these factors, no two cases are ever alike, even though two derelicts might start from the same place.

The first essential is the obtaining of the very best information possible. This information includes the last well-established position of the derelict, the direction and force of the wind (from the time of last-known position to the expected time of arrival in the search area), and the set and drift of the current. After these facts are known there appear many conditions which, though they may appear minor, might possibly become the dominant influence in the drift of the derelict. Chief among these are:

Draft of vessel and deck height above water.

Shape of hull (which determines the position the derelict assumes).

Under water body shape.

Load conditions.

Sail conditions (was any sail left hanging on vessel).

Height and number of masts.

Whether vessel's under water body is damaged or not.

Length and beam of vessel.

All of these pertain more or less directly to the derelict itself. In this discussion it must be understood that no human agency interferes with the movements of the derelict.

Each "search problem" includes all factors which tend to drive the derelict in *definite* directions at (more or less) *indefinite* speeds per hour. These factors are:

(*a*) Current—found from pilot charts.

(*b*) Wind—found from daily weather reports.

(*c*) The surface current—(known from experience to be set up by winds of long-continued duration). This current is independent of the local current and may amount to as much as ½ knot per hour.

These factors are then combined in a traverse, the departure point being the latest known position. If only three or four courses are involved they may be plotted directly on the chart. The most indefinite of the factors is naturally the wind effect. A fairly close approximation seems to be to allow for distance as follows:

Gentle breezes 0 to ¼ mile per hour.

Moderate breezes ¼ to ¾ mile per hour.

Fresh breezes ¾ to 1¼ miles per hour.

Gales 1¼ up to 3 miles or even more per hour.

These values will be much increased if the vessel be of shallow draft, great beam and uniformly high bulwarks such as a coal barge, thus presenting a large sail area, normal to the wind, with small resistance below the water. The effect will be greater in smooth water than in a seaway.

In March 1929 an unloaded old coal barge drifted through Fenwick Island Shoals almost due southeast for a distance of 35 miles in 12 hours. The crew of this barge had been taken off by the *Gresham* during a northeast gale. Attempts to take the barge in tow had been made without success due to the fear, inexperience, and shortage in number of the crew of the barge. The rescue of the crew was effected at 7 p. m. just in the edge of the breakers. At 10 p. m. the wind shifted to NNW. and increased to a moderate gale during the night. The barge was located at 10:30 a. m. the following morning, 6 miles inside of the southern limit of "probable triangle of drift." The late Lieut. Comdr. I. W. Buckalew worked out the problem. The same experience was found in the Gulf of Mexico in the winter of 1913 when search was made for a lumber laden schooner. In this case the "probable triangle of drift" was about 400 miles in length. The derelict was found on the beach opposite Ship Island Lighthouse on the extreme right side of the triangle. Comdr. S. V. Parker, then a lieutenant, worked out that particular "search problem." The reason for this derelict being on the extreme right was probably due to the fact that the coastal (easterly) current was increased due to a long period of southwest winds.

As was said before too many variable factors enter into each problem to make this derelict searching an exact problem, but by observation and discussion much valuable information may be acquired. Each officer should know the general principles involved and the

commanding officer, executive officer, and navigating officer should be thoroughly familiar with them.

SALVAGING OF VESSELS (By Capt. R. W. Dempwolf, U. S. C. G.)

737. In 1906 while I was attached to the *Onondaga* we towed into Hampton Roads a 4-masted schooner bottom up. As you may realize, there was no place on the bottom to make fast a towing line, therefore something had to be improvised. We sent over the ship's carpenter to the schooner in a pulling boat in a moderate to rough sea. The ship's carpenter by means of a large auger bored a hole through the forward end of the keel near the scarph of the stem post (fig. 34). Through this hole a wire strap was passed (strap being parceled and served to prevent chafe of towing line). A 10-inch hawser was then run from the *Onondaga* through the strap along the keel, where it was made fast at the after end of the keel between the rudder post and the rudder with several half hitches. With this arrangement we towed the derelict schooner bottom up into Hampton Roads, where the vessel was turned over to the salvage company and later turned over to the underwriters.

During the same year, 1906, a large schooner was ashore on the Virginia beach several miles south of Cape Henry (see fig. 33). The *Onondaga* was unable to get in very close to the schooner aground on the beach, but that vessel was pulled off safely by the following method. The *Onondaga* was anchored as close to the wreck as practicable and veered about 100 fathoms of the port chain and ran a 12-inch hawser to the schooner, where it was well made fast through chocks and around the foremast. When conditions were right, the hawser, about 150 fathoms in length, was hove taut by means of the windlass and by heaving in on the port anchor chain. Nothing further was done at this time except to keep the port chain taut. Then in 1 hour or so an easterly swell made up which caused a strain and swigging effect which eventually heaved off the schooner on the beach. The port anchor was then hove in, and the *Onondaga* proceeded to Hampton Roads with the schooner, which was turned over to the underwriters.

ASSISTANCE TO VESSELS BY THE COAST GUARD (By Commander James Pine, U. S. C. G.)

738. The tendency in recent years has been toward a standardization of methods used in assisting vessels in distress. This is due in part to the accumulated experience of the service, which has directed attention to the most successful methods employed, and in part to the greater concentration of the vessels of the service into classes of ships having similar characteristics.

With reference to the experience of the service, it has been found in general that a method successfully used under the most difficult conditions would serve equally well under less trying circumstances and that a definite advantage results from using the same procedure over and over again, so that the evolution becomes in sense a drill in which the groups of the crew become proficient in their individual parts through constant repetition. Similarity of ships in their general characteristics has also played its part in standardizing the methods most commonly used.

In spite of this general tendency, it is of course true that no two cases will ever be exactly the same, that in consequence any rules laid down must be stated in broad terms and capable of instant modification to suit existing conditions, and finally that cases will arise in which all rules fail, and in which the solution must lie in the application of methods based on common sense, sound seamanship, and resourcefulness.

The following examples, typical of the work of the service, will serve to illustrate the broad principles applying to similar cases.

A. Taking a Vessel in Tow at Sea

739. This is, generally speaking, one of the commonest maneuvers. It is simple of execution in most cases, but under trying conditions demands excellent judgment and perfect execution.

(1) Take as an illustration the simple case of a vessel drifting in a rough sea. The assisting cutter takes position astern and stops to observe the relative rates of drift of the two ships. The towline and running line are made ready, and in case anything goes wrong the shoulder line throwing gun and extra heaving lines are disposed for use.

If the other vessel drifts the faster, as will often be the case where a large vessel is concerned, steam down to leeward on a parallel course, distant 200 or 300 yards, and stop when abeam. Pay out a 3- or 4-inch running line attached to a light buoy (a 50-pound coffee can makes an excellent buoy). This buoy can be put over before passing the vessel's stern and will work up to windward. Regulate your speed so that the vessel to be towed will drift down on the buoy a little forward of amidships.

When the buoy is aboard and the line lead forward on the steamer go ahead until your stern will clear the other vessel's bow as it drifts across. A touch of the engine will clear you at any time should the steamer forge ahead. When within 50 fathoms or less pay out your hawser and let them heave in and shackle to their lee chain. This may take 20 to 30 minutes. Meanwhile, as the steamer drifts across, pay out your hawser until it is fast, then go ahead slowly, secure the hawser; let the steamer veer out 50 to 60 fathoms of chain and work up to a safe towing speed.

The advantage of the buoy is that it reduces the time of drift of the vessel to leeward of you, and thus

the length of the hawser in the water while making fast. Should the running line part, you can still shoot a line or take a heaving line from the vessel as it drifts past. The advantage of the method as a whole is that (1) every step is under your control; (2) there is no need to go close aboard the steamer to get your running line aboard, in fact the further to leeward you go, the more time there will be for making fast; (3) you have three chances of putting the line aboard.

If the cutter drifts faster than the vessel to be taken in tow, go to windward and let them drift a buoy up to you. When you have the line aboard, go ahead until clear of his bow, drift across as close as you think prudent, and pass the towline as before.

The line-throwing gun is of more use under these conditions as you are firing to leeward, but the advantage of the shoulder gun over the heaving line is almost, if not quite, nullified in the case of two drifting vessels by the delay incident to passing the extra line.

It is recommended that a good 3- or 3½-inch running line be kept especially for this maneuver and that this line be cut when it has reached its destination to avoid the delay and confusion incident to hauling the line back aboard when it may foul the hawser.

It often happens that the crew of a vessel being taken in tow is able to handle the hawser only with difficulty. This may be due to shortage of men, exhaustion of those available, or to the lack of power to haul in the hawser. In some cases it may be necessary to send aboard a boat's crew to help, or in the case of an abandoned vessel to do all the work. In such cases, it may be advisable to run a 5- or 6-inch hawser first, and to ride to this line while the larger hawser is being run, thus preventing the two vessels from drifting apart and avoiding the need of maneuvering the engines while the hawser is in the vicinity of the propellers. When no power is available on the tow, a heavy hawser may be hauled aboard with a whip from the cutter. Figures 128, 129, 130, 131, and 132 show the successive steps in putting a crew aboard a derelict in a rough sea.

When the vessel to be taken in tow can maneuver, the process can be simplified by the towing vessel trailing the running line and buoy over the stern and allowing the other vessel to pick it up. Both vessels should steam with the wind abeam or nearly so to avoid the possibility of their falling off on opposite tacks when stopped to secure the line.

These are about the only cases where the use of the buoy is recommended. The method described in Knight's Seamanship of towing a buoy around or across another vessel so as to foul the prospective tow does not as a rule work so well in practice as in theory. If the object is finally attained, it will often be found that the two vessels are out of position and that they drift so far apart before the hawser can be secured that it must be let go.

In all cases be sure to stop the hawser to the running line with plenty of end for the receiving crew to work with. Stops that can be cut adrift as they come aboard are better than hitches that may jam in the chock.

The essence of the whole maneuver is to reduce the time required to run the line to a minimum.

In the case of a large steamer with rudder disabled but with engines undamaged, better progress can often be made by taking a line to the cutter's bow and acting as a rudder. In this case it is important to determine the length of towline that will produce the best results. In general it may be said that the shorter the line the better the control and also the greater the strain on the line. A line with a considerable length in the water will drag and finally jump when the towed vessel (cutter) sheers to bring the towing ship back on her course. This is shown in the two illustrations, figures 133 and 134. The result will be a series of zig zags until the course is finally steadied again. On the other hand a short line is subject to sudden strains, particularly in a seaway where the two ships are out of step. A compromise is therefore necessary, depending upon conditions. If a vessel is available to tow ahead as well as one to steer, better progress can be made, but as a rule the vessel towing astern will have the greater strain on her line. In the case of towing the Army transport *Powhatan* into Halifax in the winter of 1920 the *Acushnet* steering from astern parted a 9-inch line several times with vessels assisting by towing ahead. Figure 135 shows the procedure after the *Ossipee* had relieved the *Acushnet* so that the latter could tow ahead of the *Relief*. The photograph was taken from the *Acushnet*.

B. TAKING OFF THE CREW OF A VESSEL

740. The problem here is very similar to that of taking a vessel in tow, the principal difference being that, since in this case, no tow line is required to be run, it is better seamanship to keep your propeller clear and to approach the other vessel's stern with your bow. The method used by Admiral Hamlet in rescuing the crew of the mine sweeper *James* as described in Knight's Seamanship is the best possible way of accomplishing this dangerous and difficult task. The only additional suggestion would be to use the buoy, or possibly a small Carley life raft in the same way as suggested under A, in order to gain the advantage of a few minutes in establishing contact. It may be further noted that at some time in the future one of our cutters may be faced with the decision whether or not to risk actual contact with another vessel in order to save lives where all other methods fail. In this extreme situation placing your bow on the quarter of the other vessel protected as well as may be possible by cane fenders, mattresses, etc.,

offers the best prospect of success. The probability of damage in this case must be accepted as justifying the risk.

C. TAKING A STRANDED VESSEL IN TOW

741. The wide variation in conditions existing in the case of stranded vessels makes the outlining of a standard procedure more difficult than in the previous cases. There are, however, a number of points of general application which will be outlined.

The work outlined may be divided into two parts:

(1) Passing the hawser.—In general this differs from getting a hawser aboard a vessel at sea because of the restriction imposed on maneuvering due to shoalness of the water in the vicinity and the fixed position of the vessel ashore. It is further complicated by the usual necessity of awaiting high water before towing, by the presence of tidal currents setting along the beach, and by the presence of the anchors of the stranded vessel which may interfere with close approach.

In some cases it may be possible to get close enough with the ship to heave or shoot a line aboard while underway. This is a desirable procedure, as in the case of a vessel anchored close to a lee shore and in danger of being driven up on the beach. This is not strictly speaking a case of a stranded vessel, but the emergency may be great to prevent its becoming one, and any delay may be fatal. In this case approach from down current, maneuver as close to the vessel's bow as possible and after passing the heaving line, sheer out to avoid the vessel's chain, work up current, and unless the line can be made fast immediately, anchor on the weather bow until the line is fast.

Where, as in the case of a stranded vessel, the water is too shoal to prevent this action, anchor as close in as possible and up current from the vessel, veer out a good scope of chain (75 to 90 fathoms), run the line by whatever means is practicable and as high water approaches take a strain on the line and heave in on the anchor chain.

(2) Towing on the stranded vessel.—The anchor, if planted well on the bow, will serve to prevent your being set down by the current, which is usually the greatest obstacle to success. If, in spite of the anchor, you are swept down by the current, the line must be let go promptly. This should be done from the stranded vessel, on your signal. The need for a thoroughly understood signal for this is apparent for, if the line is not cast off promptly, you will be in danger of being swept ashore or at least under the necessity of cutting the hawser at your end. Cases have occurred where in this extremity the hawser has been cut from both ends at the same time and so lost.

Where strong currents prevail, it is almost essential to have 2 ships, 1 to tow and 1 to hold up the head of the towing ship. The method employed, however, will not be materially changed.

When time permits, the vicinity of the stranded vessel should be carefully sounded out, the location of the best water determined and the endeavor made to take full advantage of this and other conditions. As a vessel will be driven higher and higher on the beach as time passes, every effort should be made to prevent this by laying out an anchor. The stranded vessel should not be lightened until this has been done. It will often be found that a steady strain on the anchor will work a vessel loose to the point where a short pull at high water will float her. Where a vessel is hard and fast aground on a sandy beach it is often necessary to await an onshore swell to loosen her up. In such a case everything should be made ready before-hand and prompt advantage taken of the onset of a heavy surf before it gets so heavy that the hawser must be let go.

SOUND ADVICE (By Commander R. L. Jack, U. S. C. G.)

742. I have been pretty lucky in "avoiding pitfalls" and my only thought along that line is that "eternal vigilance is the price of safety." Nothing can be taken for granted or left to chance. My philosophy has always been "Luck is like a bank account, don't use any of it needlessly." We have to take chances all the time in our work and I always figured that the old law of average worked in this just as in any other game of chance, hence I never tried any fool stunt to see if I could get away with it. One practical suggestion is the importance of getting out an anchor as soon as possible after stranding. By doing just that I saved the *Jouett* from serious damage when she stranded at Melville.

Work on stranded vessels is 90 percent common sense and a full knowledge of forces favorable and unfavorable. First determine if the vessel will float after release from the beach. Then study how she is stranded and the way she must come off; when must tow line be made fast. Study the underwater terrain carefully for hidden obstructions. Next determine the place you wish the towing vessel and put her in the closest place to the ideal one that is consistent with safety. Take into consideration the direction of current at *the time you intend to pull.*

If there is no natural swell, create one if possible by using a boat like a patrol boat which can travel in shallow water and kick up a swell. If you intend to "jump" on the hawser, synchronize the jump to take place at the time the swell reaches the stranded ship. (Have successfully used the artificial swell method on a number of occasions, even pulled a vessel off a broken-down marine railway.)

A skipper should study the problem logically; the forces pro and con. He should know what his craft can do and how best to make her do it. The whole thing boils down to judgment, study of the situation, and the application of common sense. The only

other factor, "guts", is common to all Coast Guard skippers and is not stressed. So much for attempts to *save*.

If it appears certain the vessel cannot be saved, her crew must be saved. If she is stranded, it may be difficult to take them off in boats or rafts, or drifting lines. (Some may be saved but others will probably be lost.) The only other method is the use of the breeches buoy. The use of the buoy from the mast of the cutter to the wreck may be feasible and should be tried if other schemes fail. However, it may be found more practicable to land the gear and use it from the shore side. The only thought here is that all officers should have a thorough working knowledge of the method of handling this equipment (even as to how much powder to use and how to estimate distance and windage in laying the gun).

The only other feature is "Will the vessel become a menace to navigation?" All officers should know how to use explosives to best advantage in demolition work. "The Blasters Handbook", gotten out by the Du Pont Co. should be in the library at the academy. While not applicable to our particular job, it contains some good dope on how to think out an explosive problem in demolition work.

AN AID WHEN A STRANDED VESSEL WILL NOT COME OFF (By Commander G. W. MacLane, U. S. C. G.)

743. If the cutter is unable to pull a stranded vessel off the beach there is one trick that may help. While pulling suddenly put the rudder hard over; the cutter's stern is thrown around so as to throw its weight on the towline. Have observed that this works fine. Judicious jumping on the line also may assist.

RESCUING THE CREW OF A FOUNDERING VESSEL

744. There can be no doubt that the best method under the circumstances is that which was adopted by our commandant, then Capt. H. G. Hamlet, while in command of the U. S. S. *Marietta*, a gunboat, during the World War. By means of a Carley life raft which was hauled back and forth between the sinking mine sweeper and the *Marietta* the entire crew of 47 were rescued. By placing the *Marietta* in the *James'* wake it was found that the *Marietta* drifted the faster. The *Marietta* was then placed with her bow lapping the lee quarter of the *James*, on the same heading, a short distance away and a heaving line placed aboard. Holding the two vessels within 50 yards of each other by judicious use of the *Marietta's* engines, a 4-inch line was used to haul the raft back and forth nine times between the two vessels. By means of bowlines lowered from the forecastle head of the *Marietta*, the men were hauled on board from the raft. Oil was freely used by both vessels. Admiral Hamlet points out that a raft with a sunken deck is much better adapted to use than a decked one, the former type assisting in keeping the men from being swept overboard by the seas.

In the use of such a raft, the following points are emphasized. The assisting vessel should, while making a zig-zag figure eight curve to leeward of the helpless vessel, spread quantities of oil so that during the operation both vessels will work into the area of the oil-covered sea. Whereas fuel oil is not nearly as efficient as storm (animal) oil, the action of a heavy sea tends to break it up and thus offer a filmy surface which acts marvelously to flatten out the seas. Storm oil released from both ships and oil bags trailing on the hauling line near the raft and trailing from the raft itself are important. Whenever possible the raft is to be handled along the lee side of both vessels. An important detail is to nest layers of kapok life jackets or mattresses, etc., on the deck of the raft so men will not be injured in jumpng, sometimes from considerable height, into the raft. Of course, conditions permitting, the men would be lowered into the raft.

Important on the rescuing ship is the placing of cargo net type life lines over the side, which will aid materially in helping the rescued men aboard. It is gratifying to note that most cutters are equipped with such nets and use them whenever a lifeboat is handled alongside in a seaway. Men thrown out of a capsized or smashed boat have a split second opportunity to grab the net before they are swept away or crushed. It is invaluable in getting men out of the boat to lighten it for hoisting.

Another method, when it is too rough for boating, is the breeches buoy apparatus. However, the average officer will prefer, in the case of a stranded vessel, if possible, to land the apparatus and work from the shore.

A ring or breeches buoy also may be hauled back and forth through the water in a manner similar to the raft. The disadvantage of this method is that if the distance is great, the rescued person is apt to suffer from immersion.

Much has been written about the use of oil. Without a doubt it is the greatest single aid in rescue work. A few tons of fuel oil versus the saving of lives—there can be only one answer—*use oil and more of it.*

The cutter recently on duty off the Washington and Vancouver Island coasts on numerous occasions each year used the large Lyle gun which could be mounted in fixed sockets on either side of the vessel just forward of the pilot house. From a distance of approximately 100 yards to windward a charge of 3½ ounces of powder with the gun elevated about 35° sent the projectile over the average vessel. Charges of 6 ounces were used with safety. The records of Coast Guard stations show that charges as high as 8 ounces have, under exceptional conditions, been used.

ANOTHER OFFICER RECOMMENDS BEACH APPARATUS ON CUTTERS (By Lt. Comdr. H. G. Belford, U. S. C. G.)

745. In February 1934 the cutter *Shoshone* rescued the crew of the *Swifteagle* when she went ashore on the Mexican coast. In this case it was necessary to rig an improvised breeches buoy and to remove the crew from the shore side. It was accomplished very successfully and without accident. The method used was along the conventional Coast Guard practice. As a result of this experience Commander R. L. Jack recommended that the *Shoshone* be equipped with sufficient breeches-buoy apparatus, including Lyle gun, for performing similar work in the future. His recommendation was approved by headquarters, and the *Shoshone* is now equipped with sufficient standard Coast Guard breeches-buoy equipment.

HANDLING OF SMALL BOATS

746. The method usually recommended for heaving-to small boats is the one described by Commodore R. O. Crisp, (R) in his story of the *Loss of the Tahoma*, in the chapter on damage control. This method of lashing sails, spars, etc., together for use as a drogue, was of great value in heaving-to a whaleboat in which the writer rode out a gale in the Gulf of Alaska. However, when we landed through the surf our boat was capsized and badly damaged and all equipment and camping gear lost. This incident impressed me with the necessity of using anything but a keel boat for surf work. Once it touches bottom, when the surf is heavy, there is absolutely no chance of jumping out and holding the boat upright and head to the sea.

In working boats through the surf sufficient experience has been gained to convince me that the method used on a comparatively flat sandy beach, by the officer in charge of the Nome, Alaska, Coast Guard Station, Thomas A. Ross, chief boatswain, is the best. He used flat-bottomed dory-type light boats, pulling either 3 or 5 oars. In approaching the beach to go through the surf he invariably turned around and proceeded in stern first, intermittently giving away, in lie of backing, to meet heavy seas. With a steering oar he maintained full charge of his boat even in heavy surf. In coming in to land on the beach the flat bottom allowed the boat to ride well up on the beach and then to be quickly pulled out of the boiling surf. In rowing to seaward he watched his chance to make a quick get-away from the beach during the period in between the heavy rollers. Mr. Ross probably bears as fine a reputation for his ability to deal with surf as any person in the service. By borrowing the station boats it was possible for us to work stores out through the surf to the cutter via the power boat which was anchored just outside of the breakers.

TOWING RESISTANCE

747. (a) In deciding upon the size of towline to use and a safe speed for towing a disabled vessel it is well to recall that towline resistances may be estimated from the law that in smooth water the towline resistances vary as the displacement to the 7/6 power, i. e., $\frac{R}{D^{7/6}}$, which can be conveniently reduced to pounds pull per ton. Appropriate allowances are made for the sea conditions, which greatly increase the resistance of the tow.

As will be noted from the table below, speed also greatly increases the resistance. In first getting the tow into motion, even ever so slowly, the resistances will greatly exceed the values shown in the table.

Estimated towline resistance (smooth water)

Displacement of vessels towed	Speed			
	2 knots	4 knots	6 knots	8 knots
Tons	*Pounds*	*Pounds*	*Pounds*	*Pounds*
1,000	310	1,250	2,800	5,000
2,000	540	2,050	4,800	8,600
3,000	675	2,700	6,050	10,800
4,000	830	3,300	7,500	13,500
5,000	960	3,800	8,600	15,000
6,000	1,075	4,250	9,500	17,000

(b) *Three-strand manila rope*

Name and size in circumference	Approximate diameter	Approximate length and weight standard coil		Approximate tensile strength new manila rope
		Feet	Pounds	
6 thread, 9/16 inch	3/61 meter	3,333	50	480
6 thread, ¾ inch	¼ inch	2,750	50	620
9 thread, 1 inch	5/16 inch	1,820	50	1,000
12 thread, 1⅛ inch	⅜ inch	1,350	50	1,275
15 thread, 1 7/32 inch	13/32 inch	1,200	50	1,600
1¼ inch	7/16 inch	1,200	65	1,750
1⅜ inch	15/32 inch	1,200	75	2,100
1½ inch	½ inch	1,200	90	2,400
1¾ inch	9/16 inch	1,200	125	3,150
2 inch	⅝ inch	1,200	160	4,000
2¼ inch	¾ inch	1,200	198	4,700
2½ inch	13/16 inch	1,200	234	5,900
2¾ inch	⅞ inch	1,200	270	7,000
3 inch	1 inch	1,200	324	8,000
3¼ inch	1 1/16 inch	1,200	378	9,500
3½ inch	1⅛ inch	1,200	432	10,500
3¾ inch	1¼ inch	1,200	504	12,500
4 inch	1 5/16 inch	1,200	576	14,000
4¼ inch	1⅜ inch	1,200	648	16,000
4½ inch	1½ inch	1,200	720	17,500
4¾ inch	1 9/16 inch	1,200	800	19,500
5 inch	1⅝ inch	1,200	900	21,500
5½ inch	1¾ inch	1,200	1,080	25,500
6 inch	2 inch	1,200	1,296	30,000
6½ inch	2⅛ inch	1,200	1,512	34,000
7 inch	2¼ inch	1,200	1,764	38,000
7½ inch	2½ inch	1,200	2,016	43,500
8 inch	2⅝ inch	1,200	2,304	49,000
8½ inch	2⅞ inch	1,200	2,590	55,000
9 inch	3 inch	1,200	2,915	61,000
9½ inch	3⅛ inch	1,200	3,240	67,000
10 inch	3¼ inch	1,200	3,600	73,000
11 inch	3 11/16 inch	1,200	4,320	84,000
12 inch	4 inch	1,200	5,184	95,000
13 inch	4 13/32 inch	1,200	6,048	106,000
14 inch	4 15/16 inch	1,200	7,050	115,700
15 inch	5 inch	1,200	8,064	124,200

CUTTER TOWING GEAR

748. Headquarters approved furnishing the *Sebago* with a towing gear (fig. 127), which was conceived by

Capt. H. R. Searles, U. S. C. G. It consists of a 1⅜-inch plow steel-wire cable (or chain cable), which secures around the towing bitts in a bight, the two ends having thimbles which engage a shackle on the forward end of a specially designed heavy pelican hook. The thimble in the 12-inch hawser engages in the after end of the pelican hook, thus providing a quick way for letting go. Such an arrangement is only advisable for use when the hawser shackles into the chain cable of the vessel being towed, which provides for getting both vessels in step by veering or heaving in cable on the tow. Stops are used to hold the hawser during the process of engaging its shackle in the pelican hook. Precaution would indicate placing the pelican hook very close up to the towing bitts on the cutter, so as to minimize its surge, in the event of the hawser snapping under strain; also for the same purpose a preventer made fast to the forward side of the pelican hook and leading aft for securing. In emergencies the link to disengage the hawser from the pelican hook may be worked with full strain on the towline, but in most instances it would no doubt be possible to stop the engines to ease the strain and lessen the danger incident thereto. After engaging in long, heavy tows, in bad weather, with the severe manila chafe on the towing bitts, any towing gear which will eliminate such dangerous and costly chafe is welcome.

NEW MOTOR LIFEBOATS "INVINCIBLE" AND "TRIUMPH" (By A. Hansen, naval architect, U. S. C. G.)

749. The Coast Guard has in operation at this time various classes of motor lifeboats, namely, type (E) which are 34 feet and 36 feet long; type (H) which are 36 feet long; type (HR) which are 36 feet long, but are provided with a forward cabin; type (T) which are 36 feet 6 inches long; and the latest design which is 36 feet 8 inches long. All the above-mentioned types of motor lifeboats are self-bailing and self-righting, but of relatively shallow draft.

A real need has existed for some time for a larger sized motor lifeboat, designed for locations where extreme conditions of sea are met and where deep draft could be carried. Sometime ago a board of district commanders convened at headquarters for the purpose of setting up, in general, certain characteristics considered desirable for these larger lifeboats. The work of designing was taken in hand and construction of two of these boats, the *Invincible* and *Triumph* was begun in 1934, and completed in 1935. They are designated type (F) motor lifeboats (fig. 125). Following are the general characteristics:

Length over all	feet and inches	52	0
Length load waterline	do	50	0
Beam over guards	do	14	3½
Beam load waterline	do	12	5¾
Draft maximum	do	6	0
Displacement, approximate	tons	30	
Speed, about	miles	10½	
Radius, approximate, ¾ speed	do	500	

This type of motor lifeboat is of flush-deck design, obtaining maximum clear deck space for wreck and rescue operations, a three-high lifeline railing being fitted for protection of the crew. Deck erections consisting of wheelhouse, engine trunk, and companionway hatch are of welded bronze, watertight doors being fitted, and the entire vessel may be battened down to prevent entrance of any water. The hull construction is of abnormally robust details, utilizing specially designed double-web frames in conjunction with numerous longitudinal members and stiffening girders. Propeller wheel and rudder are protected by means of a large cast-bronze skeg. The hull is subdivided into watertight compartments, including wing compartments outboard of the engine space. These compartments have been so arranged that any two may be open to the sea and the boat will still float. The athwartship and longitudinal bulkheads are of welded bronze all stiffened by angles and watertight doors and manholes are fitted as required. The hull planking is of 1⅜-inch Honduras mahogany, garboard, sheer and adjacent strakes are of increased thickness, and the main deck is double diagonal planked with the upper layer of teak. As mentioned above, all frames are of heavy size with special web frames spaced at intervals; deck beams, in general, being of laminated construction.

The interior arrangements of the boat are as follows: Forward is the chain locker and general stowage compartment, next aft is the forecastle provided with small galley equipment, seats, and lockers. Pipe berths will probably be fitted in this compartment and in conjunction with an electric or gas range, fresh-water supply and limited messing facilities, the boat should be able to cruise for some length of time with ample provision for taking care of the crew. The wheelhouse deck is sunk below the level of the main deck and directly underneath are concentrated the various units of the heating system. This is of the combined hot-water, hot-air, forced-circulation type, the circulation being obtained by a motor-driven blower, the boiler being automatically controlled by a temperature regulator. Coal bunker and coal are provided for simplicity of operation. The heating system involves the use of hot-air supply and cold-air return ducts which are led to the various compartments, and a positive circulation of air is assured. The heating system is also arranged so that forced ventilation is available when the vessel is battened down. Specially designed fresh-air intakes are installed on deck, which devices automatically permit fresh air to be drawn in but prevent water from entering the compartments below. The engine room is directly aft of the heating system compartment, and, as

previously described, is protected by watertight wing compartments and the main bulkheads. The wing compartments contain the main fuel-oil tanks. The arrangement of the engine room will be described later. The two compartments aft of the engine room are primarily intended for accommodation of refugees; however, the forecastle can also be used for this purpose. It is estimated that approximately 60 people can be stowed below decks in case of emergency, and, in addition, approximately 100 people can be mustered on the main deck without appreciably affecting the stability and safety of the boat. All cabins are provided with necessary seat lockers and required stowage spaces. The amidship cabin is also fitted with enclosed toilet compartment wherein is installed a pump water-closet and other fixtures. The lazarette aft contains the steering gear, miscellaneous stowage, and, in addition, the storm-oil tank and valves.

As mentioned, the boat is of flush-deck design, forward is a double-acting, hand-operated windlass with a 100-pound and a 200-pound anchor. The pilot house is provided with all operating and navigating equipment, and in conjunction there is provided a bridge abaft the wheelhouse where duplicate controls and steering gear are provided. When proceeding to sea or in cruising, the operation of the boat can be handled from inside the wheelhouse, allowing for the comfort and protection of the personnel. However, when the scene of action is approached, the operation station can be shifted to the bridge where vision, audibility, and direction can best be had. The dual steering gear is provided with clutches for locking in or out of the respective steering wheels. Duplicate compasses of the spherical type are installed, also a double telegraph signal system. Radio transmitting and receiving apparatus is installed for communication with shore or vessels. Powerful searchlights, air signal horn, and other fittings are installed as necessary for efficient operation of this type of craft. Abaft the bridge is a low engine trunk which is provided at the after end with a companionway or booby hatch permitting convenient access to and from the engine room. In the engine trunk is also located another emergency hatch, the engine and generating set exhaust pipes and mufflers, and the galley smoke pipe. On the after deck is the companionway hatch to the cabins below and this is of a size that will afford good entrance and allow the handling of disabled people. Aft on deck are located extra substantial towing bitts, towing rail, and hawser rack.

Guards and fenders are of very substantial size and shape to obtain protection when laying alongside, and in addition bilge keels are fitted to the hull for stiffness and steadiness. It is contemplated providing the boat with a modified sailing rig consisting of a mast fitted in a tabernacle so arranged that it may be lowered and this, in conjunction with 2 or 3 triangular sails for jib and mainsail with boom, may provide an emergency rig in case of engine failure or for steadying purposes.

The main propelling engine is a 150 horsepower, solid-injection, 6-cylinder Buda Diesel engine with reduction gear. The engine is provided with an electric starter and a 32-volt bank of batteries is installed in the after end of the engine room. Adjacent is located a 3-kilowatt, 32-volt Diesel generating set together with necessary switchboard. In the engine room, also, are provided a motor-driven bilge pump, signal horn, air compressor, ventilating blower, and induced-draft blower for the heating system. The engine room is protected by a two-cylinder CO_2 fire-extinguisher system. A work bench and tool lockers are also installed. The main engine is provided with a fresh water cooling system, the cooling unit being mounted alongside of the engine, together with necessary circulating pumps. Provision is also made for salt-water circulation in the event of emergency. The switchboard controls all circuits for the electric lighting and power supply of the boat throughout.

The general outfit and equipment of the vessel is very complete and comprehensive and includes all necessary items for the navigation and operation of the boat in conjunction with a certain amount of wrecking gear such as might be used to meet service requirements. Special long pudding fenders for coming alongside and other devices are provided for. The design throughout endeavors to produce the most sturdy, safe, and modern lifeboat that it is possible to build. All materials and workmanship are of the very highest order, and satisfactory results from the general operation of the boat are anticipated as soon as the trial and shake-down cruise is completed. Calculations made for the determination of the design characteristics indicate technical conditions of stability and buoyancy that are exceedingly gratifying considering the special and unusual type of craft involved.

ESCANABA — ICE-BREAKING — LAKE MICHIGAN (By Lt. Comdr. L. W. Perkins, U. S. C. G.)

750. Working in fresh water during temperatures below freezing presents a problem different than when working in salt water. The ice freezes thicker at the same temperature, and seems to be more tenacious. The *Escanaba* being stationed on the east side of Lake Michigan encounters more ice than most Coast Guard vessels. This is due to the prevailing northwest winds, which, during the winter months pile up the ice formed on the lake along the east coast, where it freezes to the bottom. This ice blocks up the harbors to such an extent that nothing but the larger vessels are able to run in subfreezing temperatures. After two winters in this area, the following conclusions have been formed:

(*a*) While ice varies greatly in thickness and conditions, according to the nature of the forces which have caused its formation, certain general principles apply in all cases.

(*b*) It is readily understood that a vessel, which because of low power could not make way directly into the ice, could make up somewhat for its lack of power by using its weight to ride up on the ice and crush it. However, the use of this method is limited to operations in brittle ice of moderate thickness, and since it is expected that Coast Guard ice breakers would have adequate power, it will not be discussed here.

(*c*) The type of ice formation in Lake Michigan that impedes navigation to such vessels as run in winter is of such mass and thickness that it would support the weight of any vessel that hit it hard enough to run any considerable part of its hull upon the ice.

(*d*) Consequently, every effort is made to prevent the bow from climbing on the ice. To this end, the greatest possible amount of ballast is indicated, especially forward. The efficiency of this vessel as an ice breaker is directly proportioned to the oil and water ballast and to the draft.

(*e*) Experiments were made in ice-breaking with the ballast tank empty. The vessel would invariably run up on the ice from one-half to two-thirds its length and hang there. It would then be necessary to dredge for as much as an hour to free the vessel.

(*f*) In clear ice of a thickness of less than 2 feet, the cutaway forward is of some value, in that it has a downward bending effect on the ice and facilitates crushing the solid sheet. In really thick ice or in slush ice, it is doubtful if it is of any appreciable value.

(*g*) Progress through heavy ice or slush ice is obtained by making parallel cuts about one-fourth the length of the vessel, pausing between each advance to wash away dislodged ice with the screw.

(*h*) It frequently happens that the vessel runs too far and hangs on the ice. It has been found that letting go the anchors, emptying the ballast tank, or both, will enable the vessel to back off without long periods of washing with the screw.

(*i*) With the present arrangement, an hour is required to empty the ballast tank. If a more rapid method of filling or dumping this tank were devised, progress through the ice would be accelerated immensely.

(*j*) This vessel, while endeavoring to make its way through several miles of heavy, broken ice, under enormous pressure, from a fresh onshore breeze, the toughness and tenacity of this broken ice was so great that less than a mile of progress was made during a period of 36 hours, but notwithstanding, the hull showed no sign of strain or damage.

(*k*) (Assistance rendered steamship *Missouri*, Jan. 3, 1933.)

A field of slush ice completely closed the Muskegon, Mich., channel from the mouth, 3 to 5 feet thick, 1,500 feet inshore, and held the *Missouri* about midway. Passage through was secured by going ahead at full speed until stopped, then backing and repeating the process. This was effective until the *Escanaba* reached the side of the steamer where the densely packed ice held the cutter fast for about 20 minutes. Here it was necessary to run the propeller ahead and then back at full speed, constantly shifting the rudder. The action of the two screws in such close quarters aided considerably in freeing the vessel. The remainder of the ice was then broken, and the steamer proceeded into open water.

(*l*) (Assistance rendered steamship *Missouri*, Feb. 13, 1933.)

Ice fields extended about 2 miles from Grand Haven, Mich., Harbor and consisted of close-packed slush ice, individual pieces measuring up to 8 feet in diameter, clear ice in the harbor measured about 10 inches thick. *Missouri* entered ice field during the forenoon of previous day, penetrated the field to within 200 yards of breakwaters and remained fast with no prospect of being able to release herself. A channel was broken through the harbor, and the *Missouri* cut out of the field. As she was still unable to penetrate the close-packed ice between the breakwaters this vessel again cleared a channel through the harbor and preceded her into port. *Missouri* aided appreciably by intelligent cooperation during the maneuvers in the ice field.

(*m*) (Assistance rendered steamship *Grand Rapids*, Feb. 18, 1933.)

Steamship *Grand Rapids* had ridden up on the ice near Grand Haven Harbor entrance. Ice formation at this point consisted of packed slush ice, 10 feet thick, beneath which globular masses of solid ice up to 10 feet in diameter and submerged bergs up to 20 feet square were packed. When churned up by working the ship, the presence of mud and sand on this ice revealed that it had been packed against the bottom. *Missouri* assisted in working away ice near *Grand Rapids* and attempted with *Escanaba* to pull *Grand Rapids* off ice but were unsuccessful. A shift of wind to eastward enabled *Grand Rapids* to free herself and enter harbor.

NOTE.—The *Escanaba* has a 16-ton capacity deep ballast tank forward. She is also equipped with two sea valves for the admittance of condenser cooling water, one well above the other. In working in ice as one of the valves becomes clogged by slush the other one is put into use and meanwhile the slush is blown out of the clogged chest by means of steam. This double-valve arrangement will be of great value in the event of grounding on a sandy or muddy bottom, use being made of the most suitable inlet.

LESSONS LEARNED BY OLDEST BOATSWAIN IN THE SERVICE (By Chief Boatswain Nels Johnson, U. S. C. G.)

751. Experience covering 40 years as a boatswain has shown me that when preparing to pull on a stranded vessel or getting ready to take a disabled craft in tow, success of the operation depends greatly on thorough advance preparation. If it is realized that everything may go wrong, and if gear is at hand ready to cope with the emergency, it will not be necessary to

make explanations for failures. I wish to emphasize also the necessity of proper instructions being given to the disabled-craft personnel or to the men sent aboard from the cutter. So much depends upon this.

Consider the case where a vessel is ashore with an offshore wind. The cutter usually anchors and of course presents her bow toward the strand. It is suggested that the stops used to secure the large towing hawser along the side of the cutter, pending her getting up anchor and heading to seaward, be of light enough material so they will carry away as the operation progresses.

Another valuable lesson learned regarding the handling of the running line (3-inch) between the cutter and a helpless vessel, which is undermanned and the weather unfavorable for sending men aboard, is to send the bight of the running line, which must be long, aboard the craft. Instruct them to run it through a snatch block or dip it over anything strong enough, so as to enable the cutter to heave the hawser aboard by a gypsy. The running line thus acts in the same manner as the whip of the beach apparatus.

Cutters should always keep their supply of 8-inch, 10-inch, and 12-inch lines renewed as necessary. A spare line will be used sooner or later. They are handy when lines become iced up, etc. Use a 3-inch running line, manila, length 600 fathoms or more. Always fake the towing hawser on deck of the cutter running fore-and-aft; this will save injuring men. If faked athwartship the bight is apt to throw men overboard. Have the running line faked on deck in such a manner that both ends are available. When sending the running line over in a small boat place the end of the line in the bow of the boat and coil down in the stern sheets as much of the line as it is safe to carry, of course, paying out from the cutter up to the point that the weight of the line in the water impedes the headway, then pay out from the boat.

Parceling with strips of canvas 3 or 4 inches wide, then serving with marline is a good chafe protector. Be sure the marline hitch is used or else when a few turns of the marline chafe through the parceling will be released. If you parcel several times the amount of the cutter's end of the hawser, as you think necessary, you may have enough on to meet all emergencies.

One suggestion in regard to the lowering and hoisting of boats by cutters: Rig permanently a tail line of 2-inch manila on the end of the snatch block at the foot of each boat davit. The line is used for two purposes, first, to forehand the falls and thus save placing men up on the davit for forehanding, a procedure which is especially dangerous when the cutter is rolling, and, second, in securing for sea the tail is made fast to the davit cleat so as to lift the snatch block up off the deck.

I believe there is no way to make the boat falls fast on the davit as good as taking a short bight of the falls inboard of the cleat up over the cleat and outboard around the davit to the inner side of the cleat, where it is snugged down with the end of the bight over the neck of the cleat. Then proceed with the figure eight turns with the remainder of the falls.

GALE HAVOC

752. The following article is furnished for its informative value rather than under the heading of Damage control.

About 7 p. m. February 19, 1927, the cutters *Tuscarora* and *Redwing* and the Coast Guard destroyers *Paulding* and *Jouett* responded to a distress call from *C. G. 238* anchored about 3 miles northeast of Highland Coast Guard Station, Cape Cod. A northeast gale and blizzard which reached as high as 76 miles per hour was in progress. In their efforts to reach the disabled patrol boat the following damages occurred.

Paulding.—Experienced difficulty in getting clear of other vessels as she left her anchorage in President Roads, Boston Harbor. Before midnight she lost her number 1 stack, the afterdavits were crushed to the deck, gasoline drums were torn adrift, the sounding machine smashed up, the foremast backstay parted, other boat davits were damaged, stanchions and life lines were swept overboard, the chain locker and forehold were flooded, the generator in the radio room was torn from its fastenings, and the vessel's radio put out of commission. During the trying operation of stopping up the large hole left when number 1 stack went overboard, it is reported that one man was washed overboard but was held and brought back by another man. The *Paulding*, in command of Commander J. S. Baylis, was able to return to port for repairs.

Jouett.—The intensity of the gale made maneuvering out of President Roads very difficult. It was necessary to anchor twice to avoid being blown against anchored vessels. At 9:15 p. m. the starboard thrust bearing overheated, resulting in a delay of 30 minutes. At 12:30 a. m. the 20th, as the result of quick and jerky pitching and rolling, the forward starboard whaleboat davit snapped off at its base and went overboard, leaving the whaleboat hanging vertically from the after davit. Soon this davit sheared off at its deck fitting and went overboard along with the whaleboat. The forward davit left an exposed 14-inch hole in A-11 fuel-oil tank, resulting in the loss of 4,000 gallons of oil and permitted water to enter. Decks were constantly awash with heavy seas, deck chests, oil and gasoline drums were carried away, the dory on the stern was smashed to splinters, the starboard waist dory was stove in, gun covers were torn to shreds, the forward trimming tank was salted, steam pressure dropped on account of water in the fuel oil, steerageway was lost and the vessel fell off in the trough with tremendous seas hurling her about almost bodily. Steam was finally regained and the

battle renewed to claw off the lee shore of Cape Cod. At noon the 20th a gasket on the bleeder connection of the main stop valve blew out. They fought off shore to provide a safe distance for drift while repairs were made. This required a stop of over 1 hour during which the *Jouett* drifted toward the beach at the rate of 6 knots per hour. To keep everything from being swept off the decks while stopped, fuel oil was pumped overboard by means of a handy billy. The destroyer rolled 45°. At this period the gunner's chest and the midship dory were swept overboard and the stern frame of the power boat was smashed. During the night a heavy hailstorm demolished bridge windows. From 4:30 to 5 a. m. the 21st, fires were out as the result of water in the oil. Steering was either very difficult or impossible. Lt. Comdr. John Trebes, Jr., made port with his command.

Tuscarora.—Lost overboard one boat and smashed another. Their efforts to claw off the lee shore were greatly hampered by the parting of the wheel ropes. Most of the time their vessel was unmanageable and in a precarious condition from inability to work to windward. Comdr. T. A. Shanley was fortunate in being able to save his command from disaster.

Redwing.—The motor launch carried away and smashed into the radio house, putting the radio out of commission. The manhole plate to the quadrant room went adrift, the quadrant room filled with water, and by following along the wheel-rope openings, water filled the afterhold and ran from there into the berth deck where the level was kept down to between 3 and 4 feet by constant bailing. The forward bulkhead of the afterhold was buckled. The vessel's stern was partly submerged and heavy seas continuously boarded her aft. Both feed pumps broke down at the same time; however, repairs were made to one which enabled water to be fed into the boilers. Chief Boatswain Oscar Vinje was able to get his ship back to port.

C. G. 238.—She was lost with all her brave men. In running from a position about 8 miles off Plymouth, Mass., for Provincetown Harbor to escape the gale, as the result of the blinding snow they were carried by the strong ebb tide to the east side of Cape Cod. They were first observed at about 5 p. m., February 19, 1927, about 3 miles northeast of Highland Coast Guard Station. Being unable to make it around the cape they anchored and requested assistance. Boats were not launched from the Cape Coast Guard stations owing to the severity of the seas. While the four vessels were endeavoring to reach her, at about 5 a. m. the 20th the patrol boat's anchors dragged and the craft was observed to strike broadside on the outer bar, about 1,300 yards offshore. Here for 15 minutes the boat was hammered, capsized, and finally demolished. It is believed that all 8 of her crew lost their lives at this point. Only two of the bodies were found. Splintered wreckage was strewn along the beach. The officer in charge of the Highland Coast Guard Station was of the opinion that the *C. G. 238*, after finding that her anchors would not hold, might have rigged some kind of drogue to hold her stern to seaward and let her come inshore with speed, bow first. This he thought might have saved some of the lives.

CHAPTER VIII

COAST GUARD AVIATION

HISTORICAL

801. The Navy Deficiency Act of August 29, 1916, authorized the establishment of 10 Coast Guard air stations on the Atlantic, Pacific, and Gulf coasts and on the Great Lakes. Concurring with the authorization by Congress in this act, a group of officers and enlisted men were assigned to a course of training as aviators at the Naval Air Station, Pensacola, Fla. The period of development for these air stations and administration was interrupted by the late World War. The personnel trained as aviators and those under training were automatically inducted into the Navy along with the entire Coast Guard, by Executive order. This group of officers, trained as aviators and the enlisted men who qualified as aviators, and made warrant officers, held positions of great responsibility through the entire period of hostilities, a number of the commissioned officers being in command of naval air stations overseas and in the United States.

In 1919, when the Coast Guard reverted back to the Treasury and assumed its regular status, one air station was commissioned by the Treasury Department, Coast Guard, at Morehead City, N. C. This station functioned for a period of only 1 year. Having received no appropriation for its establishment, it was operated only upon material, aircraft, and necessary equipment graciously loaned by the Navy Department. During the period this station was in commission it was proven that aircraft had a potential and useful mission in the saving of life and property at sea, and for the transportation of emergency cases from isolated places, in addition to being the eye or vision, so to speak, of any group of surface craft.

Lt. Comdr. E. F. Stone, U. S. C. G., was selected as first pilot of the naval seaplane *NC-4*, on the first successful crossing of the Atlantic by seaplane, in May 1919. Lieutenant Commander Stone was loaned to the Bureau of Aeronautics, Navy Department, for several years, and was largely instrumental in the development and testing of many features of modern aeronautics, notably the powder catapult.

In 1925 Lt. Comdr. C. C. von Paulsen, U. S. C. G., commanding officer, Coast Guard Base 7, Gloucester, Mass., procured by loan from the Navy Department one Vought seaplane. A temporary arrangement was made for housing and servicing this plane at the United States Naval Reserve Air Station, Squantum, Mass., with Lt. L. M. Melka, U. S. C. G., acting as pilot and mechanic. Several months later a tent hangar was procured from the U. S. Army for the sum of $1 and arrangements were made with the Bureau of Fisheries for a small tract of land on Ten Pound Island, in Gloucester Harbor, on which the canvas hangar was erected and operations were carried on from there. At that time the major force of the Coast Guard was engaged in the prevention of the smuggling of contraband on the eastern American coast. Vessels of all sorts were carrying contraband and smuggling it into the country without a great deal of effort or occasion to be apprehended by any Federal law enforcement force. By use of this seaplane 1 to 3 patrols were made daily, Pilots von Paulsen and Melka alternating, and supply vessels of contraband at sea were located, contact boats were spotted, their rendevouz located, and this information conveyed to the Coast Guard division commanders and operating forces. It is evident that the seaplane was a most useful weapon for the blocking of this illicit traffic. In 1926 Congress gave the Coast Guard an appropriation for additional seaplanes for the Gloucester unit and Cape May, N. J., in the sum of $152,000. Five planes were purchased, 3 of the Loening amphibian type (*OL-5s*) and 2 Voughts (*UO-4*). The money for the acquisition of this group of planes was the first that Congress appropriated for Coast Guard aviation, and from that period on the Coast Guard included plane construction along with its surface craft construction. Concurrent with this policy, additional air stations were established and commissioned, namely, Gloucester, Mass.; Cape May, N. J.; and Miami, Fla. During the present administration, 1933-34, funds were obtained from the Public Works Administration for enlarging this activity. Additional planes were authorized, contracts negotiated for planes, and some of these are at this time (November 1934) being delivered.

After the eighteenth amendment was rescinded by Congress, smuggling activities were a menace inland on the international borders as well as on the coasts. Narcotics, aliens, and miscellaneous merchandise were being smuggled by airplane and other methods across the borders of the United States. It was apparent to the Customs Bureau that to restrict or stop this traffic would involve the use of aircraft. The Customs

Bureau used seized planes and operated them for a period of time, and it proved to be the only method whereby any progress was made. The Secretary of the Treasury, realizing and appreciating the tremendous value of aircraft in connection with antismuggling and life-saving activities, was interested in further expansion. An additional air station on the coast was authorized at Charleston, S. C., and the border-patrol aviation establishments transferred from the Customs Bureau to the Coast Guard for administration and operation. The Coast Guard absorbed the Customs flying personnel along with the flying equipment used by that unit. The Customs Bureau, never having received an appropriation for aircraft, was operating only the planes seized by forfeiture. They were old, of a nondescript type, and not considered in all respects safe for general Coast Guard duty. The major portion of these planes were surveyed and destroyed. Those that were airworthy in all respects were reconditioned and are now being used. Six landplanes of the Vought-Corsair type (*O2U-2*) were procured from the Navy and used in connection with antismuggling activities.

During the period of Coast Guard aviation activity, 1925 to date, numerous catastrophes at sea were aided and lives saved by aircraft; vessels were identified; serious medical cases were transferred from ship to shore, from isolated points on the coast to hospitals; serum and medical supplies transported by air from one point to another; fishermen were aided in locating schools of fish; stolen boats recovered and the thieves apprehended; derelicts were located; drowned bodies were recovered and regattas were patrolled. It is evident that the manifold uses of aircraft have cemented its permanency in the service, its justification being established by its usefulness.

The aircraft checking system installed for checking and reporting aircraft along the Atlantic seaboard reported 11,592 airplanes during the fiscal year of 1934. During the same period Coast Guard airplanes cruised 219,572 miles and searched over an area of 1,975,014 square miles. The planes were in the air 2,752 hours, and 5,494 vessels and planes were identified. During the same year contracts were let for 10 Douglas and 9 Grumman amphibians. Seven additional planes are authorized in the building program. New air stations were established at St. Petersburg, Fla., Biloxi, Miss., Port Angeles, Wash., and Salem, Mass. On March 9, 1934, the Secretary of the Treasury transferred to the Coast Guard all aviation activities of the Treasury Department. Three air patrol detachments were established to aid in combatting the smuggling of contraband over the Canadian and Mexican borders. They are located at Buffalo, N. Y., San Antonio, Tex., and San Diego, Calif. It is planned to establish several more patrol detachments along the borders. Six land planes of the *O2U-2* type were transferred from the Navy to the Coast Guard during 1934. Commissioned officers undergo flight training at the United States Naval Air Station, Pensacola, Fla., and enlisted men are trained at the Cape May Coast Guard Air Station.

802.

Number	Name	Type	Maximum speed	Cruising range	Engines	Total horsepower	Built	Commissioned	Station
128	*Sirius*	Douglas amphibians	140	600	2 Whirlwinds	600	1931	1931	Air station, Miami, Fla.
129	*Adhara*	do	147	600	2 Wasps	840	1932	1932	Air station, Cape May, N. J.
130	No name	do	147	720	do	840	1934	1934	Do.
161	do	Grumann amphibians	174	450	1 Cyclone	700	1934	1934	Air station, Salem, Mass.
162	do	do	174	450	do	700	1934	1934	Do.
163	do	do	174	450	do	700	1934	1934	Air station, Biloxi, Miss.
164	do	do	174	450	do	700	1934	1934	Do.
165	do	do	174	450	do	700	1934	1934	Air station, Miami, Fla.
166	do	do	174	450	do	700	1934	1934	Do.
167	do	do	174	450	do	700	1934	1934	Air Patrol Detachment, San Diego, Calif.
168	do	do	174	450	do	700	1934	1934	Air station, Cape May, N J
169	do	do	174	450	do	700	1934	1934	Air station, St. Petersburg, Fla.
227	*Procyon*	Douglas flying boat	132	600	2 Whirlwinds	600	1929	1931	Air station, Cape May, N. J
251	*Antares*	Gen. Av. flying boat	144	500	2 Wasps	1,000	1932	1932	Air station, Miami, Fla.
252	*Altair*	do	120	500	do	840	1932	1932	Air station, Cape May, N. J.
253	*Acrux*	do	125	500	do	840	1932	1932	Do.
254	*Acamar*	do	125	500	do	840	1932	1932	Air station, Miami, Fla.
255	*Arcturus*	do	120	500	do	840	1932	1932	Do.
301	No name	Vought *O2U-2* land plane	125	700	1 Wasp	450	1929	1934	Air Patrol Detachment, San Antonio, Tex.
302	do	do	125	700	do	450	1929	1934	Air Patrol Detachment, San Diego, Calif.
303	do	do	125	700	do	450	1929	1934	Air station, Miami, Fla.
304	do	do	125	700	do	450	1929	1934	Do.
305	do	do	125	700	do	450	1929	1934	Do.
306	do	do	125	700	do	450	1929	1934	Air station, Cape May, N. J.
310	do	Consolidated	85	300	1 Lycoming	200	1932	1932	Do.
311	do	New standard land plane	100	250	1 Whirlwind	300		1934	Air station, Miami, Fla.
312	do	do	80	250	do	225		1934	Air station, Cape May, N. J.
381	do	Stinson landplane	132	560	1 Lycoming	245	1934	1934	Do.
404	do	Vought seaplane *UO-4*	100	350	1 Whirlwind	220	1926	1926	Do.
405	do	do	100	350	do	220	1926	1926	Air station, Salem, Mass.

Assignment of Coast Guard aircraft, Dec. 17, 1934.

Extracts from Coast Guard Aviation Instructions

AIRCRAFT BASED ON SHIPS

803. (1) Authority for flights of aircraft based on the ships shall be vested in the officers who have authority to direct the operations of the ships upon which the aircraft are based.

(2) Reports of movements of aircraft will be made in accordance with communication instructions.

PERSONNEL AUTHORIZED TO TAKE FLIGHTS

804. The policy of headquarters is to limit the flying of Coast Guard aircraft to such activity as is necessary, (1) in maintaining and improving the efficiency of the Coast Guard, (2) in the interest of humanity, (3) in the interest of the Government. All officers who are authorized to direct the operations of Coast Guard aircraft will be governed by this policy.

FIRE EXTINGUISHERS

805. Three types of fire extinguishers are installed in Coast Guard aircraft, the hand-operated or pump type, the stored air pressure or pressure type, and Lux (CO_2 type). The hand fire extinguisher is intended for use on the ground, as when starting engines or working around the airplane, and the pressure type is used in smothering fires in the engine compartment at any time. It should be thoroughly understood that no fire extinguisher can control a bad gasoline fire. Greatest care must always be taken to maintain the fuel system in efficient condition with tight joints and fittings and to prevent the accumulation of any free fuel or any inflammable substance in the engine compartment or nacelle of any aircraft, since whenever an engine is operating stray sparks may start a fire. In case of a fire in the air, it is particularly important to shut off the supply of fuel to the engine at once, at the same time opening the throttle wide to use up all the gasoline which may be present in the carburetor bowls and fuel lines. If this procedure is followed, the pressure fire extinguisher may be expected to control the fire and prevent its spreading outside the engine section.

The vapors of carbon tetrachloride are dangerous to personnel if employed in confined spaces, but this condition does not obtain in aircraft operations, and both hand and pressure fire extinguishers may be employed freely. The approved pressure type fire extinguisher has extinguishing fluid and compressed air in separate compartments with a sight glass and pressure gage, respectively, for checking the state of readiness of the extinguisher. Periodical inspections shall be made as required to insure that pressure fire extinguishers are maintained in instant readiness for use.

LAUNCHING

806. When launching airplanes from handling trucks, care should be taken to insure that there are no nails or broken parts on the trucks which may catch and damage the bottoms. If there are bottom plugs in the wake of the truck, inspection should be made to see that they are in place. If the bottom has been recently painted or the temperature is below freezing, the airplane should be raised clear of the truck before launching to insure that the paint or ice has not attached the truck to it. Such cases have occurred and involve danger of tearing loose the bottom planking or effecting other damage.

RECOVERING

807. When airplanes are landed on trucks special care must be taken that no driftwood or other obstruction lies above the face of the padding, and the airplanes must be accurately centered before full load is taken by the truck.

GASOLINE

808. Gasoline is a highly volatile liquid which will give off an inflammable vapor if left exposed to the air. Air at ordinary atmospheric temperature will absorb from 5 to 28 percent of gasoline vapor, the amount depending on the quality and grade of the gasoline; the lighter and better grades causing the higher percentages. Gasoline vapor is about three times as heavy as air, and in a room containing gasoline vapor the highest percentage is found near the floor. However, the mixture will gradually diffuse throughout the whole room.

The low limit of explosibility of gasoline vapor and air is about 1.4 percent. One quart of gasoline left exposed in a closed space will render explosive upon complete evaporation under ideal conditions 525 cubic feet of air, or a space of 10 feet square by 5¼ feet high. One cubic inch of gasoline will do the same thing for a space of 9.1 cubic feet or a space 3 by 3 by 1 foot. These figures will give an idea of the minuteness of the amount of gasoline needed to produce an explosive mixture.

The mixture formed by gasoline vapor and air is highly explosive in character and needs but a slight spark to set it off, a violent explosion and a very hot roaring fire resulting. A dangerous feature of gasoline vapor is that it may travel a considerable distance from the gasoline and there be ignited, the flash traveling back to the source of supply and causing an explosion of fire some distance from the location of the spark. This is especially important in connection with safety regulations as regards smoking in the vicinity.

In gasoline engine installations and where gasoline is stored it is difficult to prevent slight leaks in the gasoline system. This will cause gasoline vapor to be

present more or less continuously, especially in the lower spaces, such as bilges, under floor plates, etc. The danger of the spark necessary for an explosion is always existent and cannot be wholly eradicated. Therefore, it is of the utmost importance to prevent an accumulation of the vapor in sufficient quantity to form an explosive mixture. This can be done by ventilation. Gasoline vapor, in addition to its fire hazard, may cause sickness and even unconsciousness to personnel breathing it.

SPECIFICATIONS

809. Specifications for gasoline are issued in leaflet form and may be obtained upon request from headquarters.

TESTS

810. Nearly all aircraft engine fuels are at least mildly corrosive. Any trace of moisture attacks aluminum and its alloys, but free sulphur or sulphur compounds which attack copper or brass are the chief sources of trouble. Undesirable proportions of sulphur nearly always occur in benzol. All gasoline or engine fuel which is received should be subjected to the tests prescribed in current specifications. As an added precaution, a sample of fuel shall be drained off from time to time into a glass bottle of suitable size, and a polished copper strip shall be immersed in this sample and left for 48 hours. The presence of any undue amount of free sulphur or sulphuric acid will make itself evident by a gray or black deposit on the copper strip.

SMOKING

811. No smoking shall be permitted in a hangar or within 50 feet of any airplane.

SEAPLANE FORCED LANDINGS

812. (*a*) Seaplanes, as a rule, fly at lower altitudes than airplanes and have fewer guides to assist them in determining the direction of the wind; on the other hand, their alighting surface is seldom limited as it is on land. It is of the utmost importance that a pilot should always note the direction of the wind at the commencement of a flight and check it whenever opportunity occurs during an overseas patrol; the pilot has only enough height to turn into the wind just before landing.

(*b*) As a forced landing may occur a considerable distance at sea, it is of great importance to send back information by radio. The radio operator or observer should, therefore, be kept informed of approximate position on all overseas flights and instructed to send forced landing report while gliding down.

(*c*) When it becomes known to the pilot that he will be forced to land, he should at once notify or signal the observer or radio operator, if one is carried, so that no time be lost in getting away a signal or pigeon.

(*d*) Whenever the sea is rough, the pilot should, if possible, land in the wake of a surface craft, where the surface is always less broken.

(*e*) Pilots should flatten out with plenty of speed and hold the seaplane off the surface until she can be placed on a swell or in a calm patch. Only very experienced pilots can effect a cross-wind landing in a sea, so the general rule should be to land into the wind, even if there is a cross sea running. Once on the sea, sudden and judicious use of the rudder may prevent the sea breaking over the wings by causing the seaplane to ride a crest, rather than put her nose into it. As soon as the steerage way is lost, the seaplane will automatically ride head to wind, due to the center of side pressure being aft of the center of gravity.

AFTER LANDING (SEAPLANES)

813. (*a*) The control column should at once be lashed back; otherwise, the elevator will probably be driven below the surface, submerging the tail, as the seaplane drifts tail first down wind. The sea anchor should then be prepared and attached. Any leaks or other damage caused by the landing should be repaired if possible.

(*b*) If the sea is running high and broken and no assistance is within sight, some fuel should be run off if it can be spared. If the main floats are very much awash, the pilot and observer should not stay in their cockpits. They should watch for water collecting in pockets in the fabric and at once split the fabric to drain. The pilot or observer may be obliged to get out along one or the other of the wings in order to trim the seaplane.

(*c*) The Aldis lamp should not be used by day unless a ship or the shore is in sight. On a foggy night a beam shot upward is useful. Very's lights do not show far by day. The Lewis gun is an excellent means of attracting attention; bursts should be fired into the air as a signal of distress. A small mirror carried in the emergency kit should be used, if the sun is visible, for heliographing to all parts of the coast or to ships that may be visible, as its use conserves the Aldis battery and it has an excellent range.

Adrift at sea in heavy weather, a sea anchor should be used to retard drift and augment effect of air controls which should be manned to prevent yawing and to meet breaking seas head on. If the seas are so heavy as to cause coasting, it is particularly necessary to avoid yawing while racing astern.

Adrift at sea in light weather, courses may be made good several points off the wind, thus enabling more favorable course to make port or to avoid bad beach to leeward.

OIL

814. The value of oil for calming a breaking sea has long been known to mariners; breaking sea is the greatest danger to seaplanes when drifting.

RESCUE

815. If the sea is too rough to allow the rescuing seaplane (or boat) to embark the crew, the men will have to swim from one craft to the other.

SEA ANCHORS

816. Seaplanes, when riding free on the water with all motors stopped, normally head into the wind, and their leeway astern is considerably greater than that of ordinary surface craft. When wind and sea increase, the seaworthiness of the seaplane is in danger, due both to the angle of incidence that it assumes when drifting down the lee side of the waves and to the tendency to dig its tail and trailing edges of wings into the next wave. The sea anchor tends to counteract this inherent characteristic of the seaplane by considerably reducing its rate of drift and by maintaining the seaplane at a more constant angle of incidence, thus tending to keep wings and tail clear of water. In all cases the sea anchor should be designed for the type of plane for which it is intended to be used, and when so designed and properly used, it can be counted on to render invaluable service in enabling a drifting seaplane to weather a severe blow. When a regular sea anchor is not available, a jury sea anchor can be utilized to great advantage, such as a metal bucket with a hole in the bottom. A sea anchor is an essential part of the equipment of all seaplanes required to make extended flights over water.

TOWING IN GENERAL

817. Only the most elementary rules can be laid down upon this subject, for the same situation rarely repeats itself. However, certain fundamentals are of sufficient importance to necessitate the following established procedure.

As a rule, arrangements provided on seaplanes for securing a towline are not sufficiently rugged except for smooth water conditions. Therefore, when a seaplane is to be taken in tow in other than fairly smooth water conditions, the towline should be made fast to a substantial member of the structure of the plane. This should always be as low as practicable and in no case above its center of gravity. The seaplane must be made to head in the direction of the tow. Wing lines may be used to assist in maintaining this heading. The seaplane may be very readily towed into the wind, but the operation becomes more difficult as the wind veers away from ahead, depending on the force of the wind. When the stern wave of the towing craft is suitable, the seaplane may be towed more readily by adjusting the length of the towline so that the seaplane will ride the stern wave. The movable weights should be stowed aft, and if necessary the crew should ride the top sides of the horizontal stabilizers.

The center hull compartment of boats should be cleared so that pumping or bailing may be done expeditiously.

GETTING A LINE TO A DISABLED SEAPLANE

818. Under ordinary conditions of sea and wind, no trouble will be experienced in taking a plane in tow, but in a heavy sea and high wind, the rapid drift of the plane makes such an undertaking difficult for vessels not used to working with aircraft. The pilot of the plane will, as soon after landing as practicable, rig a sea anchor to reduce his rate of drift. If the seas and wind are high the vessel should steam slowly across the stern of the plane trailing a long towline and creating an oil slick, if necessary. The line can be readily picked up as the plane drifts over it. This method, in point of time and safety, is the most satisfactory that can be employed in the majority of cases. The seaplane may be approached by steaming down on it head on. The towline may be supported with a wood or kapok buoy.

TOWING BRIDLES

819. Due to the relatively short length of seaplane hulls and floats, satisfactory towing can only be accomplished by the use of towing bridles which make fast at a good distance from the center line on each side and meet some distance forward of the bow. For boat types, it is convenient to attach these bridles to the lower strut points of twin or triple engine planes or the equivalent distances on single engine planes. For twin float types the bridles should attach to or lead through the fittings at the bow of the floats. The towline scope should be kept as low as practicable, usually determined by trial under the conditions to be met. With large boats, a line should also be made fast to the bow chock or towing fitting but should be so adjusted as to be relatively slack and used more as a prevention.

TOWING UP WIND

820. This is the simplest situation encountered in towing or taxiing. In spite of the wind from ahead, the plane may yaw considerably unless the weight is concentrated aft and a tail drag rigged. The best speed of towing will depend upon the sea.

TOWING ACROSS WIND

821. Greater difficulty will be experienced under this condition because of the weather cocking tendency of the plane. To effect this a heavy tail drag and perhaps a drag from the lee wing will be required. A windward wing line to the towing vessel will also be

of help. If the wind is moderate in velocity, it might be advisable to ride one man on the windward wing to prevent the wind from getting under it and thereby burying the lee wing tip. This tendency marks the initial step in capsizing. The best speed of towing varies with the velocity of the wind and the state of the sea. Great care must be exercised by the towing vessel under any but calm weather conditions, and a man should be stationed at the stern to relay messages from the plane to the officer of the deck.

TOWING DOWN WIND

822. Towing down wind should never be attempted under any but ideal conditions of wind and sea. The plane will attempt to override the towing vessel and will yaw excessively. With light winds it can be accomplished with heavy tail drags and speed equal to or in excess of the wind. If the seas are heavy and the wind is strong, far better results can be obtained by allowing the plane to make leeway or drift, headed directly in the wind. A light sea anchor may be rigged to keep it from falling offwind. The bow cockpit cover should be secured and, if the seas are breaking, an oil bag should be used. The weight must be placed well aft, and it is well to have one or two members of the crew in a position so they can quickly move to one wing or the other.

HOISTING IN

823. Ships alongside which seaplanes are to land for hoisting in should, if possible, maneuver to take them over the lee side, if the water is very rough, a landing lee may be formed by the ship, which may in extreme circumstances use oil. The hoisting boom, slings, and wing lines should be in readiness and tended from the ship. If the airplane is to be placed upon a catapult, the latter should be swung into position to receive it, if the arrangement permits.

RULES AS TO LIGHTS

824. The word "visibility" in these rules, when applied to lights, shall mean visibility on a dark night in a clear atmosphere. The angular limits laid down in these rules shall be determined when the aircraft is in its natural attitude for flying on a straight horizontal course.

The rules concerning lights shall be complied with in all weathers from sunset to sunrise.

Only circumstances of military necessity shall permit noncompliance with these rules.

All lights on airplanes, free balloons, and fixed balloons shall be equipped with bulbs of not less than four candlepower.

All lights on airships shall be equipped with bulbs of not less than 12 candlepower.

AIRPLANE LIGHTS

825. (*a*) An airplane, when in the air maneuvering under its own power, shall carry the following lights:

(1) One white light above the top wing, approximately on the center line and visible all around the horizon.

(2) One white light below the lower wing or fuselage approximately on the center line and visible all around the horizon, except that boat seaplanes and amphibians of the boat type shall be provided with two white lights, one near the extreme end of the under surface of each lower wing, and visible through as wide an arc as possible.

(3) Near the extreme end of the upper surface or right top wing, one green light so constructed and fixed as to show an unbroken light between two vertical planes whose dihedral angle is 110° when measured to the right from dead ahead.

(4) Near the extreme end of the upper surface of left top wing, one red light so constructed and fixed as to show an unbroken light between two vertical planes whose dihedral angle is 110° when measured to the left from dead ahead.

(5) The said green and red sidelights shall be fitted so that the green light shall not be visible from the left side nor the red light from the right side.

(*b*) An airplane under way on land or water shall carry the lights specified in subparagraphs (*a*) (1) to (5) above.

(*c*) An airplane, stationary upon land or water, but not anchored or secured, shall carry the lights specified in subparagraphs (*a*) (1) to (5) above.

(*d*) An airplane when at anchor, or moored on the water, shall carry lights as follows:

(1) An airplane of less than 75 feet span shall carry one white light above the top wing, approximately on the center line and visible all around the horizon. (The same light as in paragraph (*a*) (1).)

(2) An airplane of more than 75 feet span shall carry two white lights above the top wing, one mounted on each of the extreme right and left wings of the airplane, and visible all around the horizon.

Every aircraft maneuvering under its own power on the water shall conform to the regulations for preventing collision at sea, and for the purpose of these regulations shall be deemed to be a steam vessel, but shall carry the lights specified in the preceding rules and not those specified for steam vessels in the regulations for preventing collisions at sea.

FORCED LANDING SIGNALS

826. Aircraft proceeding in company, when forced to land, shall use the following signals to indicate their condition:

Signal	Meaning to aircraft	Meaning to a ship
White Very signal..	Slight damage, can proceed shortly, wait if practicable.	Slight damage, can proceed shortly, do not wait for me.
Green Very signal...	Long delay, need mechanic and tools, will be able to proceed to base under own power. Do not wait for me.	Long delay, send mechanic and tools. Stand by until I am ready to return to base.
Green and white Very signal (alternated).	Need tow, or plane will have to be disassembled, and hauled back to base. Do not wait for me.	Need tow, or plane will have to be hoisted, pick me up.
Red Very signal....	Emergency. Immediate danger to personnel. Land and assist if possible.	Emergency. Immediate danger to personnel. Send assistance immediately.
One arm, vertical...	Slight damage, can proceed shortly. Wait for me.	Same as column 2. Use semaphore if necessary.
One arm, horizontal.	Long delay. Need mechanic and tools. Will then be able to proceed under own power to base. Do not wait for me.	Do.
Two arms, vertical..	Need tow; or plane will have to be disassembled and hauled back to base. Do not wait for me.	Do.
No signal at all.....	Emergency. Immediate danger to personnel. Land and assist if possible.	Emergency. Immediate danger to personnel. Send assistance immediately.

NOTE.—Aircraft noting the above signals shall be guided accordingly, and will notify the nearest base at the earliest practicable moment.

DURALUMIN

Protection Against Corrosion

827. Duralumin is very susceptible to corrosion in the presence of moisture and more especially salt water, and should always be given a protective coating of an approved paint, lacquer, or enamel.

Inspection

All parts of aircraft fabricated of duralumin or aluminum shall be frequently inspected for bare spots in the protective coating and for corrosion of the metal. Any bare spots shall be coated as soon as practicable. These spots shall be thoroughly cleaned of corrosion residue, dirt, grease, or other foreign substance, by the use of benzol or high-test gasoline, before the application of the protective coating. All faying surfaces should be painted.

Coatings

Protective coatings that have been found to give satisfactory protection are aluminum wing enamel and aluminum bitumastic paint.

Use with Dissimilar Metals

Duralumin shall not be placed in contact with a dissimilar metal or a moisture-retaining material, such as fabric or wood, unless absolutely necessary. If the structure necessitates a construction of this kind, the duralumin shall be given a suitable insulating protective coating to prevent electrolysis attending the subsequent corrosion.

Replacement

All duralumin used for purposes of replacement in the structure of aircraft shall be heat treated in accordance with approved practice.

Temporary Coatings

Heavy oils, greases, or rust-prevention compound may be used to protect duralumin for short periods in the absence of other protective agents. Such temporary coatings, however, must be carefully removed before the application of any other protective coatings.

Protection in Storage

Air stations and ships carrying stocks of aluminum and duralumin intended for use in naval aircraft shall give this material a light coat of rust-prevention compound (Navy Department Specification No. 52C11a) before placing in store. A light coat of oil shall be used on duralumin propellers if the rust-preventative compound is not available.

HANDLING OF HIGHLY VOLATILE AVIATION GASOLINE ON CUTTERS

828. The handling of ordinary gasoline on our vessels has presented a problem in the past. Now, with the induction of aviation gasoline, which on the 328-foot cutters is stored in a 3,000-gallon tank, it is necessary for the service to become as well acquainted as possible with its handling. Pending the issue of instructions from headquarters covering this important subject, the following information, furnished by request, by the Standard Oil Co. of New Jersey, aviation department, is quoted.

"The practice aboard vessels is to carry the gasoline in cylindrical steel tanks and to use the hydraulic system for handling the gasoline. As the hydraulic system is based on the closed pressure system, vents are not provided for the tanks but the compartment in which the tanks are installed is effectively ventilated by natural air supply venting and mechanical exhaust venting; the vents being fitted with flame arresters—that for the exhaust vent is fitted on the vented compartment side of the exhaust fan.

"Gasoline tanks should be accurately calibrated for capacity and equipped with gages of the Liquidometer or Telegauge type. If an indicating gage is not considered feasible, instructions should be given that great care be observed when gaging and that nonferrous gage bobs or rods be used.

"The gasoline handling pumps on these vessels are of the water turbine actuated Northern or similar rotary type; the water for operating the hydraulic system is supplied under pressure from the ship's main.

"All electrical wiring and fixtures should be installed outside of the compartment in which the tank is located and the lighting should be of the reflected type. In any case, all electrical fixtures and equip-

ment in the gasoline storage area should be vapor proof, or preferably the explosion proof type.

"In testing aviation storage systems a safety fuel, Safe-T-Esso or a similar product, is used."

METHODS OF HANDLING AVIATION AND LUBRICANTS

829. Safety considerations make it imperative to guard against contamination in handling fuels and lubricants for aviation purposes. The presence of water, dirt, or other foreign substances in the fuel and oil systems of the airplane has often resulted in serious engine failure.

In refueling the airplane, careless methods may introduce a grave fire hazard as well as impair the quality of the gasoline. Static electricity may be generated in the process of fueling the tanks by the passage of gasoline through the filler hose, and a spark may result if the filling equipment is not properly bonded. To prevent this, before transferring the gasoline, a metallic ground should always be established between the airplane tank and the tank from which the fuel is being supplied.

To detect the presence of water in gasoline, use a strip of "water thieving" paper (obtainable through any chemical laboratory supplier) attached to a pole long enough to reach to the bottom of the fuel tank. Water in the fuel will remove the color of the paper.

Warning.—Oxygen and lubricating oil are liable to form very explosive mixtures, especially when they are brought together under pressure in a closed container. Use extreme care with welding equipment or other oxygen apparatus to guard against the possibility of mixture of these products. *Never connect an oxygen bottle to the air connection of a compressed-air starter.*

FIRE-SAFE AVIATION FUEL

830. Safe-T-Esso, the hydrogenated safety fuel now produced by the Standard Oil Co. of New Jersey, acts like water in actually extinguishing a blaze and will burn only where it is supposed to burn, that is, in an engine or burner. The explanation lies in the fact that in developing this fire-safe fuel the flash point has been raised successfully to above 110° F.

The flash point of a fuel is the temperature at which the vapor given off will ignite upon the introduction of a spark or flame. The flash point of kerosene is about 105° F., and this point is now recognized as the dividing line between hazardous and safe fuels for handling at normal outdoor and indoor temperatures. The new safety fuel has been certified by the Underwriters' Laboratories as being in the same category with kerosene. The use of this new fuel should reduce, if not eliminate, the fire hazard in an airplane crash. One of the tests to which this fuel was subjected was the firing of incendiary bullets through a tank partly filled with the fuel and it did not ignite. The flash point of ordinary motor gasoline commercially used varies from about −40° to −80° F. In the field of marine and air transportation where enormous advances have been made in gasoline engine design, the explosion hazard is of vital importance, and the new fuel will fill a great need. With this safe fuel it may be possible to revert to hydrogen as a lifting gas for dirigibles and eliminate the helium supply problem. (Professional Notes, U. S. Naval Institute Proceedings, August 1934, by special permission.)

FIRE HAZARDS IN AIRPLANES

831. The fire hazard involves two aspects: (a) the danger from the presence of explosive or combustible mixtures, and (b) the danger from the combustion of the fuel itself. Of these the volatile combustibles are perhaps the most to be feared. The danger from this source may decrease in proportion to the volatility of the fuel, but it must be remembered that even the heaviest of the oils are not entirely free from this danger. From the standpoint of the combustion of the liquid, the heavy oil is not so attractive as it would appear at first glance. If we pour gasoline on a hot plate we find that the fuel is frequently vaporized without being ignited. On the other hand, if we pour lubricating oil or Diesel oil on the same plate, it will almost invariably ignite. Fires in aircraft have been initiated in the lubricating oil, and it is frequently the lubricating oil which burns most violently. (Extract from Oil Engine and Aeronautics, paper read before A. S. M. E., at New York, Nov. 22, 1927. Professional Notes, U. S. Naval Institute Proceedings, December 1928, by special permission.)

ICE ON PLANE WINGS

832. Man's conquest of the air has met with many obstacles. The formation of ice on the wings and other parts of an airplane in flight is not a new phenomenon; it was reported as early as 1921, but it has always been considered a freak consequence of freak conditions. Fog is unusual at freezing temperatures. It has even been said to be impossible. But it has and it does occur. It is a very serious hazard in flight. Col. Charles A. Lindbergh has called it the greatest. The conditions which provide the phenomenon are not understood. It is similar to the formation of sleet on trees, but that does not appear by any means to be the whole story. Attempts at reproducing the ice condition in the laboratory have failed. Further mystery is supplied by the fact that it has not been reported except by American planes in North America. The accumulation of the ice, once it starts to form, becomes distributed over the front edges of the wings, of the struts and other parts. That it could form on the blades of a propeller running at 1,500 revolutions per minute has been scoffed

at as an impossibility, nevertheless it is a definitely established and recorded fact. Ice is heavy and even a thin coating on an airplane can provide a considerable overload. As the ice forms it mushrooms out along the front edges and forms bulges and bumps along the forward part of the wings. In the first place this increases the air resistance, requiring more power to pull it through the air, and in the second the proper shape of the wing contour which provides the lifting force is seriously interfered with. These, with the added weight of the ice, drive the plane down lower and lower and finally force it to the ground.

Some suggested remedies for this condition have been: Smear the airplane with grease or oil so that it will shed ice before it sets. Or add salt or a chemical to the oil which will form a solution with a lower freezing point. But it has been impossible to try them out properly so illusive are the conditions which produce the effect. (Professional Notes, U. S. Naval Institute Proceeding, May 1928, by special permission.)

ICE FORMATION REMEDY

833. The following experiment proved to be successful in fighting ice formation on aircraft and could be utilized on aircraft used for special service. On March 31, 1931, a plane equipped with rubber "overshoes" developed by the B. F. Goodrich Rubber Co., the National Air Transport, Inc., and Dr. William C. Geer, of Cornell University, was successfully piloted through low-hanging clouds at freezing temperature by Charles Meyers, of Cleveland.

The "overshoes" consisted of pouches of specially treated rubber fabric fitted over the leading edges of the plane wings and struts. These pouches were made to "breathe" as the ice formed on them, and as they breathed, the ice crumpled away. The inflation and dilation, working similar to man's lungs, were created by a motor-driven air pump in the cockpit. The ice was quickly discarded, and the process involved no noticeable change in the plane's flying character. (Professional Notes, U. S. Naval Institute Proceedings, May 1931, by special permission.)

GLOSSARY OF AIRCRAFT TERMS

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834.

Aerobatics.—A general term covering all violent airplane maneuvers such as spins, rolls, and loops; also called "stunting."

Aerodynamics.—That branch of dynamics which treats of the motion of air and other gaseous fluids and of the forces acting on solids in motion relative to such fluids.

Aeronautics.—The science and art pertaining to the flight of aircraft.

Aerostat.—A group name for all those aircraft whose support is chiefly due to buoyancy derived from aerostatic forces. The immersed body consists of one or more bags, cells, or other containers, filled with gas that is lighter than air. An aerostat is any lighter-than-air craft; it includes the airship and the balloon.

Aileron.—A hinged or pivoted movable auxiliary surface of an airplane, usually part of the trailing edge of a wing, the primary function of which is to impress a rolling moment on the airplane.

Aircraft.—Any weight-carrying device or structure designed to be supported by the air, either by buoyancy or by dynamic action.

Airfoil.—Any surface designed to be projected through the air in order to produce a useful dynamic reaction.

Airfoil Section, or Profile.—A cross-section of an airfoil made by a plane parallel to a specified reference plane. A line perpendicular to this plane is called the axis of the airfoil.

Airplane, Pusher.—An airplane with the propeller or propellers in the rear of the main supporting surfaces.

Air Speed.—The speed of an aircraft relative to the air.

Air-Speed Meter or Indicator.—An instrument for indicating the speed of an aircraft relative to the air. It is actuated by the pressure developed in a suitable pressure nozzle or against a suitable obstruction and is graduated to give true air speed at a standard air density. The speed indicated by the instrument is termed the "indicated air speed." The indicated air speed is a direct measure of the lift or drag exerted on the airplane at any altitude. Stalling at all altitudes occurs at the same value of the indicated air speed.

Altigraph.—An altimeter equipped with a recording mechanism that registers the altitude of the airplane by a line on a chart. The chart, driven by clockwork, is usually graduated in feet or meters in accordance with some empirical or arbitrary pressure-temperature-altitude formula. In other words, it is a barograph whose scale is designed to read heights.

Altimeter.—An instrument for measuring or indicating the elevation above the given level, or datum plane. In ordinary types, it indicates the elevation above the zero altitude to which the instrument was set on taking off.

Amphibian.—An airplane designed to rise from and alight on either land or water.

Anemometer.—An instrument for indicating or measuring the speed of an air stream, such as the wind.

Angle, Aileron.—The angular displacement of an aileron from its neutral position.

Angle, Critical.—An angle of attack at which the flow of air about an airfoil changes abruptly with corresponding abrupt changes in the lift and drag.

Angle, Downwash.—The angle through which an air stream is deflected by any lifting surface of an airplane.

Angle, Drift.—The horizontal angle between the longitudinal axis of an aircraft and its path relative to the ground.

Angle, Elevator.—The angular displacement of the elevator from its neutral position.

Angle, Landing.—The acute angle between the line of thrust of an airplane and the horizontal when the airplane is resting on level ground in its neutral position; also called the "ground" angle.

Angle, Longitudinal Dihedral.—The difference in angle of wind setting and of stabilizer setting.

Angle, Minimum Gliding.—The acute angle between the horizontal and the most nearly horizontal path along which an airplane can descend steadily in still air when the propeller is giving no thrust.

Angle of Attack.—The acute angle between the chord of an airfoil and its direction of motion relative to the air.

Angle of Roll, or Angle of Bank.—The acute angle through which an aircraft must be rotated about its longitudinal axis in order to bring its lateral axis into a horizontal plane.

Angle of Stabilizer Setting.—The acute angle between the line of thrust of an airplane and the chord of the stabilizer.

Angle of Wing Setting.—The acute angle between the plane of the wing chord and the line of thrust. It may differ for each wing. The wing chord is defined under chord of an airfoil section.

Angle of Yaw.—The acute angle between the direction of the relative wind and the plane of symmetry of the aircraft.

Angle, Rudder.—The acute angle between the rudder and the plane of symmetry of the aircraft.

Angle, Wing-Dihedral or Dihedral.—The acute angle between the transverse reference line in the wing surface and the lateral axis of the airplane projected on a plane perpendicular to the longitudinal axis.

Angle, Zero-Lift.—The angle of attack of an airfoil when its lift is zero.

Apron.—A hard surface area of considerable extent directly in front of the entrance of a hangar or aircraft shelter used for the handling of aircraft or for repair in clear weather.

Aspect Ratio.—The ratio of span to mean chord of an airfoil; that is, the ratio of the square of the maximum span to the total area of an airfoil.

Attitude.—The position of an aircraft as determined by the inclination of its axis to some frame of reference. If not otherwise specified, this frame of reference is fixed to the earth.

Autorotation.—A spin from which the airplane will not recover because of faulty design.

Avigation.—A new term coming into use to denote aerial navigation.

Axes of Aircraft.—Three fixed lines of reference, usually meeting in a common point and at right angles to one another. The longitudinal axis is in the plane of symmetry, usually parallel to the axis of the propeller; the axis perpendicular to this in the plane of symmetry is called the normal axis; and the third axis perpendicular to the other two is called the lateral axis. In mathematical discussions, the first of these axes, drawn from front to rear, is called the X axis; the second, drawn upwards, the Z axis, and the third, running from right to left, the Y axis.

Balanced Surface.—A control surface that extends on both sides of the axis of the hinge or pivot in such a manner as to reduce the moment of the air forces about the hinge.

Bank.—To incline an airplane laterally, that is, to rotate it about its longitudinal axis. To make a right bank is to incline the airplane with the right wing down. Also used as a noun to describe the position of an airplane when its lateral axis is inclined to the horizontal; as a 30° right bank.

Bay.—The portion of a face of a truss, or of a fuselage, between adjacent bulkheads or adjacent struts or frame positions.

Blade Back.—The side of the propeller blade that corresponds to the upper surface of an airfoil.

Blade Face.—The surface of a propeller blade that corresponds to the lower surface of an airfoil. Sometimes called the thrust face, or driving face.

Body.—The fuselage or hull, or nacelle (including cowling and covering) and nacelle mounting.

Cabane.—A framework for supporting the wings at the fuselage; also applied to the system of trussing used to support overhang in a wing.

Camber.—The rise in the curve of an airfoil section from its chord, usually expressed as the ratio of the departure of the curve from the chord to the length of the chord. Upper camber refers to the upper surface of an airfoil and lower camber to the lower surface; mean camber is the mean of these two.

Ceiling, Absolute.—The maximum height above sea level at which a given airplane would be able to maintain horizontal flight, assuming standard air conditions.

Ceiling, Service.—The height above sea level, assuming standard-air conditions, at which a given airplane loses its ability to climb at a rate higher than a small specified rate (100 feet per minute in the United States and England). This specified rate may be different in different countries.

Center of Pressure of An Airfoil Section.—The point in the chord of an airfoil section, prolonged if necessary, which is at the intersection of the chord and the line of action of the resultant air force.

Chandelle.—A steep zooming turn.

Chord of an Airfoil Section.—The line of a straight edge brought into contact with the lower surface of the section at two points; in the case of an airfoil having double convex camber, the straight line joining the leading and trailing edges. These edges may be defined, for this purpose, as the two points in the section that are farthest apart. The line joining the leading and trailing edges should be used also in those cases in which the lower surface is convex except for a short, flat portion. The method used for determining the chord should always be explicitly stated for those sections with regard to which doubt seems likely to arise.

Chord Length.—The length of the projection of the airfoil section on its chord.

Chord, Mean, of a Wing.—The quotient obtained by dividing the wing area by the extreme dimension of the wing projection at right angles to the chord.

Cone, Wind.—A cloth device for showing the direction of the wind; also called a sock.

Controllability.—The quality in an airplane that makes it possible for the pilot to change its attitude easily and with the exertion of but little force.

Controls.—A general term applied to the means provided to enable the pilot to control the speed, direction of flight, attitude, and power of an aircraft.

Control Stick.—The vertical lever by means of which the longitudinal controls, or elevators, and the

steady motion, or, in case such a motion is disturbed, to restore it to its steady state. Includes gyroscopic stabilizers, pendulum stabilizers, inertia stabilizers, etc.

Stagger.—The amount of advance of the leading edge of an upper wing of a biplane, a triplane, or multiplane over that of a lower, expressed either as a percentage of gap or in degrees of the angle whose tangent is the percentage just referred to. It is considered positive when the upper wing is forward and is measured from the leading edge of the upper wing along its chord to the point of intersection of this chord with a line drawn perpendicular to the chord of the upper wing at the leading edge of the lower wing, all lines being drawn in a plane parallel to the plane of symmetry.

Stall.—The condition of an airplane when from any cause it has lost the air speed necessary for support or control.

Statoscope.—An instrument for detecting minute changes of altitude of an aircraft. The indications of the instrument usually depend on small changes of the static pressure of the air.

Stay.—A wire or other tension measure; for example the stays of the wing and body trussing.

Step.—A break in the form of the bottom of a float or hull designed to reduce resistance when under way by rapidly reducing the wetted surfaces as speed increases. It also serves to eliminate suction effects.

Streamline.—The path of a small portion of a fluid relative to a solid body with respect to which the fluid is moving. The term is commonly used only of such flows as are not eddying.

Streamline Flow.—Steady flow past a solid body; that is, a flow in which the direction at every point is independent of time.

Streamline Form.—A solid body that produces approximately streamline flow.

Strut.—A compression member of a truss frame. For instance, the vertical members of the wing truss of a biplane (interplane struts) and the short vertical and horizontal members separating the longerons in the fuselage.

Strut, Drag.—A fore-and-aft compression member of the internal bracing system of a wing.

Surface Control.—A movable airfoil designed to be rotated or otherwise moved by the pilot in order to change the attitude of the airplane or airship, as, for example, ailerons, rudder, and elevators.

Surface, Main Supporting.—A set of wings, extending on the same general level from tip to tip of an airplane; for example, a triplane has three main supporting surfaces. The main supporting surfaces include the ailerons, but no other surfaces intended primarily for control or stabilizing purposes.

Sweep-Back.—The acute angle between the lateral axis of an airplane and the projection of the axis of the wing on the plane which includes the lateral and longitudinal axes.

Tail Group or Tail Unit.—The stabilizing and control surfaces at the rear end of an aircraft, including stabilizer, fin, rudder, and elevator; also called the empennage.

Tail-Heavy.—In heavier-than-air craft, the condition in which, in normal flight, the tail sinks if the longitudinal control is released; that is, the condition in which the pilot has to exert a push on the control stick to keep the given attitude. The reverse of nose heavy.

Tail Slide.—The backward and downward motion, tail first, that certain airplanes may be made to take momentarily after having been brought into a stalling position by a steep climb.

Taxi.—To run an airplane over the ground, or a seaplane on the surface of water under its own power.

Thrust Effective.—The net driving force delivered by a propeller when mounted on an airplane; that is, the actual thrust given by the propeller, as mounted on the airplane, minus any increase of resistance of the airplane produced by the action of the propeller.

Thrust, Static.—The thrust developed by a propeller when rotating at a fixed point.

Tipping of Propeller.—A sheet-metal or equivalent protective covering of the blade of a propeller near the tip, extended a short distance along the trailing edge and a considerable distance along the leading edge.

Trailing Edge.—The rearmost edge of an airfoil or a propeller blade.

Turn, Reverse.—A rapid maneuver to reverse the direction of flight of an airplane, made by half loop and half roll.

Venturi, Power.—A venturi tube used to operate gyroscopic turn indicators and other instruments.

Venturi, Speed-Indicating.—A venturi tube may be combined with a pitot tube or with a tube giving static pressure to form a pressure nozzle that may be used to determine the indicated speed of an aircraft through the air. The pressure difference is measured by a suitable gage.

Vertical Bank.—A bank beyond 45 degrees.

Wash.—The disturbance in the air produced by the passage of an airfoil. Also called the wake in the general case of any solid body.

Weight, Empty.—The structure, power plant, and fixed equipment of an aircraft. Included in this fixed equipment are the water in the radiator and cooling system, all essential instruments and furnishings, fixed electric wiring for lighting, heating, etc.

Weight, Fixed Power-Plant, for a Given Airplane.—The weight of an engine, including ignition, carburetor, and induction systems complete, propeller and hub, exhaust manifolds, radiator and water, if used, with all interconnecting wires, controls, tanks, and pipes, lubricating-oil temperature regulators, the oil contained in the engine crankcase, and the starting

gear attached to the engine, but excluding fuel, oil, and engine instruments.

Weight, per Horsepower.—The dry weight of an engine divided by the rated horsepower.

Windmill.—An air-driven screw used to drive auxiliary apparatus on an aircraft.

Window, Inspection.—A small transporent window fitted in the envelop of a balloon or an airship, or in the wing of an airplane to allow inspection of the interior.

Wind, Relative.—The motion of the air with reference to a body, that is, its motion as observed by a man at rest on the body. The direction and velocity of the relative wind, therefore, are found by adding two vectors, one being the velocity of the air with reference to the earth, the other being equal and opposite to the velocity of the body with reference to the earth.

Wind Tunnel.—An elongated chamber, usually a tube divergent at the ends, through which a steady stream of air may be drawn or forced. Models of airfoils, of aircraft, or of propellers may be placed in the middle portion of the tunnel, called the experiment chamber or working section, and supported by suitable balances placed outside the air stream, so that the forces, moments, etc., due to the moving air may be measured.

Wing.—A general term applied to a whole or a portion of the main supporting surfaces of an airplane, but in the latter case is usually qualified as right wing, left wing, upper wing, lower wing, etc.

Wing-Heavy.—The condition of an airplane in which, in normal flight, there is a tendency for the right (or left) wing to drop, if the lateral control is released; that is, the condition in which the pilot has to exert a lateral force on the control stick to keep the lateral axis horizontal.

Wing Rib.—A fore-and-aft member of the wing structure of an airplane, used to give the wing section its form and to transmit the load from the fabric to the spars.

Wing Rib, Compression.—A heavy rib designed to have the function of a wing rib and to also act as a strut opposing the pull of the wires in the internal drag truss; also called drag strut.

Wing Rib, Former or False.—An incomplete rib, frequently consisting only of a strip of wood extending from the leading edge to the front spar, which is used to assist in maintaining the form of the wing where the curvature of the airfoil section is sharpest.

Wing Spar.—The principal transverse structural member of the wing assembly of an airplane.

Wing Truss.—The framing by which the wing loads of an airplane are transmitted to the fuselage. It comprises struts, wires, cables, tie-rods, and spars.

Wire.—In aeronautics, refers specifically to drawn solid wire.

Wire, Antidrag.—A wire designed primarily to resist forces acting parallel to the chord of the wing of an airplane and in the same direction as the direction of flight. It is generally enclosed in the wing.

Wire, Drag.—Any wire or cable designed primarily to resist drag forces. An internal drag wire is concealed inside the wing, and an external drag wire, or drift wire, runs from a wing to the fuselage or other part of the airplane.

Wire, Landing.—A wire designed primarily to resist forces in the opposite direction to the normal direction of the lift and to oppose the lift wire and prevent distortion of the structure by an overtightening of those members. Sometimes called antilift wire.

Wire, Lift.—A wire or cable that transmits the lift on the outer portion of the wing of an airplane in toward the fuselage or nacelle. This wire usually runs from the top of an interplane strut to the bottom of the strut next nearer the fuselage, or to the fuselage itself in single-bay airplanes. Sometimes called flying wire.

Wire, Stagger.—A wire connecting the upper and lower surfaces of an airplane and lying in a plane substantially parallel to the plane of symmetry; also called incidence wire.

Yawmeter.—An instrument for measuring the angle of yaw.

Zero-lift Line.—A line through the trailing edge of an airfoil section parallel to the direction of the wind when the lift is zero.

Zoom.—To climb for a short time at an angle greater than that which can be maintained in steady flight, the airplane being carried upward at the expense of its kinetic energy. This term is sometimes used as a noun, to denote any sudden increase in the upward slope of the flight path.

bination being termed a pitot-static tube. The associated tube has perforations in its side, so that it is subjected to static pressure as distinct from impact pressure. The speed of the fluid can be determined from the difference between the impact pressure and the static pressure as read by a suitable gage. In common speech the pitot-static combination is often called simply a pitot tube or pitot.

Porpoise.—To bounce a seaplane on landing.

Prop.—The common name for a propeller.

Propeller, Adjustable Pitch.—A propeller whose blades are so attached to the hub that they may be set to any desired pitch when the propeller is stationary.

Propeller Area, Projected.—The total area, on the plane perpendicular to the propeller shaft, swept by the propeller, except the portion covered by the boss and that swept by the root of the blade. This portion is usually taken as extending 0.2 of the maximum radius from the axis of the shaft.

Propeller-Blade Area.—The area of the blade face, exclusive of the boss and the root, that is, exclusive of a portion that is usually taken as extending 0.2 of the maximum radius from the axis of the shaft.

Propeller Boss.—The central portion of a propeller in which the hub is formed or mounted.

Propeller, Controllable-Pitch or Variable-Pitch.—A propeller whose blades are so mounted that they may be turned about their axis to any desired pitch while the propeller is in rotation.

Propeller-Disk Area, total.—The total area swept by a propeller, that is, the area of a circle having a diameter equal to the propeller in diameter.

Propeller Efficiency.—The ratio of thrust power to power input of a propeller.

Propeller Hub.—The metal fitting inserted or incorporated in or with a propeller for the purpose of mounting it on the propeller or engine shaft.

Propeller Interference.—The amount by which the torque and thrust of a propeller are changed by the modification of the air flow in the slip stream produced by bodies placed near the propeller, such as engine, radiator, etc.

Propeller-Load Curve.—A curve representing the engine power necessary to drive any given propeller at various speeds.

Propeller, Pusher.—A propeller mounted to the rear of the engine or propeller shaft. It is usually behind the wing cell or nacelle.

Propeller Root.—That part of the propeller blade near the boss.

Propeller Section.—A cross-section of a propeller blade made at any point by a plane parallel to the axis of rotation of the propeller and tangent, at the centroid of the section, to an arc drawn with the axis of rotation as its center.

Propeller Thrust.—The component, parallel to the propeller axis, of the total air force on the propeller.

Propeller Torque.—The moment of the forces applied to the propeller by the engine shaft.

Propeller, Tractor.—A propeller mounted on the forward end of the engine or propeller shaft. It is usually forward of the fuselage or wing nacelle.

Propulsive Efficiency.—The ratio of the product of effective thrust and flight speed to the actual power input to the propeller as mounted on the airplane, consistent units being used throughout.

Race Rotation.—The rotation, produced by the action of the propeller, of the stream of air passing through or influenced by the propeller.

Range at Economic Speed.—The maximum distance a given aircraft can cover while cruising at the most economical speed and altitude at all stages of the flight.

Range at Full Speed.—The maximum distance a given aircraft can cover at full speed at sea level.

Rate of Climb.—The vertical component of the air speed of an aircraft, that is, its vertical velocity with reference to the air.

Revolutions, Maximum.—The number of revolutions per minute corresponding to the maximum horsepower.

Revolutions, Rated.—The number of revolutions corresponding to the rated horsepower.

Righting Moment, or Restoring Moment.—A moment that tends to restore an aircraft to its previous attitude after any small rotational displacement.

Right Side of the Engine.—That side which, to an observer looking from the antipropeller end toward the propeller, lies on the right-hand side.

Roll.—A maneuver in which a complete revolution about the longitudinal axis is made, the horizontal direction of flight being approximately maintained.

Rudder.—A movable auxiliary airfoil, the function of which is to impress a yawing moment on the aircraft in normal flight. It is usually located at the rear of an aircraft.

Rudder Bar.—The foot bar by means of which the control cables leading to the rudder are operated.

Rudder Torque.—The twisting moment exerted by the rudder on the fuselage. The product of the rudder area by the distance of its center of rea to the axis of the fuselage may be used as a relative measure of rudder torque.

Seaplane.—Any airplane designed to rise from and alight on the water. This general term applies to both float and boat types, though the boat type is usually designated as a flying boat.

Shipplane.—A landplane designed to rise from and alight on the deck of a ship; also, a carrier plane.

Shock Absorber.—A device incorporated in the landing gear of an aircraft to reduce the shock imposed on the structure when alighting or taking off. Shock-absorbing devices are usually interposed between the main structure and the wheels, floats, skis, or tail skids, to secure resiliency in landing and taxying.

Side-Slipping.—Flight in which the lateral axis is inclined and the airplane has a component of velocity in the direction of the lower end of the lateral axis. When it occurs in connection with a turn, it is the opposite of skidding.

Skidding.—Sliding sidewise away from the center of curvature when turning. It is usually caused by banking insufficiently and is the opposite of side-slipping.

Skid Fin.—A fore-and-aft vertical surface, usually placed above the upper wing, designed to provide vertical keel surface and so increase lateral stability.

Skid Tail.—A skid used to support the tail when in contact with the ground.

Skid, Wing.—A skid placed near the wing tip and designed to protect the wing from contact with the ground.

Skin Friction.—The tangential component of the fluid force at a point on a surface.

Slip Stream.—The stream of air driven astern by the propeller.

Soar.—To perform sustained free flight without self-propulsion; it is called up-current soaring if performed in ascending air, and dynamic soaring in other cases.

Span, Airfoil.—The lateral dimension of an airfoil, that is, the dimension perpendicular to its chord.

Span, Airplane.—The maximum distance measured parallel to the lateral axis from tip to tip of an airplane, inclusive of ailerons.

Speed, Critical.—The lowest speed of an aircraft at which control can be maintained.

Speed, Economic.—The speed at which the fuel consumption, per unit of distance covered in still air, is a minimum.

Speed, Ground.—The horizontal component of the velocity of an aircraft relative to the earth. It is the distance covered in a given time, measured on a horizontal line, regardless of the angle of flight of the aircraft.

Speed, Landing.—The minimum speed at which an airplane can maintain itself in level flight and still be under adequate control.

Speed, Minimum.—The lowest steady speed that can be maintained by an airplane in level flight.

Spin.—A maneuver consisting of a combination of roll and yaw, with the longitudinal axis of the airplane inclined steeply downwards. The airplane descends in a helix of large pitch and very small radius, the upper side of the airplane being on the inside of the helix, and the angle of attack on the inner wing being maintained at an extremely large value.

Spinner.—A fairing of approximately conical or paraboloidal form, which is fitted coaxially with the propeller boss and revolves with the propeller.

Spiral.—A maneuver in which an airplane descends in a helix of small pitch and large radius, the angle of attack being within the normal range of flight angles.

Spiral Instability.—A type of instability inherent in certain airplanes which becomes evident when the airplane, as a result of a yaw, assumes too great a bank and side-slips; the bank continues to increase and the radius of the turn to decrease.

Stability.—That property of a body which causes it, when disturbed from a condition of equilibrium or steady motion, to develop forces or moments that tend to restore the body to its original position.

Stability, Automatic.—Stability dependent on movable control surfaces automatically operated by mechanical means.

Stability, Directional.—Stability with reference to rotations about the normal axis; that is, an airplane possesses directional stability in its simplest form if a restoring moment comes into action when it is given a small angle of yaw. Owing to symmetry, directional stability is closely associated with lateral stability.

Stability, Dynamic.—Stability of such character that, if the airplane is displaced from steady motion in flight, it tends to return to that steady state of motion, the oscillations due to restoring moments being damped out. In a general way, the difference between static stability and dynamic stability is that the former depends on restoring moments alone, while the latter includes the action of damping factors.

Stability, Inherent.—Stability of an aircraft due solely to the disposition and arrangement of its fixed parts; that is, that property which causes it, when disturbed, to return to its normal attitude of flight without the use of controls or the interposition of any mechanical devices.

Stability, Lateral.—Stability with reference to disturbances involving rolling, yawing, or side-slipping; that is, disturbances in which the plane of symmetry of the aircraft is affected.

Stability, Longitudinal.—Stability with reference to disturbances in the plane of symmetry; that is, disturbances involving pitching and variation of the longitudinal and normal velocities.

Stability, Static.—Stability of such character that, if the airplane is displaced slightly from its normal attitude by rotation about an axis through its center of gravity, as may be done in wind-tunnel experiments, moments come into play that tend to return the airplane toward its original attitude.

Stabilizer.—A normally fixed airfoil whose function is to lessen the pitching motion. It is usually located at the rear of an aircraft and is approximately parallel to the plane of the longitudinal and lateral axes. Also called tail plane. It is usually adjustable to overcome nose or tail heaviness.

Stabilizer, Mechanical.—A mechanical device to prevent an aircraft from departing from a condition of

lateral controls, or ailerons, of an airplane are operated. Pitching is controlled by a fore-and-aft movement of the stick, and rolling by a side-to-side movement.

Decalage.—The acute angle between the wing chords of a biplane or multiplane.

Drag.—The component parallel to the relative wind of the total air force on an aircraft or airfoil, or the total resistance to the motion of the aircraft through the air. In the case of an airplane, that part of the drag due to the wings is called wing drag; that due to the rest of the airplane is called structural drag or parasite resistance.

Drag, Induced.—That portion of the wing drag induced by, or resulting from, the generation of the lift.

Drag, Profile.—That portion of the wing drag which is due to friction and turbulence in the fluid and which would be absent in a nonviscous fluid.

Drift.—The lateral velocity of an aircraft due to air currents.

Drift Meter.—An instrument for measuring the angle between the fore-and-aft axis of an aircraft and its path over the ground. One form consists of a drift bar provided with a suitable angular scale. The instrument is graduated to read correctly when it is level.

Dry Weight of Engine.—The weight of the engine, including carbureter and ignition systems complete, propeller-hub assembly, reduction gears, if any, but excluding exhaust manifolds, oil, and water. If the starter is built into the engine as an integral part of the structure its weight must be included.

Elevator.—A movable auxiliary airfoil, the function of which is to impress a pitching moment on the aircraft. The elevator is usually hinged to the stabilizer.

Endurance.—The maximum length of time an aircraft can remain in the air at a given speed and altitude.

Factor of Safety.—The ratio of the ultimate strength of a member to the maximum probable load in that member in actual use.

Fairing.—An auxiliary member or structure whose primary function is to reduce head resistance or drag of the part to which it is fitted, without, in general, contributing strength.

Fin.—A fixed surface, attached to a part of the aircraft, parallel to the longitudinal axis, in order to secure stability; for example, tail fin, skid fin, etc. Fins are sometimes adjustable.

Fire Wall.—A fire-resisting transverse bulkhead so set as to isolate the engine compartment from the other parts of the structure and thus to reduce the risk from fire in the engine compartment.

Flight Path.—The path of the center of gravity of an aircraft with reference to the earth.

Float.—A completely inclosed water-tight structure attached to an aircraft in order to give it buoyancy and stability when in contact with the surface of the water. In float seaplanes the crew is carried in a fuselage or nacelle separate from the float. The term pontoon is now obsolete.

Force, Cross-Wind.—The component, perpendicular to the lift and to the drag, of the total air force on the aircraft or any part thereof.

Fuselage.—The structure, of approximately streamline form, to which are attached the wings and tail unit of an airplane. In general it contains the power plant, passengers, cargo, etc.

Gap.—The distance between the planes of the chords of any two adjacent wings, measured along a line perpendicular to the chord of the upper wing at any designated point of its leading edge.

Gear, Rotation.—An emergency gear attached to a landplane to permit alighting on the water and to provide buoyancy when resting on the surface of the water.

Glide.—A descent with reference to the air at a normal angle of attack and without engine power sufficient for level flight in still air, the propeller thrust being replaced by a component of gravity along the line of flight. Also used as a verb.

Ground-Speed Meter.—An instrument for measuring the speed of an aircraft relative to the ground. In present types of instruments some reference line in the instrument must first be set parallel to the apparent direction of motion of the aircraft with reference to the ground before the speed measurement is made. This is usually accomplished by the use of a drift meter, the adjustment of which automatically orients the ground-speed meter properly. Thus, both the magnitude and direction of the motion of the aircraft with reference to the ground are obtained.

Horn.—A short lever attached to a control surface of all aircraft, as, for example, aileron horn, rudder horn, elevator horn.

Hull, Seaplane.—The portion of a flying boat that furnishes buoyancy when in contact with the surface of the water. It contains accommodations for the crew and passengers, usually incorporating the functions of a float and fuselage in one unit.

Inclinometer.—An instrument for indicating the attitude of an aircraft. Inclinometers are termed fore-and-aft, lateral, or universal, accordingly as they indicate inclination on the vertical plane through the fore-and-aft, or in the vertical plane through the lateral axis, or in both planes respectively.

Indicator, Flight.—An instrument in which a lateral inclinometer, a fore-and-aft inclinometer, and a turn indicator are combined to form a compact unit.

Indicator, Turn.—An instrument for indicating the existence of an angular velocity of turn of an aircraft about the normal axis. In horizontal flight it indicates the presence of yawing velocity. Turn meter is the term applied to certain types.

Indraft, or Inflow.—The flow of air from in front of the propeller into the blades.

King Post.—The main compression member of a trussing system applied to support a single member subject to bending.

Landing Gear.—The understructure that supports the weight of an aircraft when in contact with the surface of the land or water and reduces the shock on landing. There are five common types: boat type, float type, skid type, wheel type, and ski type. (Amphibian may be a combination of the float or boat type with wheels or skis.)

Leading Edge.—The foremost edge of an airfoil or a propeller blade; also called entering edge.

Left Side of Engine.—That side which, to an observer looking from the antipropeller end toward the propeller end, lies on the left-hand side.

Lift.—That component of the total air force on an aircraft or airfoil which is perpendicular to the relative wind and in the plane of symmetry. It must be specified whether this applies to a complete aircraft or to the parts thereof.

Load, Basic.—The load of an aircraft when it is at rest or in a condition of unaccelerated rectilinear flight. (For purpose of stress analysis.)

Load, Dynamic.—Any load due to acceleration of an aircraft, and therefore proportional to its mass.

Load, Factor.—The ratio of any specified load on a member to the corresponding basic load. Generally applied to the ratio of the breaking load to a basic load.

Load, Full.—Weight empty plus useful load; also called gross weight.

Loading Power.—The gross weight of an airplane, fully loaded, divided by the normal brake horsepower of the engine, computed for air of standard density unless otherwise stated.

Load, Useful.—The crew and passengers, oil and fuel, ballast other than emergency, ordnance, and portable equipment.

Loading Wing.—The gross weight of an airplane, fully loaded, divided by the area of the supporting surface. The area used in computing the wing loading should include the ailerons, but not the stabilizer and elevators.

Longeron.—A fore-and-aft member of the framing of an airplane fuselage or nacelle, usually continuous across a number of points of support.

Loop.—A maneuver in which an airplane executes a circle in the vertical plane.

Maneuverability.—That quality of an aircraft which makes it possible for the pilot to change its attitude rapidly.

Nacelle.—An enclosed shelter for passengers or for a power plant. A nacelle is usually shorter than a fuselage, and does not carry the tail unit.

Nose-Heavy.—The condition of an airplane in normal flight when the distribution of forces is such that, if the longitudinal controls were released, the nose would drop. The reverse of tail heavy.

Nozzle, Pressure.—An instrument which, in combination with a gage, is used to measure the indicated speed of an aircraft relative to the air. It may be a pitot-static or a venturi tube, or a combination of a pitot tube and a venturi tube.

Over-all Length.—The distance from the extreme front to the extreme rear of an aircraft, including the propeller and the tail unit.

Overhang.—Used in two senses: (*a*) One-half of the difference in span of any two main supporting surfaces of an airplane. The overhang is positive when the upper of the two main supporting surfaces has the larger span. (*b*) The distance from the outer strut attachment to the tip of the wings.

Pancake.—To level off an airplane at a greater altitude than normal in a landing, thus causing it to stall and to descend on a steeply inclined path with the wings at a very large angle of attack and without appreciable bank. A pancake landing is very slow; it may damage the landing gear.

Panel.—Where a wing surface comprises several units of construction, these units are designated as panels.

Parasite Resistance.—See Drag.

Pitch, Effective.—The distance that an aircraft advances along its flight path for one revolution of the propeller.

Pitch, Geometrical.—The distance that an element of a propeller would advance in one revolution if it were moving along a helix of slope equal to its blade angle.

Pitch, Mean Geometrical.—The mean of the geometrical pitch of the several elements.

Pitch Ratio.—The ratio of the pitch (geometrical, unless otherwise stated) to the diameter.

Pitch, Speed.—The product of the mean geometrical pitch and the number of revolutions of the propeller in unit time; that is, the speed the aircraft would make if there were no slip.

Pitch, Standard.—The geometrical pitch taken at two-thirds of the radius; also called nominal pitch.

Pitch, Zero Thrust.—The distance that a propeller would have to advance in one revolution in order that there might be no thrust; also called experimental mean pitch.

Pitch, Zero Torque.—The distance the propeller would have to advance in one revolution in order that the torque might be zero.

Pitot Tube.—A cylindrical tube with an open end that is pointed upstream, so that the air meets the instrument head-on or is met head-on by the instrument. When the aircraft is flying at less than about 200 miles per hour, the instrument measures the impact pressure. When used on aircraft, it is usually associated either with a closed coaxial tube surrounding it or with a closed tube placed near it and parallel to it, the com-

CHAPTER IX

INSPECTION DUTY—NEW CONSTRUCTION

GENERAL SPECIFICATIONS

901. When a cutter is to be constructed for the Coast Guard, general specifications, which include all data necessary for the contractors to enable them to compute approximate costs of the completed vessel or vessels for bid purposes, are furnished. These include length, beam, depth, displacement, machinery types, estimated horsepower, speed on trial (approximate), estimated cruising radius, etc.

DESIGN PLANS

902. Plans furnished by headquarters, are composed of drawings of lines, sections, decks, inboard and outboard profiles, etc., together with detailed specifications describing a vessel of appropriate design and special construction for Coast Guard duty. Details developed on the construction plans at the plant must maintain consistent strength and obtain the features contemplated by the specifications and design plans. These plans show the general arrangement of the vessel; the absence of details therefrom does not excuse the contractor from fitting them.

Headquarters furnishes, from time to time, standard or type plans or sketches, of desired details which do not call for undue expense or for features requiring extensive designing, but which are for the purpose of securing standardization of fittings on Coast Guard cutters.

CONSTRUCTION PLANS

903. In developing his drawings the builder conforms to high grade commercial practice, and submits to headquarters general and detailed plans for approval, making at least 3 blue prints, 1 of each for the inspector, headquarters, and for return to himself. These plans are numerous and cover all data in detail.

Plans of minor details and importance are submitted to the inspector for approval, only 2 prints being furnished, 1 for the inspector and one for the contractor. No sketches or other information is allowed to go to the yard without its approval first having been confirmed by headquarters or by the inspector.

HULL MATERIALS

904. The hull material and ship's apparel must comply with the specification requirements; and quality, suitability for marine use on Coast Guard vessels, and the readiness with which service and spare parts may be obtained are considered in the approval by the Coast Guard.

Steel, iron, brass, and all other materials, such as chains, lumber, paints, etc., shall be of quality as described in the detailed specifications of the United States Government, promulgated by the Federal Specifications Board. Materials not covered in these should be of such standard manufacture and design as is approved by the various bureaus and committees.

The materials in general are ship structural steel, shapes, bars, rivets, class "B" steel forgings, soft cast steel, cast or rolled compositions. Materials of a lower class or grade are used where strength does not determine the scantlings, if approved by the inspector. Cast iron is only used where specified. Piping is genuine wrought iron unless otherwise specified.

In determining dimensions of details for strength, a tensile stress of 55,000 to 60,000 pounds per square inch in structural mild steel, under working conditions, is used, or a corresponding figure for other materials.

Two copies of all orders for materials, also test reports, are furnished the inspector, one copy going to headquarters.

Materials that are ordered in advance of action on plans are entirely at the contractor's risk.

During the construction of part of the lake-type cutters the alert Coast Guard inspector mistrusted one of the ways on account of its age. He required a weekly test, a piano wire run longitudinally, under a fixed number of pounds tension. During the construction of the cutter a sag of nearly three-fourths inch was detected and corrected.

INSPECTION TESTS

905. The rules of the American Society for Testing Materials and the American Bureau of Shipping should be studied in regard to the general requirements, as Coast Guard vessels are usually built according to their rules. Coast Guard inspectors should pay especial attention to the assembly and laying up or fabrication of members. Uniform, standard practice is necessary.

PLATES AND ANGLES

906. Plates and angles should be examined before they are set up for template markings. The surface inspection will show any laminations and folds. Also the metal thickness is checked, as often a yard with a small supply of plates will try to run in different

builder's risk insurance covering the total contract price, protecting all work and material against usual hazards covered by marine builder's risk, and so worded that the loss shall be paid to the Government or the contractors, as their interests may be determined.

Usually there is a penalty, or damage clause, which treats with the delay in completion of the work at a specified time. As the actual damage that is incurred cannot be actually determined, the contractor is required to pay the Government a stipulated sum (as agreed) for every calendar day of delay in the completion of the vessel.

Sometimes it is found desirable to accept the delivery of the vessel with items of work unsatisfactory or uncompleted, in which case such items are treated as changes. A tentative acceptance of the vessel may be made by withholding several thousand dollars to provide for subsequent work in another yard.

ARTICLES FURNISHED BY THE GOVERNMENT

932. Items that are supplied by the Government to the contractor are such as arms, boats, rangefinders, etc., outfits, various department stores, etc., radio apparatus, instruments, etc.

INTENT OF SPECIFICATIONS

933. The intent of the specifications for the hull, machinery, and appurtenances is that the contractor shall build, launch, equip, and complete the vessel, ready for service as far as the requirements of the specifications and plans are concerned, and provide the necessary plant, tools, materials, and labor, including fuel and supplies for the upkeep, tests, and trials of the vessel.

Parts of the hull, machinery, or any articles pertaining thereto, not fully described in the specifications or not shown on the plans, and exclusive of those furnished by the Government but necessary to the completion of the hull or machinery, must be furnished by the contractor even though not specified.

An article is inserted which covers defective materials and workmanship, and is construed to cover defects in design.

Minor alterations in details, with no change in cost involved, may be approved by the superintendent of construction and repair or the engineer in chief.

INSPECTION

934. Details that pertain to inspection are covered by the contract. The engineer in chief is represented by an inspector of labor and material for hull, and by an inspector of labor and material for machinery.

Injuries resulting from launching, collision, grounding, docking, corrosion, or other causes must be made good by the contractor.

WEIGHTS

935. Endeavor is usually made in the design and construction of hull and machinery details to reduce weights, without sacrificing strength, stiffness, or durability of parts.

A record of actual scale of weights and sizes of all parts are carefully kept by the inspectors and submitted when the ship is completed.

INCLINING EXPERIMENT (fig. 2 (d))

936. Shortly before the preliminary trial, when the vessel is practically completed, it is inclined to ascertain the center of gravity, using at least 2 pendulums, with 4 inclination readings. Prior thereto a careful examination of the vessel is made and all foreign matter removed as far as is practicable; compartments freed of water, tanks, boilers, etc., entirely full or empty; weights are secured as nearly as possible in their final positions, and the usual precautions taken during the experiment. (See Inclining Experiment in Stability chapter.)

TRIALS AND DELIVERY

937. The official dock trial consists of the operation of the machinery at the dock for a specified time at full power without heating of bearings or necessity of adjustments.

The standardization trial is run between a specified and full speed to determine the adequate stops on curves for revolutions, horsepower, knots, etc., and the results calculated and plotted for record.

The full-power trial consists of a run for a specified time with the machinery developing certain horsepower (shaft), using a specified fuel. Usually the hull and machinery are complete at this time, and specified amounts of oil, water, stores, etc., are carried.

Underway trials are made by and at the expense of the contractor and to the satisfaction of the officers detailed to witness the trials and to inspect the hull and machinery of the vessel before acceptance.

Upon satisfactory completion of the trials the vessel is cleaned and put in order for acceptance by the Government.

INSPECTION OF WELDED WORK (fig. 119) (by Chief Machinist W. C. Dryden, U. S. C. G.)

938. Determining the character of welded joints is of prime importance. Manufactured apparatus is generally accepted on the basis of rigid adherence to a specified welding procedure, in conjunction with a successful reaction to certain tests of sample welds, and, in some cases, tests of the finished product.

Good welding is very largely a matter of competent welders and zealous supervision. In shipyard practice, very little inspection of completed welds is done. Tests applied to completed work consists mostly of judgment by appearance, and measurement of the bead, which

should be as thick as the thinner leg of the joint. Samples of each welder's work are subjected to laboratory tests, and each welder certified as competent. Specifications for rods and manner of performance are closely followed.

The four factors which determine the physical characteristics of the weld are: Fusion, slag content, porosity, and crystal structure.

Some of the methods which have been used for determinating those characteristics are:

1. Visual examination of the weld to determine (*a*) finish, as an indication of workmanship, (*b*) length of deposits, which indicates frequency of breaking arc, and thus, agility of welder to control arc length, (*c*) uniformity of deposits, showing faithfulness with which filler metal is laid in the weld, (*d*) fusion of deposited metal, as shown by appearance of under side of weld, (*e*) predominance of surface porosity and slag.

2. The edges of deposited metal chipped with a cold chisel, to determine relative adhesion; a fair but not good weld will show faults when chipped, but only a very poor weld will come loose.

3. Penetration tests—to indicate unfused zones, slag pockets, and porosity. This test may be X-ray penetration, gas penetration, hydraulic-pressure test, or liquid-penetration test. The X-ray and gas-penetration test require elaborate equipment, and are essentially laboratory methods.

4. Electrical test—to determine variations in electrical conduction and magnetic induction. This is also a laboratory operation.

Of the above methods, visual examination is of more importance than generally admitted. Together with the chipping test and liquid penetration test, the visual inspection is the principal reliance in the field.

The liquid penetration test is very useful in showing linked slag pockets or unfused areas. The best liquid for the test is kerosene. A bright coal tar dye may be added to make the penetration more evident. Because of its high surface tension, kerosene will be drawn through the most minute openings. Penetration will be shown where hydraulic tests have failed to show any fault. The liquid penetration test will not show small and isolated slag pockets, but a considerable quantity of these may be included without seriously weakening the joint.

If a bad fault is revealed it is advisable to burn out the defective metal before rewelding under proper supervision. Large amounts of kerosene may be removed by sand blasting, steam, or gasoline. No difficulty is to be expected in welding over a thin film of the liquid.

X-ray, radium, and gamma-ray pictures are the best inspection of a welded joint. Where strength is mandatory, such as boiler shells, etc., these are the methods used.

Regardless of the metal welded by the arc, the main steps are:

1. *Preparation of the weld.*—Preparation includes cleaning and scarfing, and such heat treatment as may be necessary.

2. *Electrode selection.*—The electrode material is generally specified and should be of a composition very similar to that of the metal to be joined. The diameter of the rod is determined by the mass and thickness of the parts to be welded. Where the diameter is not specified, a table of proper sizes for different plate thicknesses should be consulted. The heavy coated rods specified for naval construction have a tendency to undercut the plate, and this should be carefully watched. The undercutting is visible at the edge of the bead in finished work.

3. *Amount of current.*—The amount of current is determined by the diameter of rod and depth of penetration required. The use of too low current produces poor fusion and makes a very weak joint. The chipping test is valuable to determine poor fusion.

4. *Maintenance of arc length.*—Maintenance of a short arc is imperative, if a homogenous, nonporous weld is to be obtained. The length without break, and the smoothness and uniformity of the bead give an excellent indication of the ability of the welder to maintain the arc.

Distortion and locked stresses can be greatly reduced by laying the weld in several small beads rather than one large bead. The thick bead carries too much heat, and in cooling leaves a violent stress in the joint.

In ship construction it is advisable to begin in the center and work to both ends. If a definite sequence is properly laid out and followed, the strains imposed by shrinkage can be greatly reduced. The shrinkage in cooling for ship-hull construction approximates one-half inch per hundred feet of length. It is very evident, therefore, that enormous strains will be set up if the welding is done haphazardly. The butts of contiguous plates should be welded before the side beams. Sequence should be carefully determined and incorporated in the specifications.

height above the top of the tank. Ordinarily, a temporary standpipe is screwed into the tank top and a small barrel fixed on top to act as a reservoir and filler; or when the tank is to be filled by a hose through an air-escape or sounding pipe, the top of the standpipe may be bent over so that a constant stream of water flowing out indicates that the proper head of water is being maintained. Occasionally, the standpipe is pierced with small holes about a foot apart, each one being plugged up so that by withdrawing the plugs from the top downwards the height of the water in the standpipe may be ascertained at any time.

The pressure of still water in pounds per square inch against the sides of any pipe or vessel of any shape whatever is due solely to the "head" or height of the level surface of the water above the point at which the pressure is considered, and is equal to 62.355 pounds per square foot for every foot of head at 62° F. The pressure is equal in all directions—downwards, upwards, and sideways—and is independent of the shape or size of the container, and the horizontal pressure is the same whether the surface is inclined or vertical. It is obvious if there is much sweating the test will not be satisfactory. Consequently, it is sometimes necessary to raise the temperature of the water supply.

Weeps will indicate the leaks. Calking will usually eliminate them. The shipyard force sometimes pretest compartments and tanks for leaks by filling with water and using sawdust to stop the leaks temporarily in an attempt to deceive the inspector; consequently any space that shows signs of being wet previous to the real test should be postponed until it is dry. During a head test be on guard to see that the water level is maintained and that there is no shut-off valve in the line. Also before testing, a thorough job of cleaning scuppers and sanitary drains should be completed. Sometimes shavings get into scuppers and drains and cause an overflow on the finished linoleum and woodwork. If the drains are of lead, care must be taken in clearing them to avoid damage. In a hose test on bulkheads make sure before the test starts that the opposite side of the bulkhead is dry, in order that weeps may be seen.

AIR TESTING

919. Prior to launching, a final or *complete test* is given watertight compartments by *air* to discover any newly developed leaks, as holes left by working parties such as electricians. Seams, rivets, etc., are smeared, by means of clean paint brushes, with soapy-water solution to which glycerine has been added. Bubbles formed will indicate leaks. The usual requirements are that all compartments not specifically required to be tested by water may be tested by air, in which case the pressure should be equivalent to the water pressure at the midheight of the compartment which would be caused by the specified water head for the compartment, except in no case should the pressure be less than 5 pounds.

In air testing, the tank should be brought under pressure by admitting the air slowly and the mercury column watched carefully, so as to prevent an excess in pressure being admitted to the compartment. When the required pressure has been reached, a man should be stationed to maintain the pressure, while examination is made, by aid of soap solution, to locate any leaks which may develop.

FALL OF PRESSURE AGAINST TIME

920. The fall of pressure against time is taken following the cutting off of the supply of air, after the maintenance of the required test pressure for a period of 15 minutes; this is considered sufficient to determine the tightness of a compartment. A fall from ⅛ to ½ pound in 15 minutes, according to the size and number of doors, manholes, hatches, and other fittings involved, and the size of the compartment itself, would indicate satisfactory tightness.

HOSE TESTING

921. There are many parts such as watertight doors, ports, etc., where watertightness cannot be tested by water or air under pressure, and in such cases a hose is generally employed with a pressure at the nozzle usually of 30 to 50 pounds per square inch. When carefully directed, a powerful jet of water may readily discover a leak, but because of its transitory or momentary character it is possible that small leaks may be passed over.

Watertight members, not tested in conjunction with compartments, including manholes, hatches, decks, recesses, bulkheads, trunks, tunnels, shell plating, etc., should be tested by playing a hose on them, or by such other means as may be approved, to insure satisfactory watertightness. A quick test of a watertight bearing surface is made by chalking the knife-edges, after which the door is closed and dogged down. Upon examination of the gasket, after opening the door, the absence of chalk on the gasket at any point will show where it will leak.

INSPECTION OF COMPARTMENTS UNDER TEST

922. During the test, careful examination should be made on all work where calking has been done, for defective rivets, portions of seams left uncalked, poor work, etc. If on testing a tank leaky rivets which cannot be corrected by moderate calking are discovered, they should be renewed, and not with tap bolts or rivets screwed in from the outside, as is sometimes attempted. After renewing defective rivets it is necessary that the tank again be filled and tested.

PLANKING (fig. 102)

923. Planking for the wooden decks should be inspected, if possible, while being unloaded at the yard.

Even after this thorough inspection and the certified inspection of the lumber company, some planks are found unsuitable when placed in position, because of cracks, cross grain, traces of knots, etc. The bolting of the planks to the deck beams is important because the men sometimes try to put in bolts when the hole is not fair with the beam and may omit bolts even though the wooden plugs are in place. If the planks are wedged in place from the side, about 12 at a time, before the holes are bored, good results will be obtained.

The boards of hardwood, finished bright, should be inspected for knots and light-colored sapwood. Color should match.

JOINER DECKS

924. To secure watertightness wood decks that are not calked, such as light superstructure decks or on tops of deck houses, are often covered with canvas, in which case lighter tongue-and-groove planking of yellow pine or Douglas fir is used and secured with galvanized nails to wood bearers, bolted to the beams and tieplates. Such planking, after being laid, should be dressed, sanded, and given two coats of approved paint, or covered with Jeffries liquid glue or *Ferdico*, then covered with felt and No. 1 canvas (or as specified), then fastened with copper tacks of suitable size and painted.

In securing canvas care should be taken that it is drawn tight, so that it shows no wrinkles. It was formerly the custom to wet the canvas with soapy water after securing in place, to remove all wrinkles and shrink it. It was then painted while still wet. Modern practice is to treat the canvas with airplane "dope." It fills the pores, shrinks it, and provides a covering.

The main points to examine when joiner decks are laid are that the faying surfaces of all metal and decking is painted with the required number of coats, that the bearers fit snugly on the beams, and as they are always exposed to view from below they must be neatly finished. The riveting in way of the margins and covering boards must be flush to allow for proper calking and to avoid cutting away the bearers.

RUDDER INSPECTION

925. The clearance of the rudder pintles should be carefully measured and if lignumvitae bushings are used they should have proper clearance under service conditions (i. e., when thoroughly wet).

BITUMASTIC MATERIAL

926. Bitumastic material sticks well if the surface is clean, dry, and free from scale, but as it is generally applied by the night gang, when dew has fallen on the surface of the plates, it is not likely to stick well under such conditions.

MILL SCALE

927. The blue mill scale which is found in some shipments of plates and angles as received from the mills will, if not removed, be a source of trouble in effecting the adherence of paint; also electrolysis after the ship is built will cause it to flake off. There seems to be no way of eliminating this scale except by pickling or sand-blasting. Letting it rust off requires about 2 years and is, therefore, impracticable. If not pickled, the punching and riveting will flake off some of this scale, but much of it will remain on the plate, in spite of all that can be done, and the surface must then be cleared by sand-blast.

FITTING OF PLATES

928. The operation of laying the flat keel plates is an important one, because they must be exact in size and in curvature, and they have an influence on the matching of holes and the fairing of butts of the upper structure. The butts of all keel plates should be planed to remove the uneven edges resulting from their cutting and the rivet holes are invariably punched undersize and then reamed to size. The end keel plates are dished and bent sharply and require careful blacksmith work to prevent fracture. The butt straps are likewise very heavy and are hard to bolt up, and it is difficult to pull up the lower or outer keel angles and the ship frames to these plates, unless the curves are worked in carefully.

OUTFITS

929. When the Government stores and outfits are received the boxes should not be opened until they are turned over to and received by the ship's officers. Once a box is opened, even in the guarded storeroom, the contents will begin to disappear. It is usually necessary, however, to furnish some samples of the silverware for joiner work in the pantries and dressers. In the confusion of placing a new cutter in commission, with some of the yard workmen still aboard, new tools, etc., are frequently lost.

PRINCIPAL EVENTS

930. The principal events occurring in the progress of construction of each ship, and of which reports are made, are: (1) First hull material ordered, (2) first hull material received, (3) lines faired complete in mold loft, (4) keel laid, (5) first compartment tested, (6) launched, (7) first dock trial, (8) first trial by contractors, (9) official trial, (10) preliminary acceptance, (11) delivery to Government, (12) displacement, draft, and conditions of loading upon delivery, (13) such additional events as are considered of special interest in the progress of a vessel.

MARINE BUILDER'S RISK

931. The contractor is required, at his own expense, from beginning to completion of the work, to furnish

thicknesses. The plates as they come from the mill are usually hot-marked with chalk, and the recording by the Coast Guard inspection force of these identification numbers in a book will be sufficient to show that these plates have been inspected.

STEEL CASTINGS

907. The assistant inspector should place his inspection mark on the castings at the plant where made. Usually they are made by a subcontractor. They should be stamped in several places, especially the large castings, in such a way that a scale falling off will not affect the stamp.

The large castings, such as the forefoot, stern frame, etc., are given a physical test by slinging them on a derrick and ringing them out with sledges. The samples cut from these castings should be carefully marked so that when they are machined down for test samples the marks will still remain. Of course, the test of the sample should be carefully observed by the assistant inspector. The surface inspection of the castings should be carefully made, and any sand spots or cracks investigated with a chipping hammer and a thin knife blade to show their extent. As a general rule a contractor is allowed to build up a crack, sand spot, or blow hole if it does not extend more than 30 percent through the thickness. The welding should be carefully done after the defective region of the casting is preheated.

The weather has a considerable influence on steel castings. For instance, if the atmosphere is damp or if there is a heavy dew at night the surfaces in the molds become wet, and this often results in bad castings, either through warping or cracks.

Chocks and bollards are generally inspected by ringing them out and dropping them 25 feet.

ANCHORS AND CHAINS

908. The inspection of new anchors and chains is generally done by a representative of the American Bureau of Shipping and a certificate then furnished by that society. The contractor arranges for this.

RIVET HOLES

909. The assistant inspector detailed to the plate shop should observe the marking of templates on the plates to see that there is plenty of landing for rivet holes, which should be about one and one-eighth times the diameter of the rivet and should make sure that the burrs on the edges of the plates are not deep and that burrs resulting from punched rivet holes are not large; such faults will prohibit the plates being drawn up closely, the drawing together being accomplished by the bolting of the plates together preceding the riveting.

Mistakes are made in punching and the custom has grown up allowing the holes to be welded and repunched if not over too great an area.

RIVETS (fig. 48(a))

910. Very few defective rivets are furnished by contractors. The style of the rivet should be determined before work is begun; whether pan-head, button-head, cone, or swell neck, and the type of point should also be determined. Swell-neck rivets are used in thin plating and in cases where there is a difficulty in getting the straight-neck rivet to fill the hole. On the shell plating the flush countersunk point has been practically adopted in lieu of the raised point. Much of the riveting of frames and bulkheads is done by machine riveting in the yard. This is very rapid work and requires quick inspection. Button-head and snap-point rivets are used on the machine. (See Rivets in chapter on Shipbuilding.)

OVERHEATED RIVETS

911. A most important point is the question of burnt rivets. It is hard to find a definition of a burnt rivet and its cause. The rivet should be heated to about 1,300°–1,500° F. (in order to retain its physical composition). If heated above that, to 1,800° or 1,900°, i. e., to a white heat, the critical transition point is reached where the steel composition is changed from the forged state to the cast-steel state (cementite), and consequently the physical properties such as tensile strength, brittleness, and coarseness of grain are very much changed. As a rivet in this state will fail, the inspector should watch the temperatures and the color of the flames of the heating ovens closely, especially if burnt rivets are found. The proper heat should show a bright yellow, and with gas heat, as used at most shipyards, the temperature can be controlled by use of pyrometers. It should be noted that an ordinary rivet, after heating, will become heavily oxidized and may be mistaken for a burnt rivet.

Poor riveting frequently occurs around cant frames and the upper limits of gun foundations, where it is difficult to work. Also in the double bottoms, forefoot, and in such obscure places there is a tendency for riveters on piecework to jag rivet points (i. e., drive the side of the point in from an angle of about 45°) so they will not show up as being loose when struck with the testing hammer, also to be careless and not to finish up the point of the rivet or to leave loose rivets. They will leave the point rough and uncalked and sometimes substitute the candle with black paint over it. The inspecting force should use a different colored chalk from that used by the yard force for marking loose rivets or bad calking, and also make note of the locations of bad rivets chalked for renewal, for the pieceworkers enjoy rubbing out the inspector's chalk marks.

Assistants should be detailed and trained to test rivets, calking, fairing up, bolting, reaming, tanks, joiner work, etc.

The old method of riveting was to hold on with a dolly bar by hand. This method is much cheaper as it eliminates one air hose. Better riveting is done by holding on with air. The head of the rivet will retain its shape better if the holding is done by air, but there is a danger of having the die too small or too large for the head of the rivet. The calking of the rivets is sometimes carelessly done when piecework is used. Good, tight riveting is most important. Not many years ago a Government vessel, in testing her guns, sheared off a large number of rivets in the underdeck gun foundations. This could not have happened had the rivet tester been dependable.

CALKING AND WELDING

912. It should be realized that the calking of seams is simply increasing the pressure of the edge of one plate against another plate, and it is only a camouflage where loose riveting is done or the plates have been improperly drawn up, or there was too much landing. Repeated calking merely serves to pull the plate landing away and then welding is usually attempted. Whenever welding is done in the way of rivets the area is generally disturbed for a radius of about 1 or 2 feet, and after the welding is finished these rivets should be tested and recalked. Finished welding should be bobbed (calked) to close the porous spots. Leaks generally develop around the rivets unless this is done.

STOPWATERS

913. The use of stopwaters is permitted by the American Bureau of Shipping under some conditions, and the conditions should be thoroughly studied, and also their use in connection with three thicknesses of plates and angles, such as at bulkheads and liners. If the fitting and riveting are properly done there will be little use for the red-lead gun and stopwaters. Before the riveting is started an understanding should be effected with the contractor in regard to where he proposes to use stopwaters.

SHIP FITTING AND FAIRING

914. The plates are fitted generally at night so that one of the first things to do in the morning is to see how the new plates fit that have been bolted in place. Sometimes a long plate will be stretched as much as half an inch on the frames, and the hammer marks around the bolts will show how much force was used in forcing a fit. If it is necessary to shift the plate edge to make it fair with the strake line, care should be taken not to reduce the landing for the rivets.

BOLTING TOGETHER OF PLATING, ETC. (fig. 100, 114)

915. Bolting up is a very important operation. Obviously the plates must be drawn up tightly on all the faying surfaces. Secondly, if the plate laps do not touch throughout, drillings from the reaming of rivet holes will drop between the plates and prevent tight riveting. Likewise, there should be no burrs in the faying surfaces to interfere with close contact throughout. Good riveting requires bolting up every other hole but some workers attempt to shirk by bolting up only every third or fourth hole. Sometimes attempts will be made to rivet by using smaller rivets before the holes are reamed. The faying surfaces of plates must be completely drawn into contact by bolting together. Riveting will not do this.

COMPARTMENT TESTING

916. In the actual work of testing compartments and tanks, there are several points to remember. It must be ascertained that the compartment is thoroughly cleaned, and that it is, as far as practicable, free of shoring, scaffolding, or cribbing. If a hydrostatic test is used, it must be verified that the tank is completely full of water; often it appears to be so, but, owing to insufficient or badly disposed air escapes, a volume of air may be imprisoned under the tank top, when, should there be a small leak—as only air would escape therefrom—it might not be observed. Also, care must be taken to see that it remains full during the test. All testing should be made with fresh water; the use of salt water for testing purposes should be prohibited.

Tests on compartments are made for two reasons; first to prove their tightness, and second to verify their ability to stand up against the pressure of the specified head of water. In new vessels, tanks are rarely found perfectly tight on the first test; the shell may be, for the fitting, riveting, and calking is here more simple, but in the case of the tank tops, sides, and ends, the work being more difficult, consequently some of the 3-ply riveting or the calking is found defective.

Surfaces, subject to a hydrostatic test under pressure, should be tested before the application of any paint, wash, or coating, either inside or outside, and all piping connections and attached hull fittings should be installed prior to testing. Steel decks which are to be covered, should be fully tested before the covering material is applied. (See Tests in chapter on Shipbuilding.)

SPACES TO BE TESTED

917. The entire shell and all compartments, tanks, and spaces must be tested for tightness. The test heads or their equivalent pressures are given in the detail specifications, and usually all compartments adjacent to the outside plating, fresh water and peak tanks, and fuel oil and reserve feed tanks are required to be tested under pressure.

HYDROSTATIC TESTING

918. When testing the vessel's tanks, the first tests are obtained by filling the compartments by means of a hose to the extent that the water rises in a vertical standpipe—fitted for the purpose—to the required

CHAPTER X

PREPARATION OF SPECIFICATIONS FOR DOCKING AND REPAIRS TO CUTTERS

1001. In drawing up for forwarding to headquarters preliminary specifications for docking and repairs, it is essential that the exact nature of the work contemplated be effectively expressed. This will enable headquarters to gain an accurate picture of the necessity of the proposed work, and enable them to intelligently pass on it. For this reason it is a good plan, after enumerating an item, to add an explanation of the need, under a heading such as "Reason." For instance:

Docking, reason.—Requirement of article 2002, Regulations.

Renewal of draft figures.—Hull board notation, August —, ——.

Renewal of plating, starboard bow.—Seam badly corroded from frame no. 1 to no. 4; hull board and date.

Hull-plating renewal.—Present plating badly corroded and pitted. Vessel is taking considerable water through this bad plating; seams beyond the possibility of calking. Very urgent. Hull board and date.

H. L. _____.

Outboard discharge fitting.—Corroded through at bottom of fitting. Hull board and date.

New anchor windlass.—Present windlass will not hoist anchor in more than 12 fathoms. Operation uncertain and very slow. Not possible to get up anchor promptly after pulling off stranded vessel. Hull board and date.

Shaft and propeller repairs.—Reference Board of Inquiry; grounding of vessel, date.

Berth deck, additional sink.—Present installation of insufficient capacity. Hull board and date.

The following relates to the preparation of *proposals* for the items which have been approved by headquarters. Bids may be solicited for only the items approved by headquarters. Frequently, owing to lack of funds and for other reasons, headquarters finds it necessary to postpone or cancel items which would otherwise be allowed. The price bid often decides whether or not certain repairs or alterations may be effected

PROPOSAL FOR DOCKING AND UNDERWATER HULL REPAIRS OF THE U. S. COAST GUARD CUTTER _____

1002.

Sealed bids, in quadruplicate, in accordance with the following conditions and specifications, will be received on board this vessel, located at Pier _____, _____, _____, until 2 p. m. _____ 19____, at which time the bids will be publicly opened.

_____

Commander, U. S. Coast Guard,
Commanding U. S. S. _____ CG.

The Coast Guard cutter _____ is a _____ screw vessel of the following description:

Length over all_____ _____
Length on water line_____ _____
Beam breadth, molded_____ _____
Molded depth, at side from base line_____ _____
Draft, maximum_____ _____
Displacement_____ _____

1. *Haul out and float vessel.*—Vessel to be hauled out of the water by the contractor on a marine railway or drydock, evenly resting on sufficient keel blocks, and securely braced by bilge blocks or shores. When all work in connection with the ship's bottom shall have been completed to the satisfaction of the inspecting officer, the contractor will float and undock the vessel, for the sum of $_____.
Time required _____.

2. *Cleaning.*—As soon as hauled out, the vessel's bottom will be thoroughly scrubbed, scraped, and wire-brushed clean of all dirt, grease, and marine growths,[1] giving especial attention to the water line area, after which the bottom will be washed off with fresh water. The contractor will furnish all scrub brushes, scrapers, staging, hose, and other material, and all labor necessary to accomplish this work to the satisfaction of the inspecting officer.
Time required _____. Cost $_____

3. *Painting.*—When dry, any bare spots on the underbody will be given one coat of American process zinc oxide mixed with gum turpentine, in the proportion of 5 pounds of dry zinc oxide to 1 gallon of gum spirits of turpentine, which shall be allowed to *dry* before application of the anticorrosive paint. Then one coat of Navy anticorrosive (14–RC) paint will be applied to the hull and allowed a minimum of 8 hours to dry. One coat of boot topping, Navy no. 3, shall be applied over the coat of anticorrosive paint be-

[1] Care shall be taken that no paint which adheres firmly shall be removed.

tween the full-load and light-load line of the vessel. (Art. 2624, par. 4, Coast Guard Regulations.) One coat of antifouling, Navy (15-RC), to be applied a minimum of 6 hours before the vessel is launched. The paints mentioned in this paragraph except the zinc primer will be furnished to the successful bidder by the Coast Guard. All bilge blocks will be moved and the ship's bottom painted at the spaces where these have rested against the ship. Keel blocks will be removed where practicable. The contractor will furnish all necessary paint buckets, paint brushes, staging, etc., and labor for accomplishing the painting in a satisfactory manner. Painting of the underbody, while the atmosphere is excessively damp or during rainy weather, will not be permitted.

Time _____. Cost $_____.

4. *Draft marks.*—Arabic numerals, 6 inches in projected height at stem and stern of the vessel, will be painted as follows: Figures are to be white on red or black surfaces, or black on light gray surfaces and on white surfaces.

Time _____. Cost $_____.

5. *Zincs.*—Old zincs indicated by the inspecting officer to be removed. New zincs of Coast Guard standard shape and quality will be furnished by the contractor, weighed in the presence of the inspecting officer, and installed by the contractor under supervision of the inspecting officer. The protective zincs shall be cut from rolled zinc sheets one-half inch thick. The zincs shall be weighed after being cut to size, their finished weight being that for which payment will be made.

Zincs to be furnished at the rate of $_____ per pound.

6. *Spare zincs.*—Spare zincs of the quantity and shape needed to complete the spare set shall be made, measured, and fitted accurately as to position and securing bolts. Certification of weighing to be furnished the inspecting officer. Requirements for such zincs furnished shall be identical with those in item no. 5.

Spare zincs to be furnished at the rate of $_____ per pound.

7. *Strainers and drain plugs.*—Remove, clean, and replace strainers. Remove and replace drain plugs.

Time _____. Cost $_____

8. *Fresh water.*—Fresh water as needed, will be provided the vessel at the rate of per thousand gallons $_____

9. *Steam.*—Furnish to vessel steam line _____ pounds pressure.

1-inch pipe line per hour $_____

2-inch pipe line per hour $_____

10. *Electric current.*—Electricity as required will be provided the vessel by the contractor at the rate of _____ per kilowatt.

(NOTE.—Stipulate direct current and volts or alternating current, volts, and cycles.)

11. *Test holes.*—Drilling holes for testing thickness of shell plating, tapping, and plugging holes with tap plugs and welding plugs.

For the sum of $ _____ per hole.

12. *Scaling underwater body.*—Should the condition of the underbody, after docking, indicate the necessity of scaling, and this be approved by the inspecting officer, and the application of a primer coat of American process zinc oxide in spirits of gum turpentine (in same proportions as mentioned in par. 3), this work in addition to that called for in item 3 may be ordered.

Time _____ cost per square foot $_____

13. *Lay days.*—Lay days will be charged for the vessel, during which it may remain in the drydock or on the marine railway, after completion of the definite items listed in these specifications. No cost for lay days shall be assessed against the Government until all definite items of work shall have been completed, and, furthermore, the days of hauling out and floating (whatever the hour), stormy days, Sundays, holidays, and days when no work is performed by the contractor shall not be counted as lay days.

Lay days per day $_____

14. *Additional items.*—If additional and unforseen repairs develop, it is understood that they will be performed at the rates listed below; the additional repairs will be undertaken only upon specific authorization of the inspecting officer.

Price per rivet, complete renewal (ordinary)	$_____
Price per rivet, complete renewal (special)	_____
Price per rivet, building up, chipping and calking	_____
Price per rivet, calking	_____
Price of electric welding, per foot	_____
Price of electric welding, per hour per man	_____
Price of calking, per foot	_____
Price of chipping, per foot	_____
Price of shipfitters, per hour	_____
Price of riveters, per hour	_____
Price of machinists, per hour	_____
Price of carpenters, per hour	_____
Price of riggers, per hour	_____
Price of painters, per hour	_____
Price of laborers, per hour	_____
Price of helpers, per hour	_____
Price of calkers, wood, per hour	_____
Furnish and apply new steel _____ per lb	_____

It is understood and agreed that the price per pound of furnishing and applying new steel *applies to any part of the vessel* and includes the following:

(*a*) The removal of old steel and the removal and replacement of all auxiliaries and fittings in any

part of the vessel necessary to accomplish the work; also includes charges for rivets, chipping, calking, testing for watertightness, etc., and all labor and materials incident thereto. The weights of the rivets shall not be calculated in the poundage of new steel. Where new steel is applied, one coat of anticorrosive paint in addition to that required by item no. 3 of this proposal shall be applied to all parts of the new steel.

(*b*) The steel used in the replacement on the vessel shall be ship's structural steel, and the *finished plate or shape ready for installation on the vessel shall be the weight for the charge of pounds of new steel.* This applies to frames, shell plating, or any steel installed on any part of the vessel.

(*c*) It is understood and agreed that the charges for the use of tools, such as lathes, portable drills, chipping hammers, etc., are included in the labor charges per hour as enumerated above.

(If vessel has cutless bearings.)

15. *Cutless bearings.*—If directed by the inspecting officer, the present rubber bearings will be removed and new rubber cutless bearings installed, diameter of shafts _____ inches. Bearings to be furnished by the Coast Guard.

Inside cutless bearings: This for the sum of $_____.

Outside cutless bearings: This for the sum of $_____.

16. *Renewal of lignum-vitae shaft bearing.*—If directed by the inspecting officer, the present lignum-vitae bearing will be removed and a new lignum-vitae bearing installed. Diameter of shaft _____ inches.
Time _____ Cost $_____

17. *Renewal of metal draft figures.*—Replace missing draft figures on stem and stern of vessel; figures are 6 inches in projected height, design and materials same as the present installation; to be set in red lead and secured in place with approved machine screws.

Numerals to be furnished at the rate of $_____ each.

18. *Doubling plate, starboard bow.*—To weld in place over lower seam of the outside doubler, superimposed on strake D, starboard bow, a strip of 12.75-pound steel plate 8 inches by 7 feet, to cover from frame no. 1 to frame no. 4. Faying surfaces to be thoroughly cleaned, dried, and painted before assembly. After welding is completed, holes to be tapped in the plate and red lead forced in under sufficient pressure to insure thorough permeation of all spaces between plates; holes then to be plugged.
Time _____ Cost $_____

19. *Renewal of hull plating.*—Remove plate no. 7 of strake E, starboard side, between frames no. 40 and no. 48, and replace with a 15-pound steel plate of the same material and quality, riveted in place in the same manner as the present hull plating. All laps, butt straps, and faying surfaces of the plating to be cleaned of rust; edges to be planed and accurately fitted; faying surfaces to be red leaded, but no red lead nor canvas, etc., to be worked in the seams; the seams and butts will be calked metal to metal; holes in new plating to be drilled and a reasonable amount of reaming will be permitted, but the use of the drift pin is prohibited.

Strake E is an outside strake; the area involved is the forehold; side stringer fastenings lie along the upper edge of strake E.
Time _____ Cost $_____

20. *Outboard discharge fitting.*—Remove outboard discharge fitting at the waterline, frame no. 42, starboard side, and replace with a new fitting of same material and design. Faying surfaces to be carefully cleaned and red leaded; all pipe joints disturbed to be made tight and without leaks.
Time _____ Cost $_____

HULL REPAIRS

1003.

1. *Fire monitor on bridge.*—Lift fire monitor and deck block supporting it, replace deck block with new, clear, dry teak of the same dimensions, and resecure monitor in place. Brass bolts and lag screws to be used throughout. New sheet lead flashings to be fitted around the deck block. All parts to be set in white lead and all joints of monitor to be tight and without leaks under a test pressure of 250 pounds per square inch.
Time _____ Cost $_____

2. *Forecastle deck.*—Remove all deck planking bolts on forecastle deck which are exposed within one-half inch of the upper plank surface and reset them in white lead, with grommets around the head of the bolt and around the lower end of the bolt in wake of the washer, with heads three-fourths inch below the upper plank surface. Wooden deck plugs, of the same material as the planking and with the grain of the wood running in the same direction as that of the planking, and flush with the deck surface, to be set in white lead. Such bolts as indicated by the inspecting officer will be replaced by new galvanized bolts of the same size.
Time _____ Cost $_____

3. *Overhaul boat davits.*—Overhaul all joints, swivels, bearings, bushings, and moving parts of four pairs of boat davits, taking up lost motion and assuring satisfactory working fit and efficiency.
Time _____ Cost $_____

4. *Armory watertight door.*—Straighten, fair, and true-up armory watertight door; renew hinge pins with three-fourths inch brass pins; renew gasket and make door watertight.
Time _____ Cost $_____

5. *Wardroom skylight bolt and lug.*—Furnish and install new bolt and lug to replace broken lug and

missing bolt, of the same design and material as present installation on the skylight.

Time _____ Cost $_____

6. *Towing arch over hawser hatch.*—Design, manufacture, and install a small towing arch of white oak, with necessary metal fittings, over the after hatch on the quarterdeck, to provide for the towing hawser passing freely over the hatch. Deck fittings for the arch to be flush deck fittings of noncorrosive metal and so designed that the arch may be quickly set up and taken down. Provide stowage clips for the arch where indicated.

Time _____ Cost $_____

7. *Toggle pins for life rails and lines.*—Replace 25 toggle pins with new ones of the same material and design.

Time _____ Cost $_____

8. *Vegetable lockers.*—Furnish and install, as replacement for present 2 vegetable lockers on boat deck, 2 sheet-metal lockers of similar design and dimensions, constructed of galvanized *Armco* rust-proof iron, or equal.

Time _____ Cost $_____

9. *Linotile.*—Furnish and apply *Linotile*, or equivalent, to the deck in the following spaces:

Watchroom, 57 square feet.
Radioroom, 100 square feet.
Cabin bathroom, 28 square feet.

Linoleum in the above areas will be removed and the deck thoroughly cleaned to bright metal by the ship's force. The *Linotile* shall be similar or equal to no. 64 brown, manufactured by the Armstrong Cork Co., and shall be in 8-inch squares, one-quarter inch thick. The tile shall completely cover the deck except for areas concealed by built-in furniture. The tiles shall be laid with their joints parallel to and square to the center line of the ship, but not in any staggered fashion. Irregularities of the steel deck in way of the laps shall be smoothed and leveled with an application of Trinidad asphalt containing 5 percent crude petroleum. The tile shall thereafter be laid in Armstrong's *Dolfinite* cement, or tested equal, rolled, and weighted down for 48 hours with sufficient sand bags to insure complete adhesion. After this the surface of the tile shall be cleaned and given two coats of clear brushing lacquer. Spare tile of an amount equivalent to 2 percent of that of the areas covered shall be furnished by the contractor for use as replacement. The contractor shall furnish evidence of having made similar successful marine installations of tile deck covering. Surf green no. 130 to be used in the cabin bathroom in lieu of no. 64 brown.

For washroom, time _____
Cost $_____
For radioroom, time _____
Cost $_____
For cabin bathroom, time _____
Cost $_____

MACHINERY REPAIRS

1004.

1. *Port sanitary pump globe valve.*—Replace one 5-inch composition globe valve, similar to the one now installed, on suction of port sanitary pump.

Time _____ Cost $_____

2. *Port fire pump discharge valve.*—Renew one 4-inch composition globe valve on the outboard discharge line from the port fire pump.

Time _____ Cost $_____

3. *Propeller blades.*—Replace bent propeller blades with spares now on board and straighten bent blades.

Time _____ Cost $_____

4. *Main engine exhaust pipes.*—These exhaust pipes, which are water cooled, are to be renewed, if found necessary, and if so indicated by the inspecting officer. Two sections, one on each main engine, water-cooled exhaust piping, each section being approximately 11 feet long; outer shell diameter, 10¾ inches; inner shell diameter, 8½ inches; space between shells, approximately ⅞ inch.

Time _____ Cost $_____

The following items may be included under the heading of work to be performed, if found necessary by the inspecting officer:

5. Remove propeller and haul tail shaft to permit an inspection. Replace shaft and propeller and connect up ready for service.

Time _____ Cost $_____

6. Rewood stern bearing in place.

Time _____ Cost $_____

7. Remove, bush and rewood, bore and replace stern bearing.

Time _____ Cost $_____

8. Remove, bush, rewood, bore, and replace inner tail shaft bearing.

Time _____ Cost $_____

9. Remove tail shaft from ship to shop for reconditioning and return.

Time _____ Cost $_____

10. True up tail shaft sleeve in lathe.

Time _____ Cost $_____

11. Renew after sleeve with composition 88 parts copper, 8 tin, 4 zinc.

Time _____ Cost $_____

12. Renew forward sleeve with composition (88-8-4), and renew jacket with brass tubing or composition.

Time _____ Cost $_____

13. *Anchor windlass.*—Lift gear casing, furnish, fit, and install six bronze bushings for gear shafts where they pass through gear housing. Realign gears, allowing the proper clearances between gear teeth, replace gear housing and make oiltight.

Time _____ Cost $_____

GENERAL CONDITIONS

1005. The following general conditions shall apply in connection with all work on the repairs specified herein:

1. No laborer or mechanic doing any part of the work contemplated by this contract, in the employ of the contractor or any subcontractor contracting for any part of said work contemplated, shall be required or permitted to work more than 8 hours in any one calendar day upon such work at the site thereof. For each violation of the requirements of this article a penalty of $5 shall be imposed upon the contractor for each laborer or mechanic for every calendar day in which such employee is required or permitted to labor more than 8 hours upon said work, and all penalties thus imposed shall be withheld for the use and benefit of the Government: *Provided*, That this stipulation shall be subject in all respects to the exceptions and provisions of the act of June 19, 1912 (37 Stat. 137), relating to hours of labor.

2. The Government will deliver the vessel at the place designated by the successful bidder for the performance of the work herein specified. From that time on until the work is completed, the contractor will furnish to the vessel, at no additional expense to the Government, all wharfage, towage, and cartage that may be necessary for the performance of the specified work, and a suitable and convenient enclosed stowage place for the stowage of stores and gear, and facilities for the disposal of ashes.

3. Any and all portions of the vessel's hull or machinery damaged, displaced, or disturbed in the prosecution of the repairs are to be replaced satisfactorily by the contractor, at no additional expense to the Government.

4. All work and materials are subject at all times to the inspection of the officer appointed for that purpose by the Coast Guard. The inspecting officer has the right to reject any work or materials which are deemed unsatisfactory. Neither the officer under whose supervision the work is performed, nor the superintendent of the work, shall, on his own responsibility, authorize any additional work to be done or materials furnished. In the event of a disagreement between the contractor and the inspecting officer, the work is to cease without further or additional expense to the Government than has been incurred for authorized labor and materials up to the time of the disagreement. Pending a decision from higher authority, the vessel shall be considered as subject to the disposition of Coast Guard headquarters.

5. It is agreed that, while the vessel is in drydock or on the marine railway, the ship's force may be employed in performing any work on the vessel, her hull, or fittings, as may be desired, and that the contractor will make no claims for royalty for work accomplished by the vessel's force.

6. *Materials.*—All defective materials removed from the vessel will be considered as scrap and will not be removed from the contractor's plant by the Government.

7. Liquidated damages, for each calendar day's delay, will be charged at the rate of one-tenth of 1 percent of the amount of the accepted proposal, which liquidated damages may be remitted to the Secretary of the Treasury, as in his discretion may be just and equitable.

(NOTE.—Par. 7. The liquidated damage clause is only inserted in cases where the amount is $500 or more, or where time is an essential element (art. 557 (3), 714 P. & S. I.).

8. The Government reserves the right to reject any or all of the bids and the right to authorize or cancel any of the items in any of the bids. In case of error in the extension of prices in a bid, the unit price will govern.

9. No additional work is to be done, no additional labor or material furnished, or any other expense incurred which is not expressly provided for in the accepted proposal without the written authority of the contracting officer.

10. All necessary underwater paints except zinc primer (see item no. 3) will be supplied by the Government (applies to steel vessels only. Art. 715 (2) (3), P. & S. I.).

11. The contractor shall not employ any person undergoing a sentence of imprisonment at hard labor.

12. During the time the vessel is hauled out, there will be permitted and provided space on the floor of the drydock or marine railway to lay out the vessel's anchor chains for cleaning, painting, and marking. This work is to be done by the ship's force during the time of the painting of the vessel's bottom.

13. *Sea valves, etc.*—The ship's force will be permitted to overhaul all sea valves, etc., as may be necessary, during the time the vessel is in drydock or on the marine railway.

14. *Fire protection.*—The contractor must furnish the vessel ample fire protection during the time it is in the contractor's yard.

15. *Toilet and washing facilities.*—Adequate toilet and washing facilities for officers and crew shall be provided during the time the vessel is in drydock or on the marine railway and adequate arrangements made for carrying away or disposing of all garbage or insanitary debris from the ship or vicinity, without expense to the Government.

16. *Performance of any additional repairs.*—It is understood and agreed that any additional repairs that may be authorized under item no. 14, or which may be found and authorized after the vessel is drydocked, will be performed concurrently with the known repairs as set forth in this proposal.

17. Estimates in this proposal are solely for the information of the bidder. The Government reserves

the right to purchase only such quantities as are actually required, not to exceed the estimated amount by 20 percent.

18. The prices quoted are net prices, exclusive of any State tax imposed on the purchase or sale of the products named, the United States Government not being liable, directly or indirectly, for the payment of such tax (decision, United States Supreme Court, May 14, 1928. *Panhandle Oil Co.* v. *The State of Mississippi*).

19. In the performance of this work the contractor, subcontractors, material men, or suppliers shall use only such unmanufactured articles, materials, and supplies as have been mined or produced in the United States, and only such manufactured articles, materials, and supplies as have been manufactured in the United States, all from articles, materials, or supplies mined, produced, or manufactured, as the case may be, in the United States, except as noted herein. If the head of the department finds that in the performance of this contract there has been a failure to comply with the foregoing provision with respect to domestic material, he will make public the name of the contractor obligated under this contract and no other contract for construction, alteration, or repair of any public building or public work in the United States or elsewhere shall be awarded to such contractor, subcontractors, material men, or suppliers with which such contractor is associated or affiliated, within a period of 3 years after such finding is made public.

20. If any Federal sales tax is imposed or changed after the date set for the opening of this bid and it is made applicable to and paid by the contractor on the articles or supplies herein contracted for, then the prices named in this bid will be increased or decreased accordingly, with the exception that no tax shall be imposed upon any payment received for electrical energy furnished to the United States. (See par. 24.)

21. Time, in connection with the discount offered, will be computed from the date of delivery of the supplies to carrier, when final inspection and acceptance are at point of origin, or from date of delivery at destination or port of embarkation, when final inspection and acceptance are at those points, or from date correct bill or voucher, properly certified by the contractor, is received if the latter date is later than the date of delivery.

22. In case of default of the contractor, the Government may procure the articles or services from other sources and hold the contractor responsible for any excess cost occasioned thereby.

23. No Member of Congress or delegate thereto, or resident commissioner, shall be admitted to any share or part of this contract or to any benefit that may arise therefrom, unless it is made with a corporation for its general benefit.

24. While there is a tax on electrical energy, the Government is exempt from payment of such tax. (Sec. 616, Revenue Act, 1932, provides: "No tax shall be imposed under this section upon any payment received for electrical energy furnished to the United States.")

25. The contractor shall hold and save the Government, its officers, agents, servants, and employees, harmless from liability of any nature or kind, including costs and expenses, for or on account of any patented or unpatented invention, article, or appliance manufactured or used in the performance of this contract, unless otherwise specifically stipulated in this contract.

_____
(Individual or firm name)

By _____

_____
(Date)

BID

_____

In compliance with the above invitation for bids, and subject to all the conditions thereof, the undersigned offers and agrees, if this bid be accepted within _____ days from the date of the opening, to furnish any or all of the items upon which prices are quoted, at the prices set opposite each item, and, unless otherwise specified within _____ days after receipt of order; place of docking _____

Discount will be allowed for prompt payment as follows: 10 calendar days _____ percent; 20 calendar days _____ percent; 30 calendar days _____ percent.

_____
(Bidder) (Address)

By _____ Title _____
(Member of firm or person authorized to sign bids for corporation)

Note.—Prospective bidders should visit the vessel between 9 a. m and 4 p. m. for the purpose of obtaining data, making sketches and notes as are necessary to make their estimate. Vessel at _____ _____. Blueprints of ship's structure may be obtained and examined on board by bidder. Four copies of the stipulation, specifications, and proposal (each as an original) addressed to the commanding officer, United States Coast Guard cutter _____ _____, _____, should be
(Address of cutter)
mailed or otherwise transmitted to reach the _____ _____ prior to the time of opening the bids. It is important that the envelop forwarding the bids be endorsed "proposal for dry-docking, _____ To be opened 2 p. m., _____ _____ 193_____." It is also necessary that each copy of the proposal be accompanied by the following certificate:

"I, _____ secretary (or custodian of records and seal) of the _____ com-

pany, a corporation organized and existing under the laws of the State of _____, do hereby certify that at a duly called meeting of the board of directors of said company, at which a quorum of said directors was present, held at _____ on the _____ day of _____, a resolution was adopted, of which the following is a correct copy.

"(Here insert copy of the resolution, showing that the person or officer who executed the contract and bond, if any, was duly authorized thereto.)

"I further certify that on the _____ day of _____ (date of execution of contract) the above resolution was still in force, and that on the _____ day of _____ (date of execution of contract) _____ (person signing contract) was the _____ of said company.

"In witness whereof, I have hereunto set my hand and affixed the seal of said company, this _____ day of _____

_____
(Title)

FIGURE 11 (ship assembly).—To make plain some of the methods used in constructing vessels, figure 11 is given. This shows partly in perspective a half midship section of a two-deck vessel having transverse frames, web frames, and a double bottom. The names and locations of the various members can be found from the numbers on the cut and the references which follow:

NAMES OF PARTS INDICATED BY NUMBERS

1. Keel; side bar keel.
2. Garboard; garboard strake.
3. Center girder; vertical center plate; center through plate keel or keelson.
4. Side girders; side keelsons.
5. Margin plate.
6. Floors; intercostal floors.
7. Brackets.
8. Inner bottom; top of double bottom; top of tank.
9. Frame brackets.
10. Web frames.
11. Side stringers.
12. Diamond plates.
13. Hold pillars; hold stanchions.
14. Main deck beams.
15. Main deck stringer (plate).
16. Main deck plating.
17. Main deck sheerstrake.
18. Topside strake.
19. Upper deck sheerstrake.
20. Upper deck pillars; upper deck stanchions.
21. Upper deck beams.
22. Upper deck planking.
23. Bulwark stanchion.
24. Bulwark plating.
25. Main rail.
26. Bottom strake plating.
27. Bilge strake plating.
28. Side strake shell plating.
29. Ordinary ship frames. (Transverse frames.)
30. Deck beam brackets.
31. Edge laps of deck plating.
32. Butt laps of deck plating.
33. Frames in inner bottom.
34. Reverse frames in inner bottom.

50. *Bow roller.*—Is a fitting with a roller capping the stem to allow a towing or other line to run free of chafing.

51. *Breast hook.*—Of brass, secured to the upper part of the engine.

52. *Stem band.*—A band which is secured to the stem and acts as a cutwater. Forming a binder for the apron and stem.

53. *Hoisting pad.*—A hoisting shackle which is riveted through the apron and stem on to the stem band.

54. *Washer.*—Placed on the inside of the stem band to obtain uniform resistance in the wood around the rivets.

55. *Bolt.*—Passes through the washer plate under the keel and bolted to the hoisting pad above the keelson.

56. *Bow chock.*—Chocks fitted to the gunwale near the bow.

57. *Mine crane sockets.*—Riveted in the bow, one a heel the other a band, to allow the crane free movement.

58. *Flagstaff plate.*—Of brass for the accommodation of flagstaff.

59. *Awning stanchion.*—Of brass fitted in the forward platform.

60. *Heel plate.*—Fitted to the forward knee to receive the heel of the stanchion.

61. *Step, towing post.*—Fitted to the keelson to take the heel of the towing post.

62. *Retaining pin.*—A pin through the towing post under the platform beams to prevent the post lifting under strain.

63. *Norman pin.*—Through towing post to secure towing line.

64. *Bowsprit.*—Is secured in the socket of the bow roller and projects out from the stem.

65. *Capacity label.*—Of sheet brass and gives indications of capacity, also number of boat and plans.

66. *Bobstay cleat.*—Secured to the stem to hold bowsprit down.

67. *Bow light bracket.*—A bracket which holds the bow light.

68. *Running light box.*—Of galvanized steel, painted.

69. *Same as 53.*

70. *Same as 53 and 69.*

71. *Washer plate.*—Composition S.

72. *Mast step.*—Of brass secured to keelson.

73. *Mast clamp.*—A band around the mast secured to the thwart.

74. *Thwart clamp.*—Hinged clamps over either end of the thwarts.

75. *Chain plate.*—Four are fitted, two on each side, to secure lines to avoid tilting when hoisting or lowering.

76. *Thole pin plates.*—Secured to capping, acts as bearings for thole pins.

77. *Thwart plate.*—Plates across the ends of thwarts to avoid warping.

78. *Engineers locker.*—A locker under the side bench for tools, etc.

79. *Engine cover.*—A boxed covering for the engine with hinged side.

80. *Bell bracket.*

81. *Gasoline tank.*

82. *Shaft log cap.*—A flanged tube cap through which the propeller shaft runs.

83. *Stern bearing.*—Extends out under the propeller and supports the heel of the rudder.

84. *Hand bilge pump.*—A pump taking suction and giving overboard discharge of fluids forming under the engine in the after bilge.

85. *Transom knees.*—Are horizontal brackets supporting transom and towing bitts.

86. *Cleats.*—To secure lines from towing bitts.

87. *Same as 63.*

88. *Short tiller.*

89. *Sailing tiller.*

90. *Stern roller.*

91. *Main sheet traveler.*—A traveling ring.

92. *Chafing plate.*—To prevent chafing on transom edges.

93. *Upper brace.*—Braces the rudder and forms the gudgeons.

94. *Rudder hangings.*—The fittings described as pintles.

95. *Lower brace.*—See 93.

96. *Shoe.*

97. *Rudder bolts.*—Riveted through the center of the rudder to securely fasten and prevent warping.

98. *Footling buttons.*—To hold the portable footlings in place.

99. *Bolts, copper.*—Fastened through the sternpost and riveted, to secure hoisting pads fore and aft.

100. *Boat plug.*—A female threaded fitting with plug threaded to fit.

101. *Chain sling.*

102. *Strap.*—For gasoline tank.

103. *Clip.*—Frame to keelson. Angles fitted to frames and keelson.

104. *Socket, bell bracket.*—

105. *Keel pad.*—A pad secured to the keel and shaft log.

Temporary repairs to a boat may be made by tacking a piece of painted canvas and sheet lead over the hole.

Boat oars.—Boat oars are to be made of the best quality tough white ash, thoroughly seasoned; of straight and close grain; free from knots, discolorations, streaks, and all other defects. To be hand dressed and smoothly finished. To be furnished with leather and copper bands.

FIGURE 49.—Small boats—30-foot motor sailing launch.—In small-boat construction thwarts are usually made of oak or ash, and in boats where saving of weight is important, spruce is sometimes used. Frames should always be made of white oak. Planking may be made from white cedar or juniper, Port Orford cedar, cypress, mahogany, white pine, and longleaf yellow pine.

The two principal methods of small-boat construction used in the Coast Guard are clinker and carvel.

Rather than a discussion of the detailed construction of a small boat, each part of a completed boat bearing corresponding numerals to the part described is furnished in figure 49.

The principal members of framing of a 30-foot motor sailing launch, given in the order in which they are usually assembled, are: Keel laid first, stem, sternpost, transom braces, breasthook, hoisting pads, keelson, lifting pads, remainder of planking, footlings, thwarts, stringer for footboard, cover piece for footboards, forward footboard, gun circle, forward platform, engine keelsons, crosspiece for after footboard, bulkhead, stern benches, spreading frames, clapping, chafing battens, and rudder.

1. *Stem.*—The perpendicular continuation fitted to the keel. The piece to which the planking of the boat is fitted in the bow. Material, white oak. Fastenings, ¾-inch copper bolts.

2. *Apron.*—Fitted to the curvature of and perpendicular to the stem and above the knee. Material, white oak. Fastenings, ¾-inch copper bolts.

3. *Stem knee.*—Is a natural growth knee forming a bracket between stem and keel. Material, white oak. Fastenings, ¾-inch copper bolts.

4. *Forward deadwood.*—The vertical flat supporting portion in the forward part under the knee and above the keel.

5. *Keel.*—The longitudinal timber extending along the bottom of the middle of the boat. Material, white oak. Fastenings, ¾-inch copper bolts.

6. *False keel.*—Fastened to the underside of the keel to strengthen and protect it. Material, white oak.

7. *Filling pieces.*—Fitted between the floor to supply the deficiency caused by empty spaces.

8. *Keelson.*—A strengthening structure above the keel and fixed to it. Material, yellow pine.

9. *Footlings.*—The strips running lengthwise to support the feet. Material, yellow pine.

10. *Bilge knees.*—Is the curved support and brace in the frames, at the bilge. Material, white oak. Fastenings, ¾-inch copper bolts.

11. *Risings.*—A ribband secured to the inner side of the frames on which the thwarts rest.

12. *Planking.*—The outer covering of the boat from the keel to lower fender. Material, white or Port Orford cedar; cypress or juniper. Fastenings above the bilge: 20d copper nails; below bilge, 20d galvanized boat nails. Planking end secured with 2½-inch no. 16 brass screws.

13. *Binding strake.*—A strip or strake of yellow pine acting as a binder for the ribs.

14. *Sheer.*—Is the top strake and takes the stress when the boat makes a warping contact. Material, white oak.

15. *Fender, upper.*—Of white oak and acts to ward off the boat.

16. *Fender, lower.*—Of white oak, fitted to binder strakes amidships.

17. *Clamps.*—A ribband riveted to the frames on the sheer strake. Material, yellow pine.

18. *Clapping.*—A strip secured above the top of the sheer ribs and the binding strakes.

19. *Thwarts.*—Form seats across the boat and rest on risers. Material, ash.

20. *Floors.*—The part of the ribs from the keel to the bilge knees. Material, yellow pine. Fastened to keel with 5-inch composition spikes.

21. *Frames.*—The framework of the boat. Shaped and fashioned so as to form the skeleton of the boat. Material, white oak. Fastened to floors with 20d galvanized nails.

22. *Forward platform.*—A platform raised to the height of the thwarts.

23. *Forward platform beams.*—Are supports for the platform. Material, yellow pine.

24. *Gun platform.*—It is secured to the platform and is the base to which the gun is fitted.

25. *Forward stringer.*—A strong horizontal to support the towing post and platform beams. Material, yellow pine.

26. *Forward flooring.*—A small raised flooring abaft the forward platform. Material, yellow pine.

27. *Forward flooring beams.*—The joist to which the flooring is secured. Material, yellow pine.

28. *Bulkhead.*—Tongue and grooved and is a water-tight bulkhead between the engine and the cargo space. Material, yellow pine.

29. *Side benches.*—Fitted on either side of the engine space. Material, ash.

30. *After flooring.*—Yellow pine, fitted close, tongue and grooved, but usually in grating form so they can be lifted to gain access to bilges in engine space.

31. *After flooring beams.*—Forming the joists for the flooring. Material, yellow pine.

32. *Stern bench.*—Forms the bench across the stern. Material, ash.

33. *Transom.*—Transverse timber fitted to the sternpost. Material, white oak.

34. *Stern post.*—Fitted above the shaft log and to the stern knee. Material, white oak. Fastenings ¾-inch copper bolts.

35. *Stern knee.*—A brace or bracket between stern post and shaft log. Material, white oak. Fastenings ¾-inch copper bolts.

36. *Shaft log.*—The log through which the propeller shaft runs. Secured to the keel and stern post. Material, teak, white oak, or laurel.

37. *Rudder.*—A flat piece or structure of wood hinged vertically at the stern of the boat. Forms a means by which the boat is steered. Material, white oak.

38. *Rudder stop.*—Two pieces of white oak, the inside ends cut at an angle to form a stop when the rudder is hard put.

39. *Stern fender.*—Half-round oak, which acts to ward off the boat, provided the rudder is clear. Material, white oak.

40. *Engine keelson.*—Strengthening structures on to which the engine is slung. Material, white oak.

41. *Engine keelson brackets.*—Brackets on either side and butted to the engine keelson for supports.

42. *Side bench stanchions.*—Are the upright posts which hold the side benches. Material, white oak.

43. *Side bench supports.*—Of white oak, to carry the weight placed on the side benches.

44. *Transom cleat.*—Secured across the upper inside of the transom to give strength and hold it in position. Material, white oak.

45. *Forward towing post.*—Stepped to a keel plate secured to the keelson through the forward platform and secured to the stringer. Material, white oak.

46. *After towing bitts.*—Placed on either side in the stern to secure ropes, etc. Material, white oak.

47. *Saddle.*—Is curved to carry a portion of the tanks and their weight. Material, yellow pine.

48. *Third strake.*—Fitted under the binding strake. Material, yellow pine.

FIGURE 20 (rudder).—The type of rudder shown in Figure 20 is called a single-plate rudder. The plate blade is supported by arms situated alternately on either side. The arms are sometimes made separate and secured to the frame by keys, or they may be shrunk on. The frame of the rudder and also the stock may be of cast or wrought steel or of wrought iron. Sometimes the blade and frame are made one, in which case cast steel is the material.

In figure 20 the different parts of the rudder and stern frame are lettered and their names are given in the following list:

(*a*) Rudderstock extending from coupling b up into the ship and through which the motion of the steering engine above is transmitted to the rudder.

(*b*) Coupling of a and f. Round flanges on each are bolted and keyed together.

(*f*) Main piece of the rudder frame with a coupling flange at the top. In figure 20 the arms, here marked e, are separate and are shrunk on.

(*g*) Rudder plate or blade.

(*e*) Arms, five in all, alternated on the two sides of the plate g and swelled out around f at D where they are shrunk on the main piece f. The extreme forward part of the arm beyond D is the rudder or pintle lug.

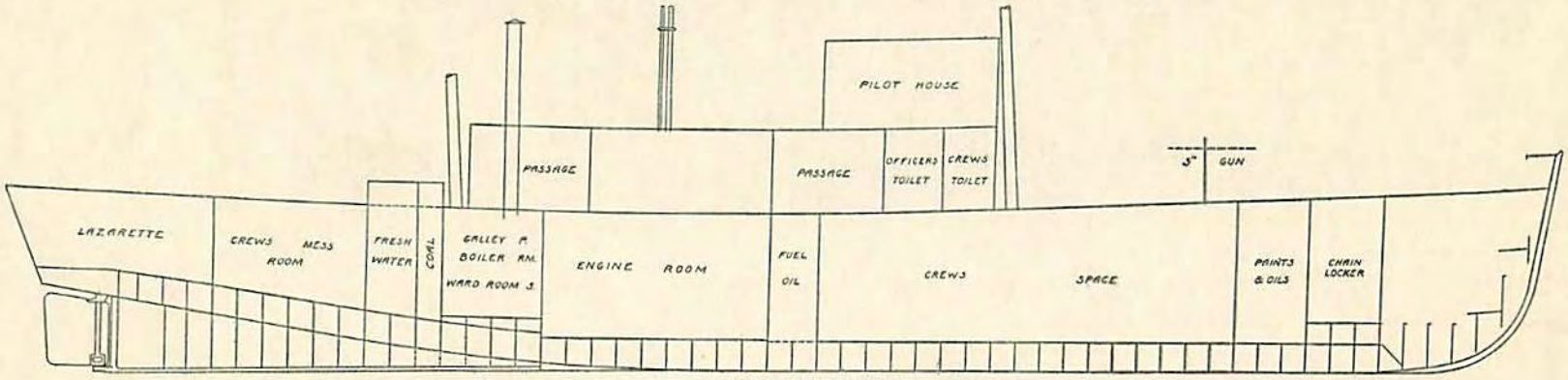
(*h*) Part of the stern frame called the rudderpost and on which the gudgeons are cast.

(*c*) Rudder gudgeons supporting the pintles, or hinge pins, on which the rudder swings. The pintles are fast in the pintle lugs and swing in holes in c.

(*l*) Part of the stern frame called the propeller post. Also called the body post.

(*m*) Part of the stern frame called the sole piece.

(*n*) Part of the hull called the counter.



U.S.C.G. 125 FT. PATROL BOAT
Fig 45

6575—36 No. 4

TYPE OF CUTTER	LATEST ESTIMATE 328 FT. NOS 65 TO 73	MENDOTA CLASS NOS 45 TO 54	MOJAVE CLASS NOS 36 TO 39	ESCANABA CLASS NOS 56 TO 60	165 FOOT PATROL BOAT
YEAR BUILT	1936	1929 1931	1921	1933 1934	1931 1934
LENGTH OVER ALL	328½'	250'	240'	165'	165'
BEAM MOLDED	41'3¾"	42'	39'	36'	25'3"
DEPTH MOLDED	23'6"	26'10"	25'6"	21'	13'2"
DRAFT MAXIMUM	12'6"	16'	16'6"	13'	8'6"
DISPLACEMENT TON	2,350	2,000	1,600	1,000	300
PROPELLERS	2	1	1	1	2
RUDDERS	1	1	1	1	2
SHAFT HORSE POWER	6,200	3,220	2,600	1,500	1,300
MAXIMUM CRUISING RADIUS	8,000	7,542	5,675	5,079	3200
KNOTS FULL SPEED	20	16.5	15	13.4	16.5
ECONOMICAL SPEED		8	10.5	9.4	12
BOWER ANCHOR LBS.	5,000	4,000	4,000	1,952 980	900

TABLE I

TYPE OF CUTTER	TYPE OF MACHINERY	NUMBER OF BOILERS AND TYPE	STEERING GEAR	SHELL PLATING LBS. PER SQ. FOOT								
				GARBOARD	BOTTOM	SHEER	BILGE	SIDE	WATER LINE AND ICE BELT	FLAT KEEL	FLOOR PLATES	NO. OF WEB FRAMES
328 FOOT	GEARED TURBINE	TWO OIL-BURNING WATER-TUBE	ELECTRIC HYDRAULIC	17.5 to 25	17.5 to 25	22 & 20	20 & 17.5	15 & 17.5	20 to 25	22 & 20	12 & 20	24
MENDOTA CLASS	TURBO ELECTRIC SYNCHRONOUS	TWO OIL-BURNING WATER-TUBE	ELECTRIC HYDRAULIC	17.9	17.9	20.4	20.4	17.9	20.4	28.1	15.3	7
MOJAVE CLASS	TURBO ELECTRIC SYNCHRONOUS	TWO OIL-BURNING WATER-TUBE	ELECTRIC HYDRAULIC	17.85	17.85	20.4	15.3	15.3	20.4	30.6	15.3	5
ESCANABA CLASS	GEARED TURBINE	TWO OIL-BURNING WATER-TUBE	ELECTRIC HYDRAULIC	17.9	17.9	15.3	15.3	15.3	35.7	20.4	17.9	6
165 FOOT PATROL BOAT	DIESEL 4-CYCLE	NONE	ELECTRIC HYDRAULIC	12.8	12.8	17.9	12.8	12.8	12.8	17.9	10.2	5

TABLE II

NAUTICAL STABILITY

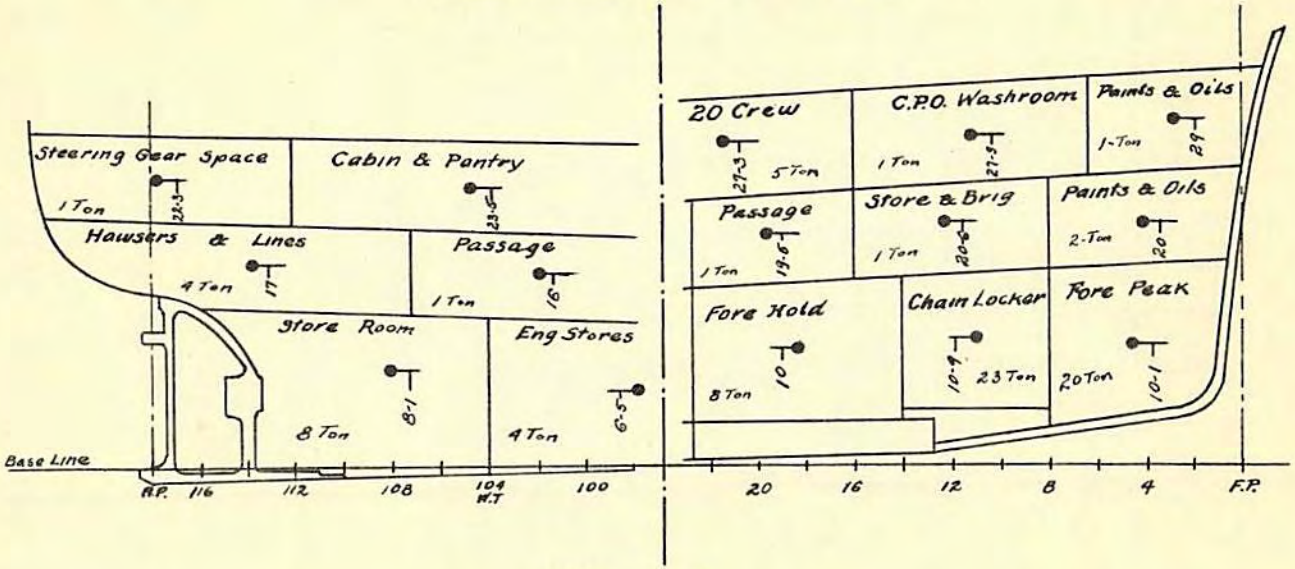
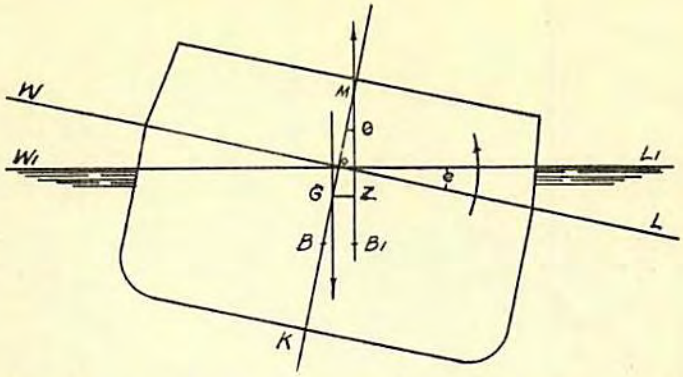
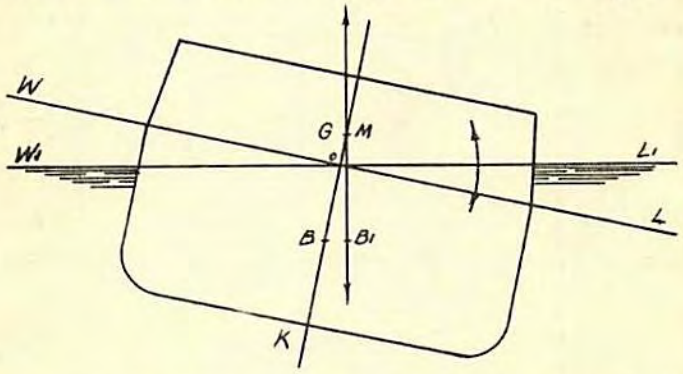


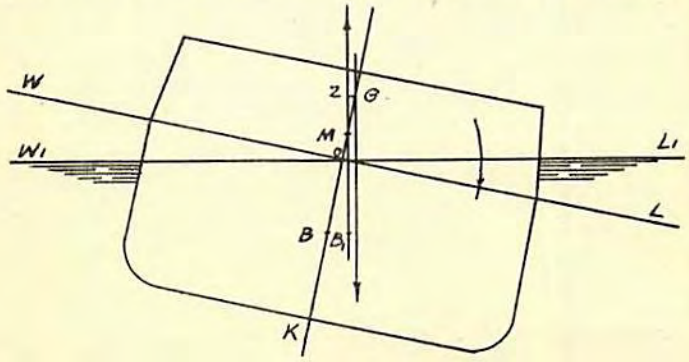
FIG 1



SHIP IN STABLE EQUILIBRIUM Fig 1(a)



SHIP IN NEUTRAL EQUILIBRIUM Fig 1(b)



SHIP IN UNSTABLE EQUILIBRIUM Fig 1(c)

CONDITIONS OF EQUILIBRIUM

From Principles of Naval Architecture & Warship Construction
By MANNING and SCHUMACHER

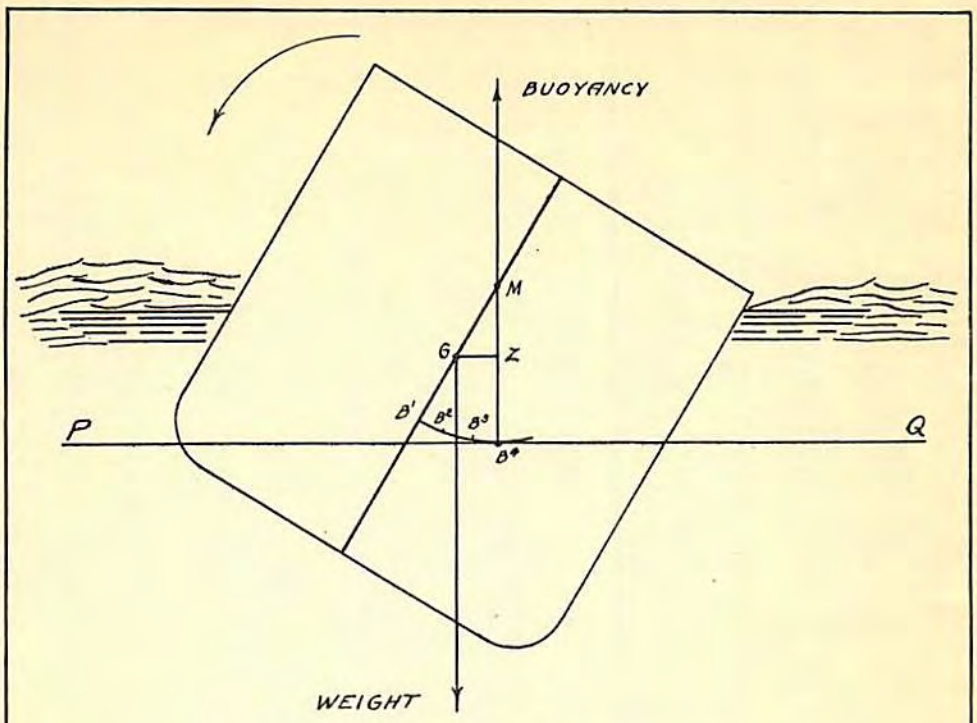
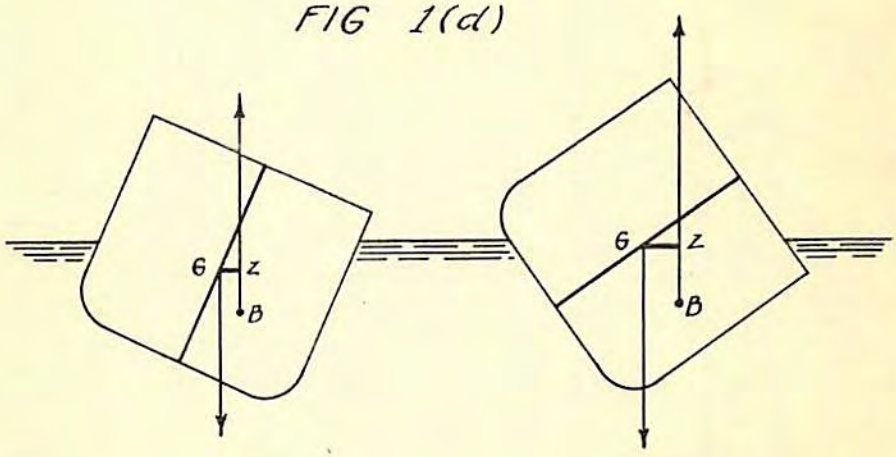


FIG 1(d)



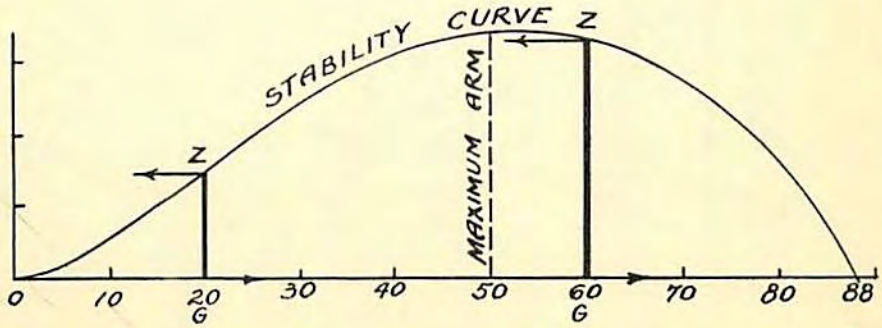


FIG 1 (E)

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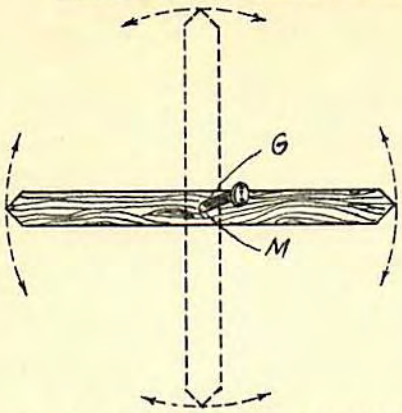
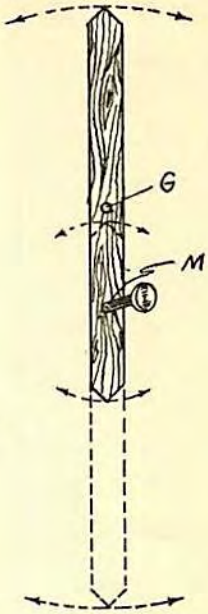
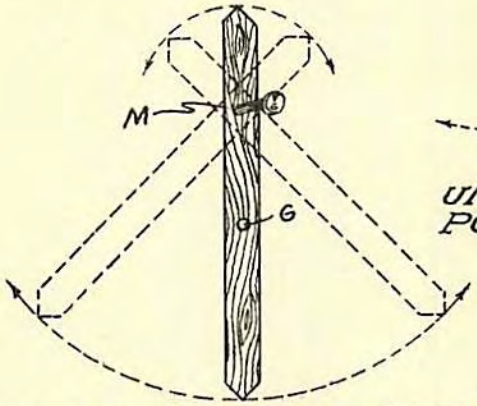
EXPERIMENTAL BOARD



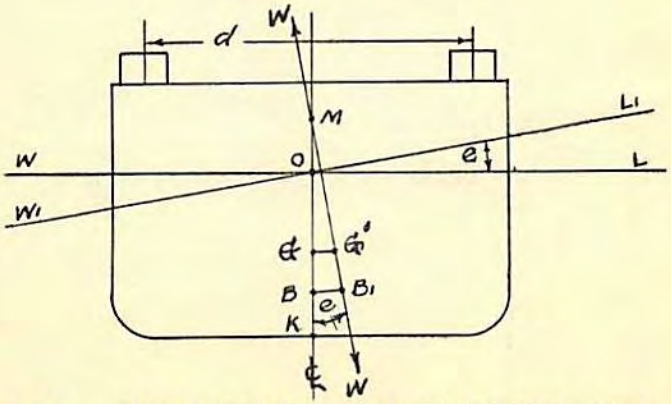
2 (a) NEUTRAL POSITION



2 (b) UNSTABLE POSITION



2 (c) STABLE POSITION



2 (d) INCLINING EXPERIMENT

(2d) Naval Architecture and Warship Construction Manning & Schumacher

STABILITY

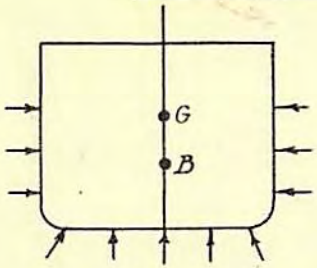


FIG 2

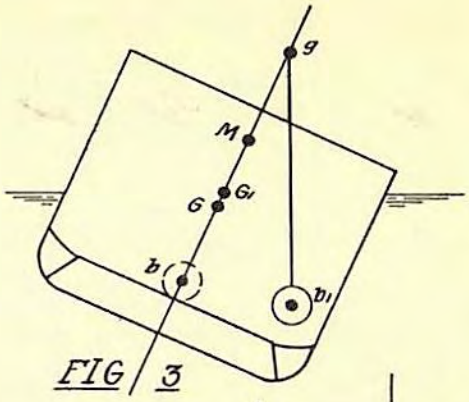


FIG 3

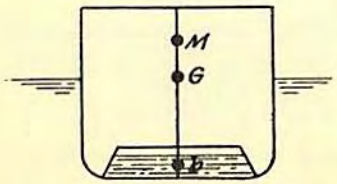


FIG 4

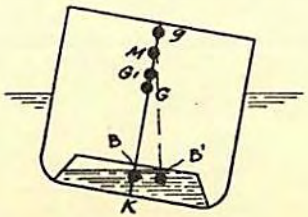


FIG 5

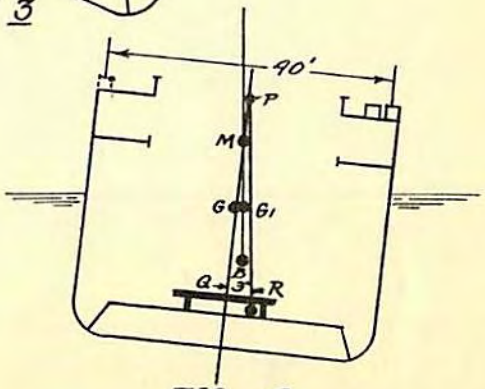


FIG 6

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GENERAL APPLICATION OF MOMENTS

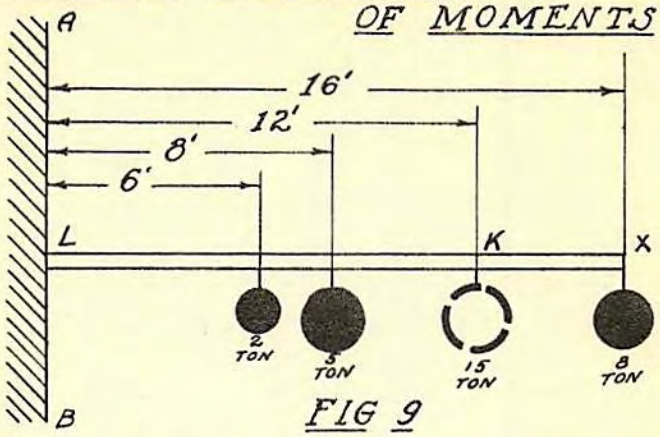

FIG 9

THE COUPLE

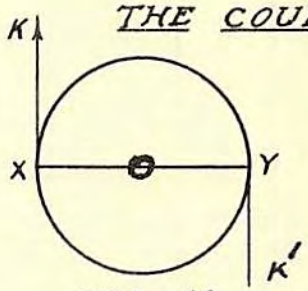

FIG 10

STABILITY

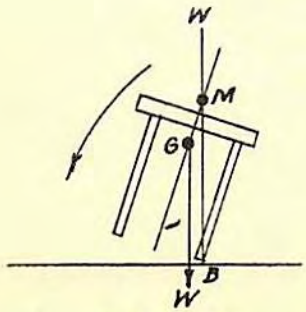

FIG 7

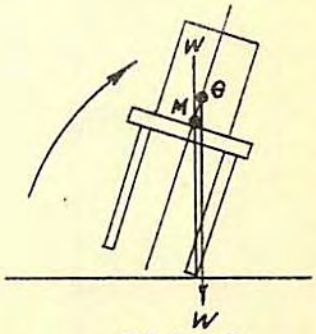

FIG 8

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ASSEMBLY

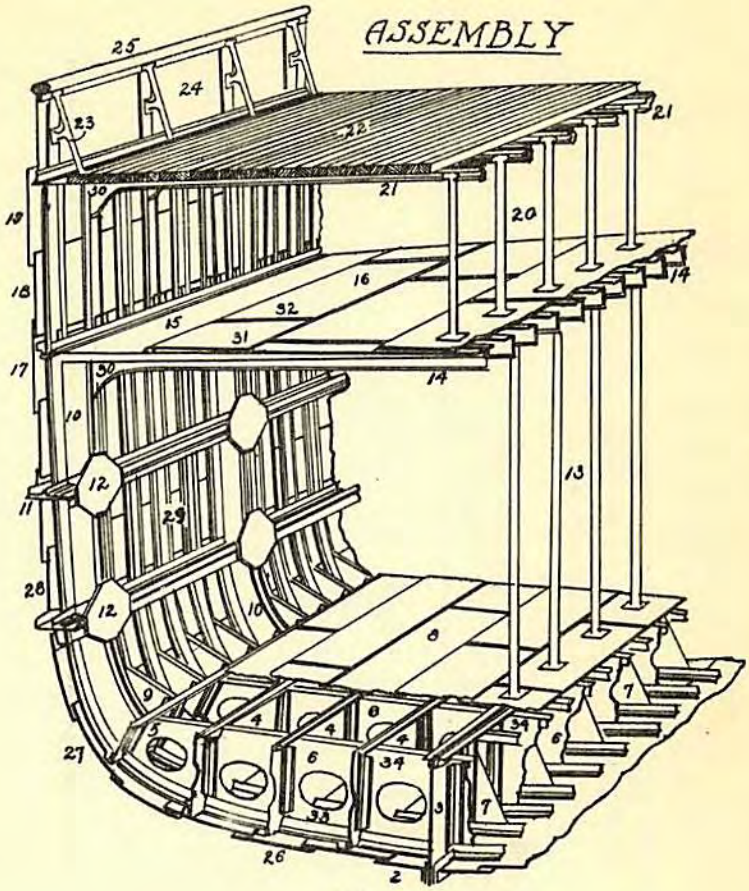

Fig 11

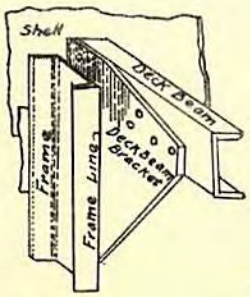

Fig 12

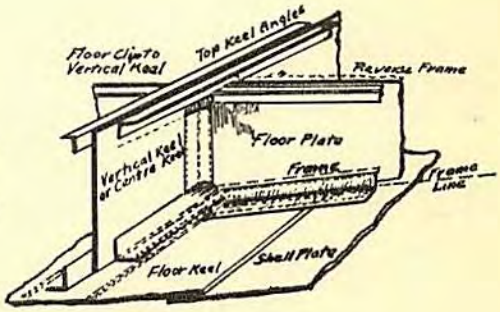

Fig 13

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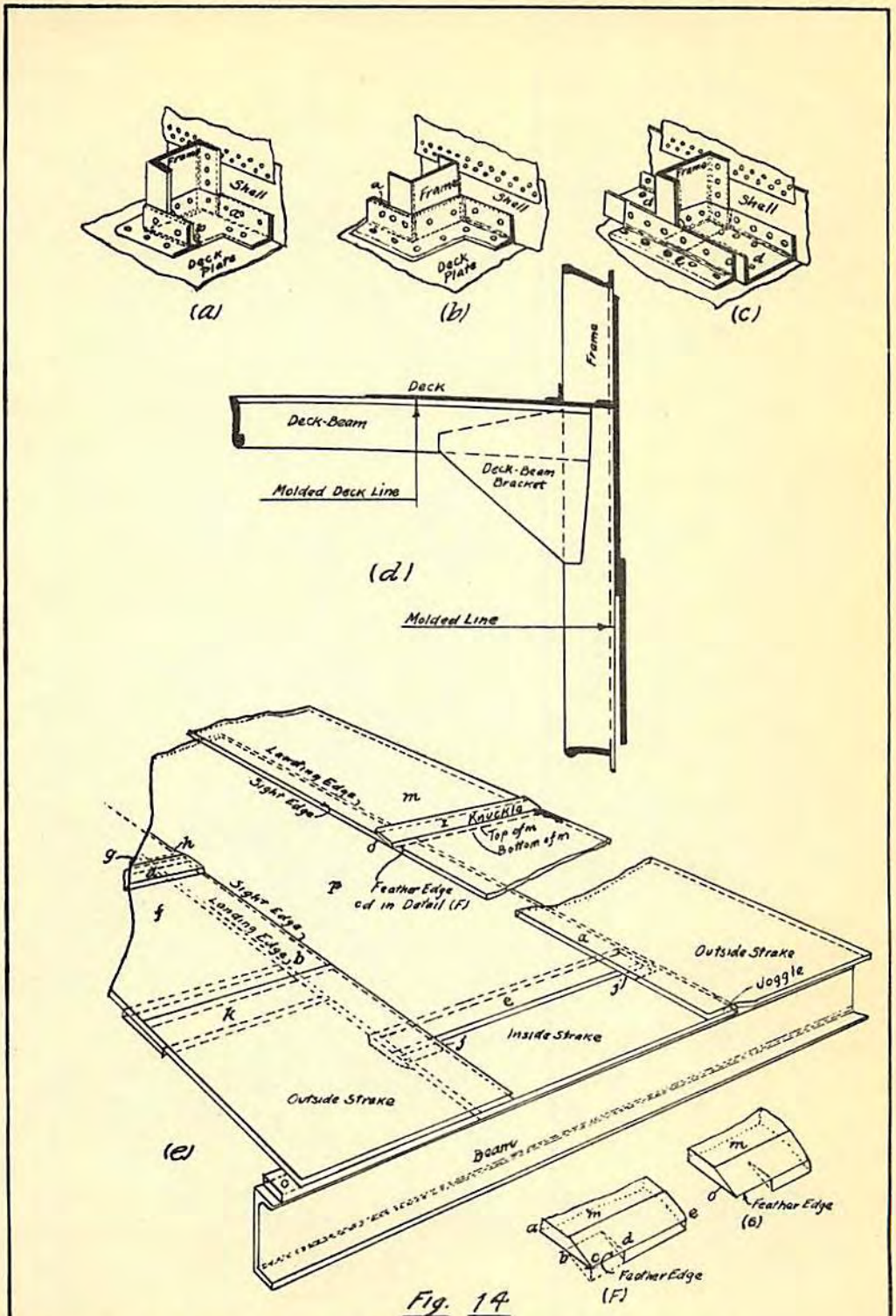

Fig. 14

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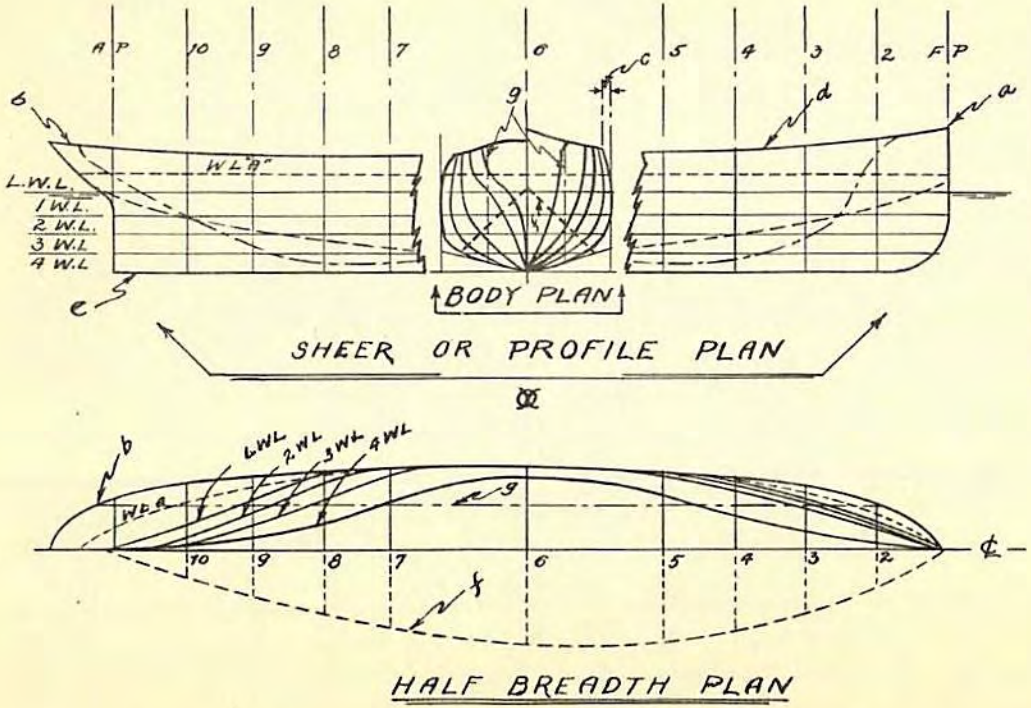
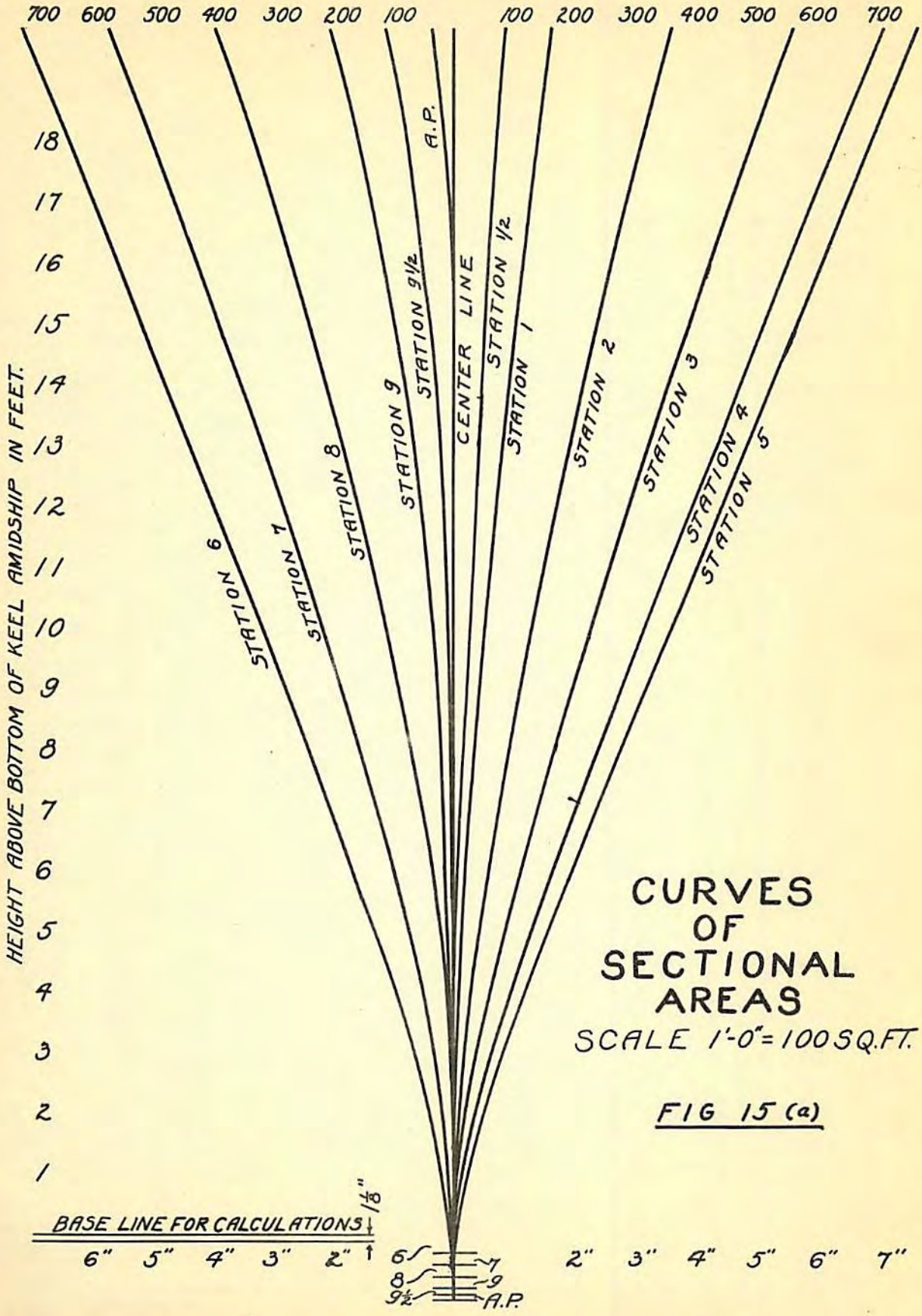


2-10	Stations
FP	Ford Perpendicular
a	Bow
b	Stern
C	Tumble Home
d	Deck at Side
LWL	Load Water Line
⊠	Midship Section
e	Base Line
f	Bilge Diagonal
g	Buttock
℄	Center Line

Fig 15 "LINES" of a ship



CURVES OF SECTIONAL AREAS

SCALE 1'-0" = 100 SQ.FT.

FIG 15 (a)

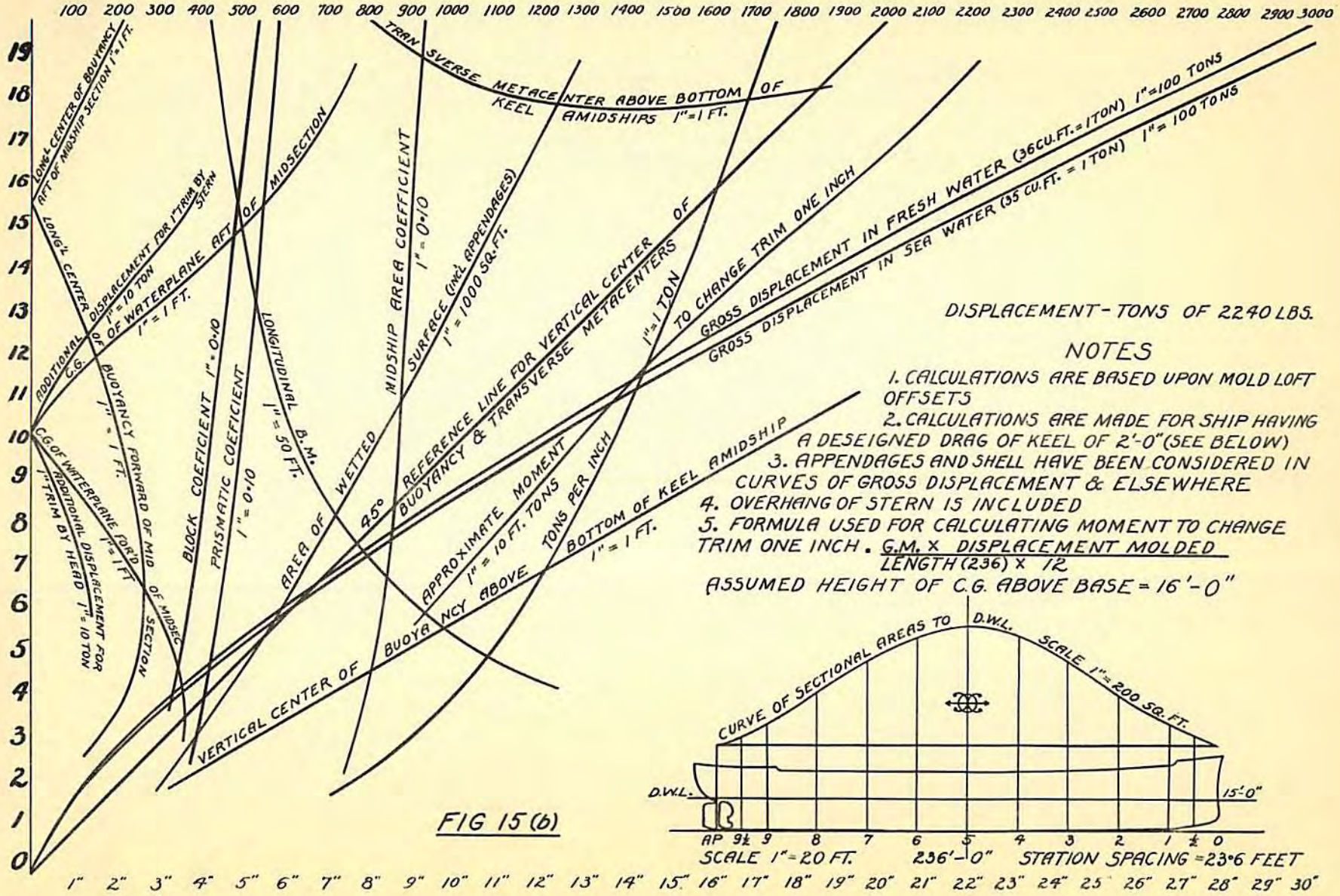

LONG'L CENTER OF BOUYANCY AFT OF MIDSHIP SECTION 1" = 1 FT.
TRANSVERSE METACENTER ABOVE BOTTOM OF KEEL AMIDSHIPS 1" = 1 FT.
LONG'L CENTER OF WATERPLANE AFT OF MIDSECTION
ADDITIONAL DISPLACEMENT FOR 1" TRIM BY STERN 1" = 10 TON
ADDITIONAL C.G. OF WATERPLANE 1" = 1 FT.
BUOYANCY FORWARD OF MID SECTION 1" = 1 FT.
C.G. OF WATERPLANE FOR'D 1" = 1 FT
ADDITIONAL DISPLACEMENT FOR 1" TRIM BY HEAD 1" = 10 TON
BLOCK COEFICIENT 1" = 0.10
PRISMATIC COEFICIENT 1" = 0.10
LONGITUDINAL B.M. 1" = 50 FT.
AREA OF WETTED MIDSHIP AREA COEFFICIENT 1" = 0.10
SURFACE (INCL. APPENDAGES) 1" = 1000 SQ. FT.
45° REFERENCE LINE FOR VERTICAL CENTER OF BUOYANCY & TRANSVERSE METACENTERS
APPROXIMATE MOMENT 1" = 10 FT. TONS
TONS PER INCH 1" = 1 TON
TO CHANGE TRIM ONE INCH
GROSS DISPLACEMENT IN FRESH WATER (36 CU. FT. = 1 TON) 1" = 100 TONS
GROSS DISPLACEMENT IN SEA WATER (35 CU. FT. = 1 TON) 1" = 100 TONS
VERTICAL CENTER OF BUOYANCY ABOVE BOTTOM OF KEEL AMIDSHIP 1" = 1 FT.
DISPLACEMENT - TONS OF 2240 LBS.
NOTES
1. CALCULATIONS ARE BASED UPON MOLD LOFT OFFSETS
2. CALCULATIONS ARE MADE FOR SHIP HAVING A DESEIGNED DRAG OF KEEL OF 2'-0" (SEE BELOW)
3. APPENDAGES AND SHELL HAVE BEEN CONSIDERED IN CURVES OF GROSS DISPLACEMENT & ELSEWHERE
4. OVERHANG OF STERN IS INCLUDED
5. FORMULA USED FOR CALCULATING MOMENT TO CHANGE TRIM ONE INCH. G.M. X DISPLACEMENT MOLDED / LENGTH (236) X 12
ASSUMED HEIGHT OF C.G. ABOVE BASE = 16'-0"
CURVE OF SECTIONAL AREAS TO D.W.L. SCALE 1" = 200 SQ. FT.
D.W.L.
15'-0"
AP 9½ 9 8 7 6 5 4 3 2 1 ½ 0
SCALE 1" = 20 FT. 236'-0" STATION SPACING = 23.6 FEET

FIG 15 (b)

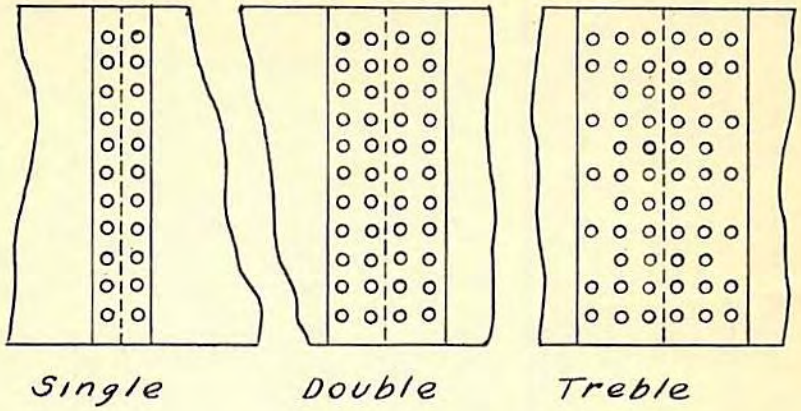


Fig 16 BUTT STRAP CHAIN RIVETED

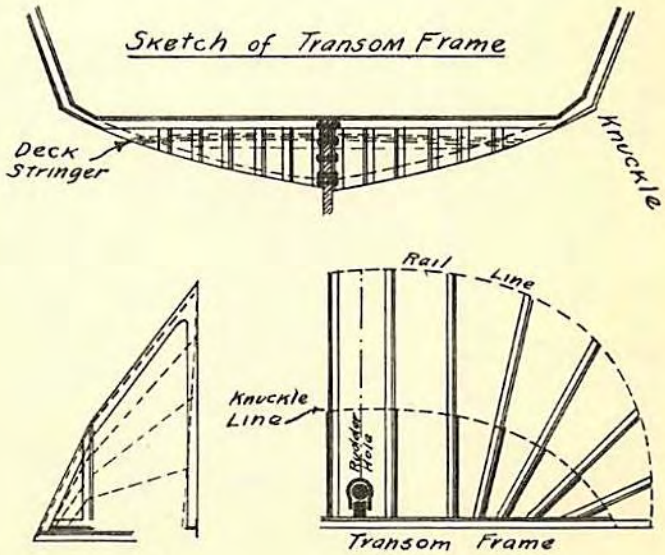


Fig 17 STERN FRAMING

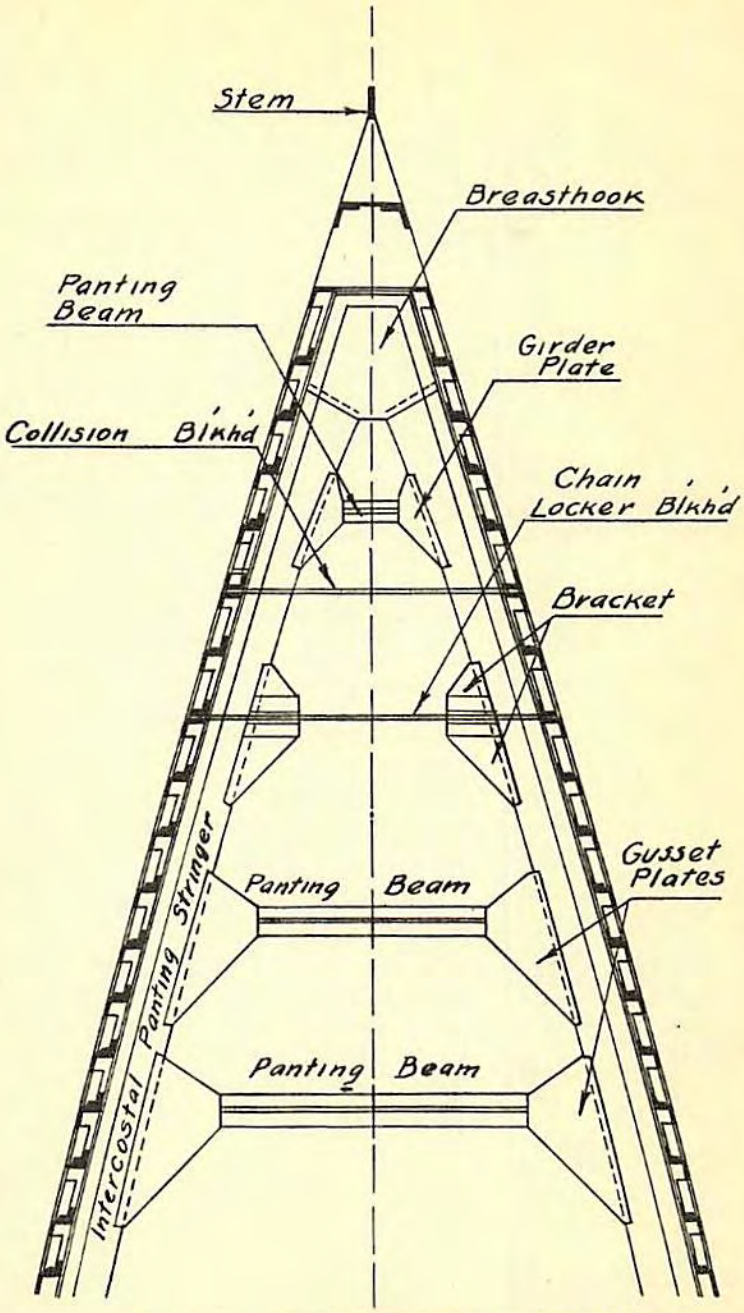


Fig 18 STRUCTURAL BRACING

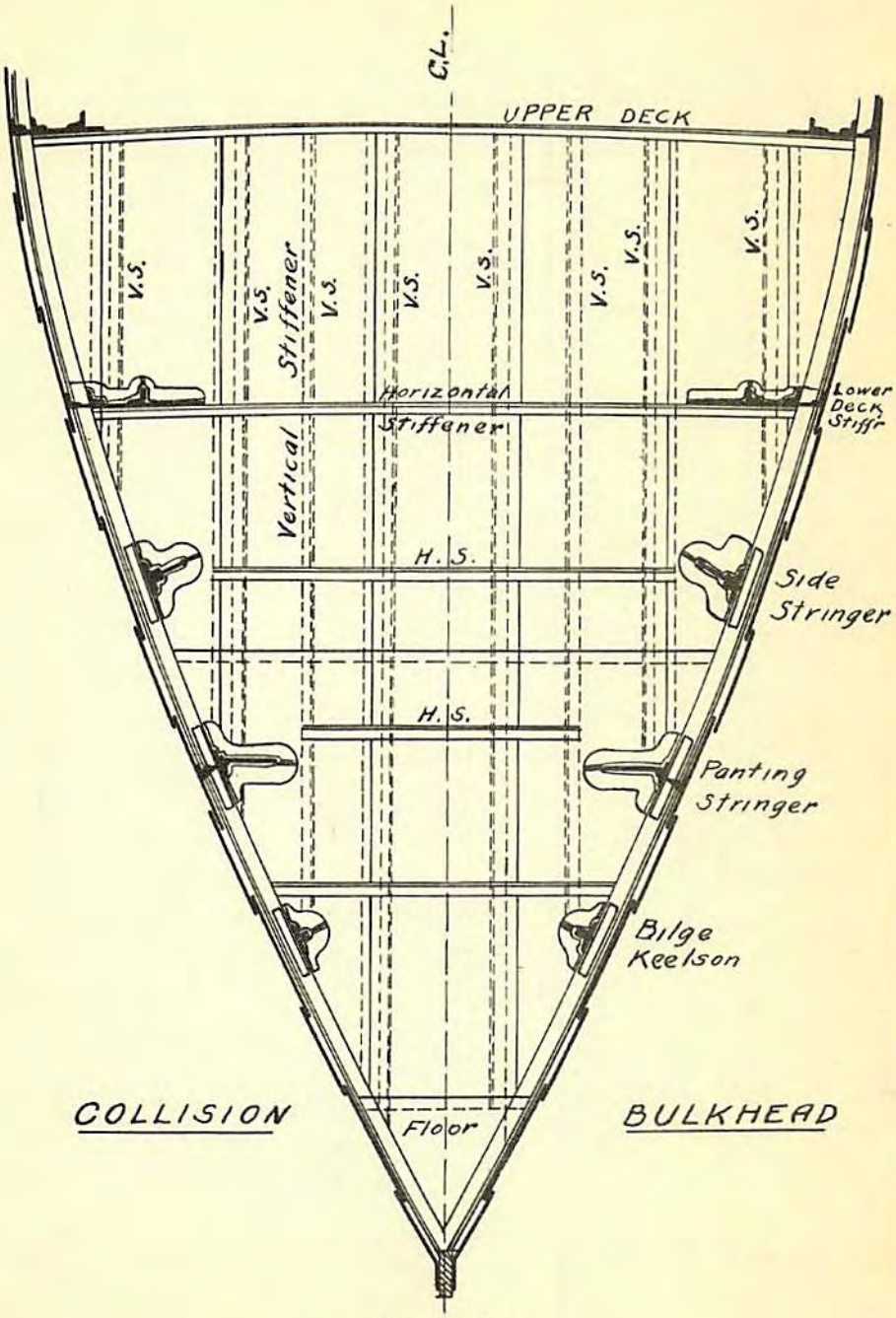

C.L.
UPPER DECK
V.S.
V.S.
Vertical Stiffener
V.S.
V.S.
V.S.
V.S.
V.S.
V.S.
Horizontal Stiffener
Lower Deck Stiffr
H.S.
Side Stringer
H.S.
Panting Stringer
Bilge Keelson
COLLISION
Floor
BULKHEAD

Fig 19

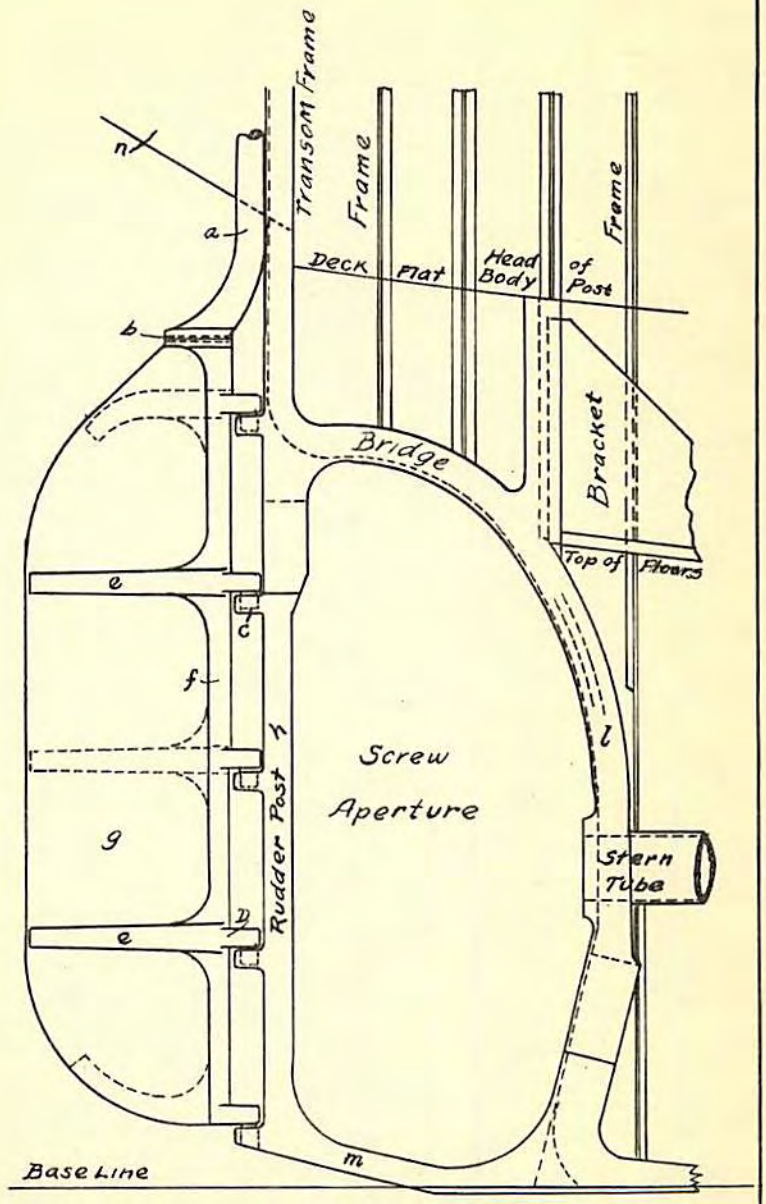


Fig. 20

STERN FRAME, RUDDER, ETC.

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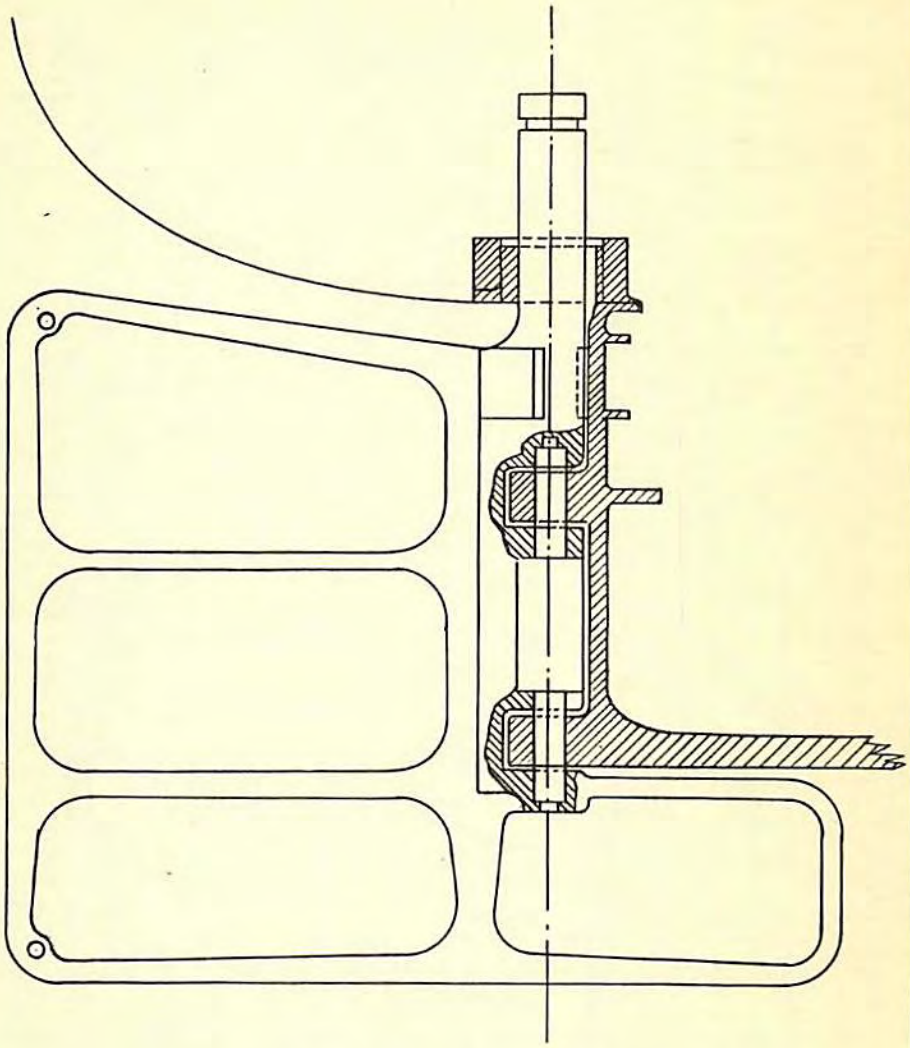


BALANCED RUDDER

FIG. 20(a)

From Hand Book of Ship Calculations, Construction and Operations
By Chas. H. Hughes: D-Appleton-Century Co. Publishers.

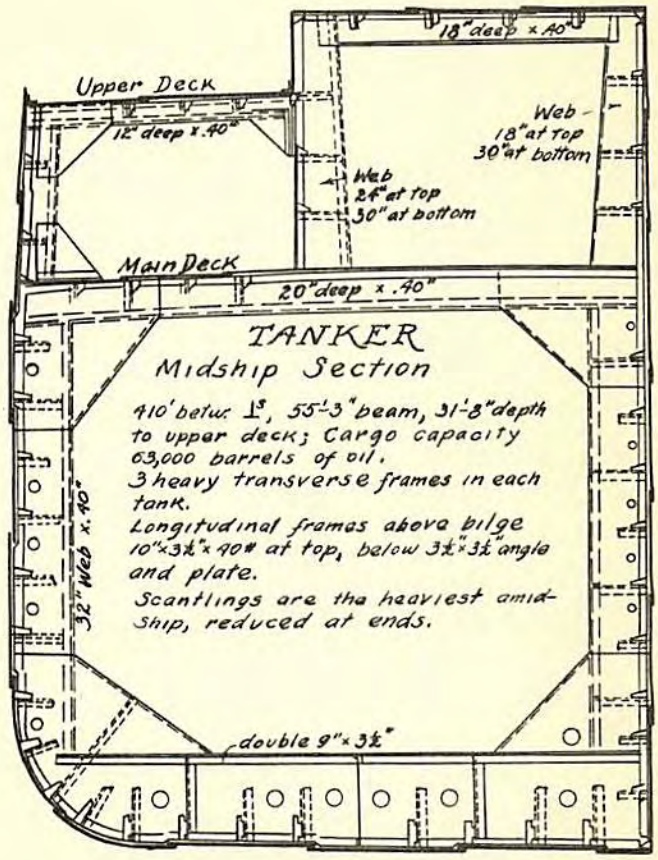


Fig 21

LONGITUDINAL
Or
ISHERWOOD
SYSTEM

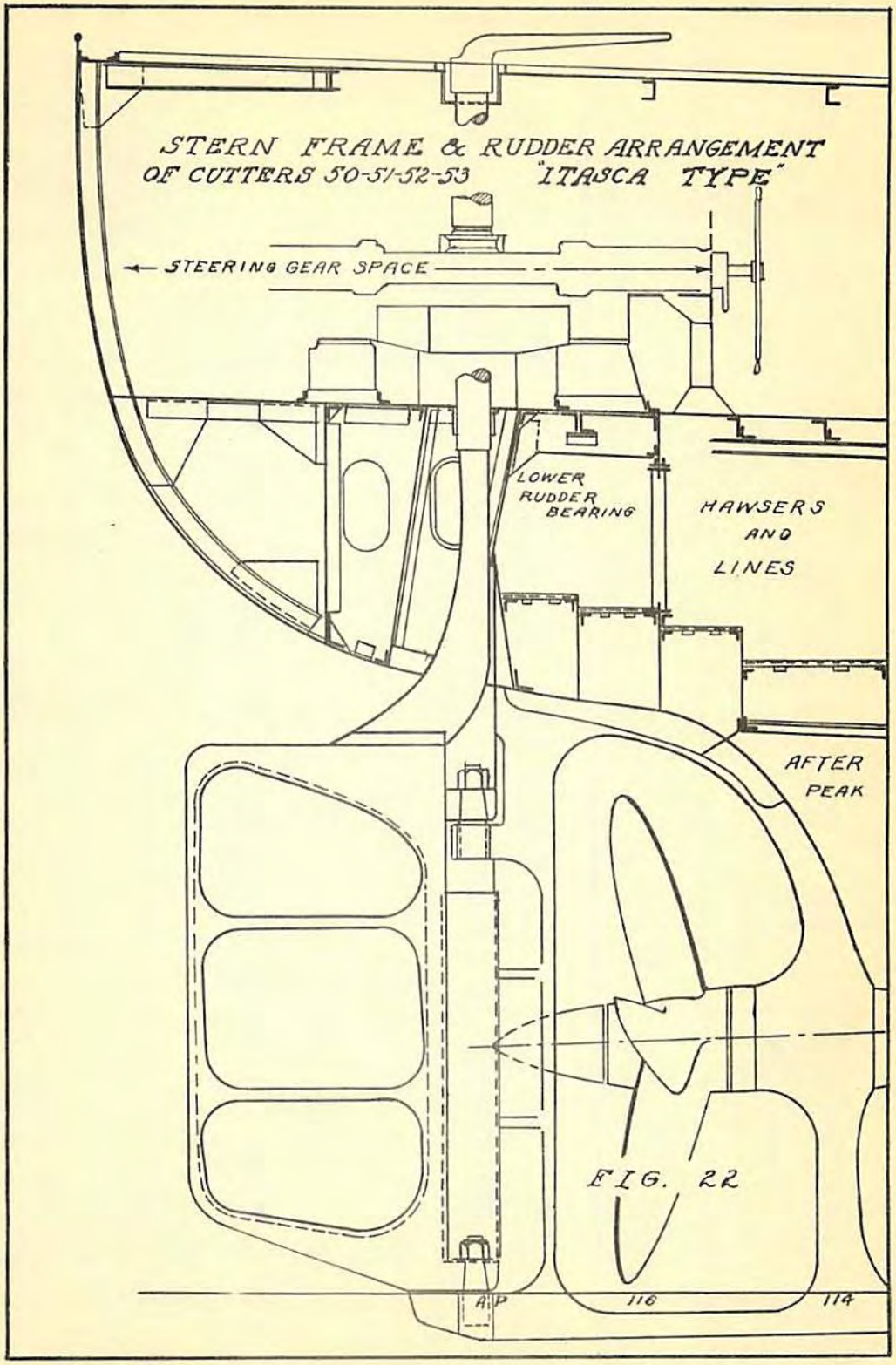

STERN FRAME & RUDDER ARRANGEMENT
OF CUTTERS 50-51-52-53 "ITASCA TYPE"
STEERING GEAR SPACE
LOWER RUDDER BEARING
HAWSERS AND LINES
AFTER PEAK
A.P.
116
114

FIG. 22

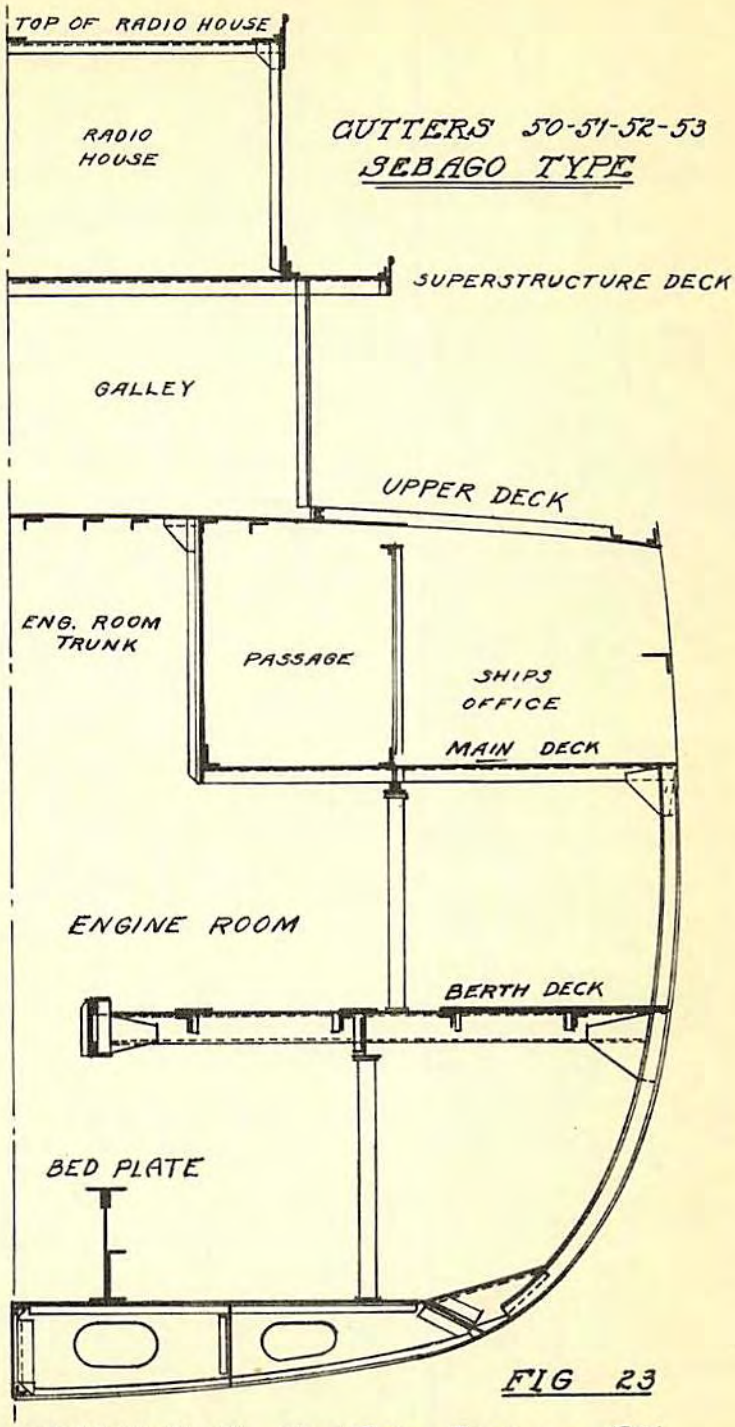
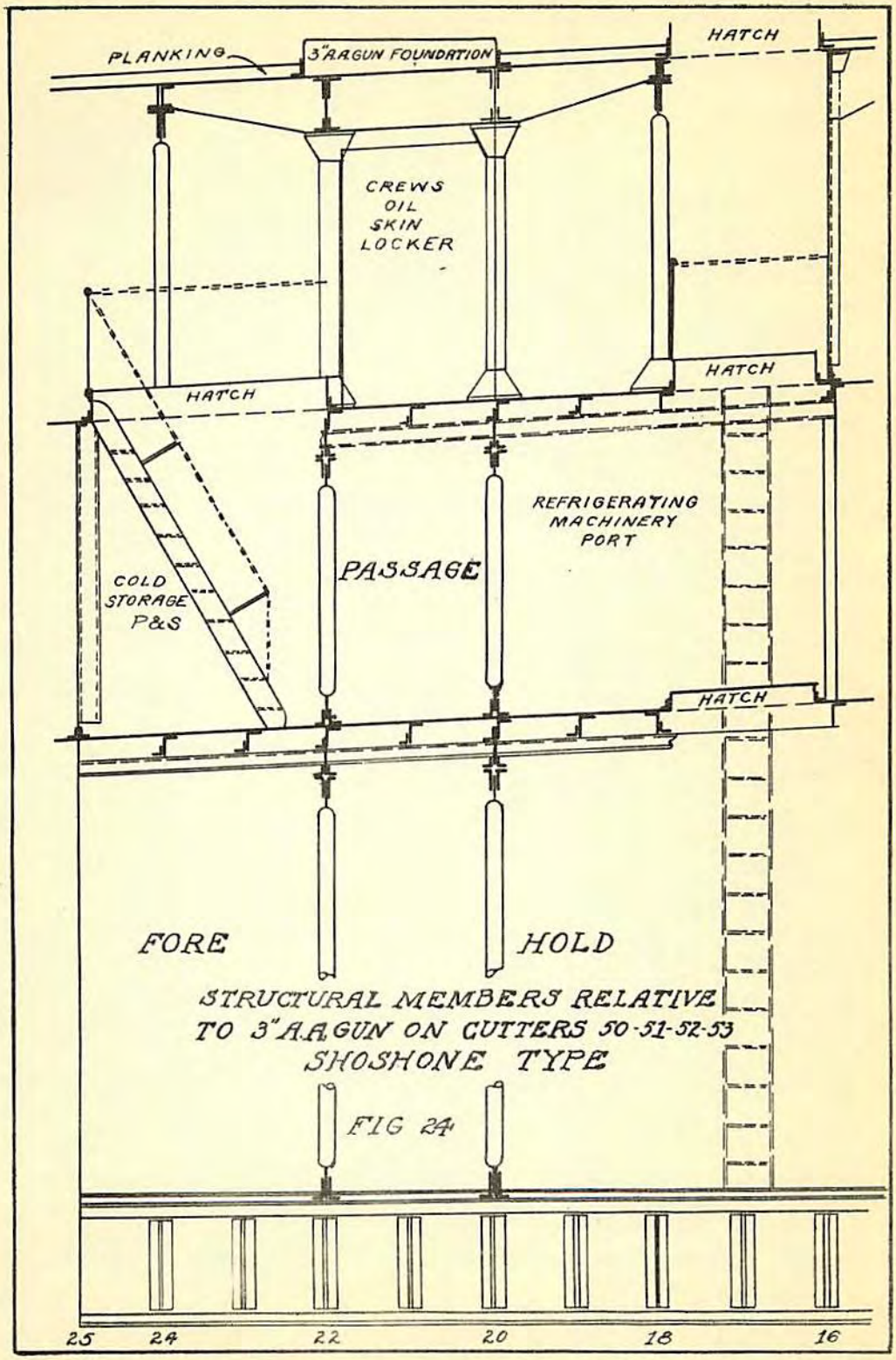


FIG 23

FRAME NO 67 Port Side Looking Aft.



STRUCTURAL MEMBERS RELATIVE
TO 3"AAGUN ON CUTTERS 50-51-52-53
SHOSHONE TYPE

FIG 24

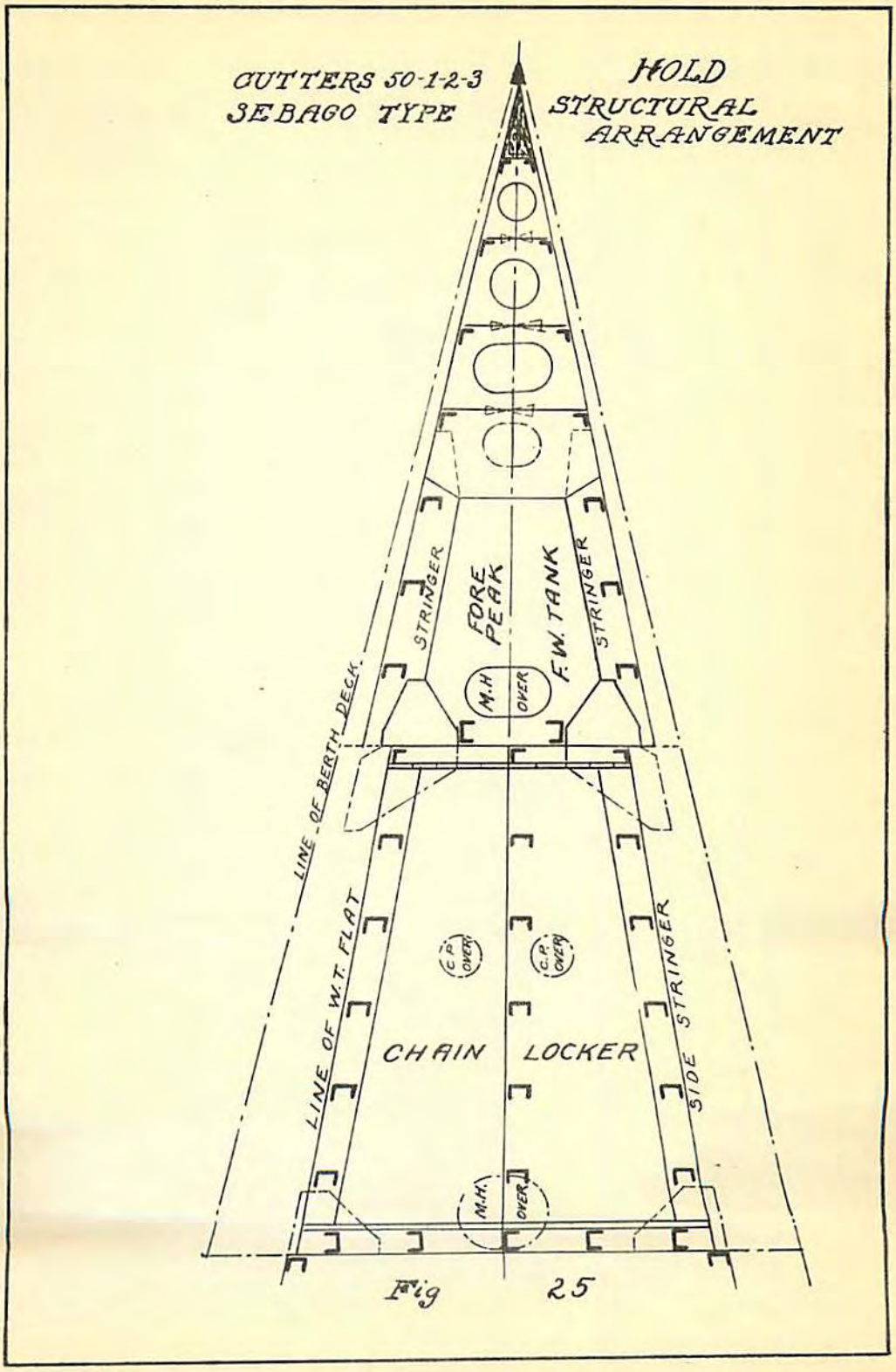

CUTTERS 50-1-2-3
SEBAGO TYPE
HOLD
STRUCTURAL
ARRANGEMENT
FORE PEAK
F.W. TANK
STRINGER
STRINGER
M.H.
OVER
LINE OF BERTH DECK
LINE OF W.T. FLAT
C.P. OVER
C.P. OVER
CHAIN LOCKER
SIDE STRINGER
M.H.
OVER

Fig 25

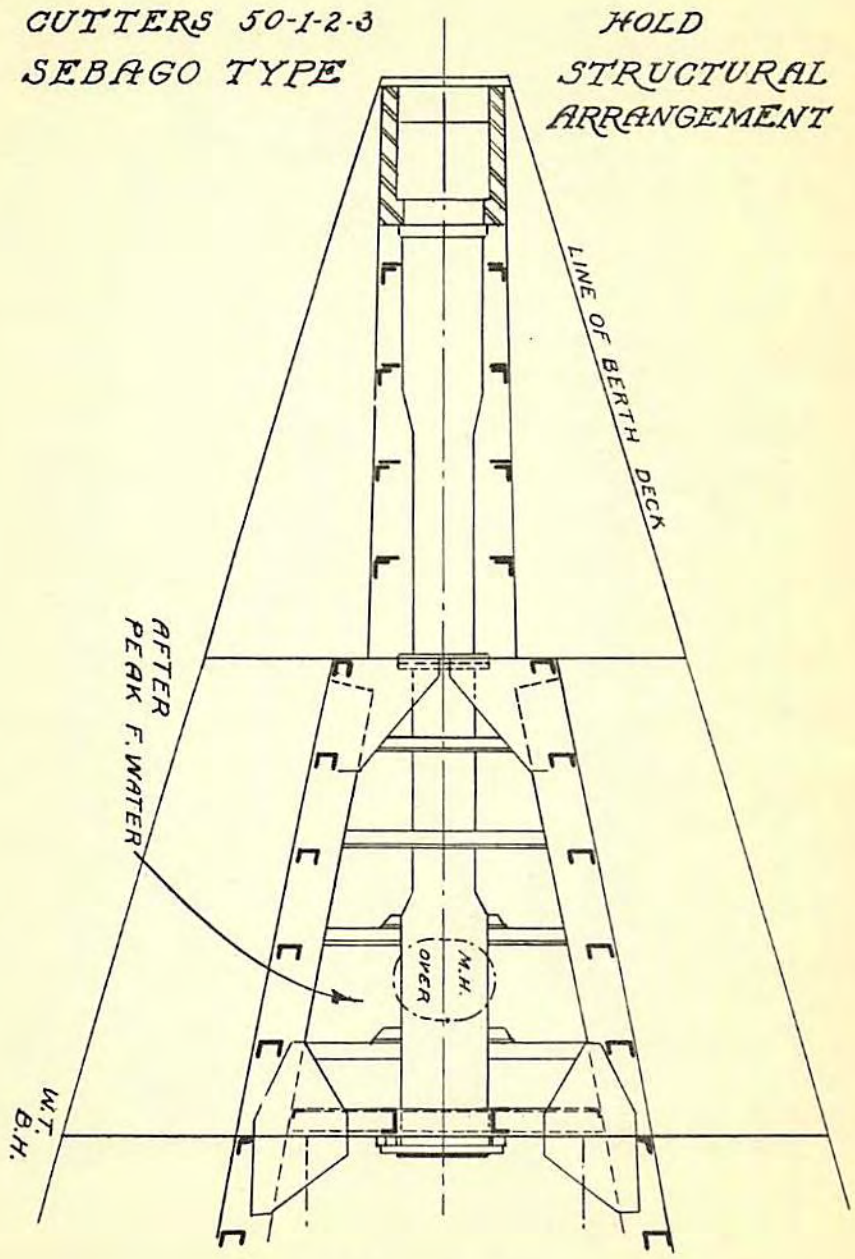
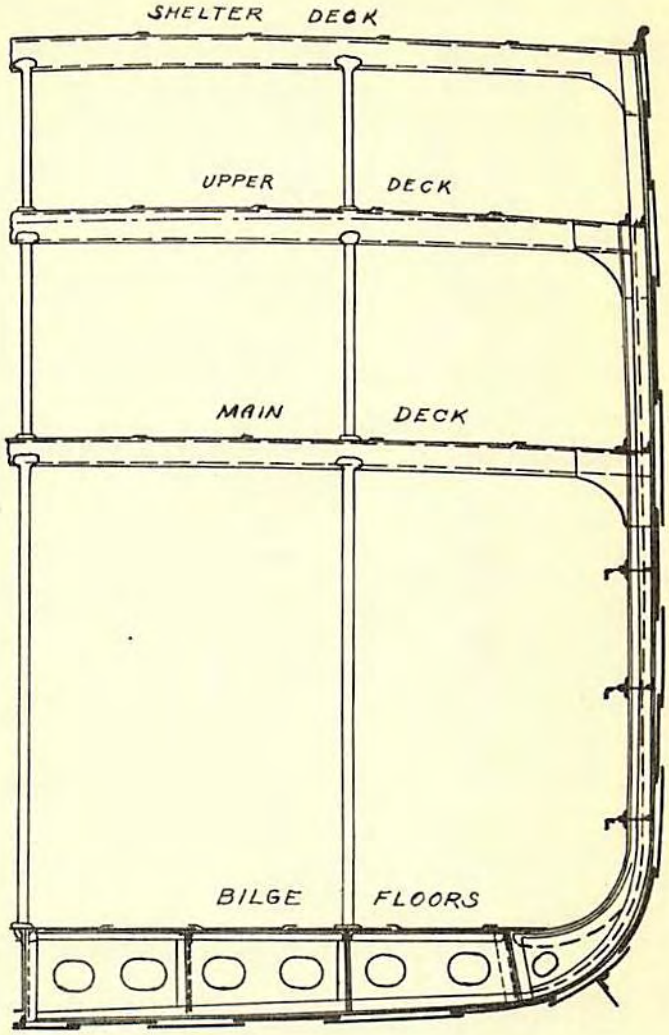

CUTTERS 50-1-2-3
SEBAGO TYPE
HOLD
STRUCTURAL
ARRANGEMENT
LINE OF BERTH DECK
AFTER
PEAK F. WATER
M.H.
OVER
W.T.
B.H.

Fig 26

MIDSHIP SECTION



TRANSVERSE SYSTEM

Fig 21.

From Hand Book of Ship Calculations Construction and Operation
By Chas. H. Hughes: D-Appleton-Century Co. Publishers.

STANDARD COLORS FOR PIPING		
SERVICE		COLORS
AIR	COMPRESSED	1 YELLOW BAND
	VENTILATION	2 YELLOW BANDS
FIRE EXTINGUISHING OTHER THAN WATER	ALL REGARDLESS OF CHEMICAL USE	1 BROWN BAND
HYDRAULIC	POWER	1 BLUE BAND
	CONTROL	2 BLUE BANDS
OIL	FUEL	1 RED BAND
	GASOLINE	2 RED BANDS
	LUBRICATING	3 RED BANDS
STEAM	SUPPLY	1 BLACK BAND
	EXHAUST	2 BLACK BANDS
WATER	ORDINANCE AND DRAINS	1 GREEN BAND
	FIRE	2 GREEN BANDS
	FLUSHING FLOODING, SPRINKLING + CIRCULATING	3 GREEN BANDS
	FRESH WATER	4 GREEN BANDS
	BRINE	5 GREEN BANDS

NOTES:

1. Identification striping shall be painted on the piping as a circumferential band or bands and of the color, width and in number as indicated above.

2. The bands shall be painted in conspicuous locations and at suitable intervals so that the lead of the piping may be easily followed.

3. Each pipe shall have at least one striping designation in each compartment through which it passes.

4. Identification bands shall not be placed on flanges, fittings or valves.

5. Pipes in cabins, officers' wardroom and messrooms, and in warrant officers' messrooms shall not be striped.

6. The body of pipes shall be painted the same color as that of the adjacent bulkheads and decks.

7. Galvanized metal pipe lagging shall not be painted or striped.

Fig 28

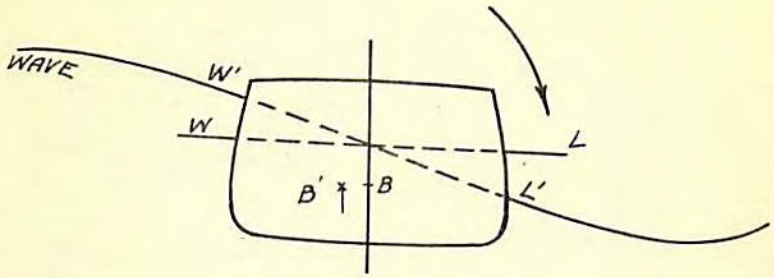


Fig 29

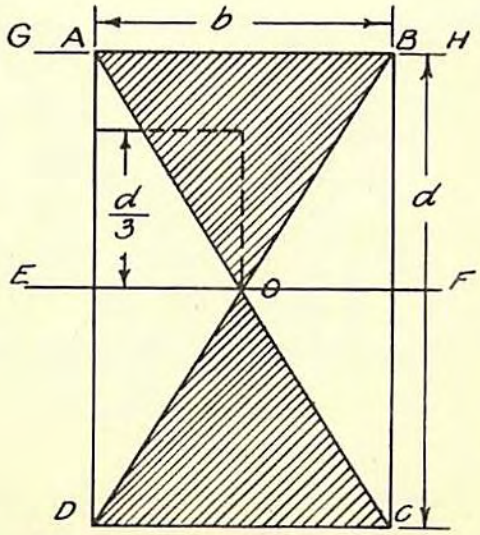


Fig 30

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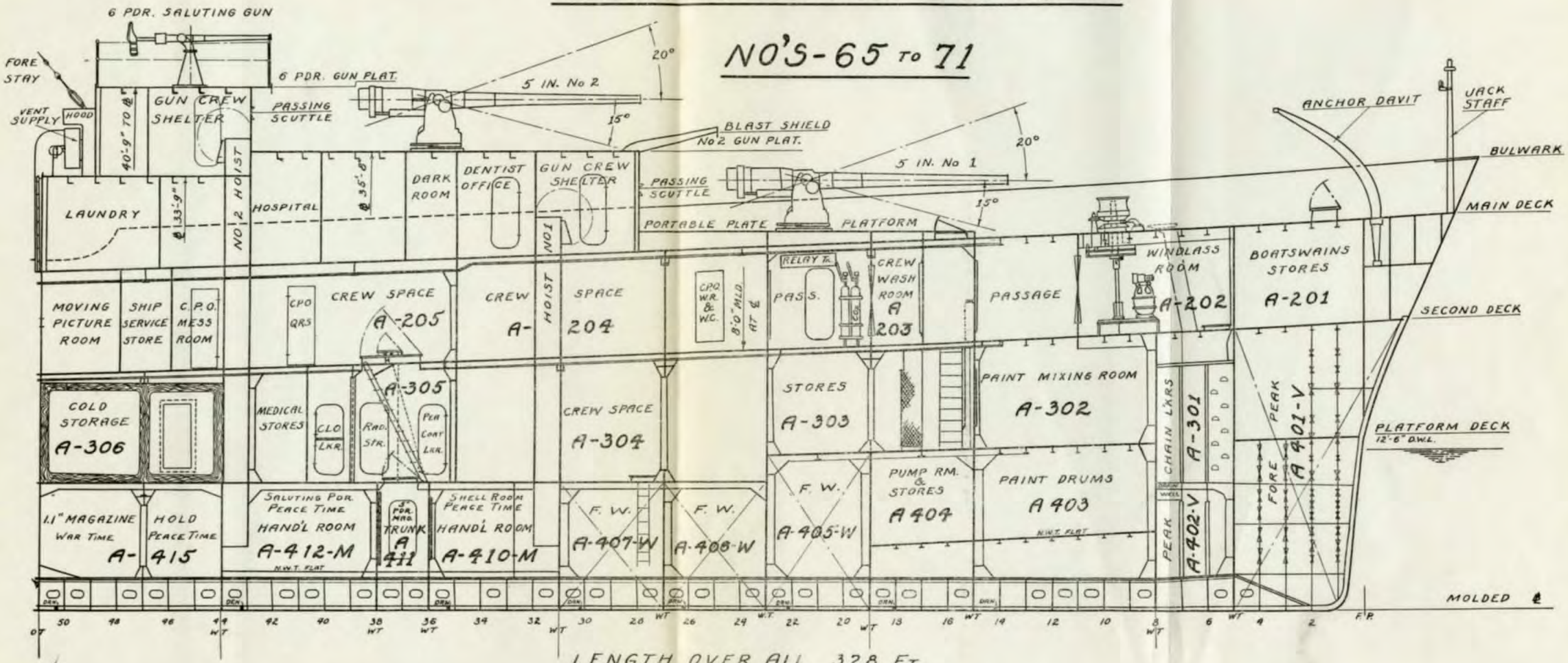
FORWARD SECTION INBOARD PROFILE

U.S. COAST GUARD CUTTERS

NO'S-65 TO 71



LENGTH OVER ALL 328 FT.

•PLATE NO 40-A

6575—36 No. 1

MIDDLE SECTION INBOARD PROFILE

U.S. COAST GUARD CUTTERS

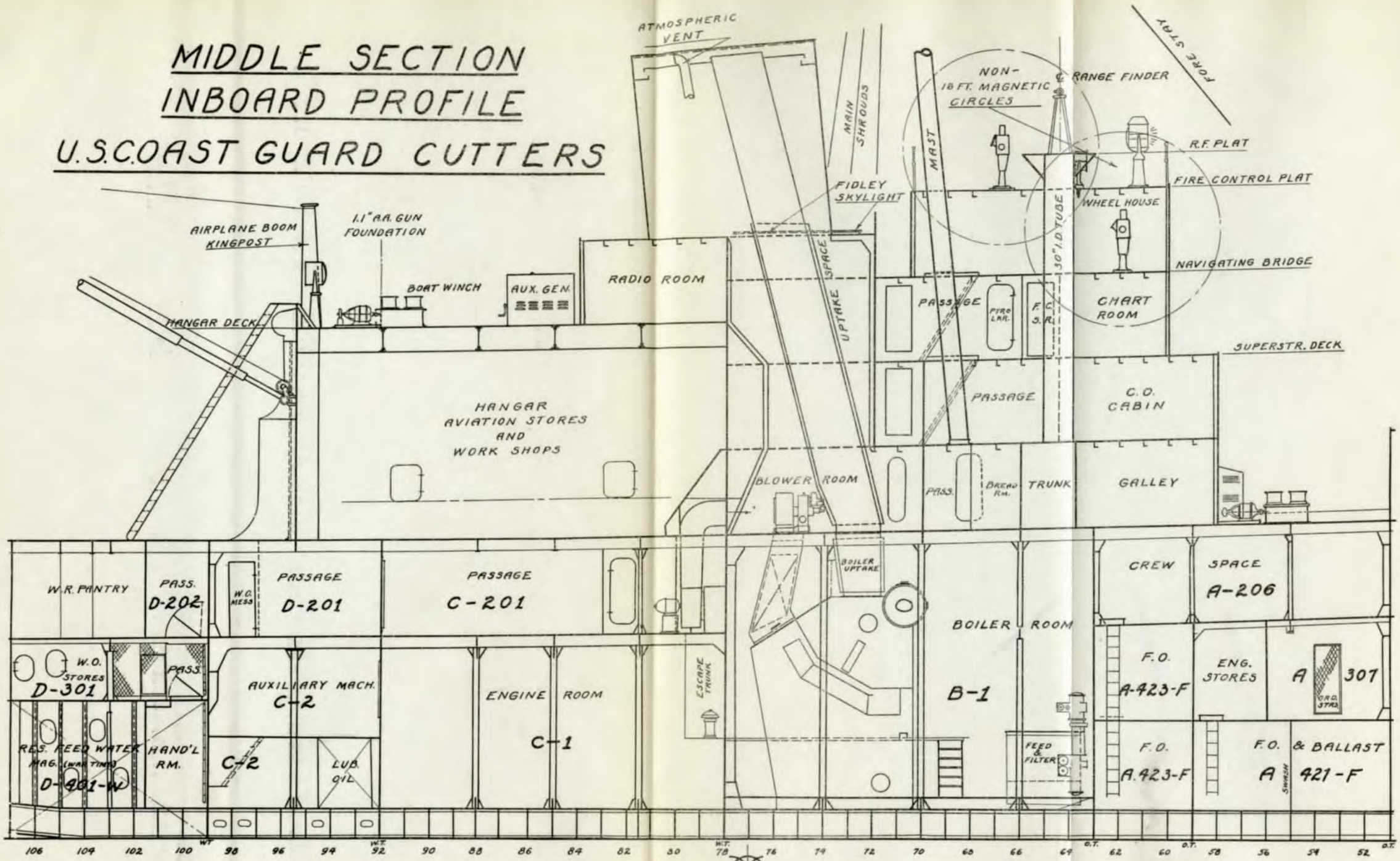


PLATE NO 40-B

LENGTH OVER ALL 328 FT.

AFTER SECTION INBOARD PROFILE

328 FT. U.S. COAST GUARD CUTTERS

NO'S-65 TO 71

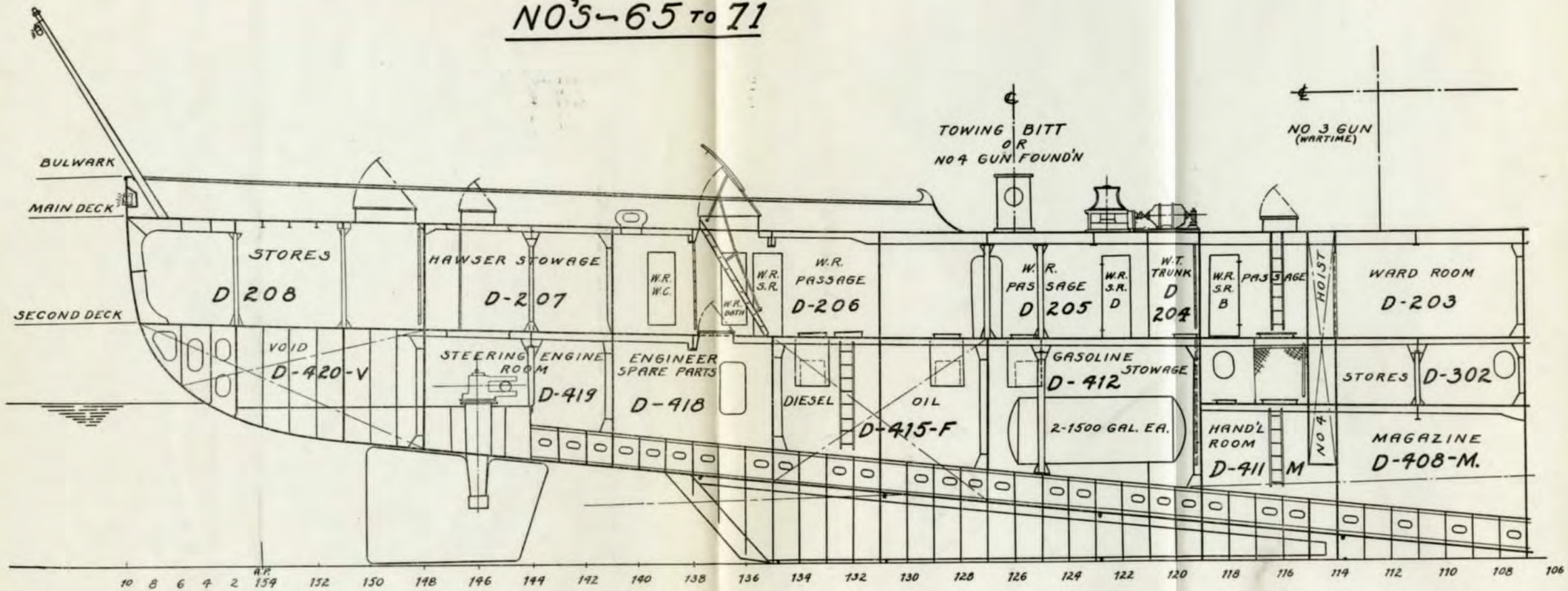
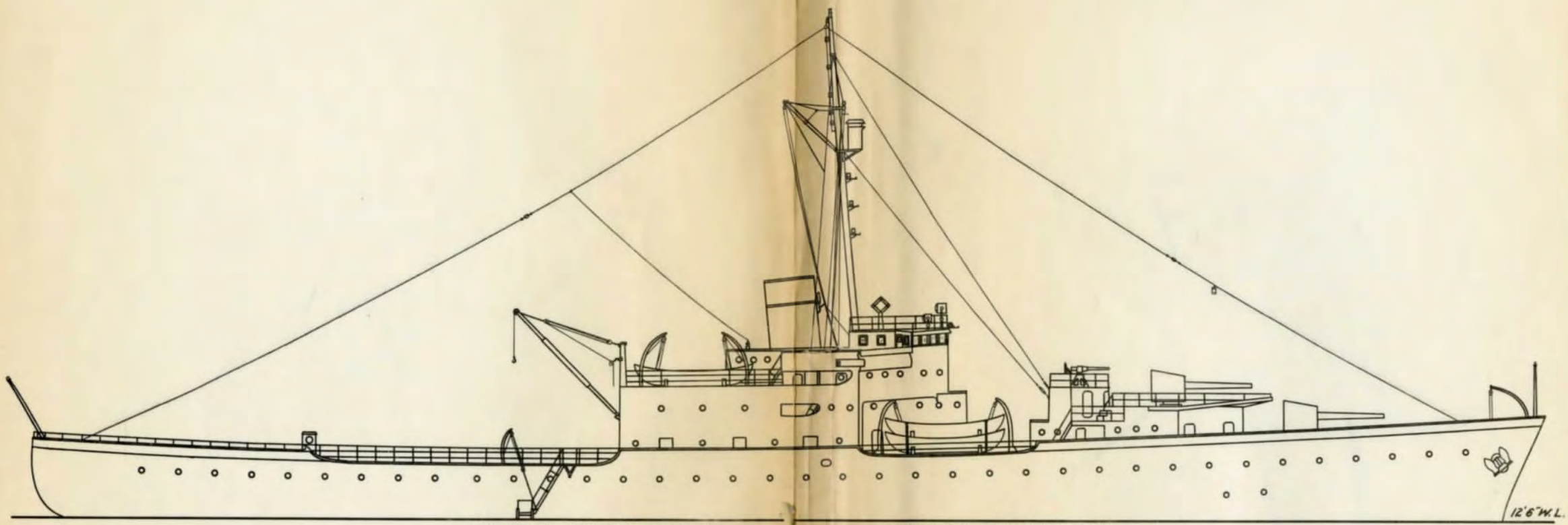


PLATE NO 40-C

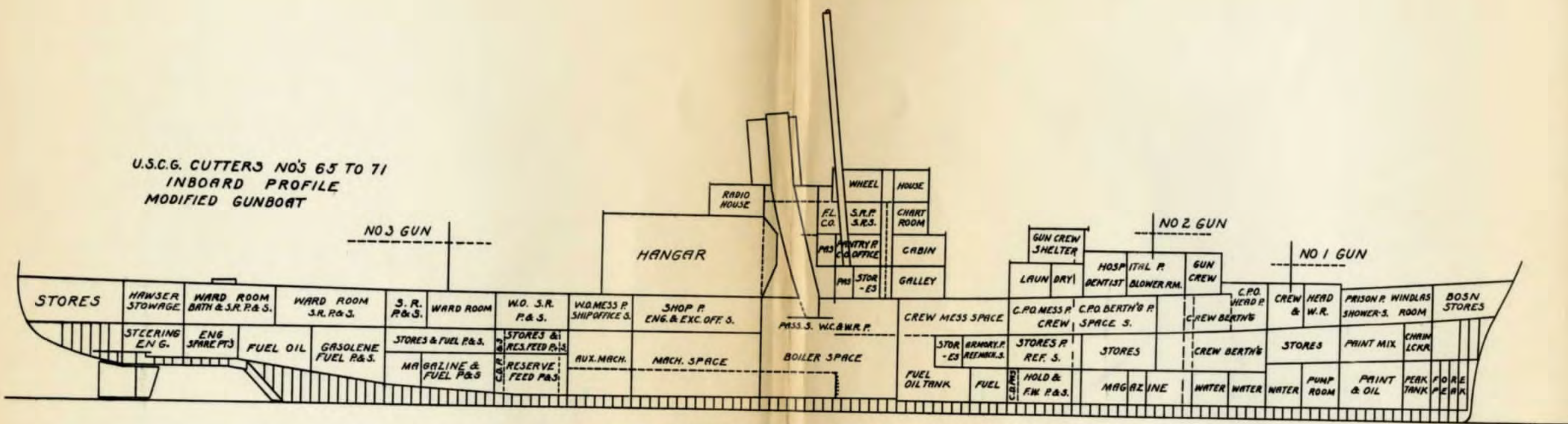
6575—36 No. 3



328 FOOT U.S.C.G. CUTTER MODIFIED GUNBOAT TYPE

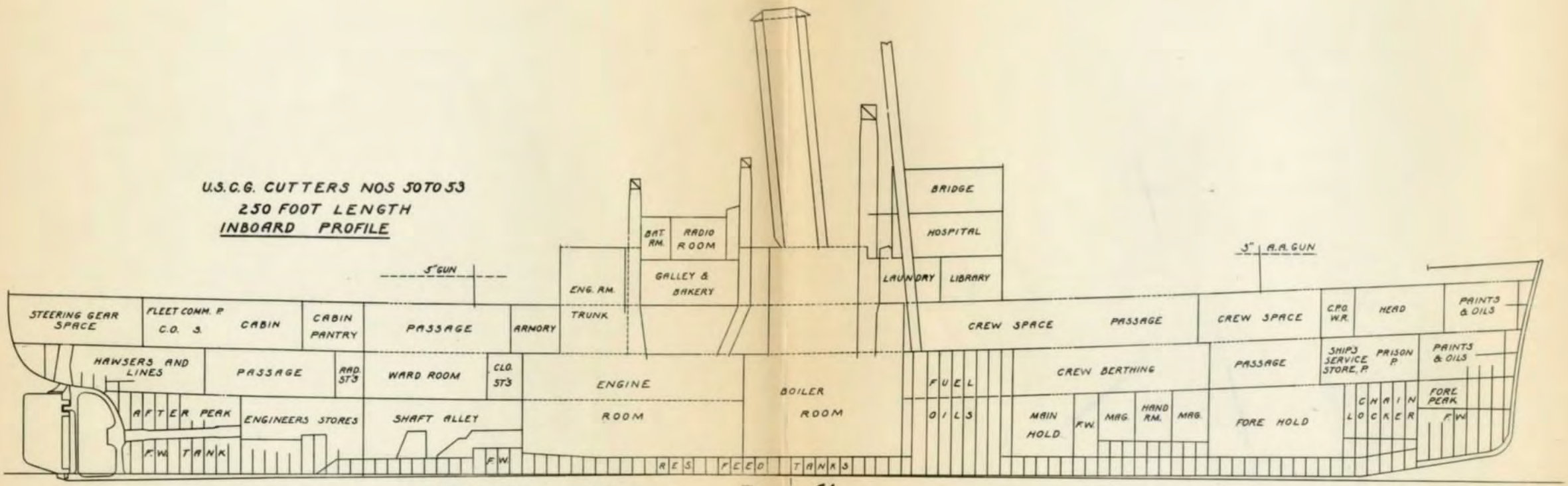
FIG. 39 TENTATIVE OUTBOARD PROFILE

U.S.C.G. CUTTERS NO'S 65 TO 71
INBOARD PROFILE
MODIFIED GUNBOAT



TENTATIVE PLAN FOR
328 FOOT CUTTERS
Fig. 40

U.S.C.G. CUTTERS NOS 50 TO 53
250 FOOT LENGTH
INBOARD PROFILE



LAKE TYPE CUTTER Fig. 41

U.S.C.G. CUTTERS NOS 36 TO 39
INBOARD PROFILE
MOJAVE TYPE
240 FOOT CUTTERS

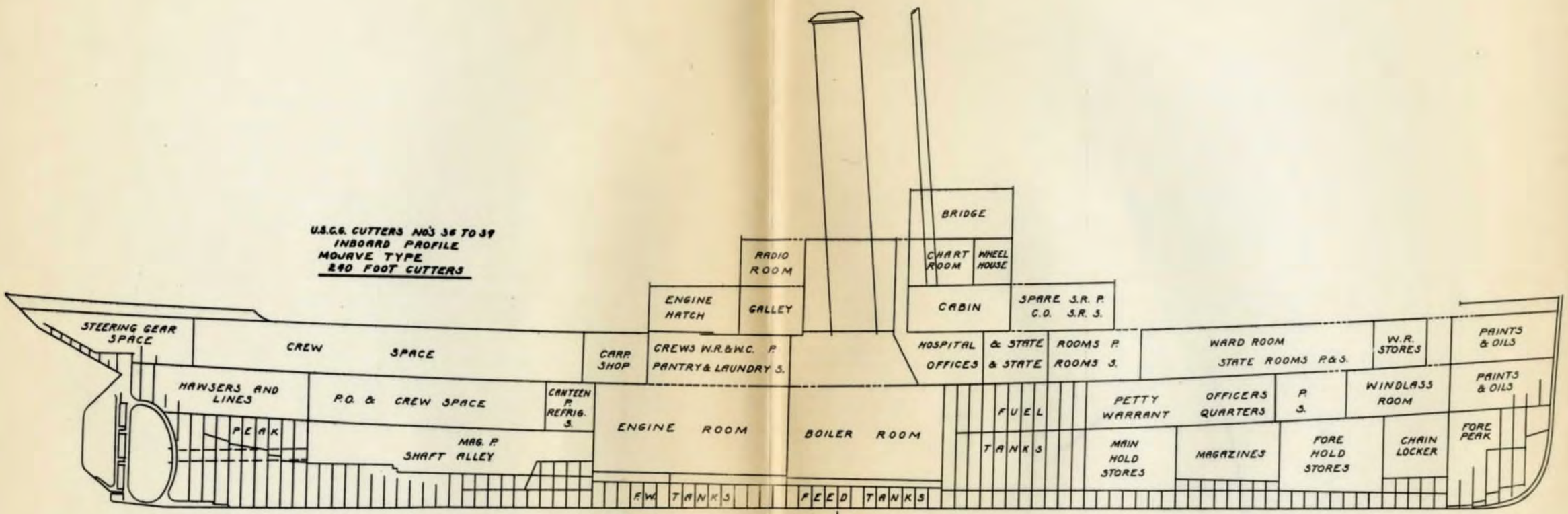


Fig. 42

U.S.C.G. CUTTERS
165 FOOT LENGTH
ESCANABA TYPE
INBOARD PROFILE

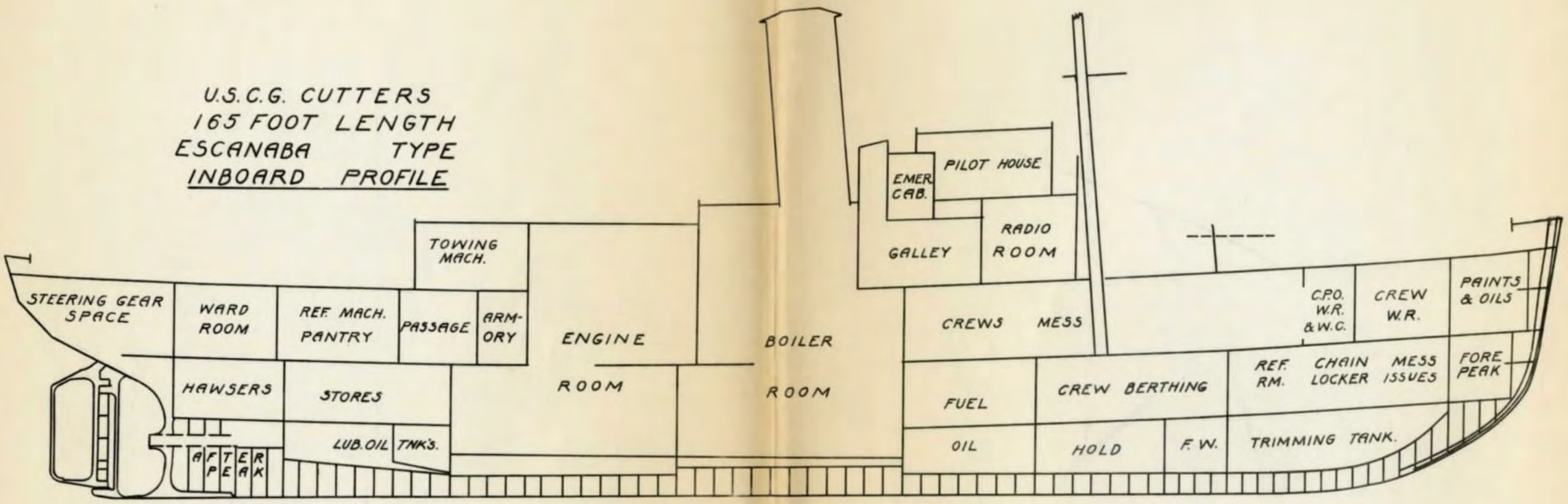


Fig. 43.

U.S.C.G. 165 FT. PATROL BOAT

INBOARD PROFILE

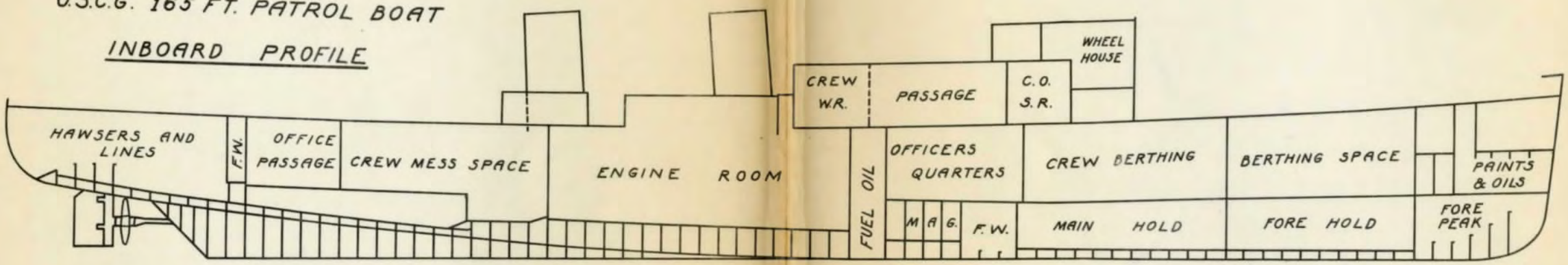
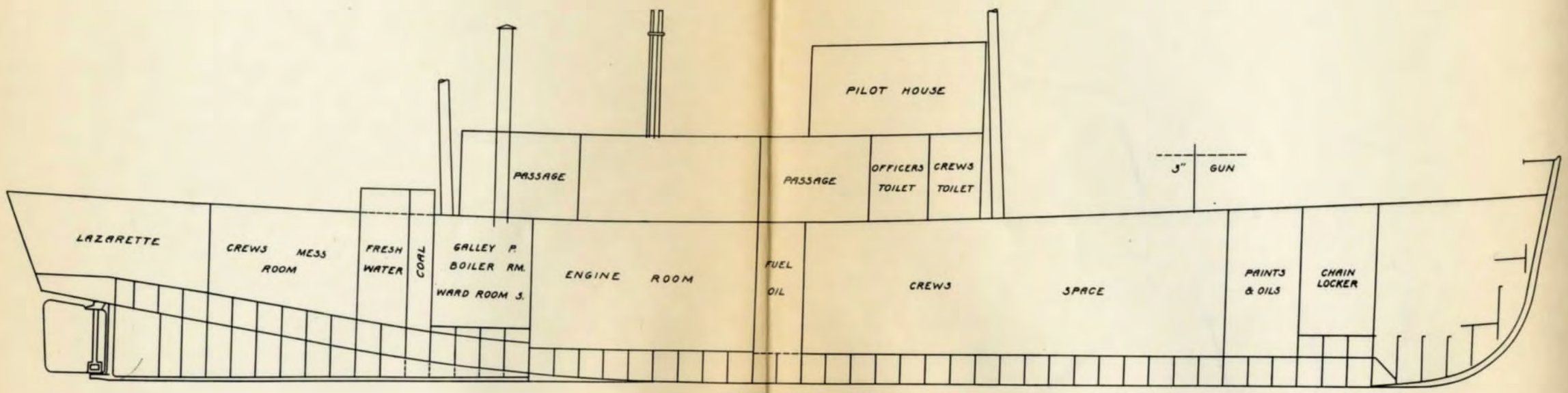


FIG. 44



U.S.C.G. 125 FT. PATROL BOAT
Fig 45

U.S.C.G. 100 FT. PATROL BOAT

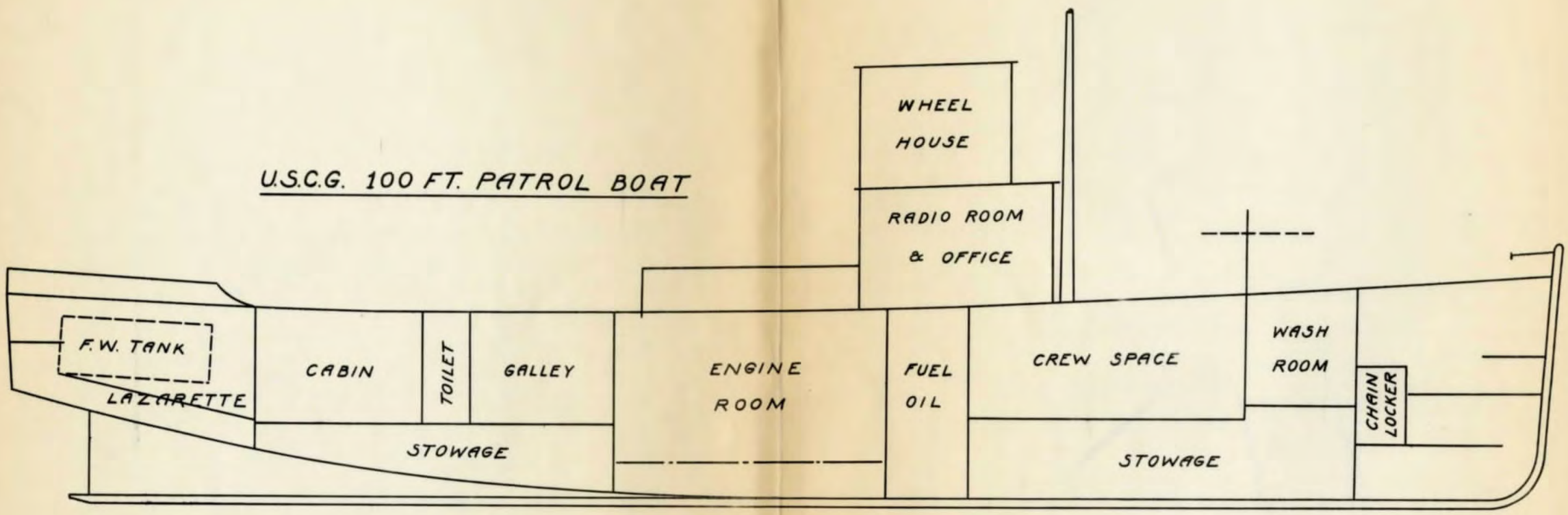


Fig. 46

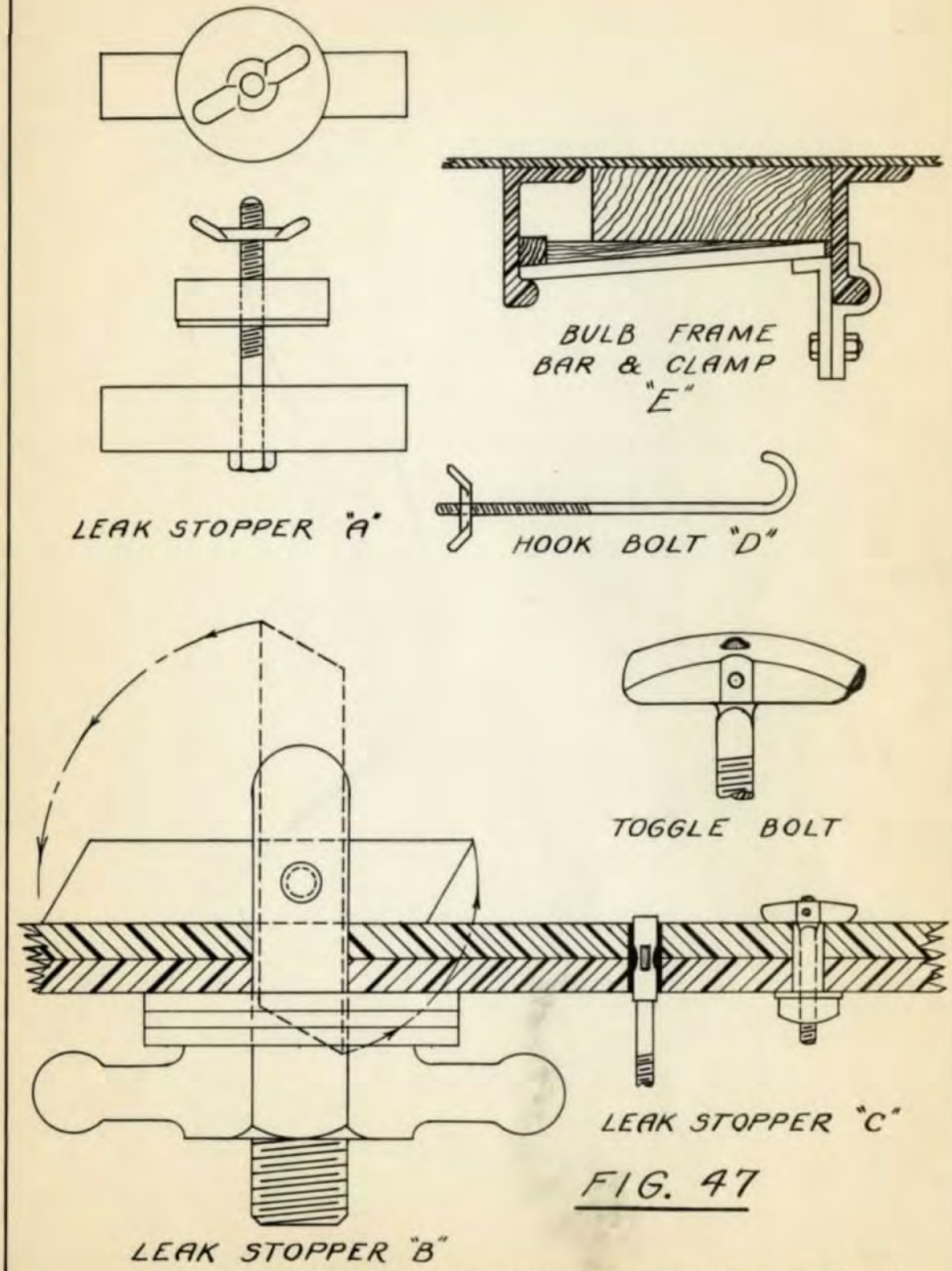


FIG. 47

SUBMITTED BY LT. COMDR. A.G. HALL

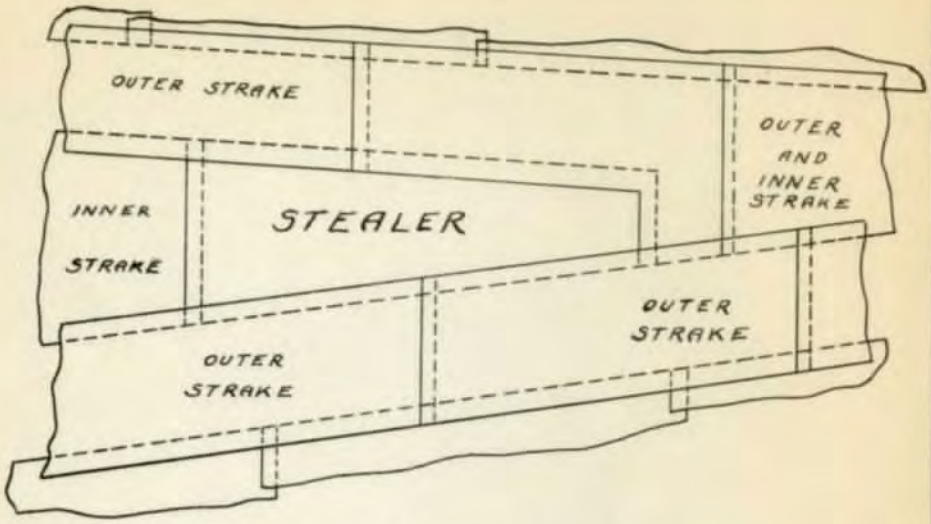


FIG 48 STEALER

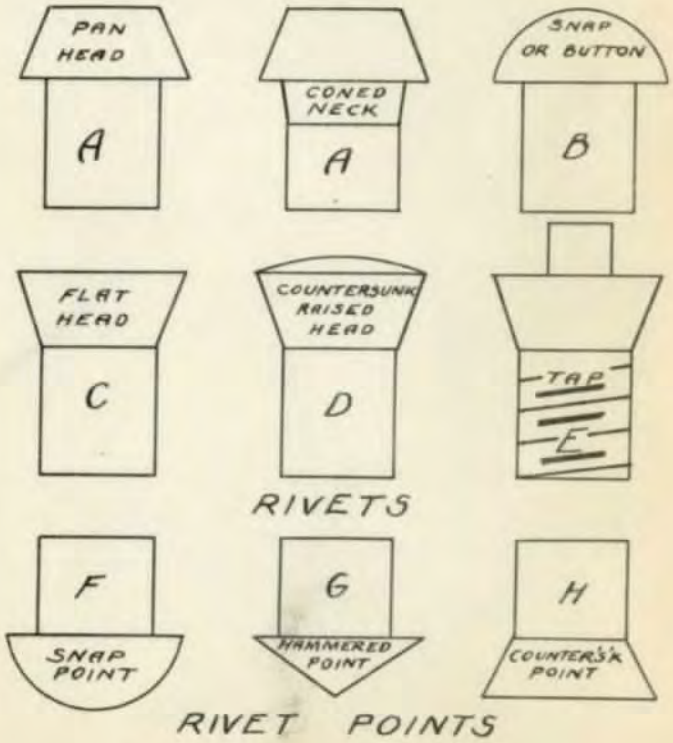


FIG 48 (a)

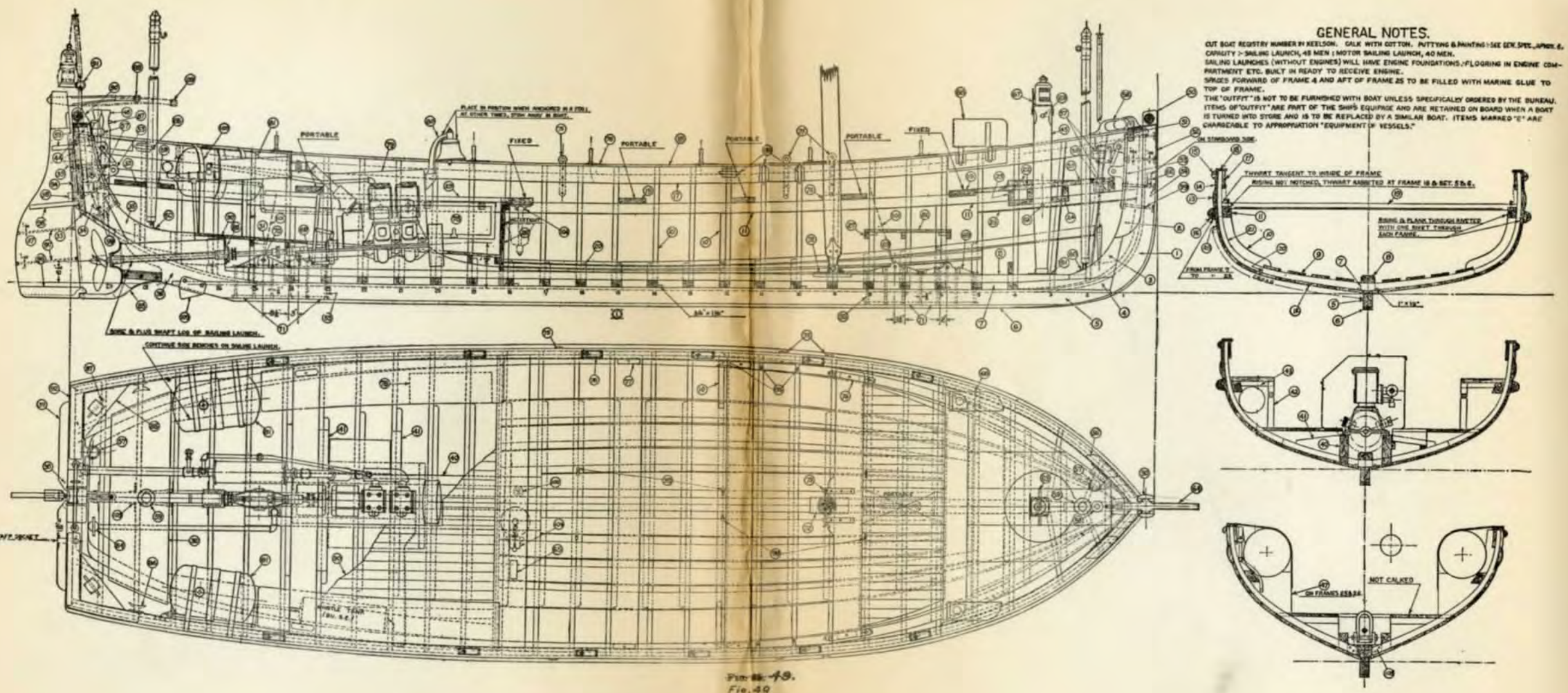


Plate 49.
Fig. 49

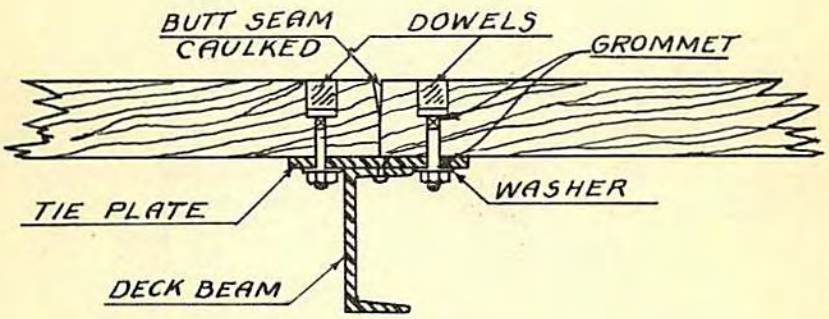


Fig 31

BUTT OF DECK PLANKING
OVER REINFORCE OR TIE PLATE

FASTENS TO FLOOR FRAME OR
TO MARGIN PLATE OR
TO WATER-TIGHT DECK
BY FLANGE ANGLES

Fig 32

CHANNEL FRAME

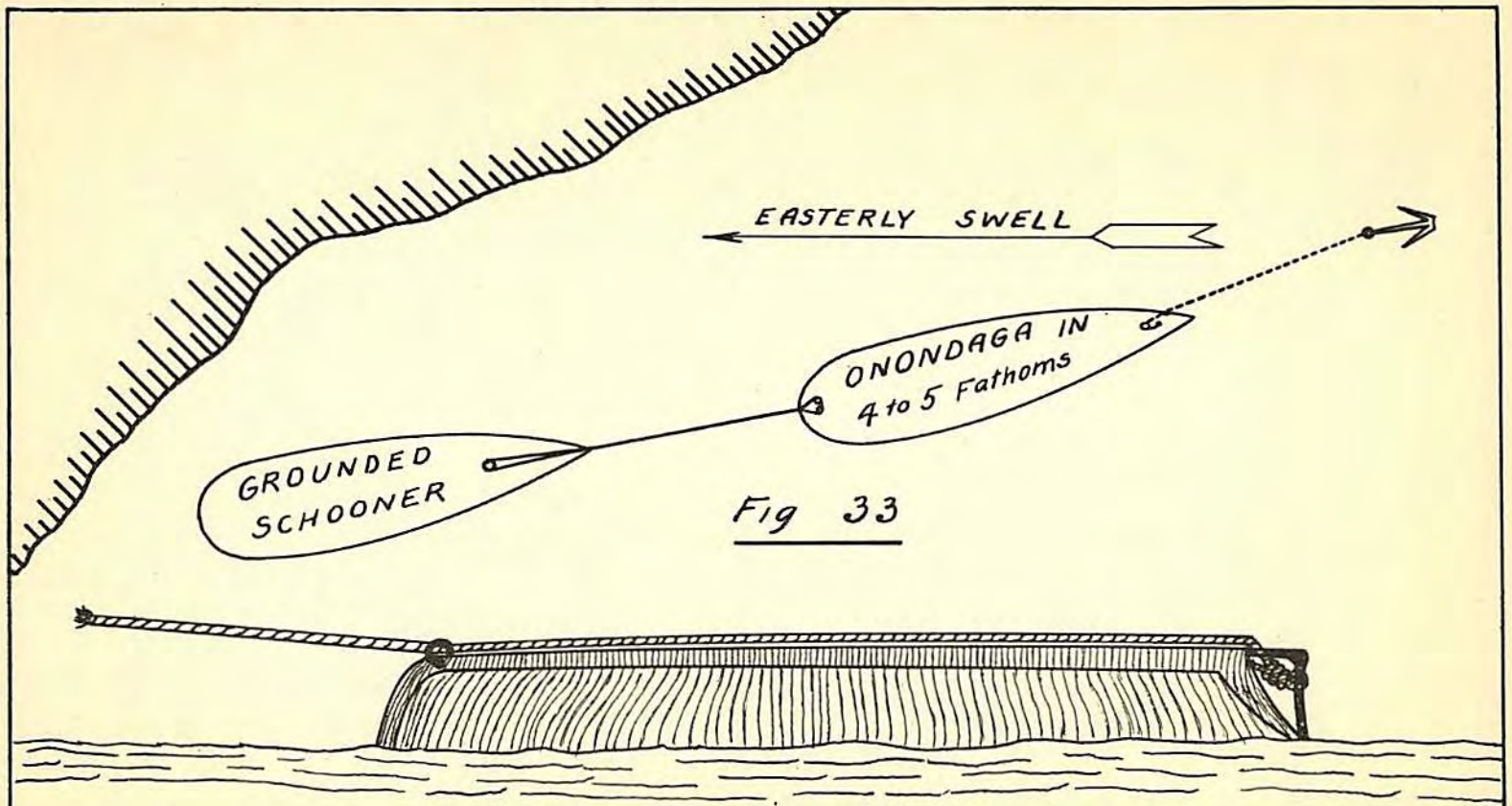
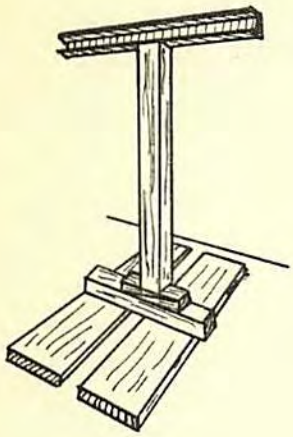


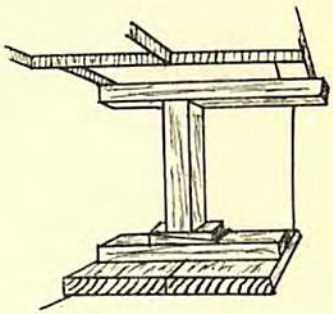
Fig 33

Fig 34

TOWING CAPSIZED SCHOONER

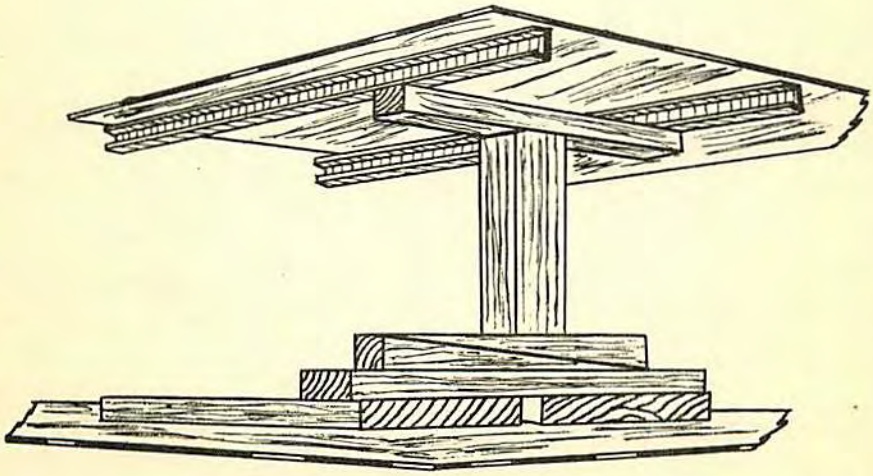


SINGLE 90°



SHORING OVER DISTRIBUTED AREA

Fig 35



SHORING UNDER DECK BEAMS

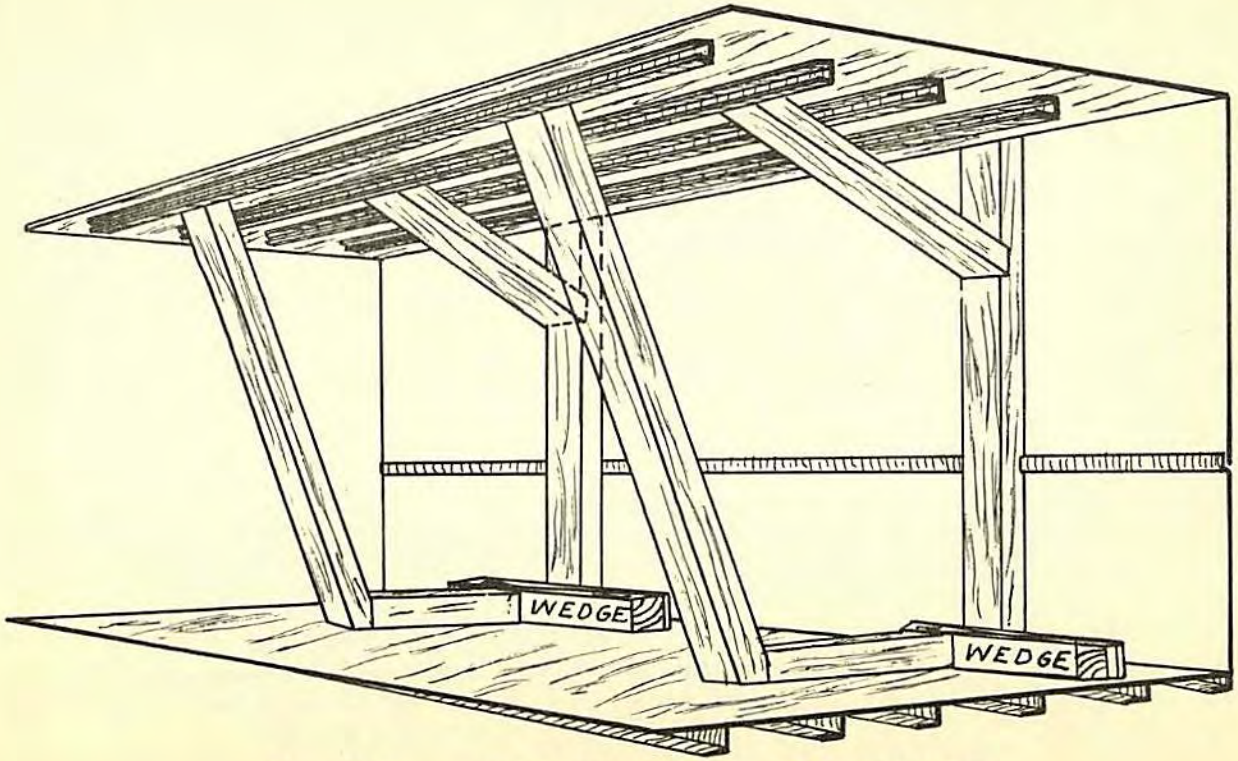
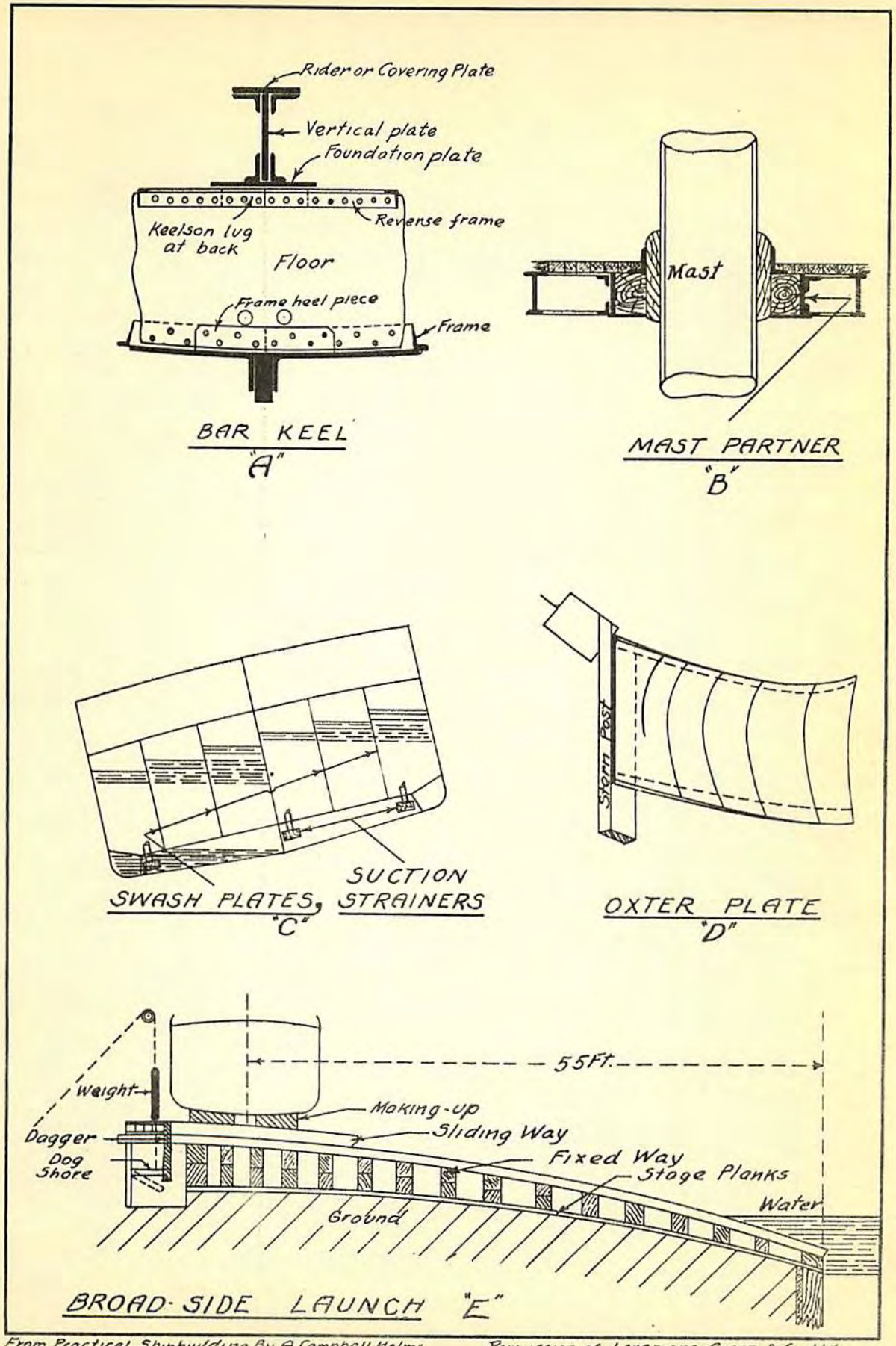
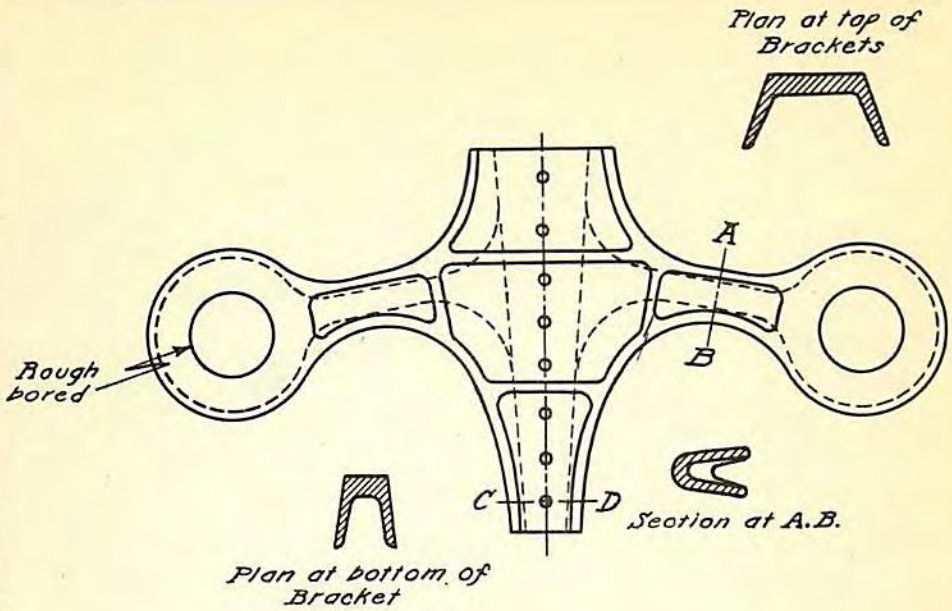


Fig 36 BULKHEAD SHORING

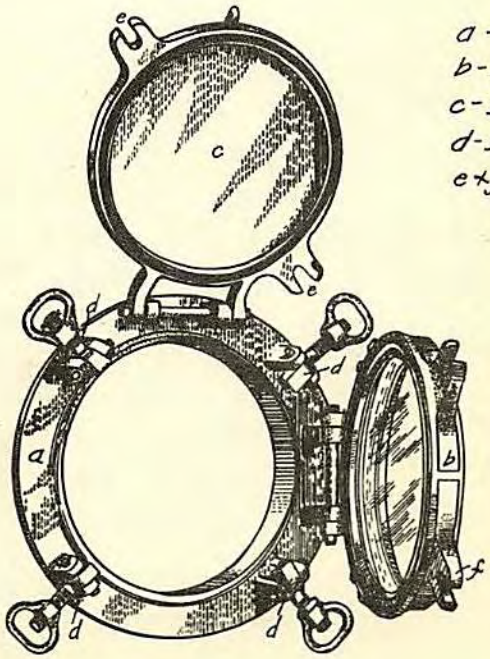


From Practical Shipbuilding By A. Campbell Holms Permission of Longmans Green & Co. Ltd.

FIG. 37

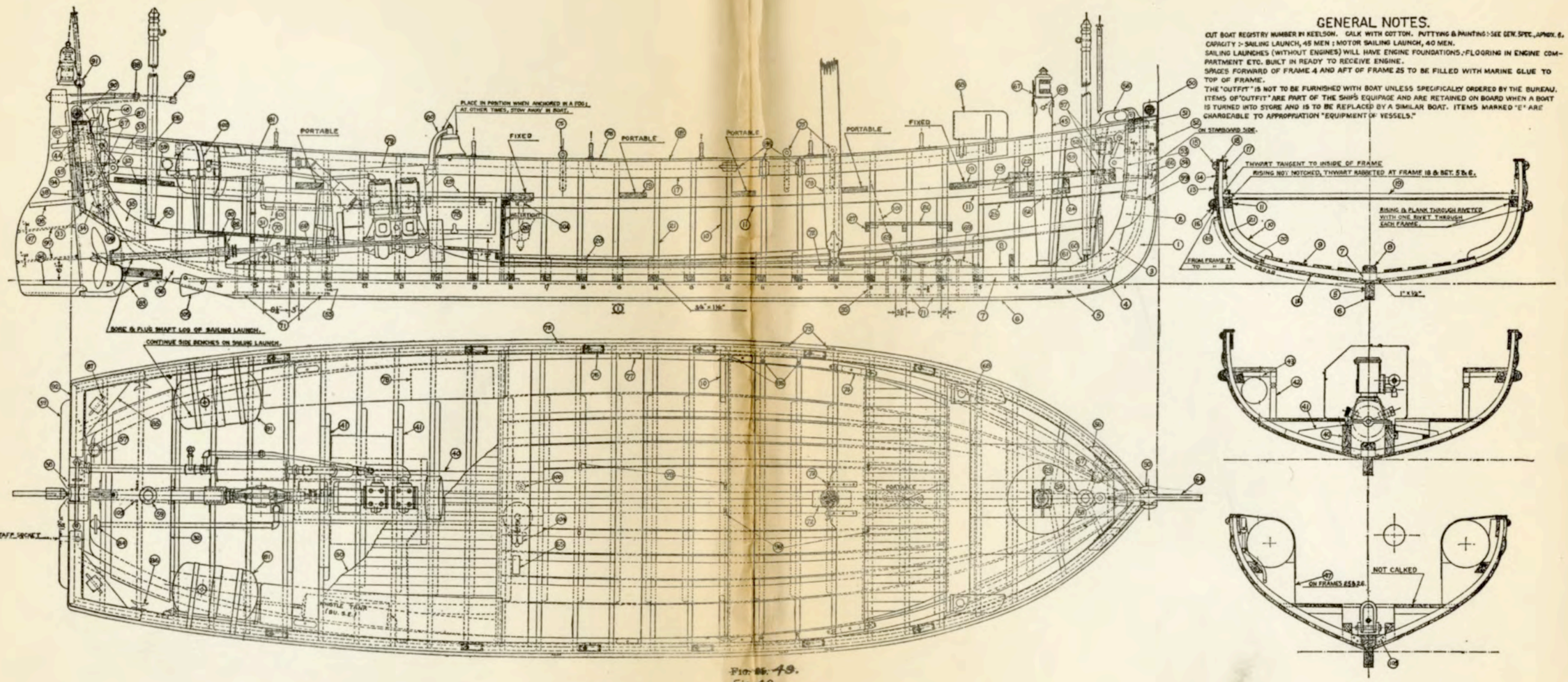


SPECTACLE FRAME



AIR PORT

FIG. 38



GENERAL NOTES.

CUT BOAT REGISTRY NUMBER IN KEELSON. CALK WITH COTTON. PUTTYING & PAINTING :- SEE GEN. SPEC., APPROX. 6.
CAPACITY :- SAILING LAUNCH, 45 MEN ; MOTOR SAILING LAUNCH, 40 MEN.
SAILING LAUNCHES (WITHOUT ENGINES) WILL HAVE ENGINE FOUNDATIONS, FLOORING IN ENGINE COMPARTMENT ETC. BUILT IN READY TO RECEIVE ENGINE.
SPACES FORWARD OF FRAME 4 AND AFT OF FRAME 25 TO BE FILLED WITH MARINE GLUE TO TOP OF FRAME.
THE "OUTFIT" IS NOT TO BE FURNISHED WITH BOAT UNLESS SPECIFICALLY ORDERED BY THE BUREAU. ITEMS OF "OUTFIT" ARE PART OF THE SHIP'S EQUIPAGE AND ARE RETAINED ON BOARD WHEN A BOAT IS TURNED INTO STORE AND IS TO BE REPLACED BY A SIMILAR BOAT. ITEMS MARKED "E" ARE CHARGEABLE TO APPROPRIATION "EQUIPMENT OF VESSELS."

~~FIG. 85.~~ 49.
Fig. 49

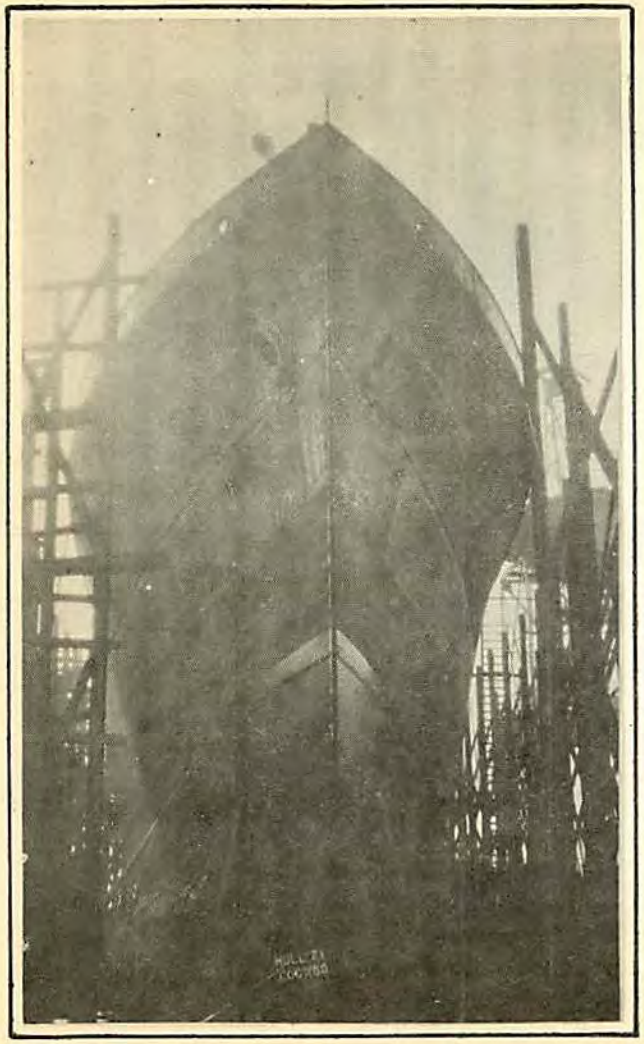


FIG. 71 BOW VIEW SHOWING ARRANGEMENT OF SHELL PLATING

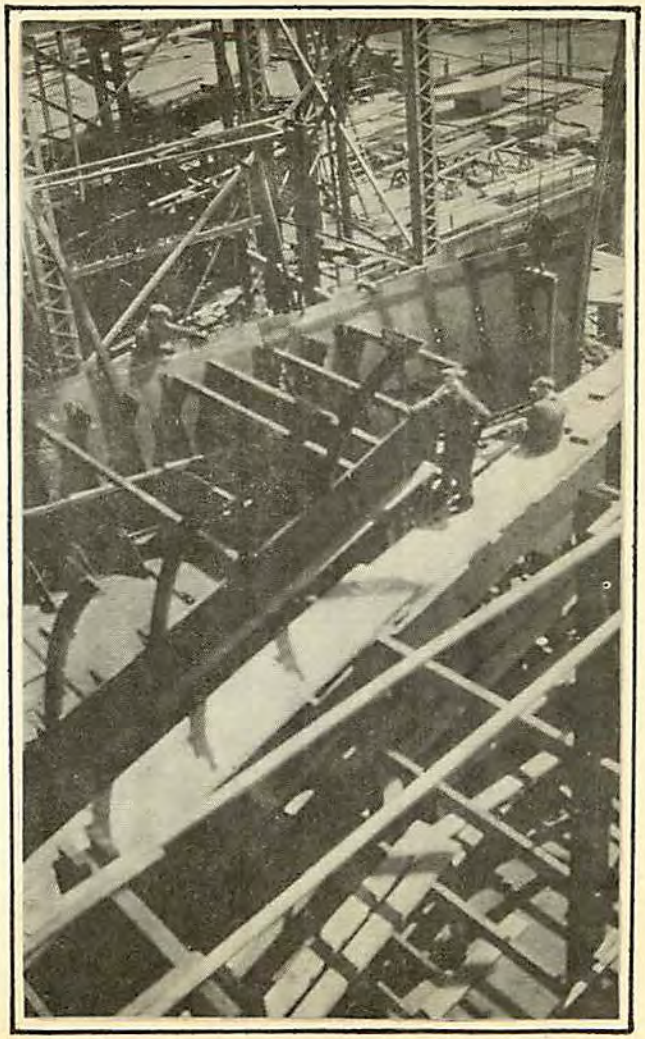


FIG. 69 STEM BERTH DECK BEAMS AND SHELL PLATING AND PANTING STRINGER

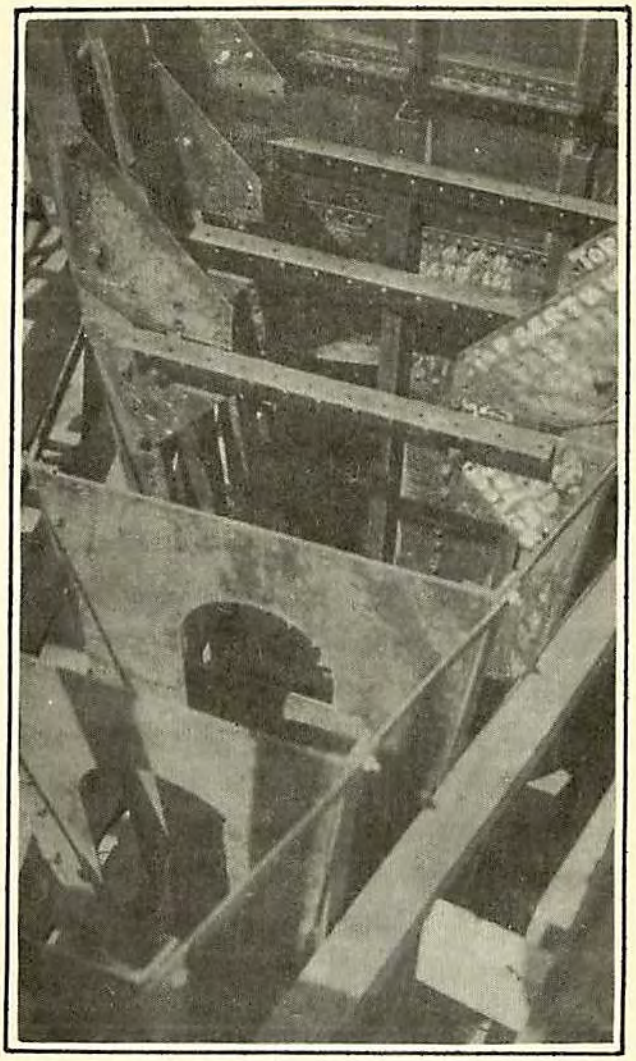


FIG. 70 FOREPEAK TANK ASSEMBLY

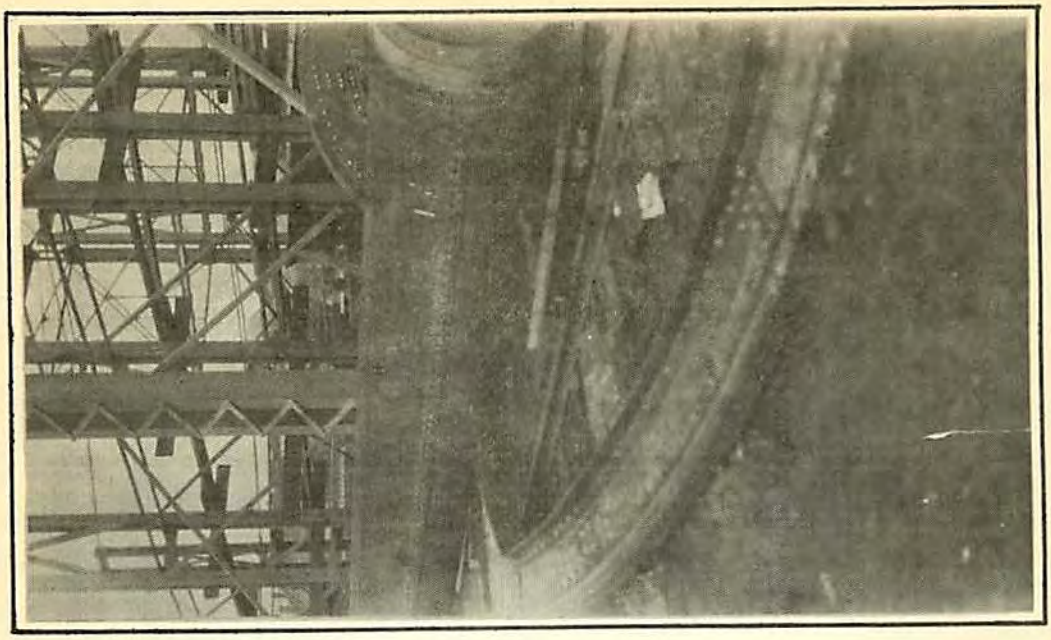


FIG. 72 WEB FRAME AND PIPE TUNNEL

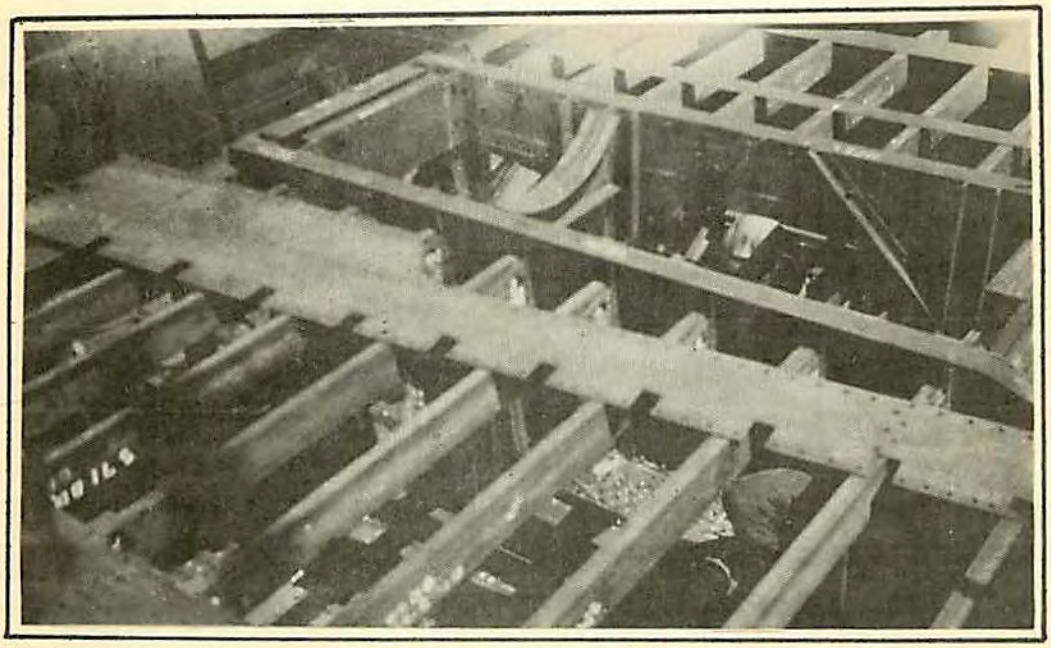


FIG. 73 MAIN GENERATOR FOUNDATION, BERTH DECK PLATING AND BEAMS IN ENGINEROOM, SHOWING RIDER PLATE OVER VERTICAL KEEL

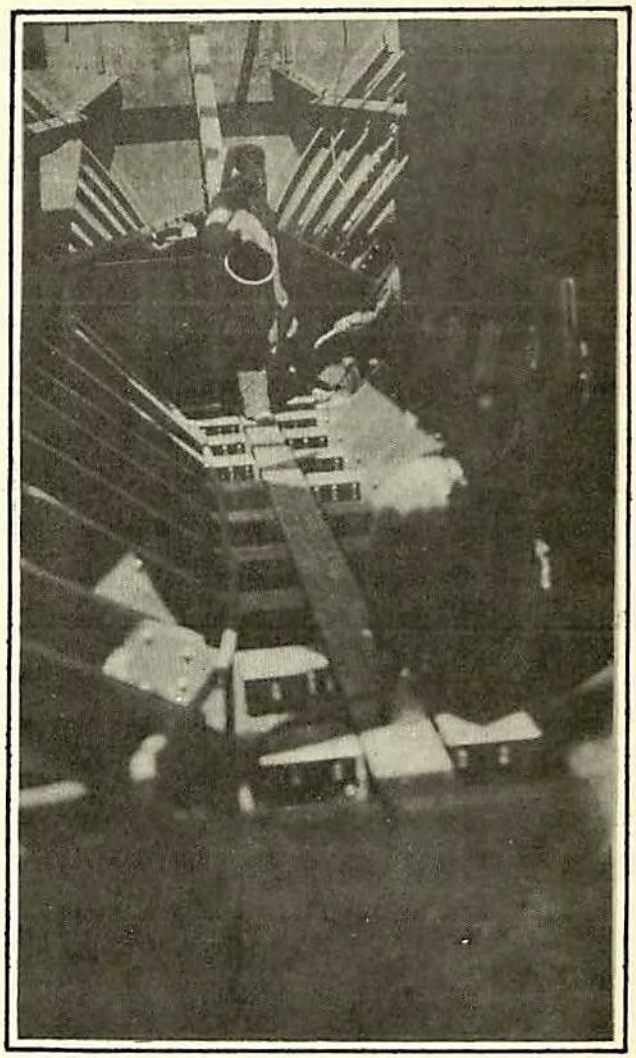


FIG. 74 SHAFT ALLEY LOOKING AFT FROM FRAME 81

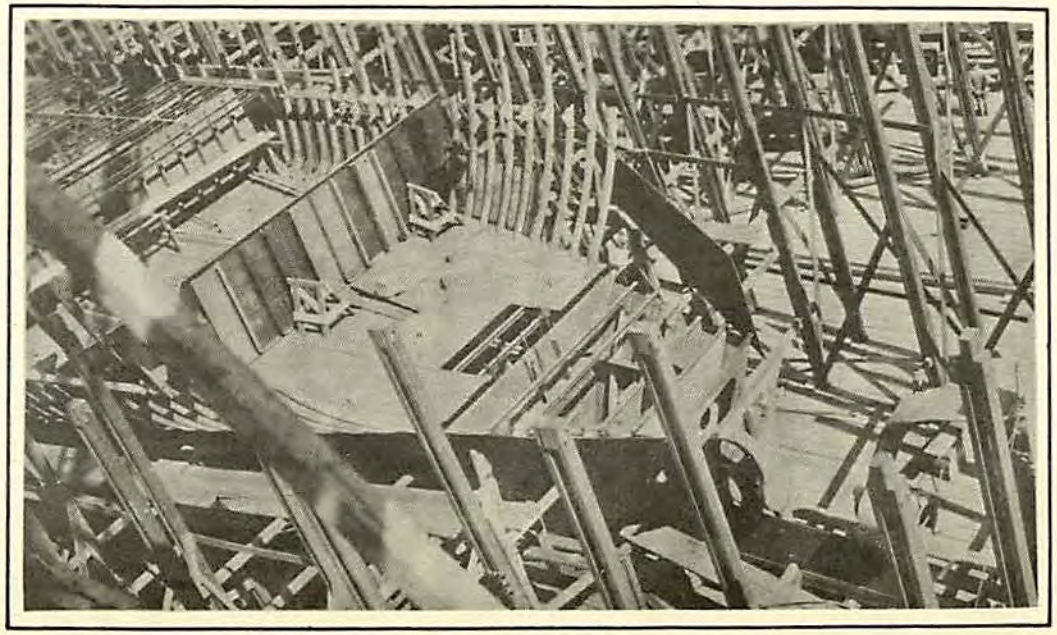


FIG.74(a) BULKHEADS, BULKHEAD STIFFENERS AND BOUNDING BARS, FRAMES, DECK PLATING, BEAMS, FLOORS, SIDE STRINGER AND SHELL PLATING

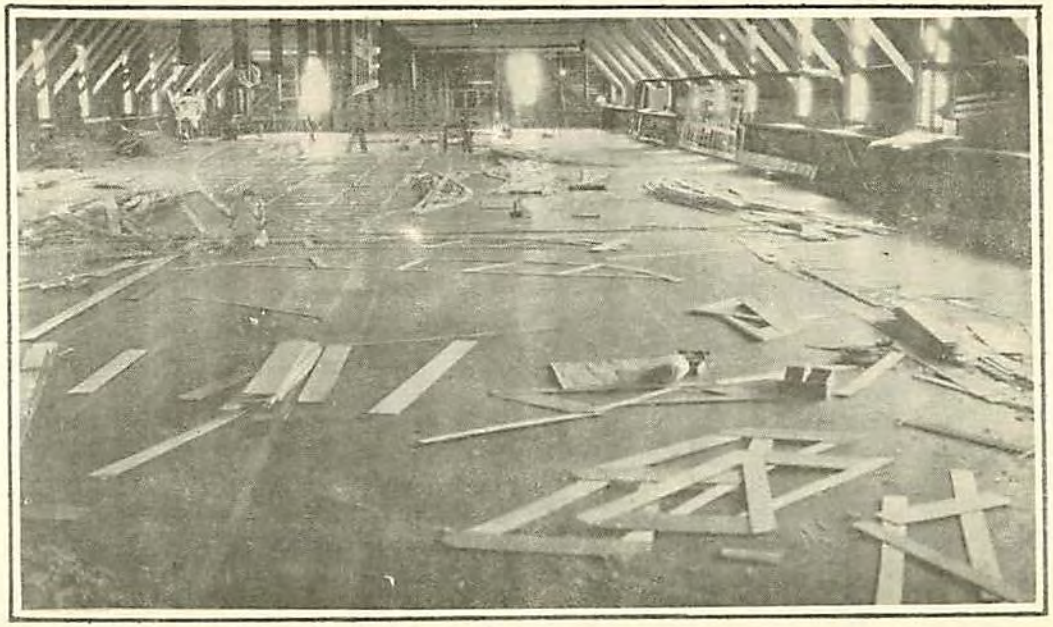


FIG. 75 BULKHEAD PLATING LAID OUT IN MOLD LOFT

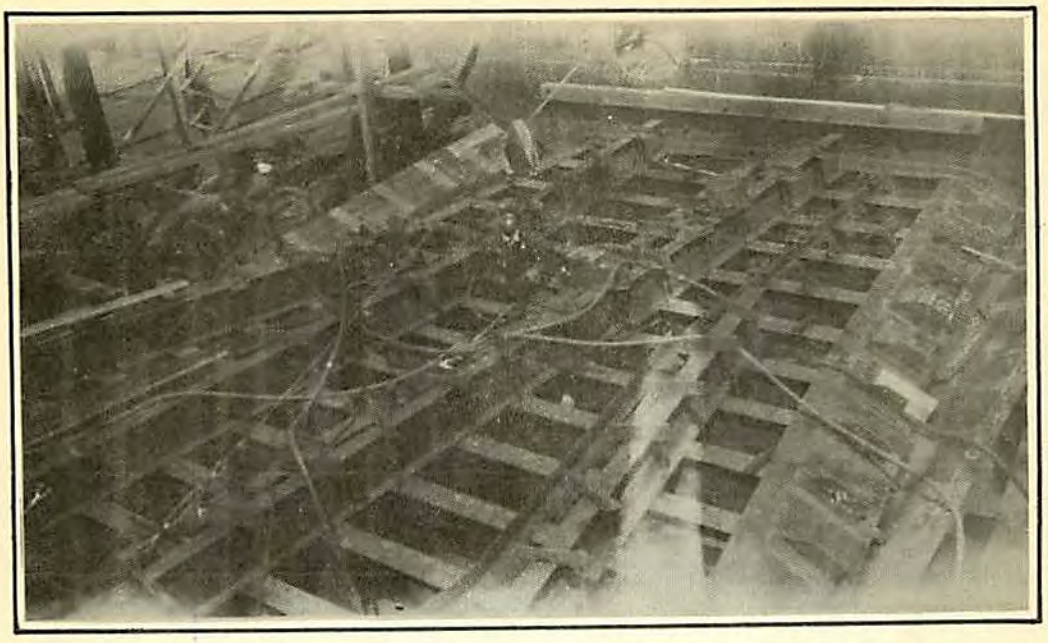


FIG. 76 SHOWING METHOD OF FAIRING FLOORS BY TEMPORARY HEAVY CHANNELS (NOTE MARGIN PLATE WITH CLIPS TO RECEIVE HEELS OF FRAMES AND STRAKE OF SHELL PLATING)

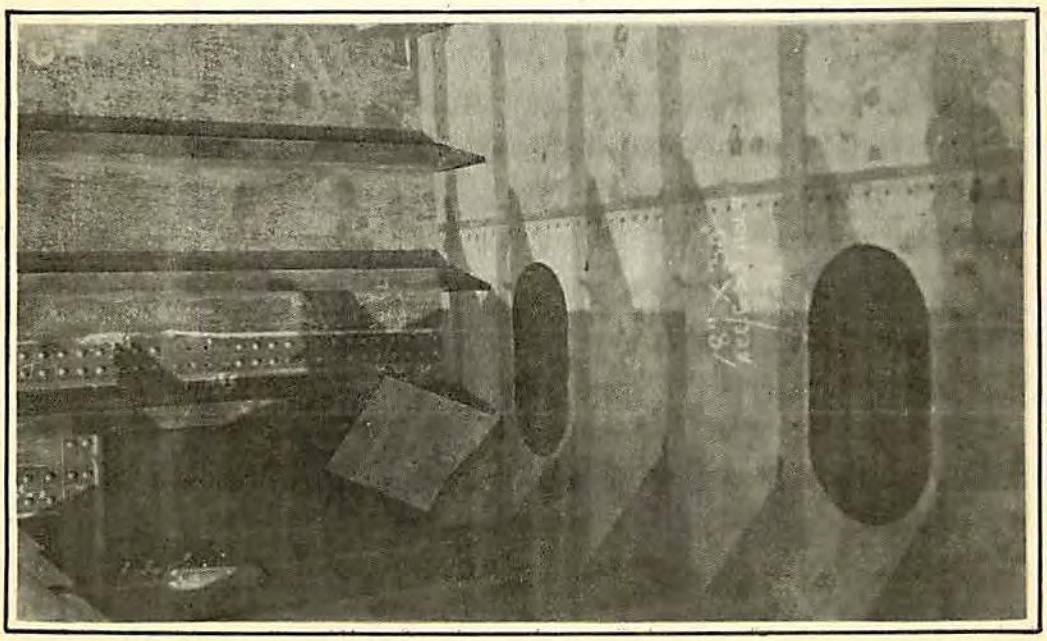


FIG. 77 HERTH DECK PLATING IN FUEL OIL TANK, FRAMES 41 - 50

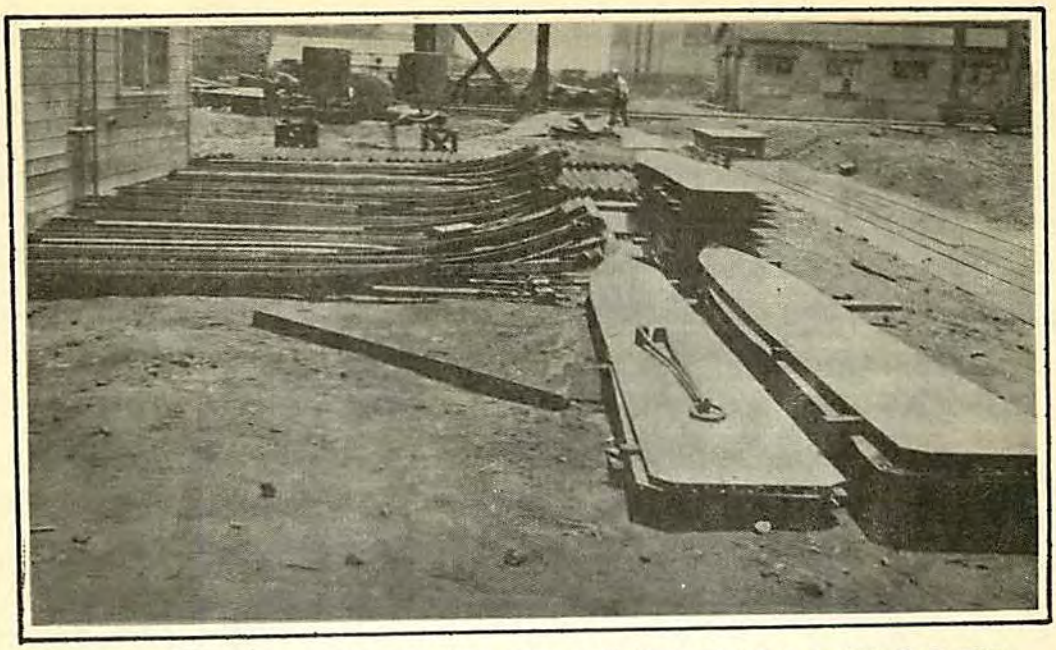


FIG. 55 FLOORS, ANGLE FRAMES AND REVERSE FRAMES LAID OUT FOR THE REMOVAL OF MILL SCALE AND FOR ASSEMBLING (LIGHTENING HOLES NOT YET CUT)

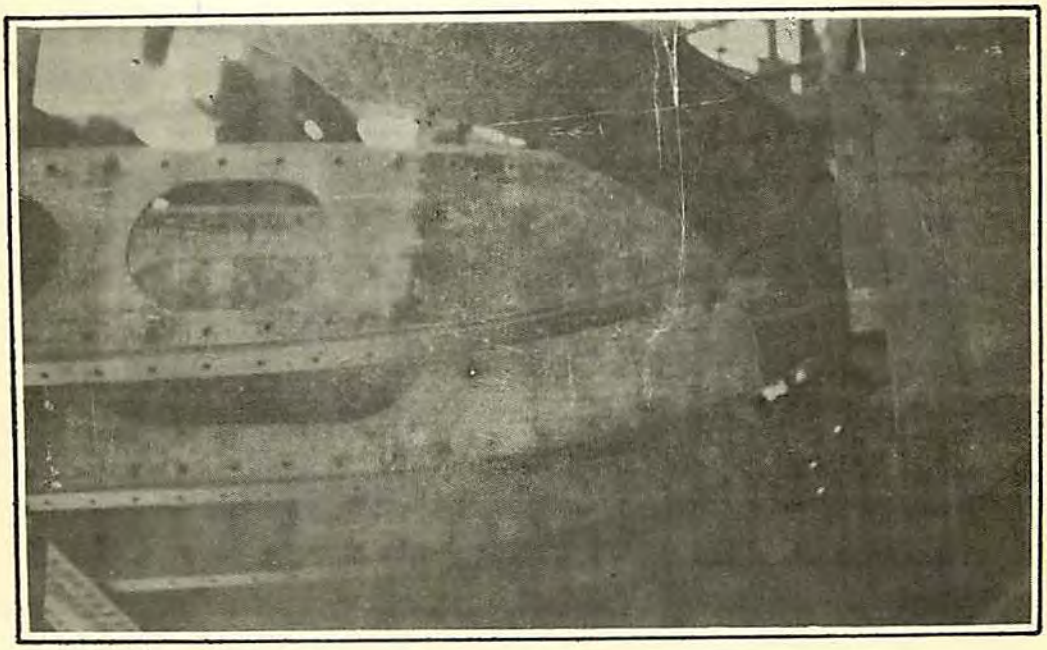


FIG. 57 STEM CASTING, BOW FLOORS, FLAT PLATE KEEL

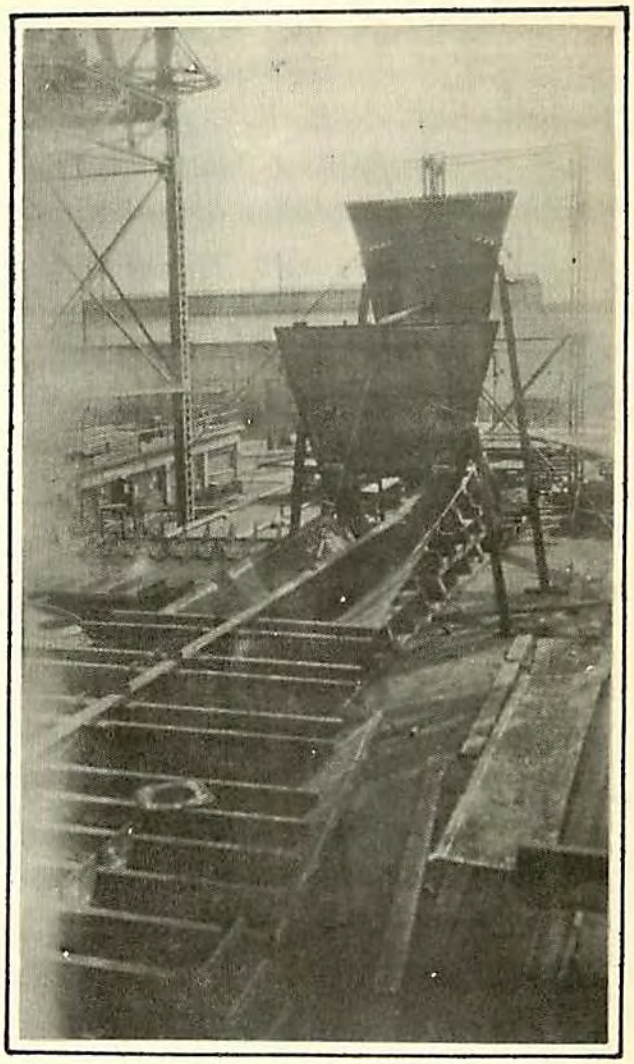


FIG. 59 VERTICAL KEEL, FLOOR FRAME ASSEMBLY AND TWO FORWARD BULKHEADS

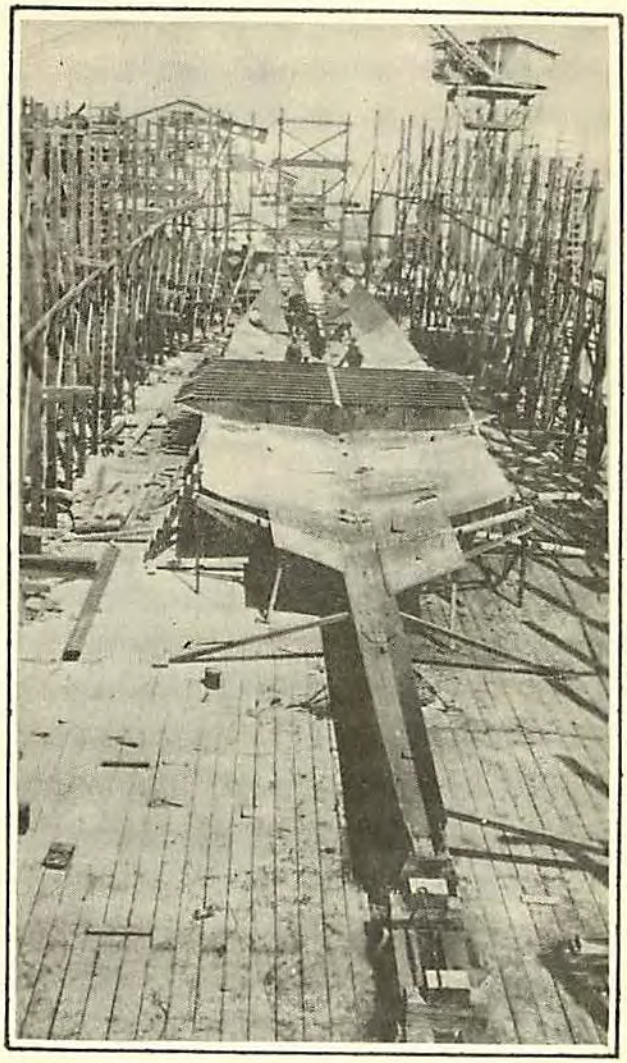


FIG.59(a) SHOWING DISHED KEEL PLATE, BOTTOM PLATING, FLOORS AND A PORTION OF VERTICAL KEEL

FIG. 61 CANT FRAME ASSEMBLY

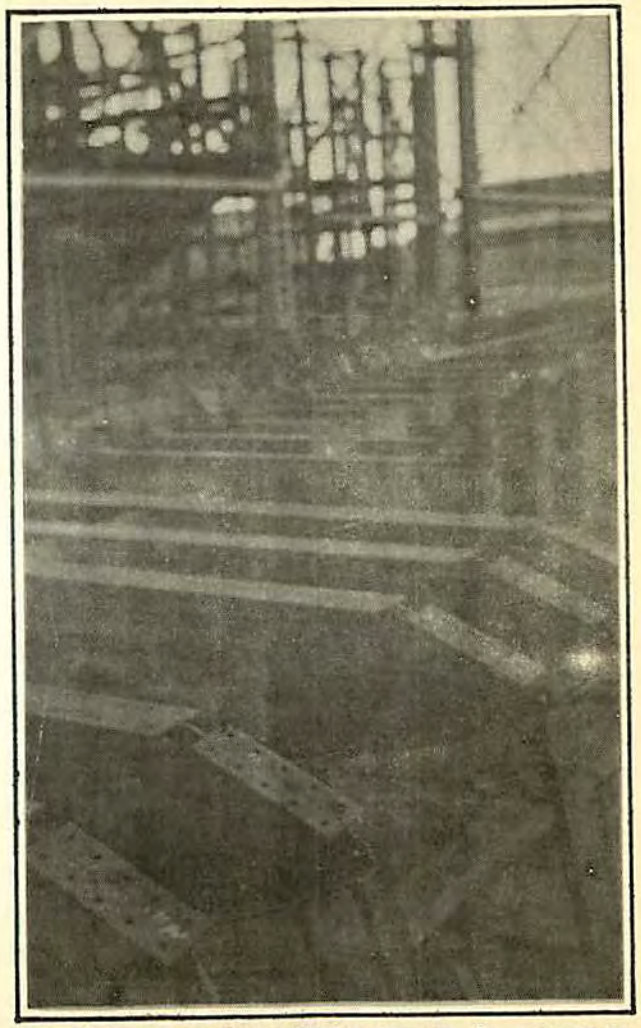


FIG. 58 FLOORS FROM FRAME 63 LOOKING FORWARD, WITH FRAME AND REVERSE FRAME ANGLES (IN READINESS FOR INSTALLATION OF MARGIN PLATE)

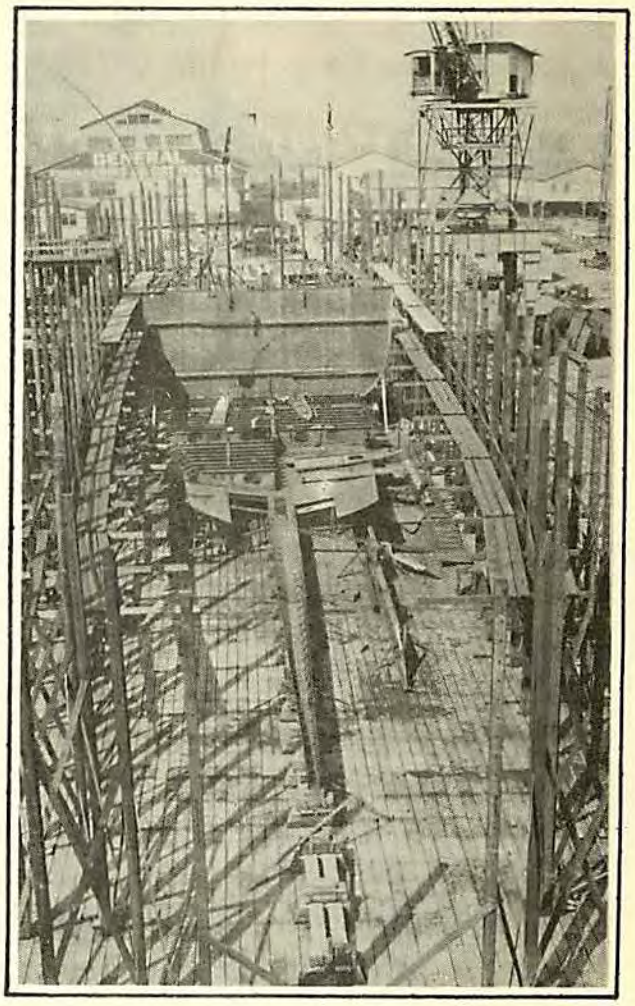


FIG. 60 AFTER SECTION OF VERTICAL KEEL; ONE BULKHEAD FORWARD OF AMIDSHIPS, FLAT PLATE KEEL (DISHED), GARBOARD AND A STRAKE SHELL PLATING, ALSO INTERCOSTAL FLOOR FRAMES READY FOR ASSEMBLY

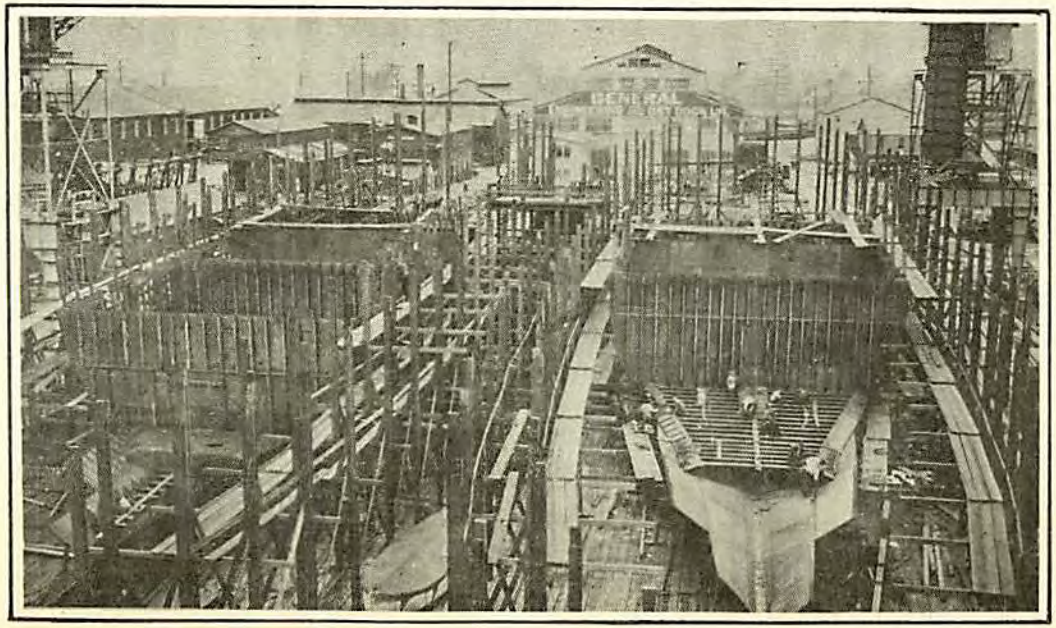


FIG. 63 FLOORS WITH MARGIN PLATES AT EACH END
(CUTTER ON LEFT IN MOST ADVANCED STAGE)

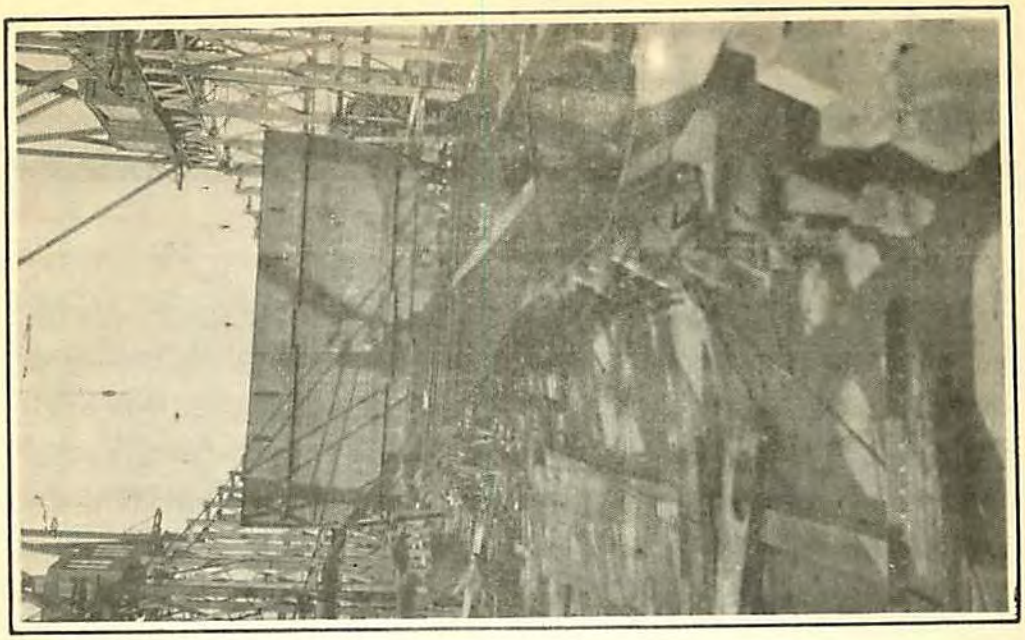


FIG. 62 VERTICAL KEEL LOOKING AFT TOWARD BULKHEAD 63, SHOWING INTER-COSTAL FLOOR PLATES IN POSITION

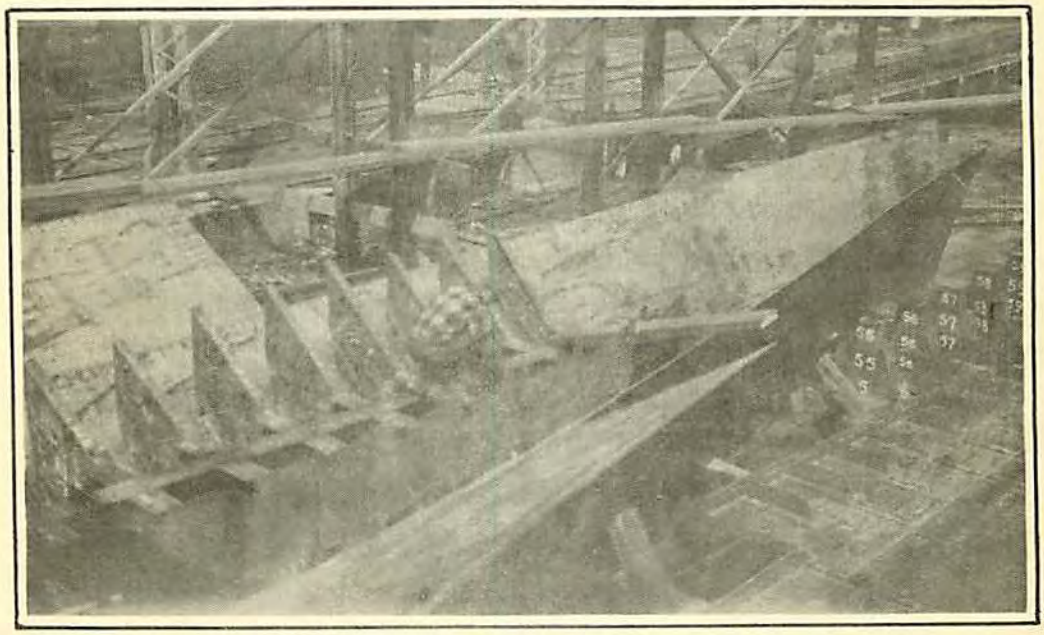


FIG. 64 INSIDE VIEW, SHAFT ALLEY FLOORS AND GARBOARD STRAKE

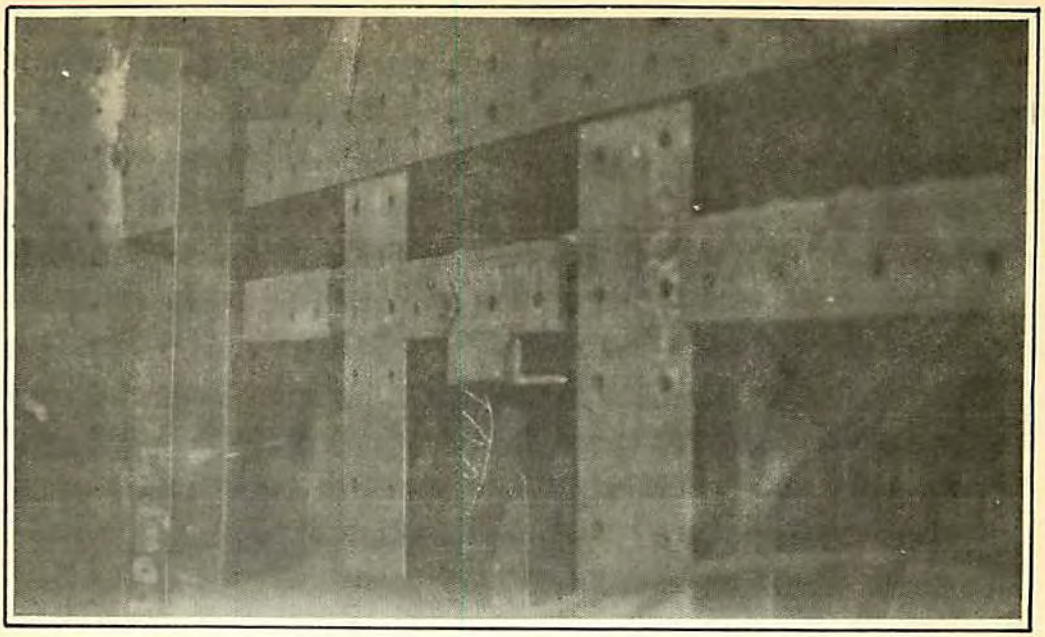


FIG. 65 EXTENSION OF BOILER GIRDER CLIP FOR HOLDING DOWN BOLTS FOR BOILERS

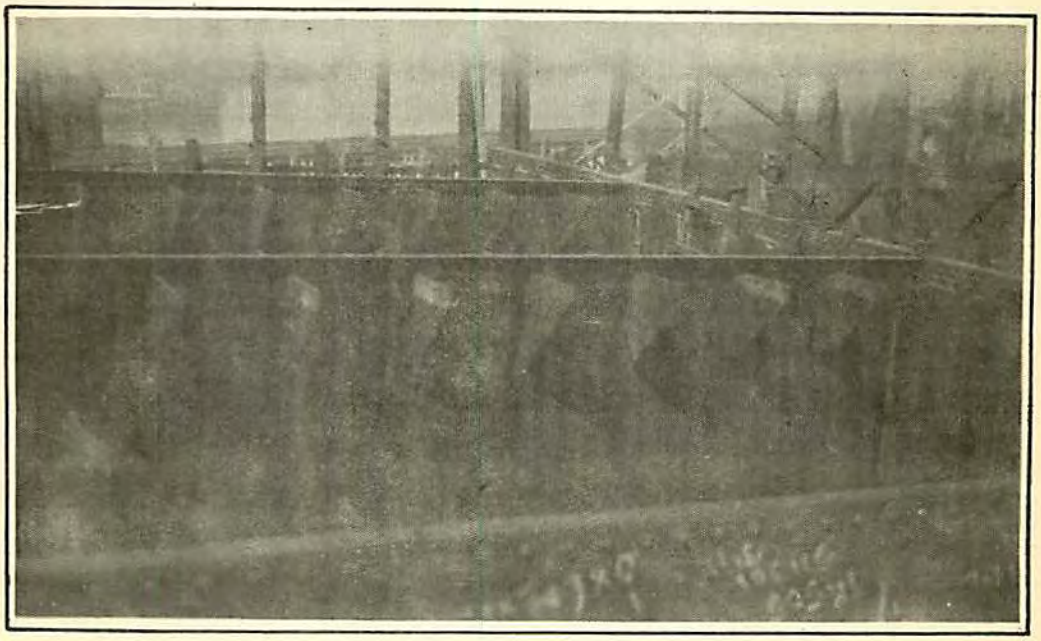


FIG. 66 FUEL OIL TANKS, SHOWING BRACKETS READY FOR ATTACHING SWASH PLATES

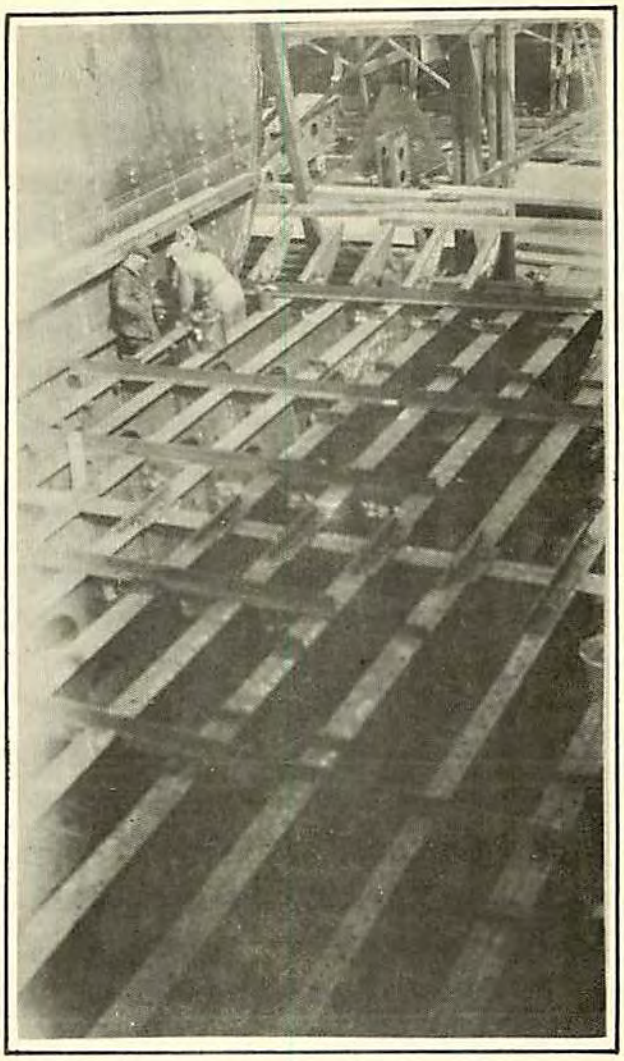


FIG. 67 AFTER STARBOARD SIDE OF AMIDSHIP BULKHEAD (NOTE ANGLE CLIP USED IN FAIRING UP FLOORS AND VERTICAL KEEL CONNECTIONS TO THE VERTICAL KEEL

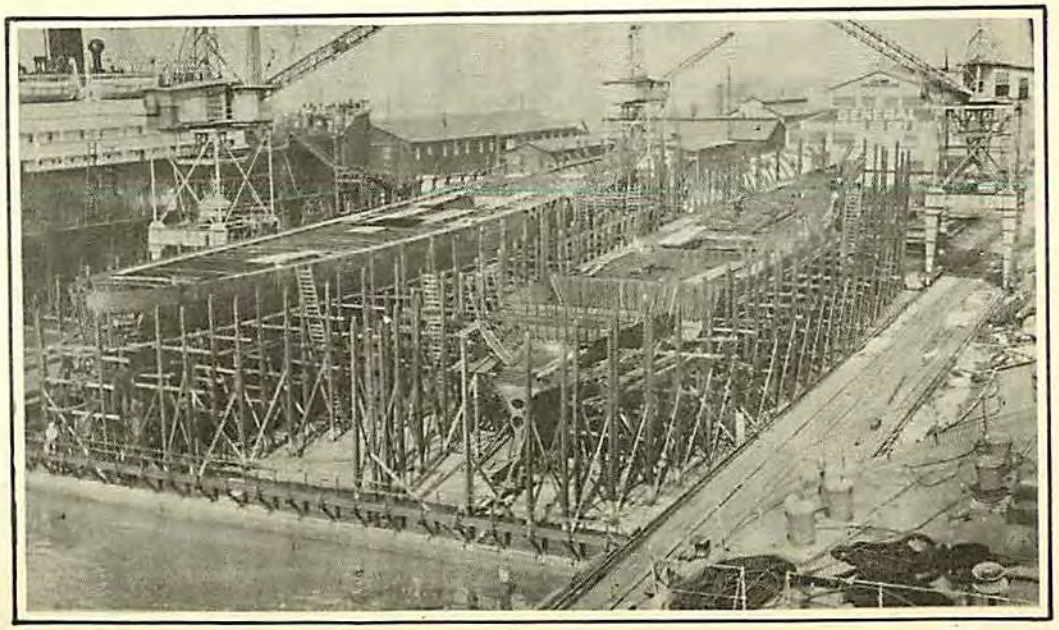


FIG. 68 ON RIGHT FIGURES SHOWING DECK BEAMS AND FRAMES AND SHAFT ALLEY, AND ON LEFT FIGURES, COUNTER AND STERN TUBE BOSS IN PLACE (NOTE STRINGER PLATE ON PORT SIDE OF UPPER DECK)

FIG. 79 FORWARD FRAMING AND STEM LOOKING FORWARD FROM BULKHEAD 41, MAIN DECK

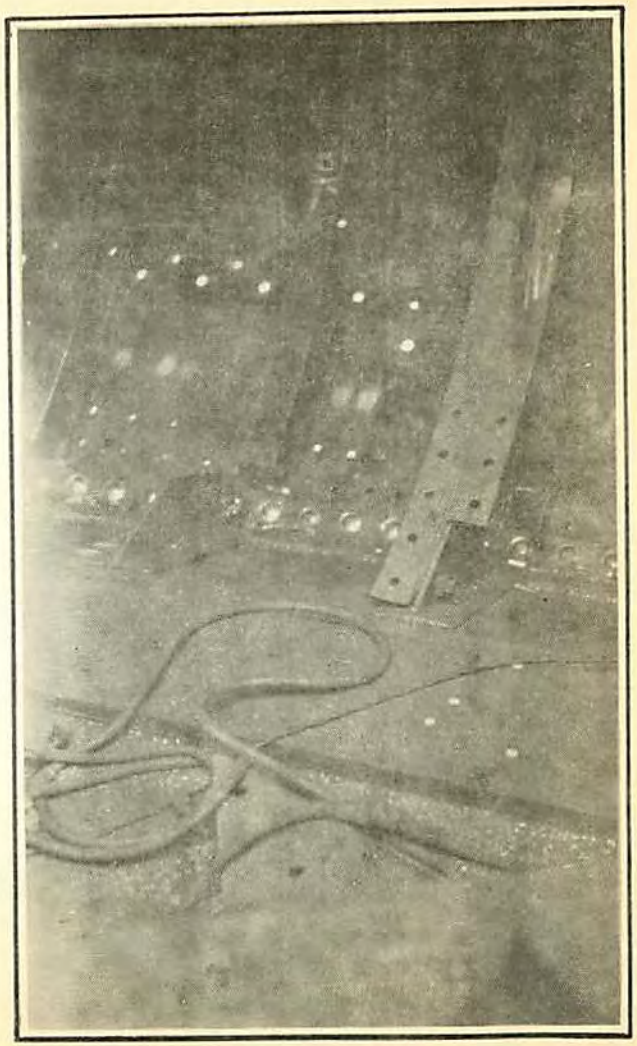


FIG. 78 SHOWING METHOD OF FASTENING FRAMES TO TANK TOP (NOTE HEAVY MARGIN BAR SECURING LOWER END OF FRAME)

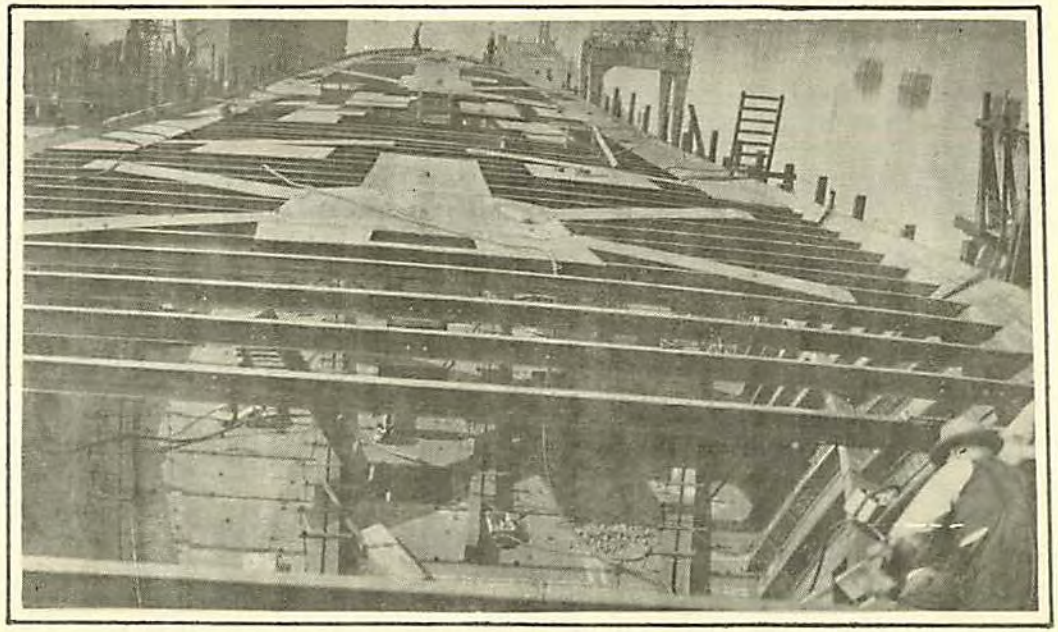


FIG. 81 UPPER DECK, SHOWING TIE PLATE AND STRINGER PLATE IN PLACE (NOTE MAN IS STANDING ON SIDE STRINGER).

FIG. 84 MAIN GENERATOR FOUNDATION

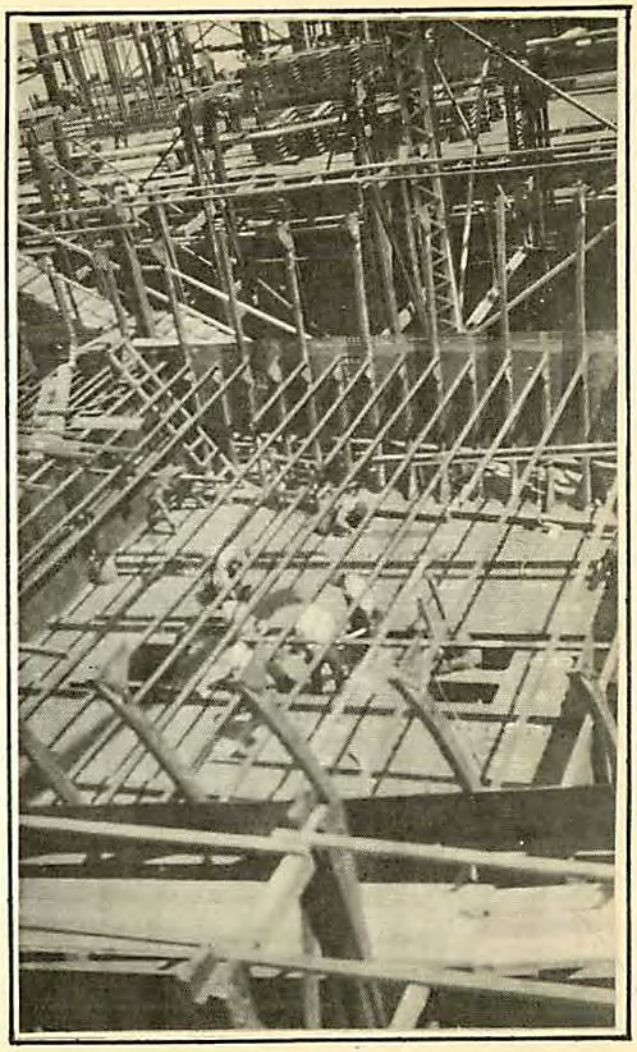


FIG. 80 MAIN DECK BEAMS AND BERTH DECK PLATING BETWEEN FRAMES 25-41 LOOKING TO PORT

FIG. 82 BULKHEAD 95, MAIN AND UPPER
DECK BEAMS LOOKING FORWARD FROM BULKHEAD 107

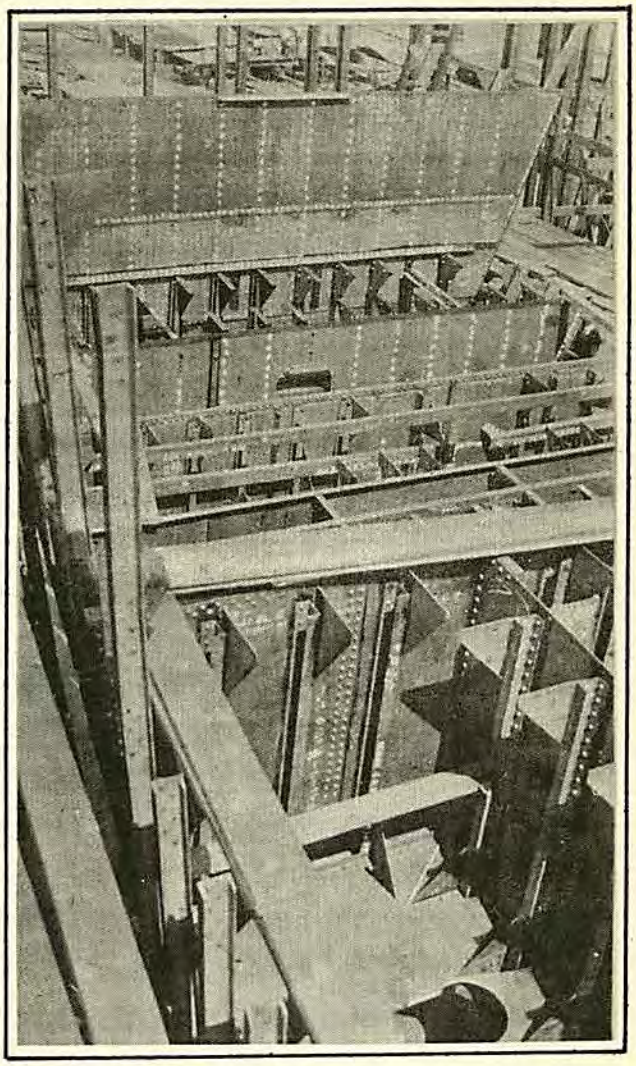


FIG. 83 ERECTION OF BULKHEADS WITH STIFFENERS, ALSO BRACKETS TO DECK AND BRACKETS TO RECEIVE BEAMS

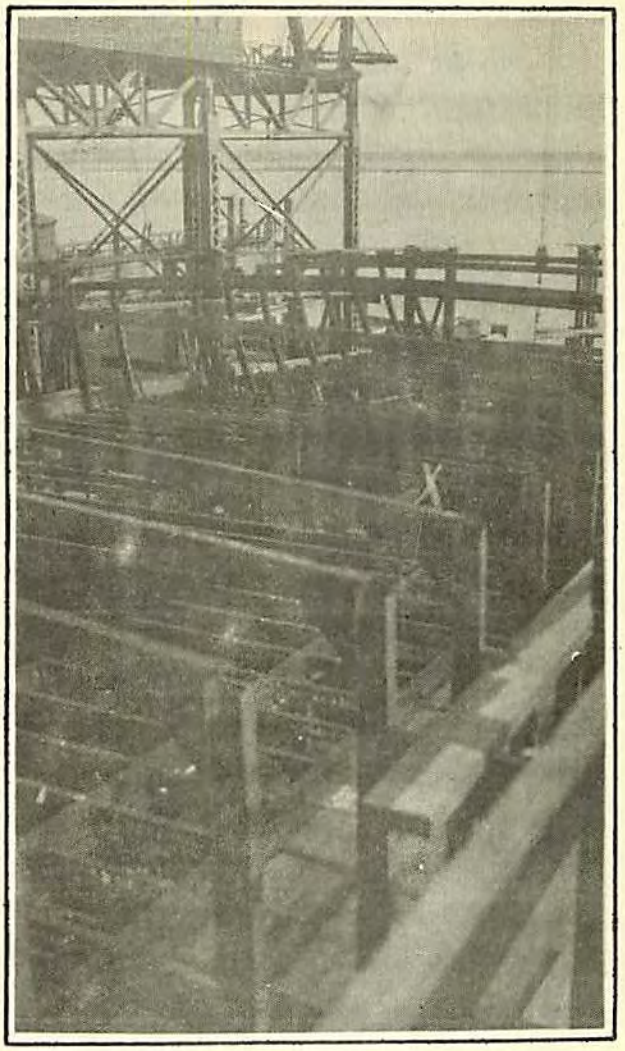


FIG. 86 MAIN AND UPPER DECK FRAMES LOOKING AFT FROM BULKHEAD 50, SHOWING BRACKETS AND MANNER OF SECURING DECK BEAMS TO FRAMES

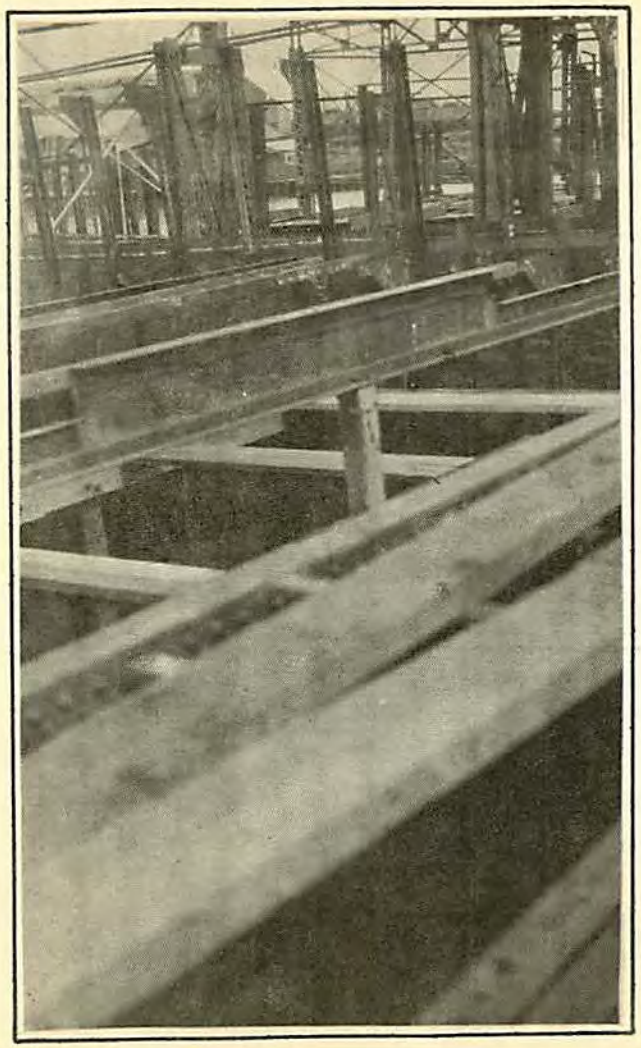


FIG. 87 MAIN DECK STRONG BEAM NO. 54

FIG. 85 MAIN DECK LOOKING AFT FROM FRAME 50, UPPER DECK BEAMS BEING PLACED

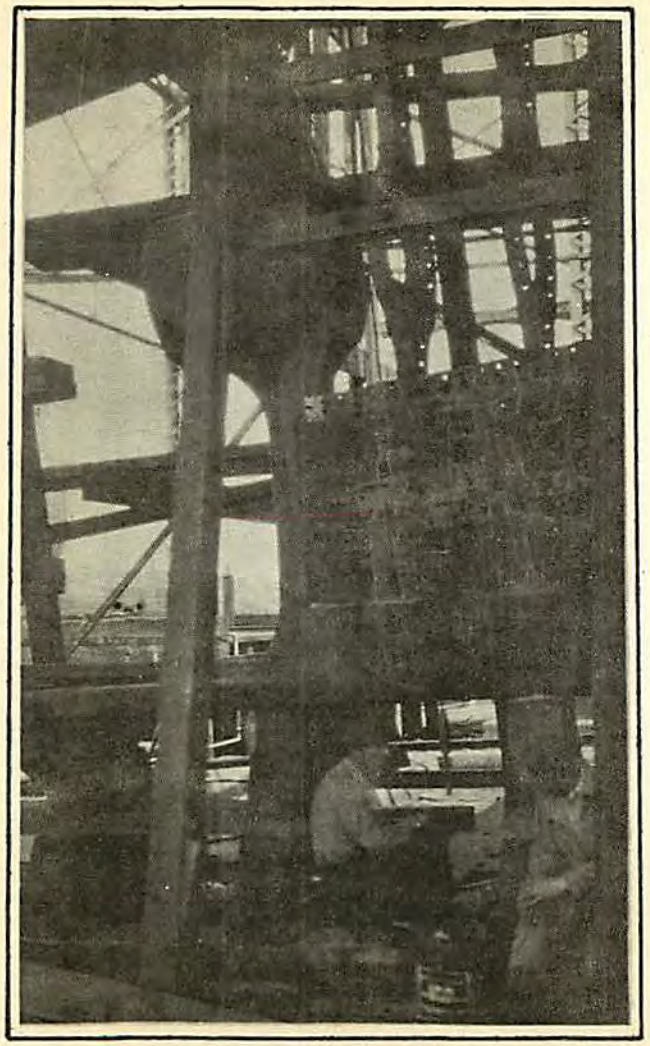


FIG. 89 SHOWING PROPELLER POST, BOSS, AND GARBOARD STRAKE

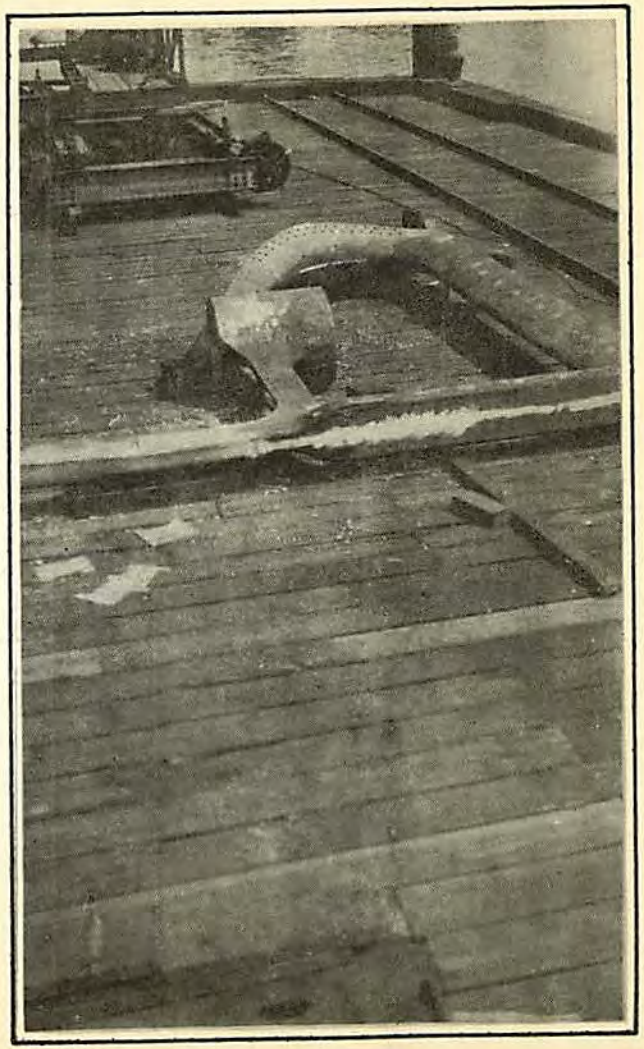


FIG. 88 STERN FRAME SHOWING PROPELLER POST WITH BOSS AND STERN POST, BRIDGE AND SOLE PIECE

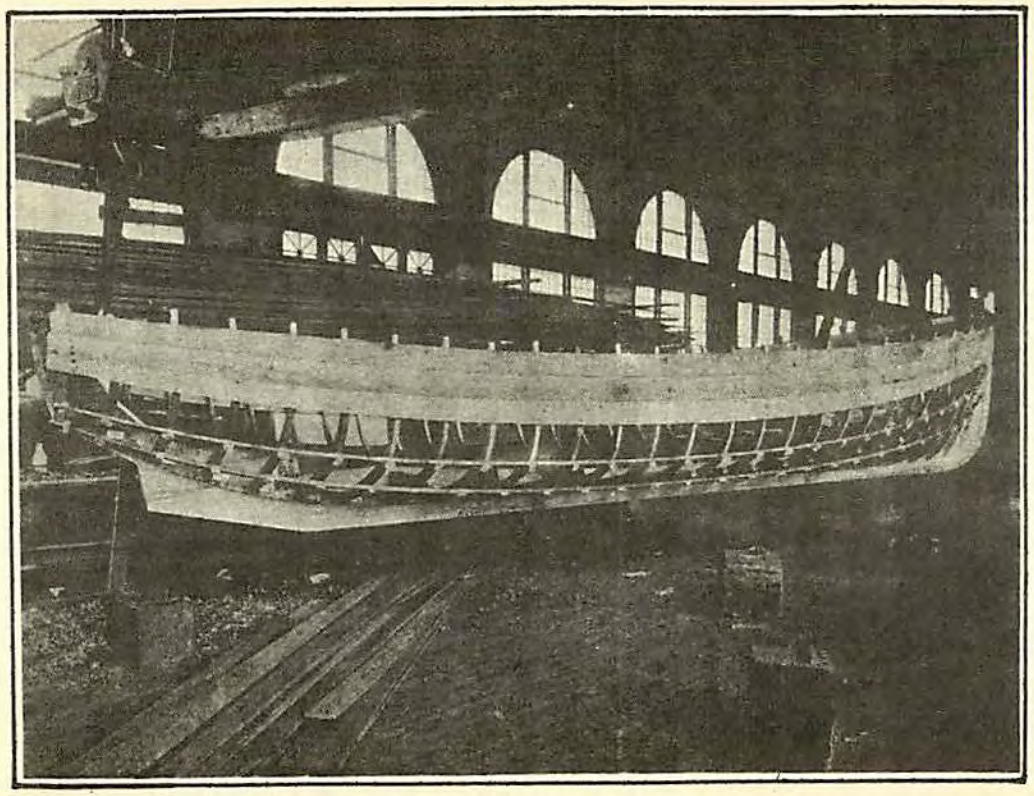


FIG. 49(a) TWENTY-FOUR-FOOT MOTOR LAUNCH

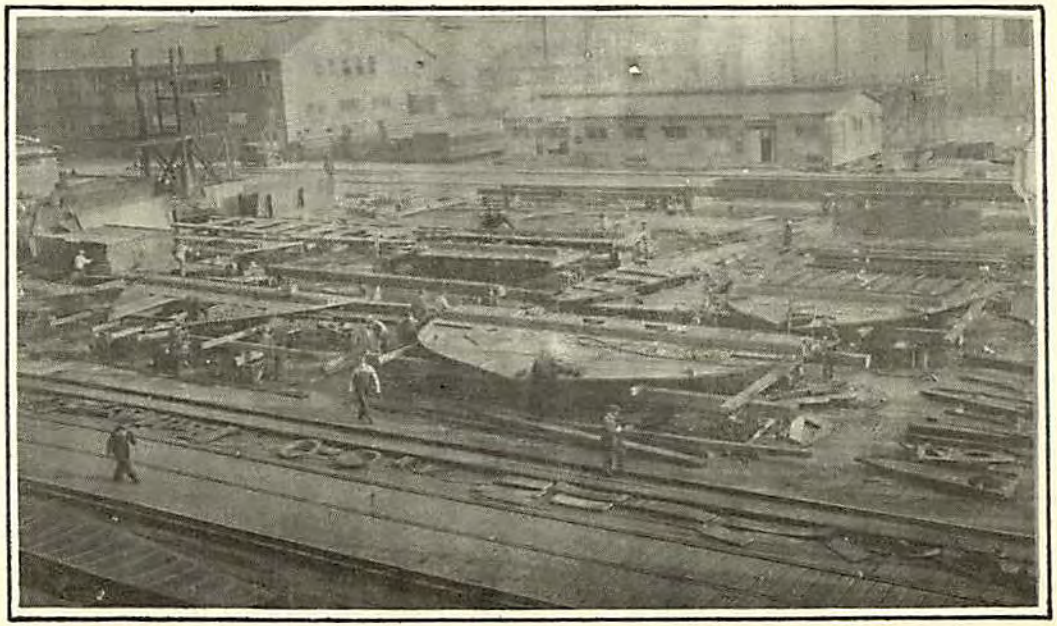


FIG. 51 YARD ASSEMBLY SHOWING BULKHEADS AND INTERCOSTAL FLOOR FRAMES

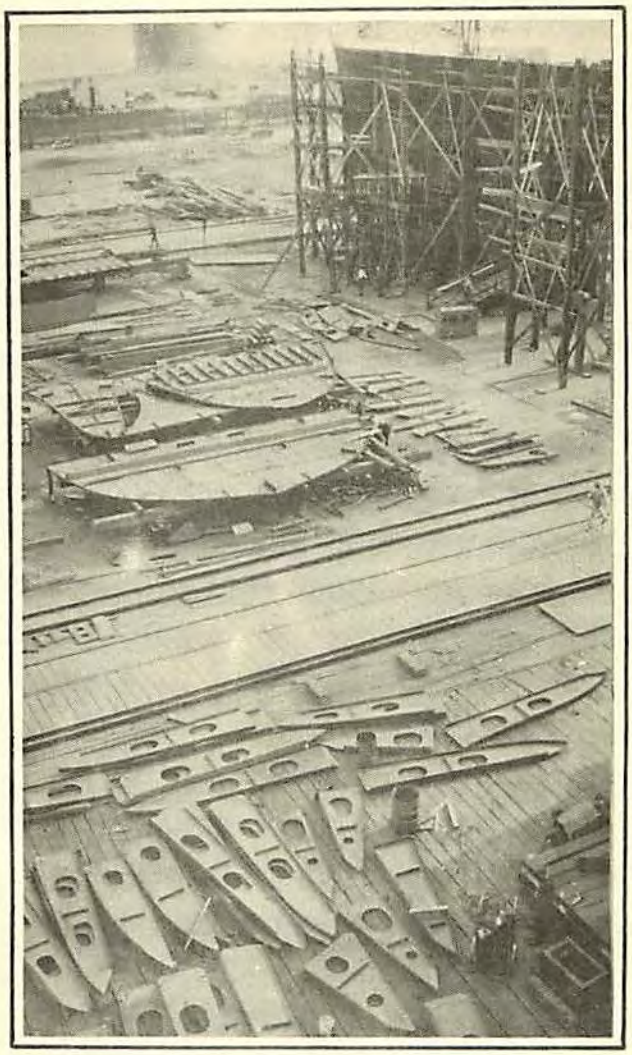


FIG. 52 YARD ASSEMBLY SHOWING
BULKHEADS AND INTERCOSTAL FLOOR FRAMES

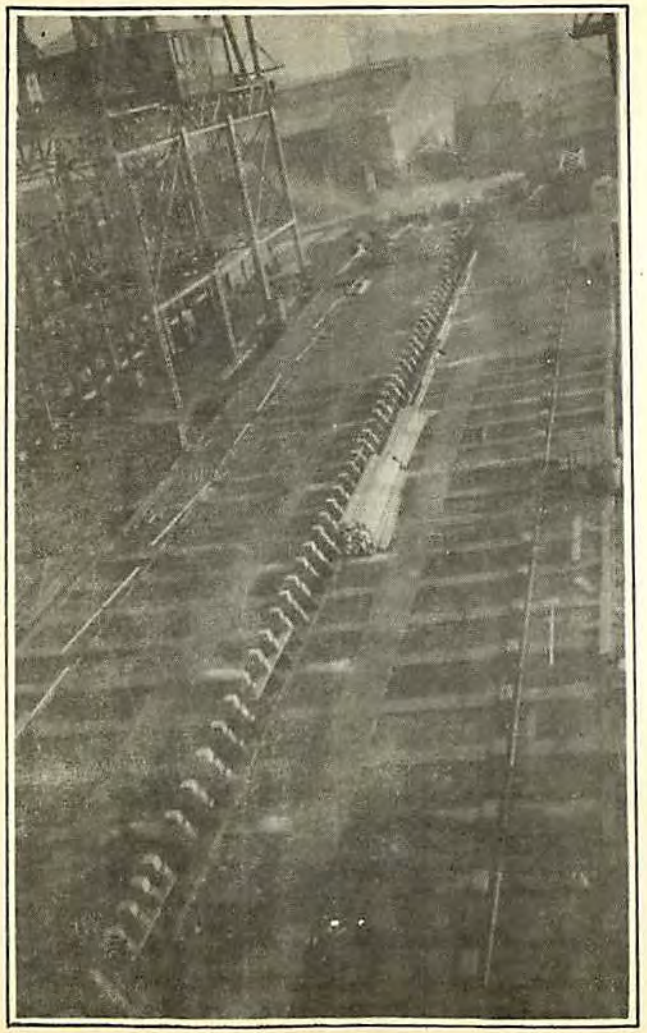


FIG. 50 BUILDING WAYS - KEEL BLOCKS

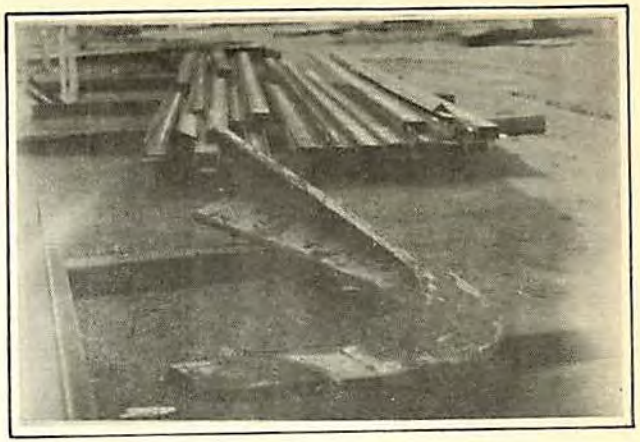


FIG. 53 STEM FOREFOOT CASTING

FIG. 54 STEM FOREFOOT-SHOWING SCARPH

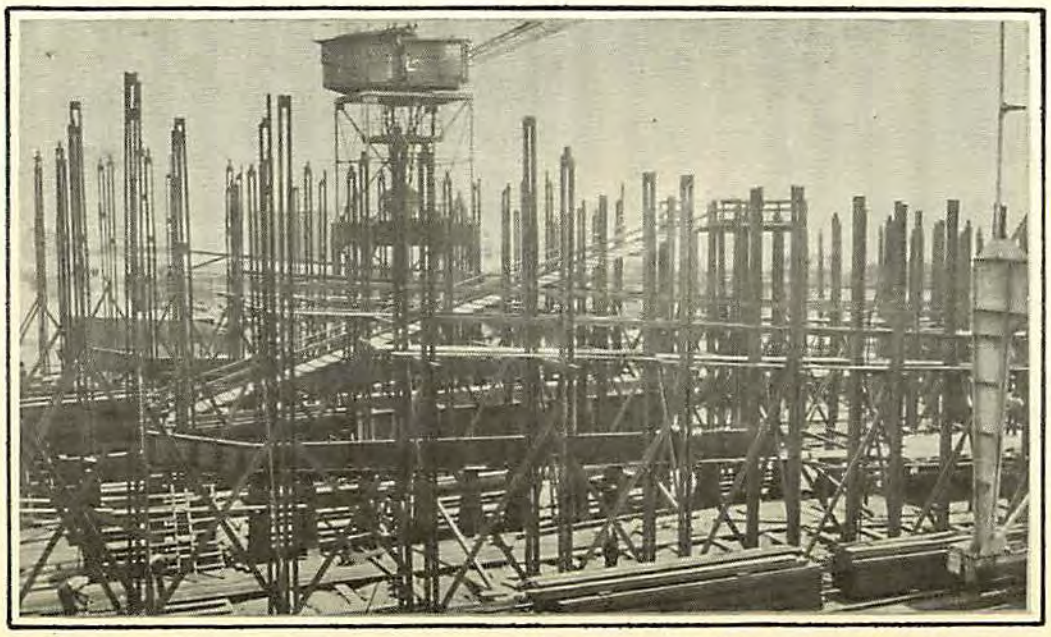


FIG. 56 AFTER SECTION OF VERTICAL KEEL WITH SCAFFOLDING FOR FRAME ERECTION

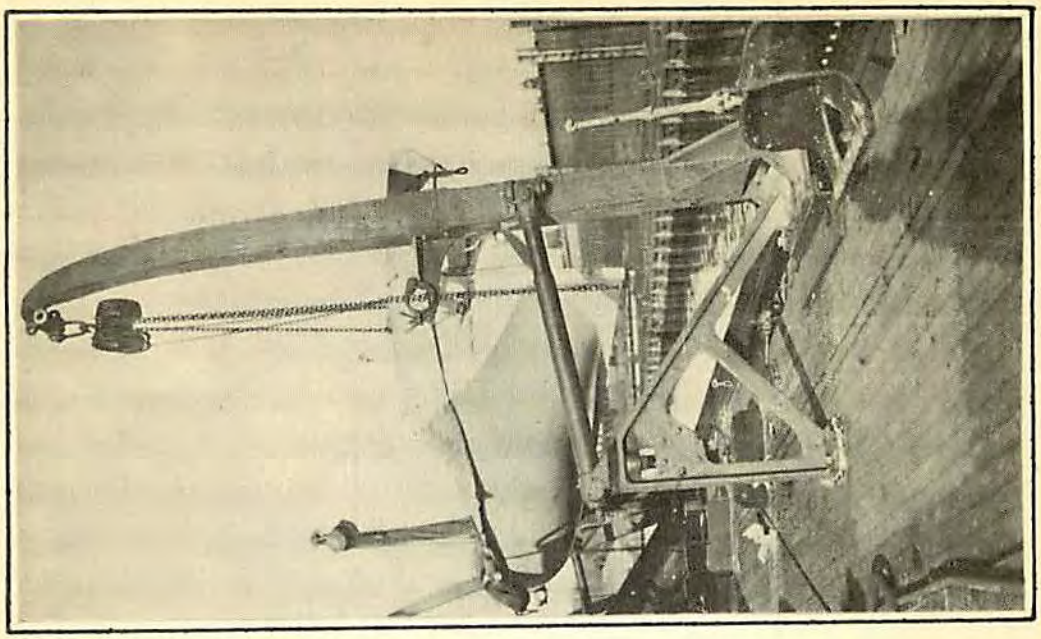


FIG. 105 WELIN DAVIT

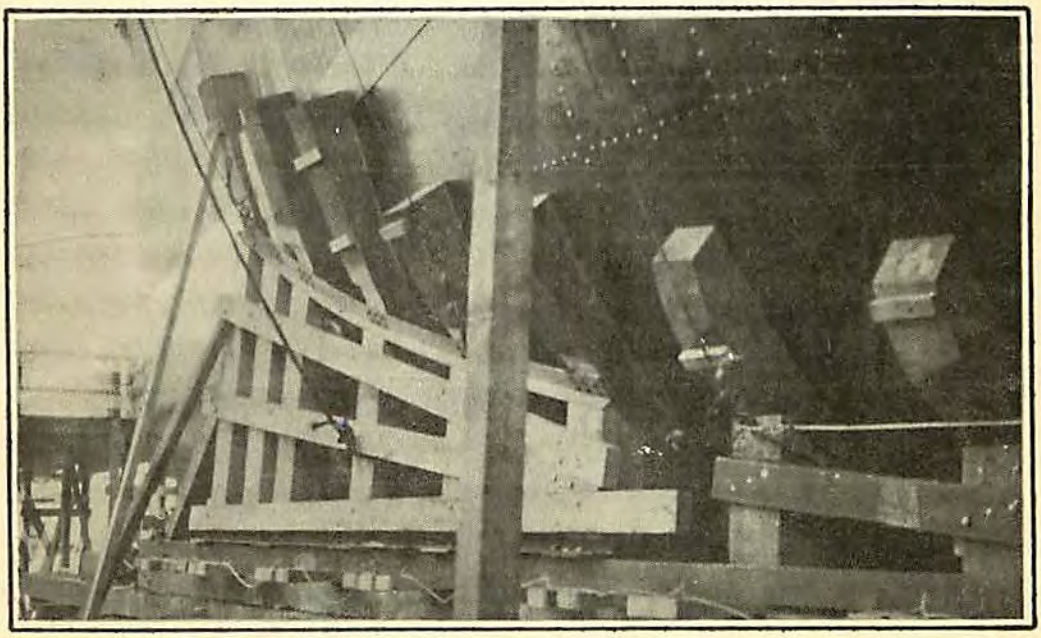


FIG. 106 FORWARD POPPET

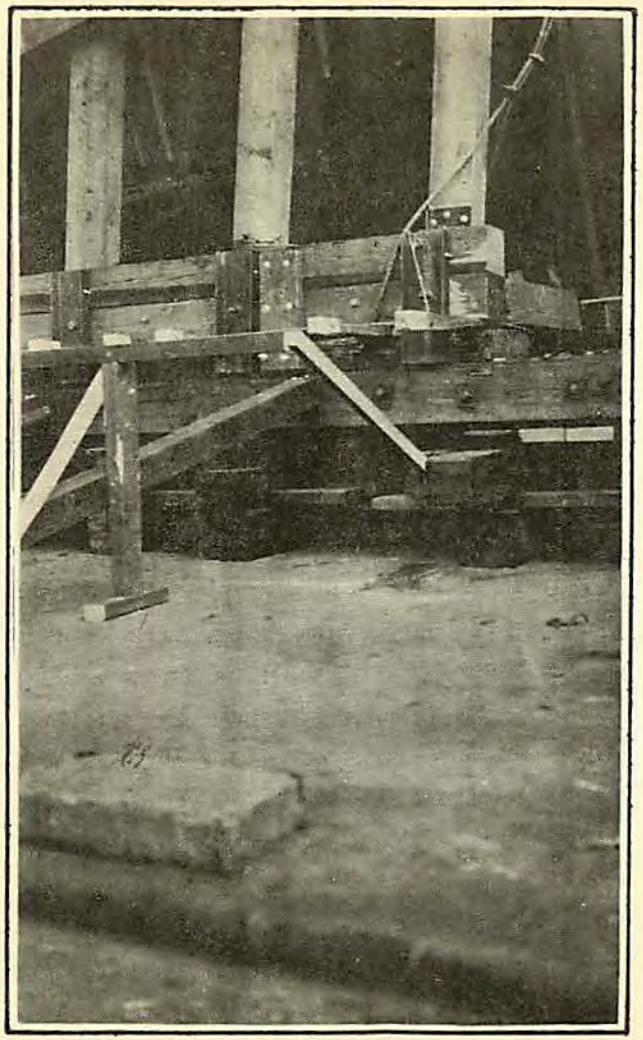


FIG. 108 FORWARD END OF LAUNCHING CRADLE

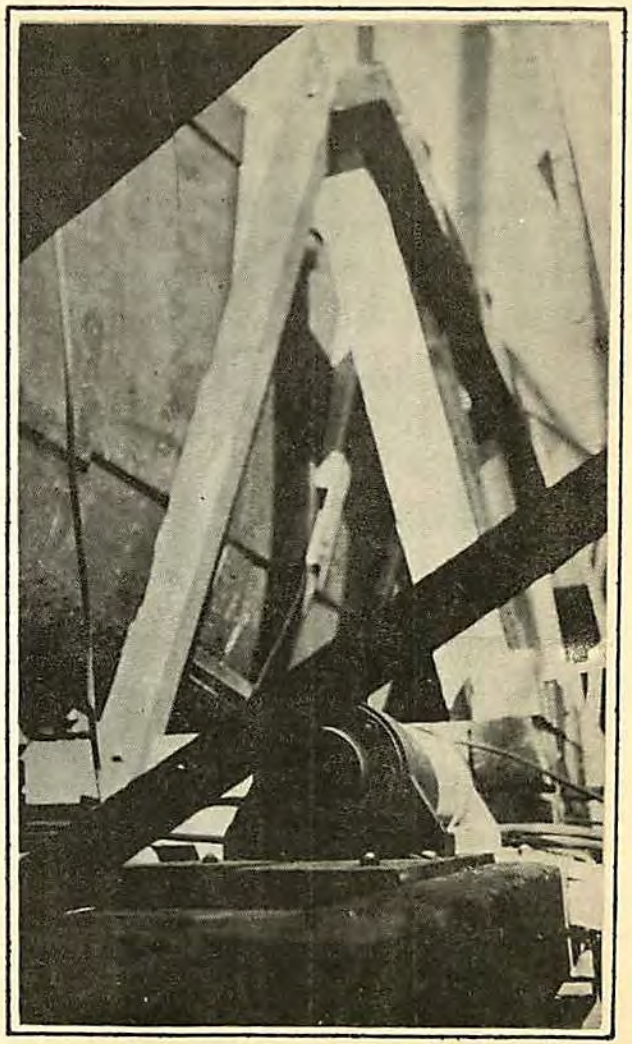


FIG. 107 LOOKING AFT SHOWING LAUNCHING CRADLE AT FORE POPPET

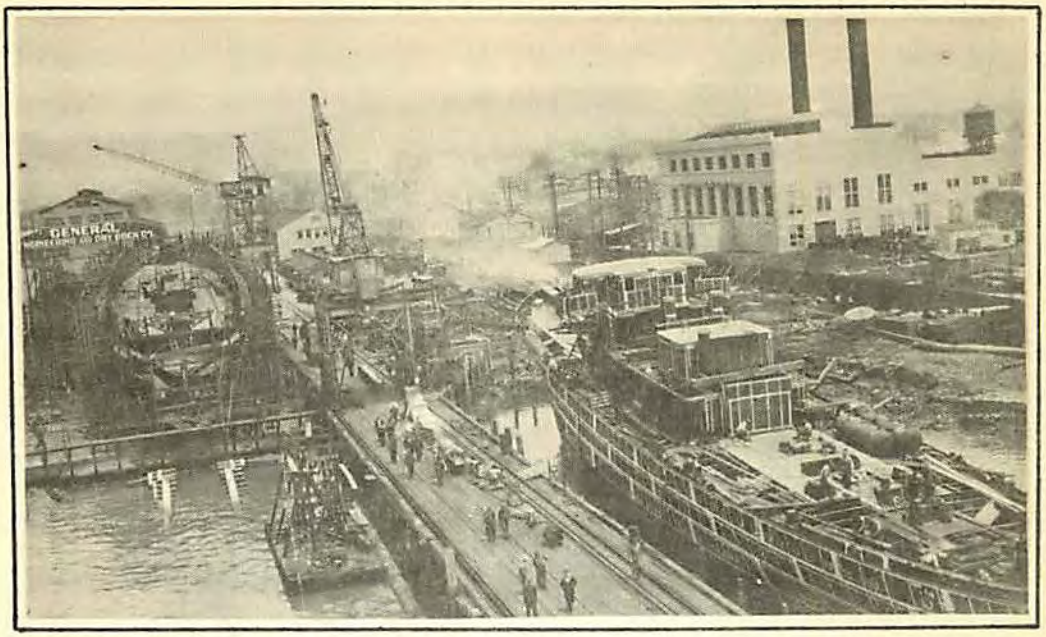


FIG. 109 "SARANAC" IN RIGHT FOREGROUND; "SHOSHONE" ON WAYS

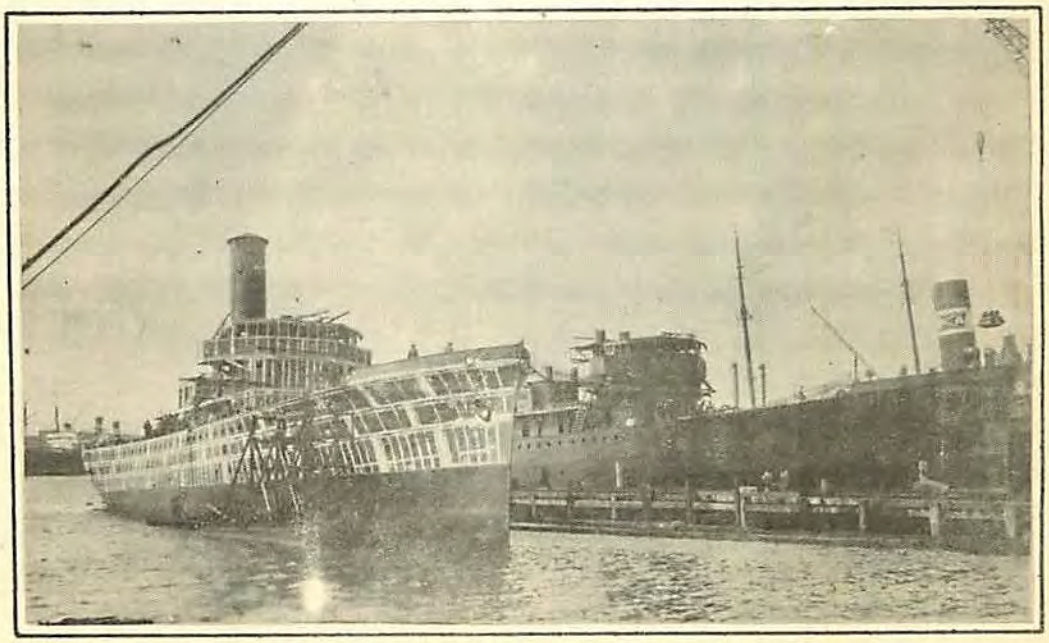


FIG. 110 "SEBAGO" ON LEFT; "ITASCA" ON RIGHT

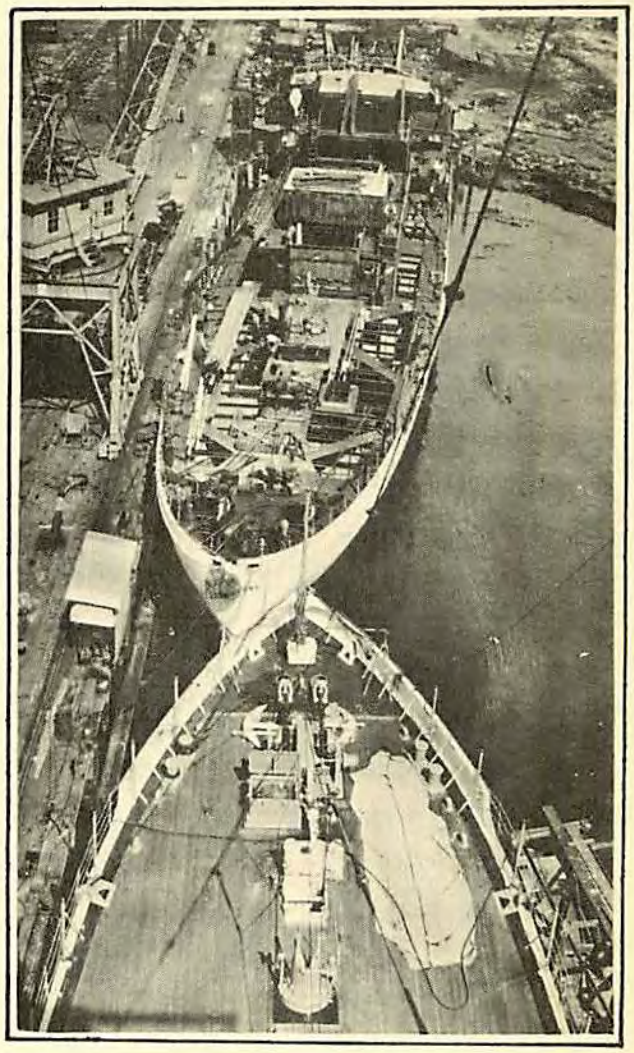


FIG. 111 "SHOSHONE" AND BOW OF "SARANAC"

FIG. 112 "SEBAGO" ON LEFT; "ITASCA" ON RIGHT

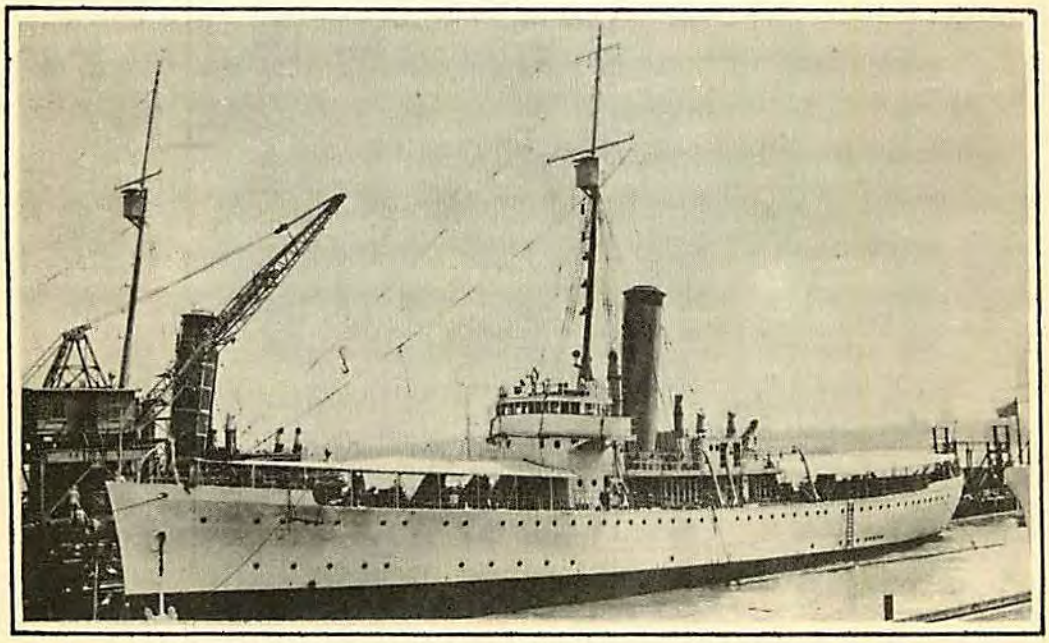


FIG. 113 "SEBAGO"

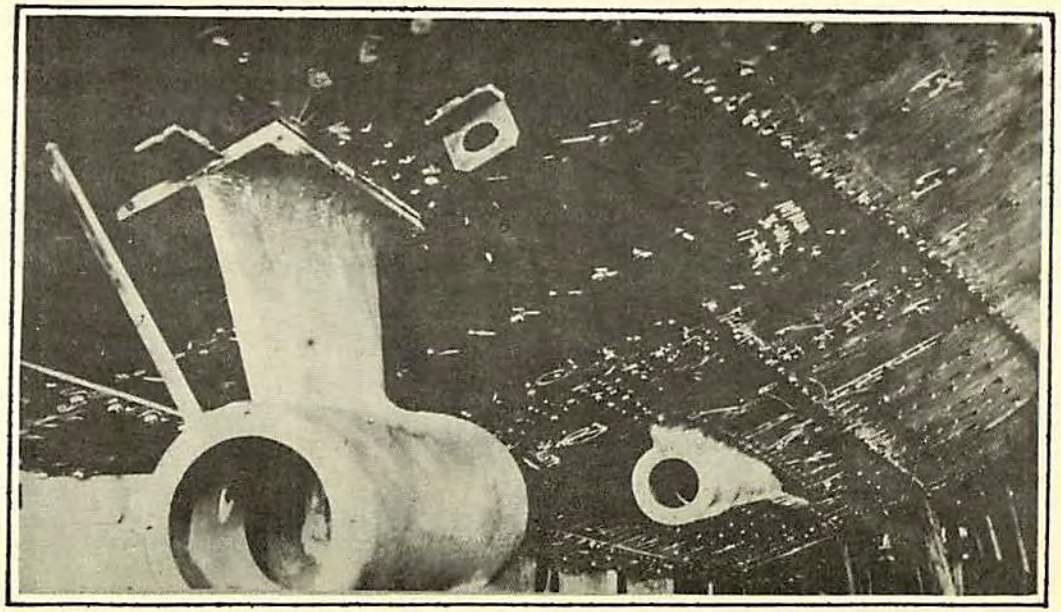


FIG. 114 PROPELLER STRUT - PLATING LINED UP

AND BOLTED READY FOR RIVETING

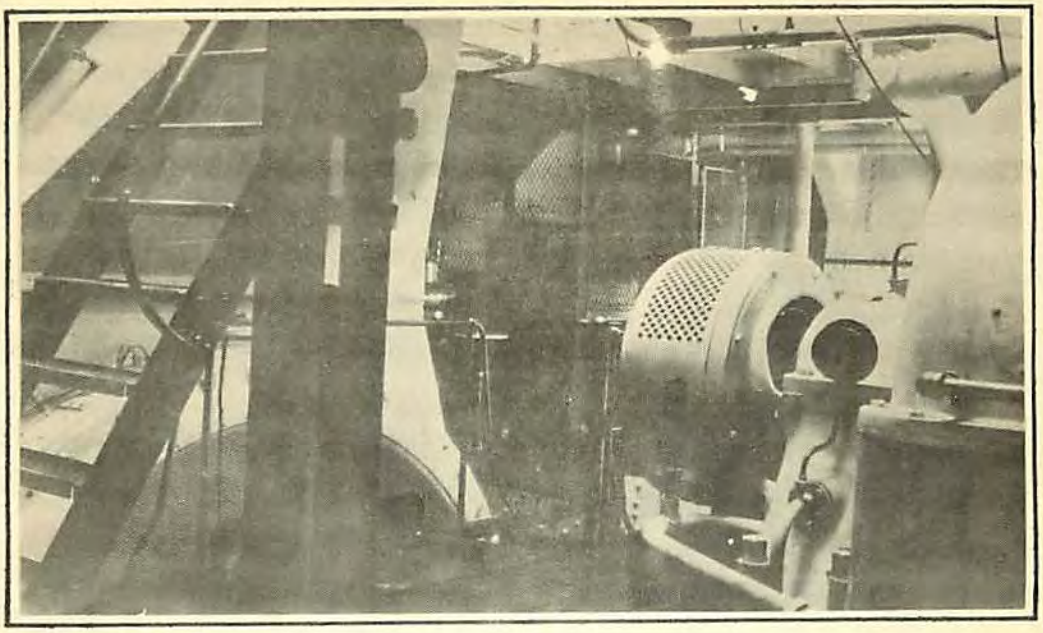


FIG. 115. LOOKING TO PORT ON BERTH DECK IN ENGINE ROOM

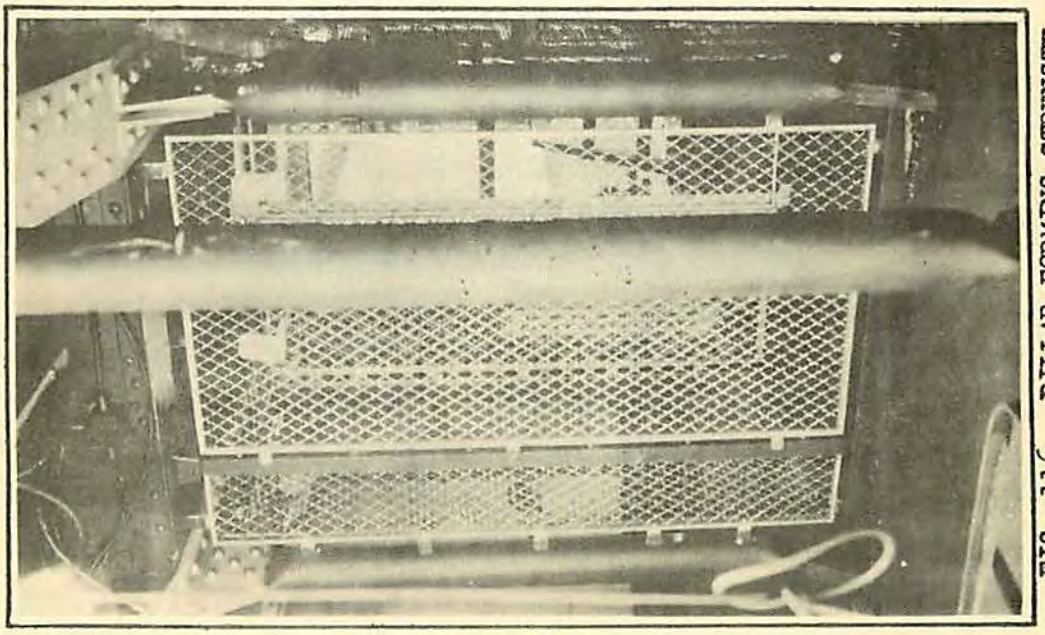


FIG. 116. PILLAR FORMING STRENGTH MEMBER UNDER GIRDER SUPPORTING GUN FOUNDATION

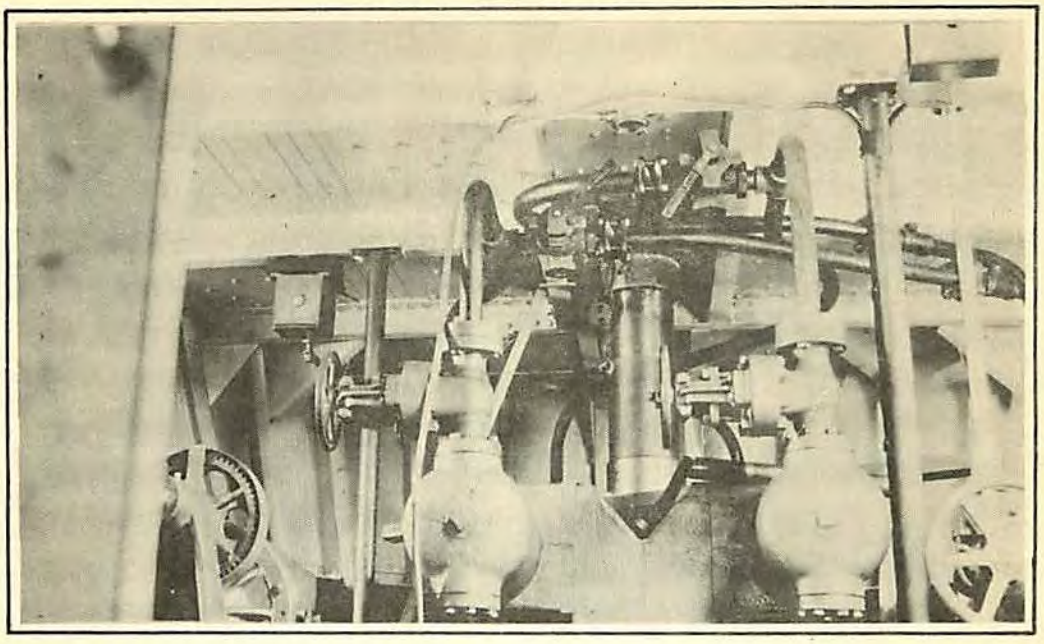


FIG. 117. STEERING GEAR MECHANISM, RUDDER POST, CHANNEL FRAMES AND BEAM BRACKETS, DECK BEAMS AND UNDERSIDE VIEW OF DECK

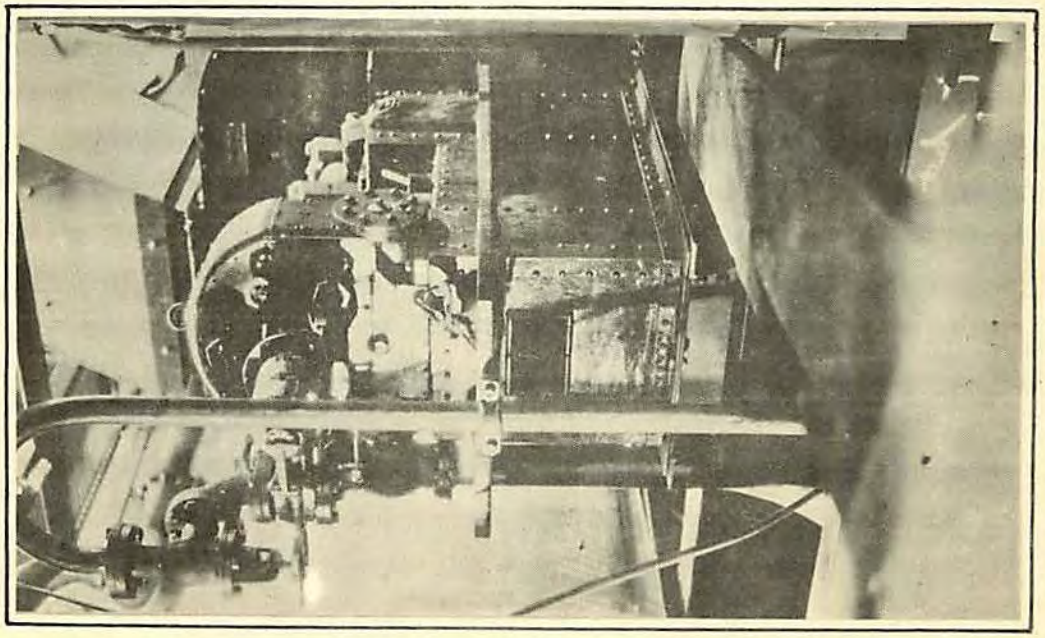


FIG. 118. INDUCED DRAFT BLOWER, MAIN DECK (NOTE FOUNDATION ASSEMBLY)

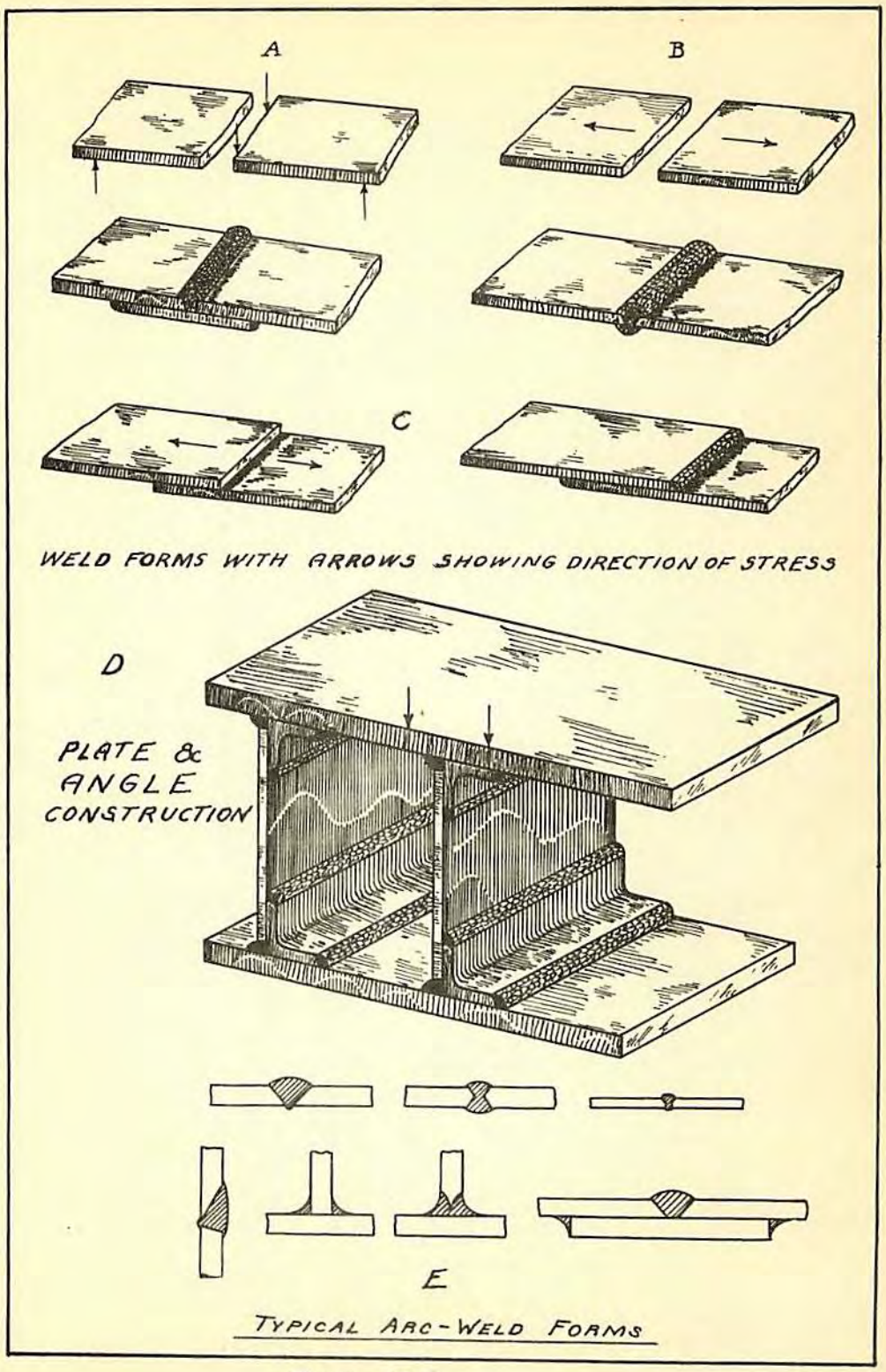

A
B
C
WELD FORMS WITH ARROWS SHOWING DIRECTION OF STRESS
D
PLATE &
ANGLE
CONSTRUCTION
E
TYPICAL ARC-WELD FORMS

FIG. 119

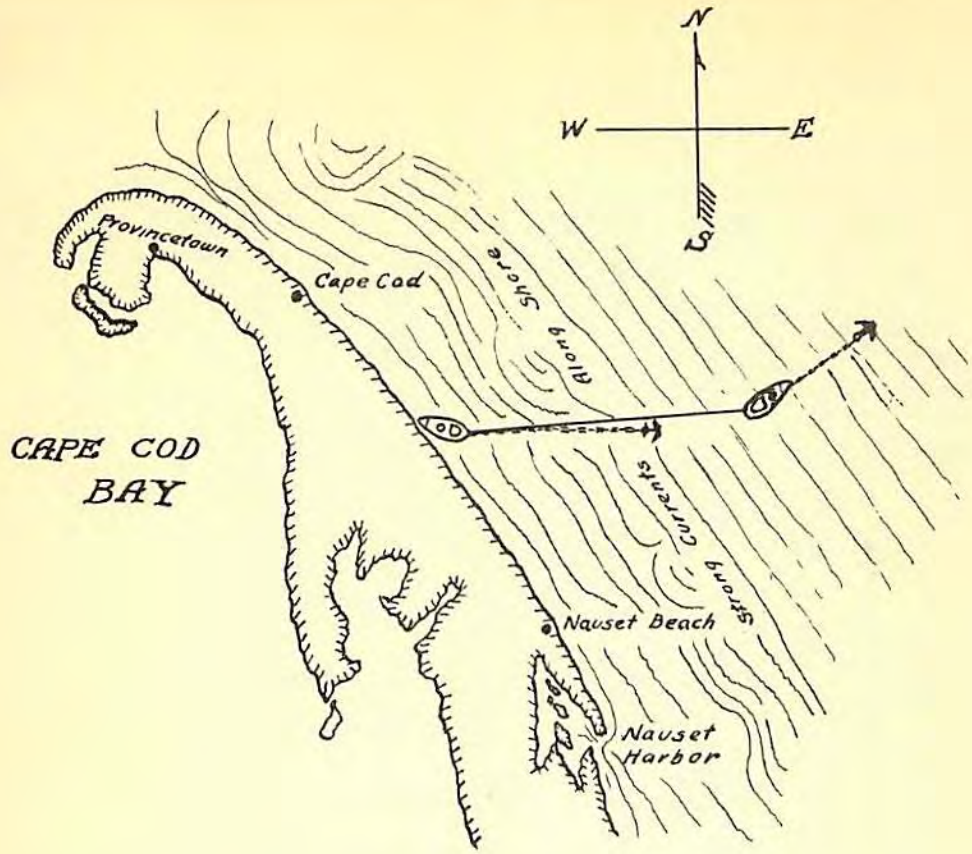


FIG 120

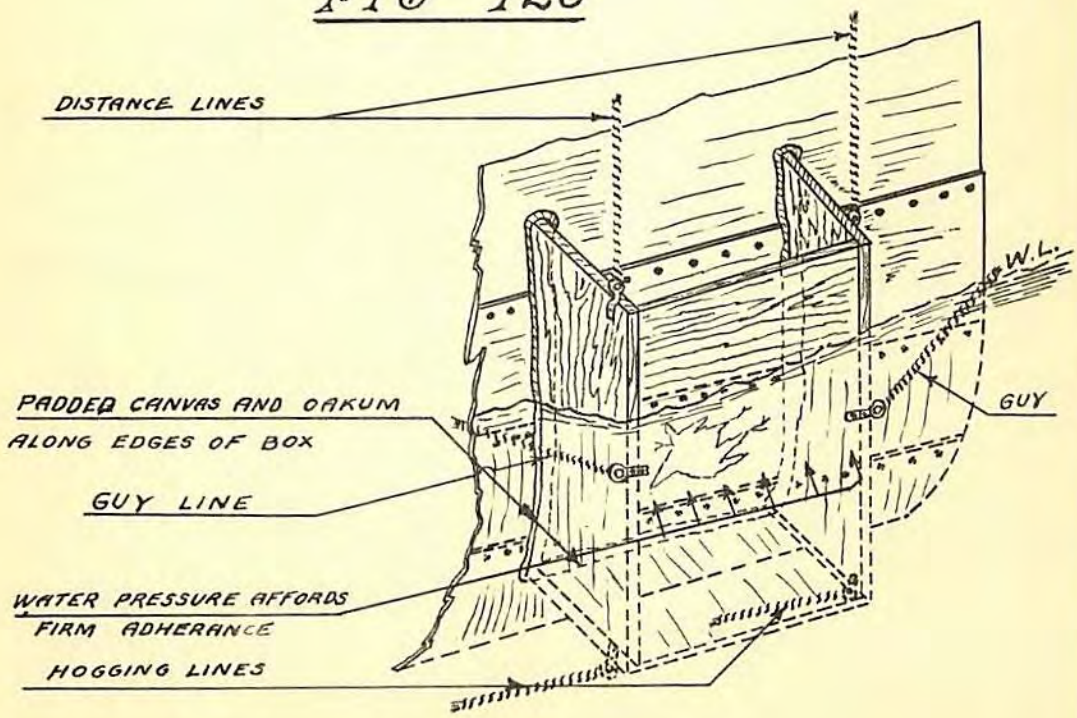


FIG 124

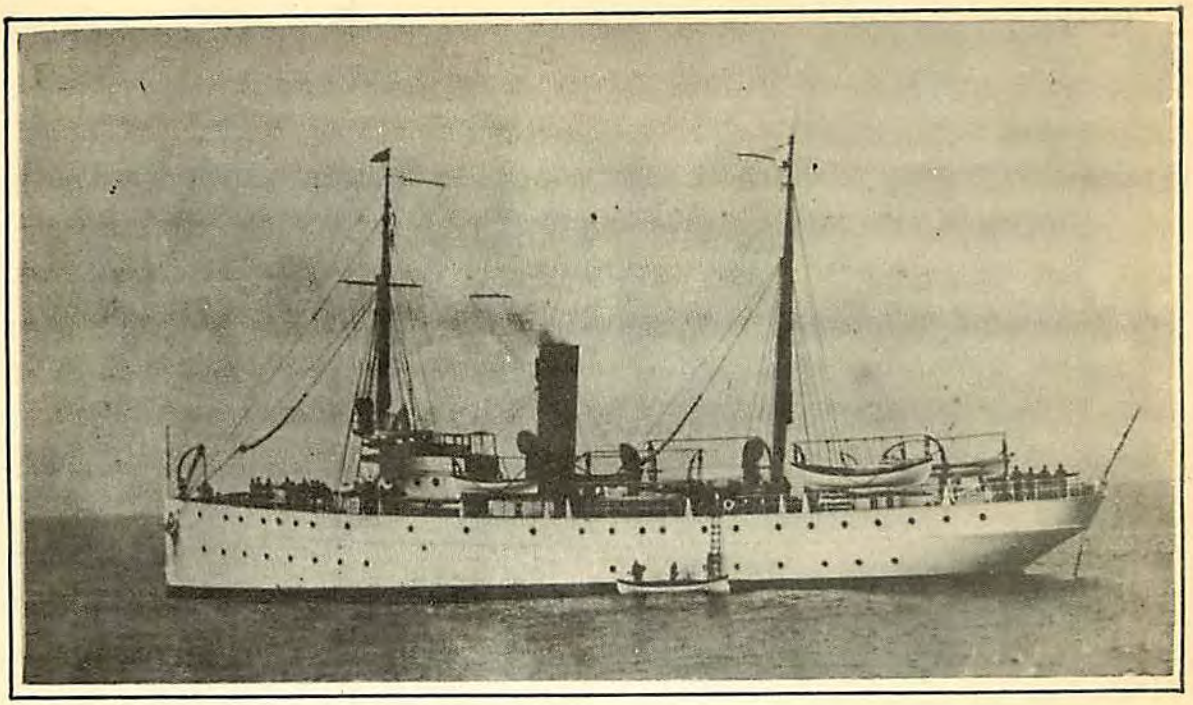


FIG. 121 THE CUTTER TAHOMA IN SEPTEMBER 1914

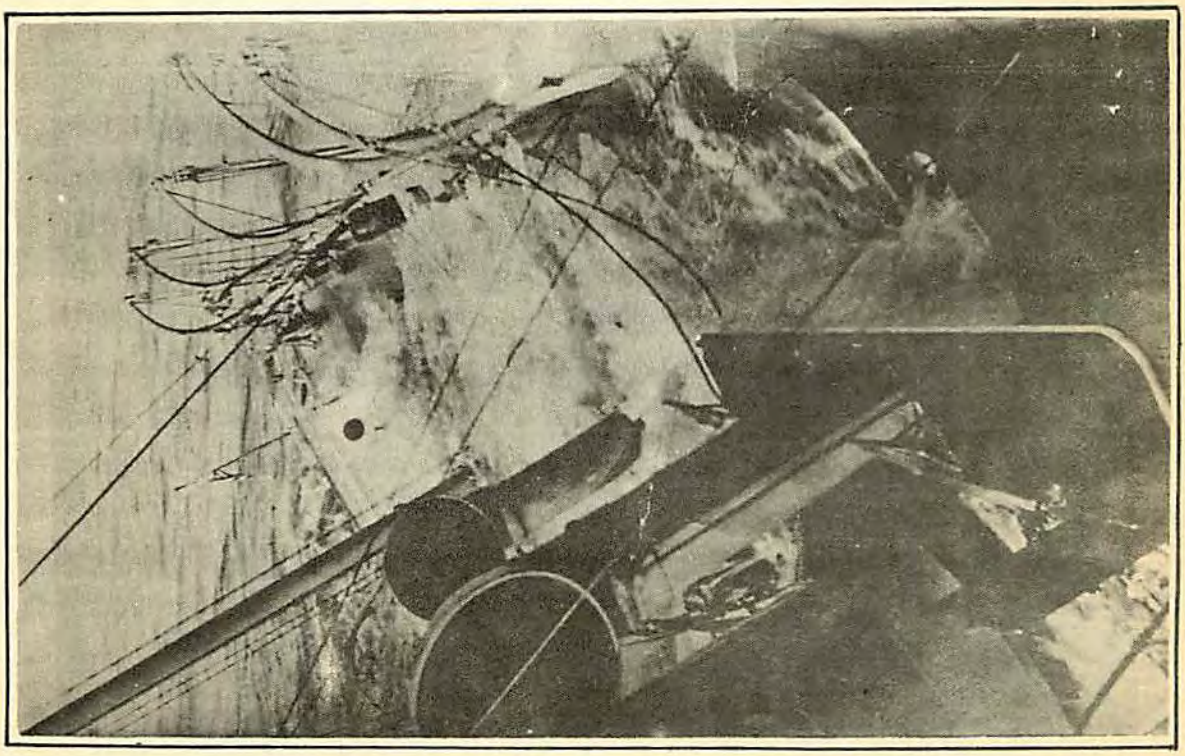
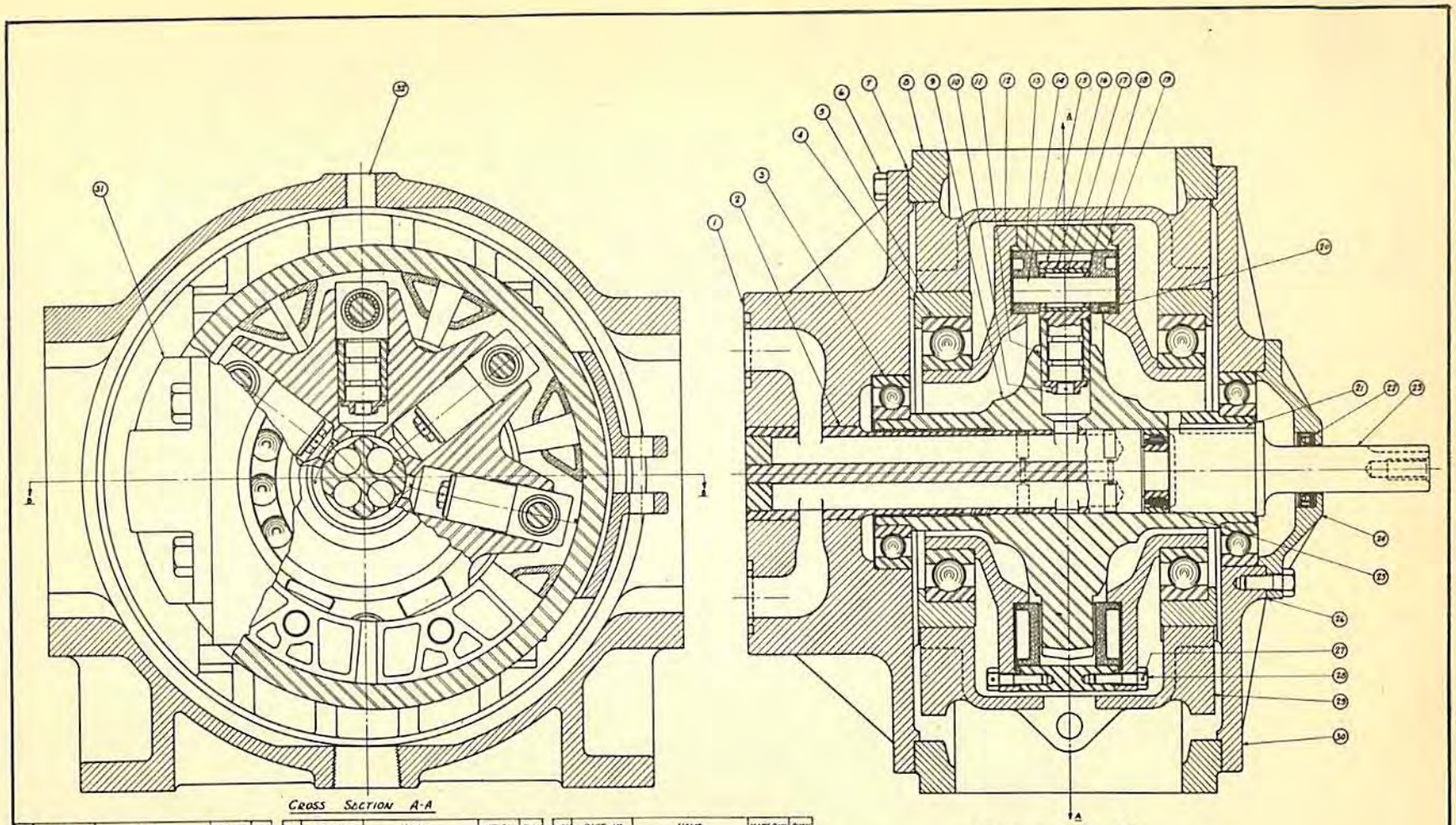


FIG. 122 THE TAHOMA WRECK ALEUTIAN ISLANDS.



CROSS SECTION A-A

HORIZONTAL SECTION B-B

NOTES	PART NO.	NAME	MATERIAL	QUAN.
1	70621-5200	REAR COVER	MC CR M ST	1
2	70643-5200	TIMING SHAFT	NITEALLOY	1
3		3/8 MAX TYPE B SEG.		2
4		HEC-113 B. GARNEY SEG.		7
5	70660-5200	ROTOR GUIDE	MC CR M ST	2
6		3/8 U.S.S. NT CAP SCREW		36
7	70680-5200	GASKET FOR HOUSING	PAPER	2
8	70602-5200	HOUSING	MC CR M ST	1
9	70681-5240	CYLINDER BLOCK	NITEALLOY	1
10	70630-5240	PISTON SLEEVE NUT	S.A.E. 1020	7
11	70600-5240	PISTON SLEEVE	NITEALLOY	7
12	70200-5240	ROTOR SUB. PLATE	MC CR M ST	2
13	70300-5200	CROSS HEAD SHOE	SO BO 40 2	7
14	70320-5200	CROSS HEAD PIN	[illegible]	7
15	70580-5240	CROSS HEAD	NITEALLOY	7
16	70550-5200	CROSS HEAD BUSHING	[illegible]	7
17	70541-5200	CROSS HEAD SEG. ROLLER	S.A.E. 52100	14 B
18	70561-5200	SPACER FOR ROLLER	NITEALLOY	14
19	70580-5200	ROTOR CENTER RING	[illegible]	1
20		1/4-20 ALLEN HD SET SCREW		7
21		1/4 x 1 1/2 KEY		1
22		2"-18 S/4 PERFECT OIL RET		1
23	70283-5210	DRIVE SHAFT	S.A.E. 4140	1
24	70160-5210	END COVER	MC CR M ST	1
25		ROLLER BRG (P-173-L.W.R.)		1
26	70620-5200	GASKET FOR END COVER	PAPER	1
27		WIRE FOR CAP SCREW 3/64 d		
28		3/8 U.S.S. 11" CAP SCREW		16
29	-	ROTOR GUIDE YOKE (LONTROL)	MC CR M ST	2
30	70660-5200	FRONT COVER	MC CR M ST	1
31		ROTOR GUIDE YOKE	MC CR M ST	1
32	70820-5200	3/8 U.S.S. EYE BOLT	STEEL FORG.	1
33				
34				
35				
36				

NORTHERN PUMP COMPANY
MINNEAPOLIS, MINN. U.S.A.

VARIABLE DELIVERY PISTON PUMP

MATERIAL | SCALE 1"=2" | DR. W.L. | CK. W. | DATE 8-23-34

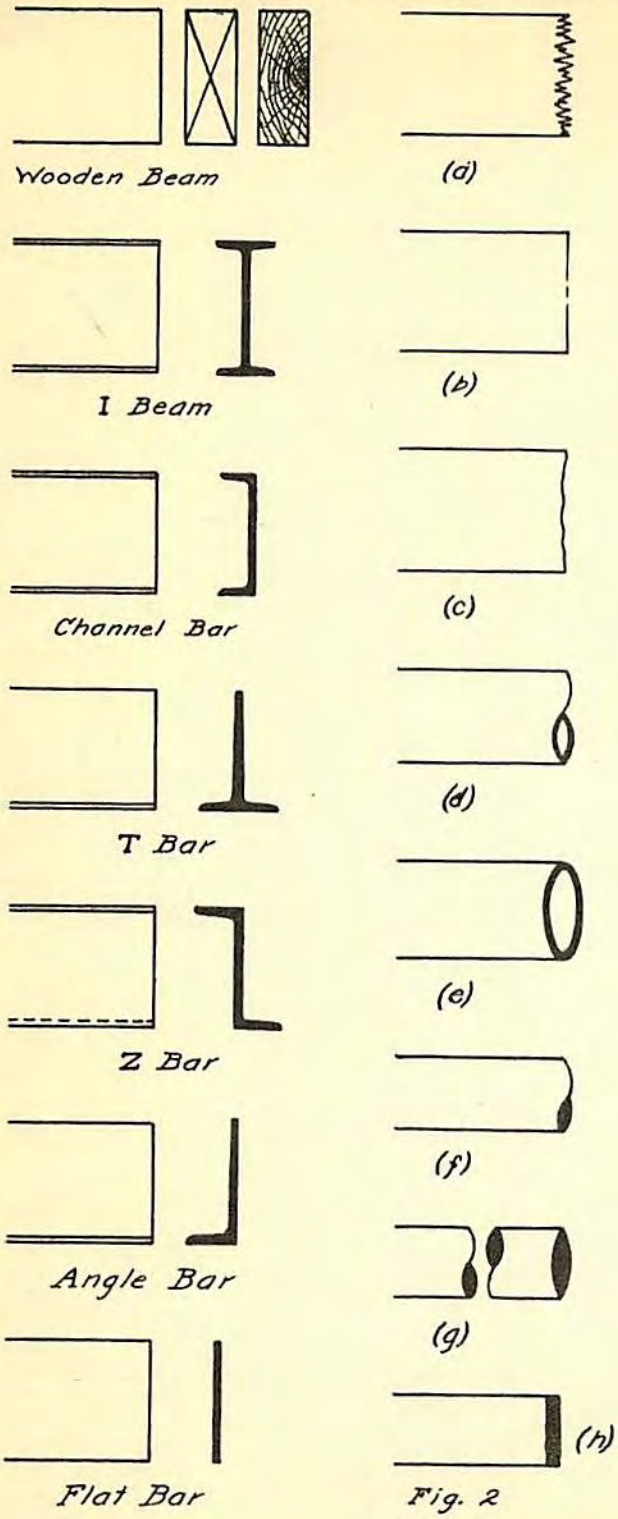
No 5240-V19AX

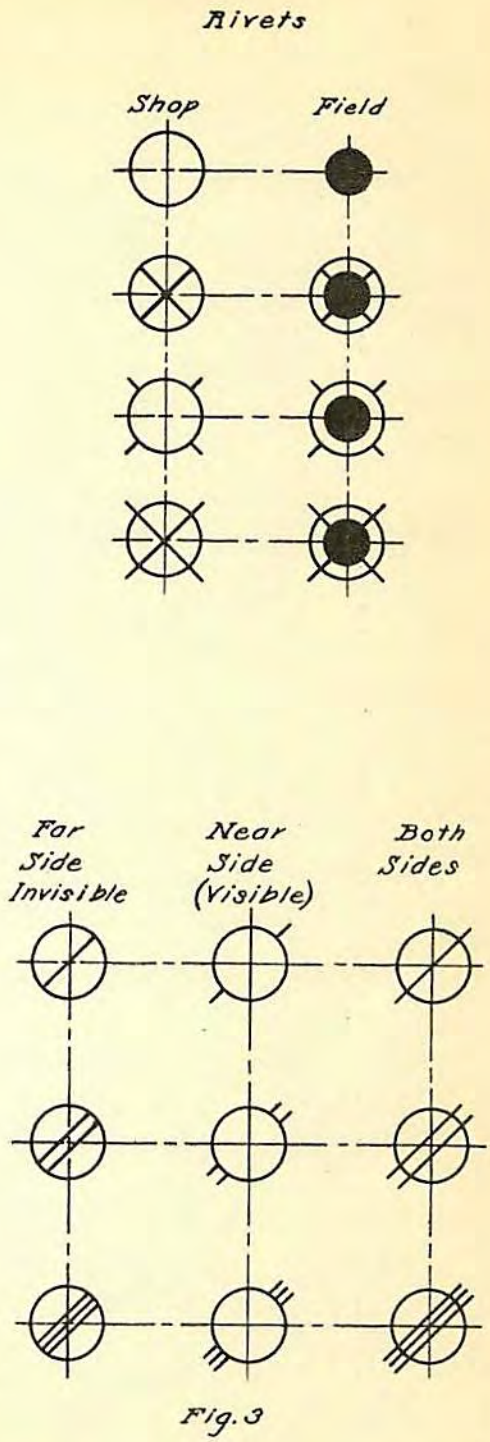
ROTARY RADIAL PISTON TYPE VARIABLE DELIVERY OIL PRESSURE STEERING GEAR PUMP

FIG 123

FIG 125

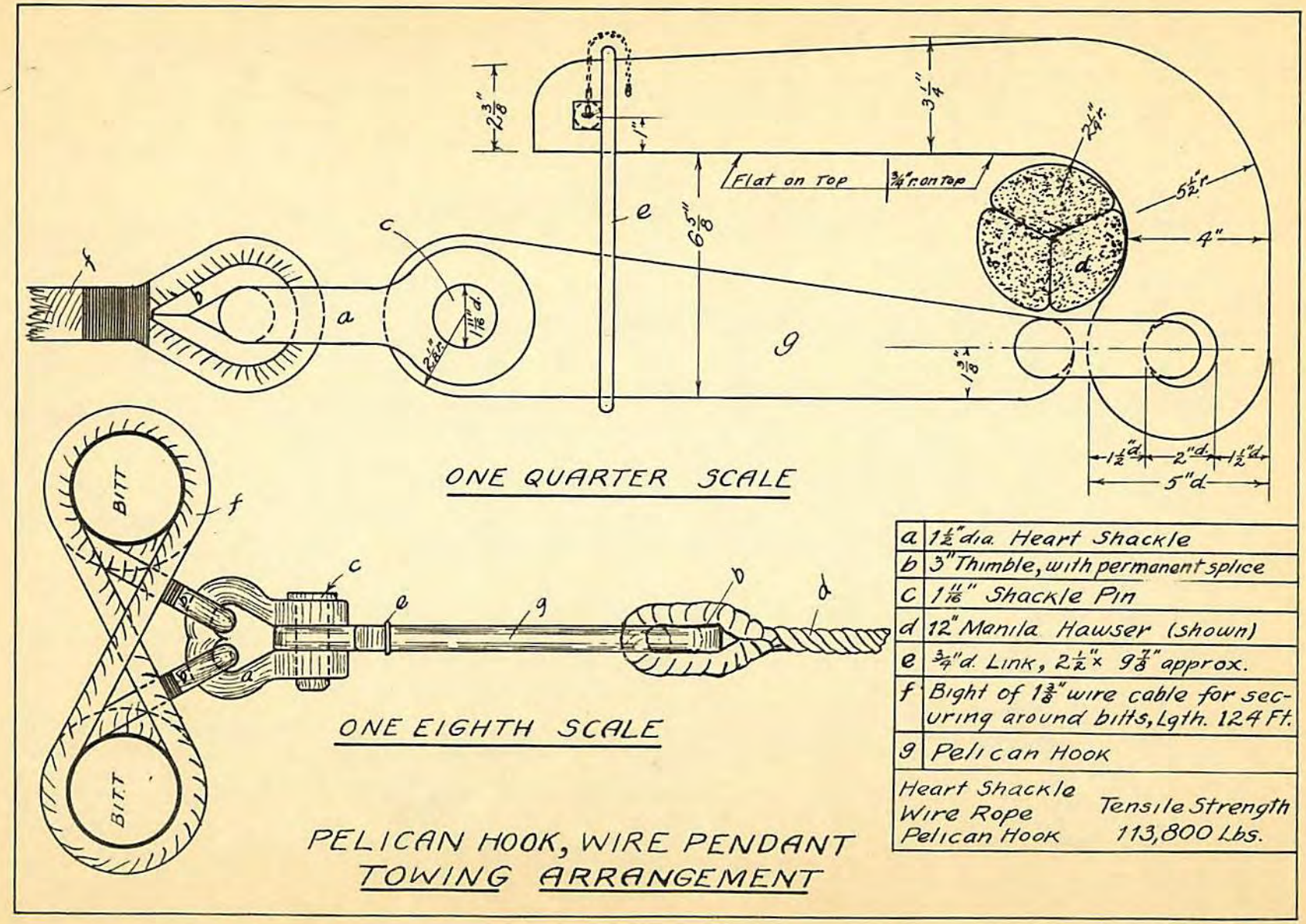
CONVENTIONAL SYMBOLS





Outlines
Hidden Lines
Center Lines
Dimension Lines

Fig. 126



PELICAN HOOK, WIRE PENDANT TOWING ARRANGEMENT

FIG 127

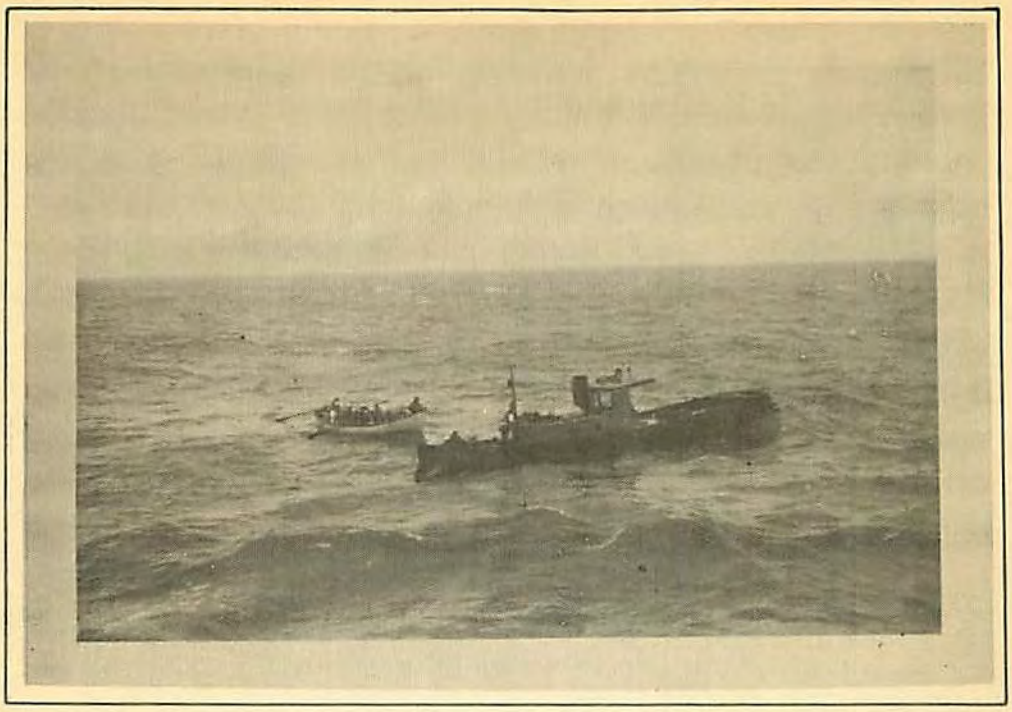


Fig 131

Boarding the tug. Note the oil slick laid down by the "ITASCA" from the windward of the tug.

Fig 132

Paying out the hawser.

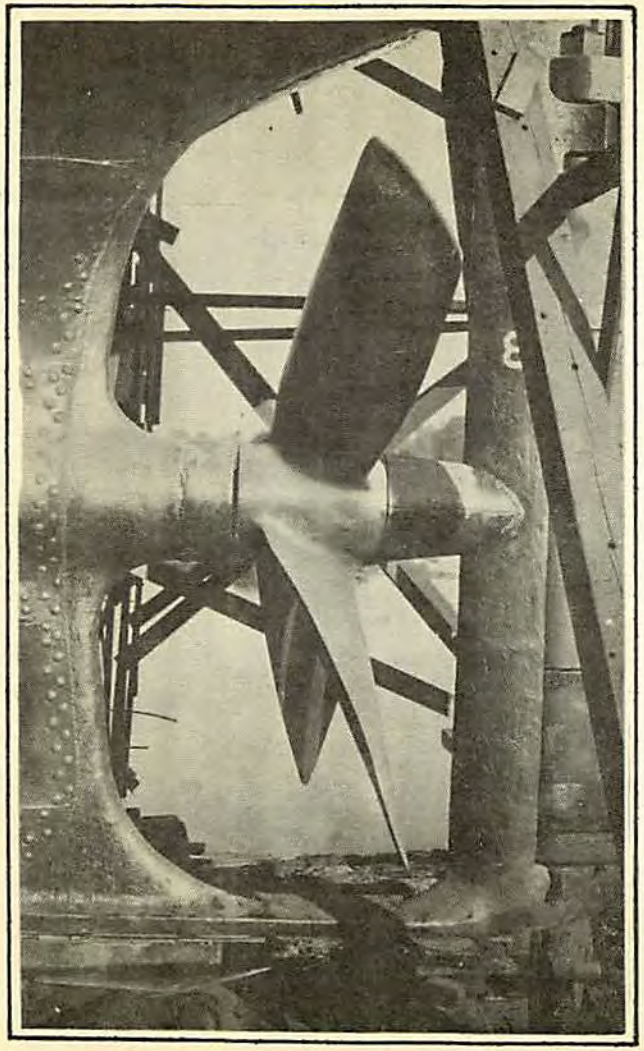


FIG. 91 STERN FRAME ASSEMBLY (NOTE FAIRWATER CONNECTED TO BOSS ON STERN POST

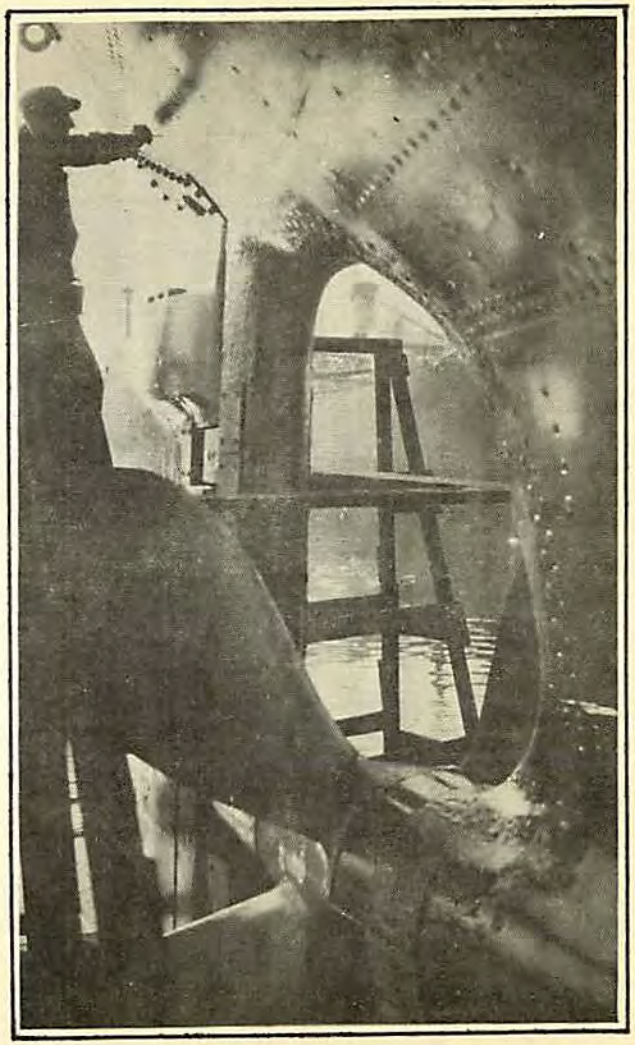


FIG. 90 SHOWING FORM AND SHAPE OF PLATING AROUND PROPELLER POST

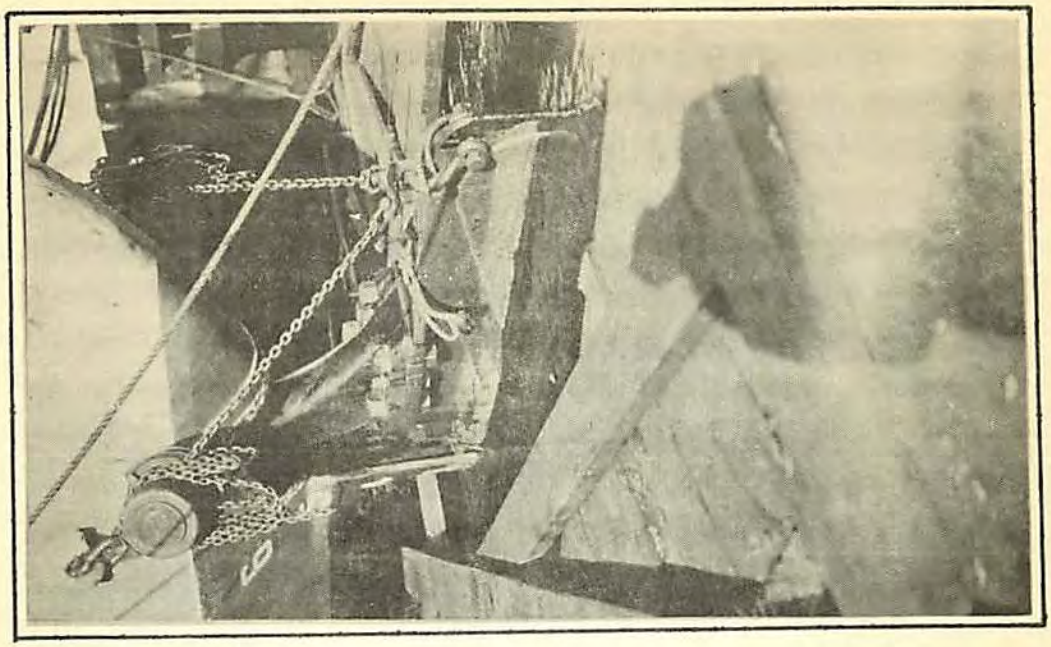


FIG. 92 RUDDER AS SECURED TO RUDDER POST

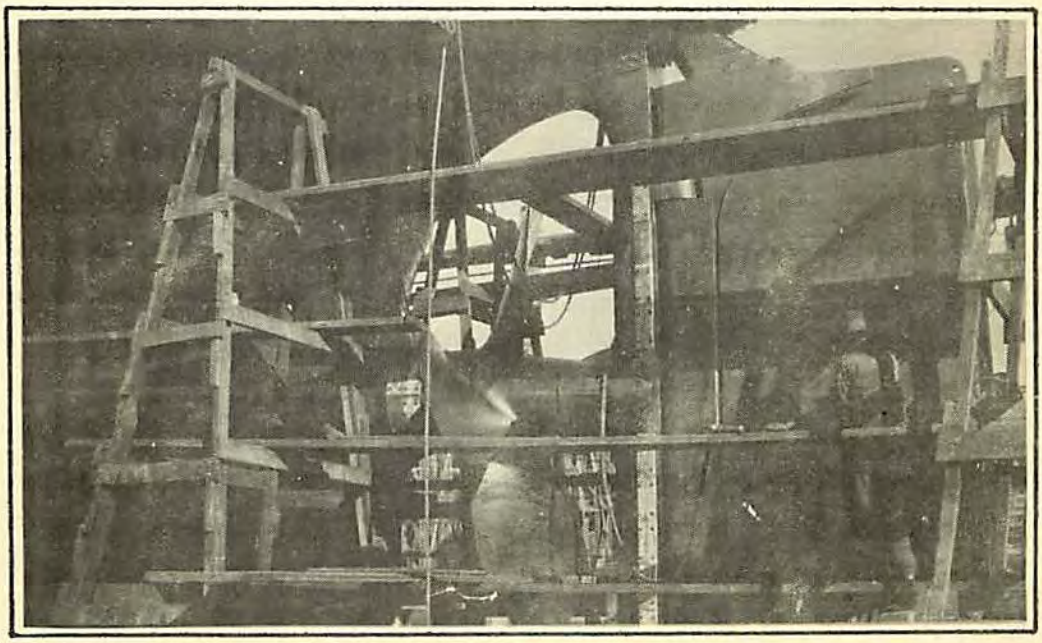


FIG. 93 PROPELLER POST, STERN POST, RUDDER POST AND PROPELLER

FIG. 94 CANT FRAMING ASSEMBLED FOR STERN

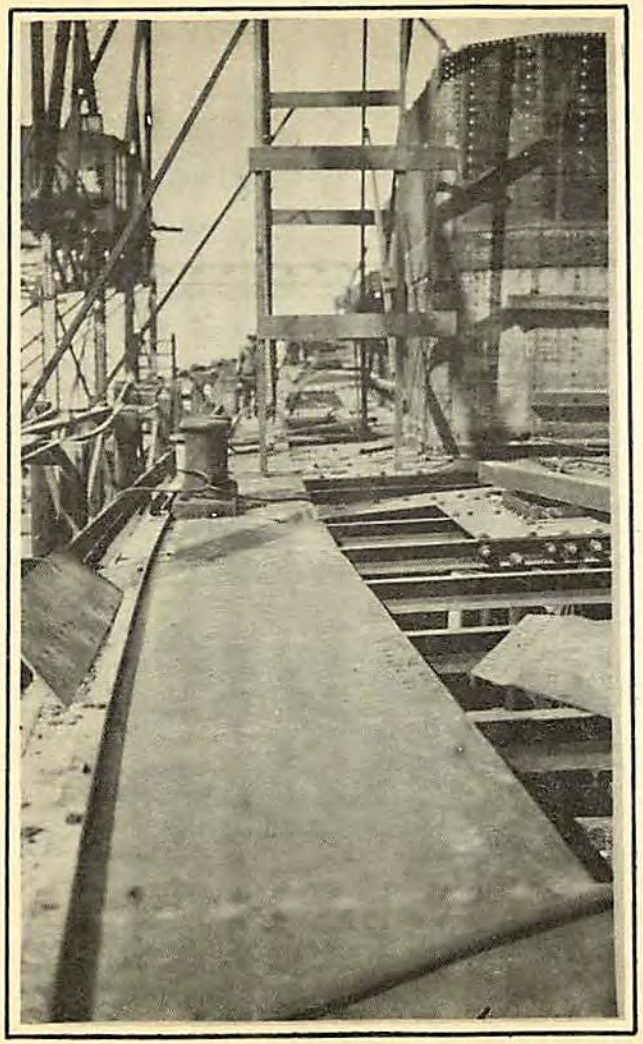


FIG. 96 STARBOARD SIDE OF UPPER DECK LOOKING AFT

FIG. 95 MAIN DECK BEAMS SHOWING PAINTING OF FAYING SURFACES OF SHELL PLATING

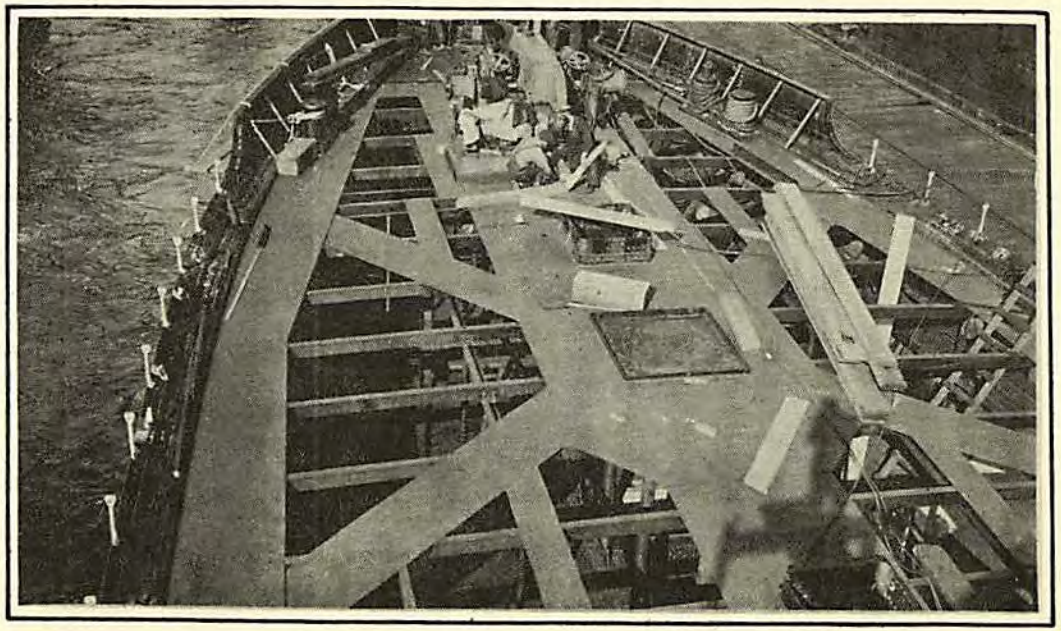


FIG. 97 UPPER DECK, FRAME 28, LOOKING FORWARD (NOTE KING PLATE CENTER WITH TIE PLATES RADIATING OUTWARD TO THE STRINGER PLATES)

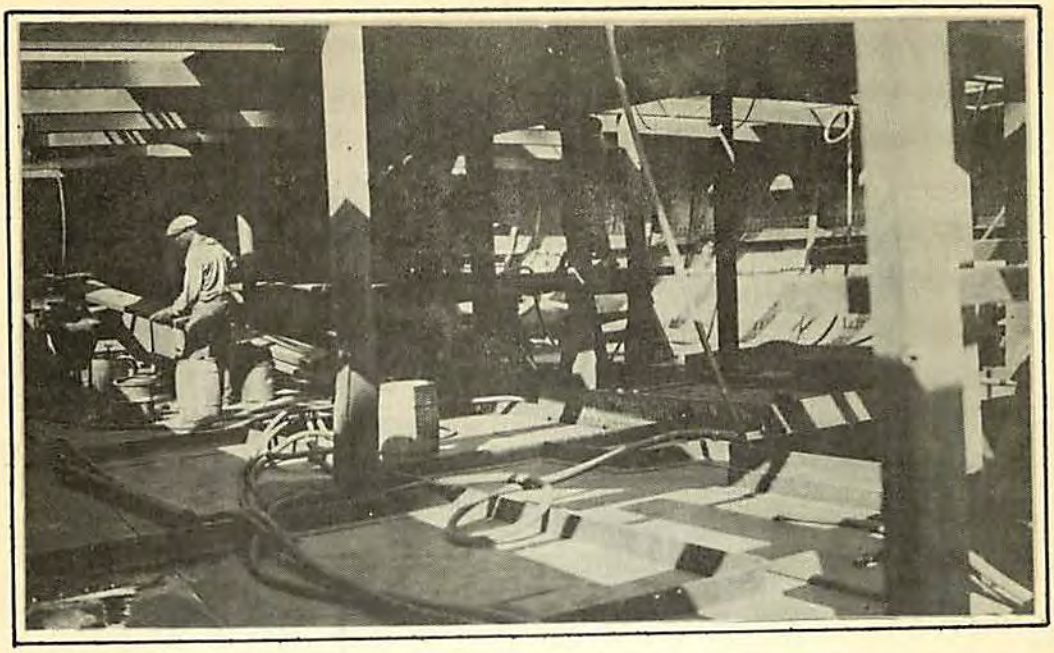


FIG.97(a). BERTH DECK LOOKING FORWARD FROM FRAME 100 SHOWING SIDE STRINGER

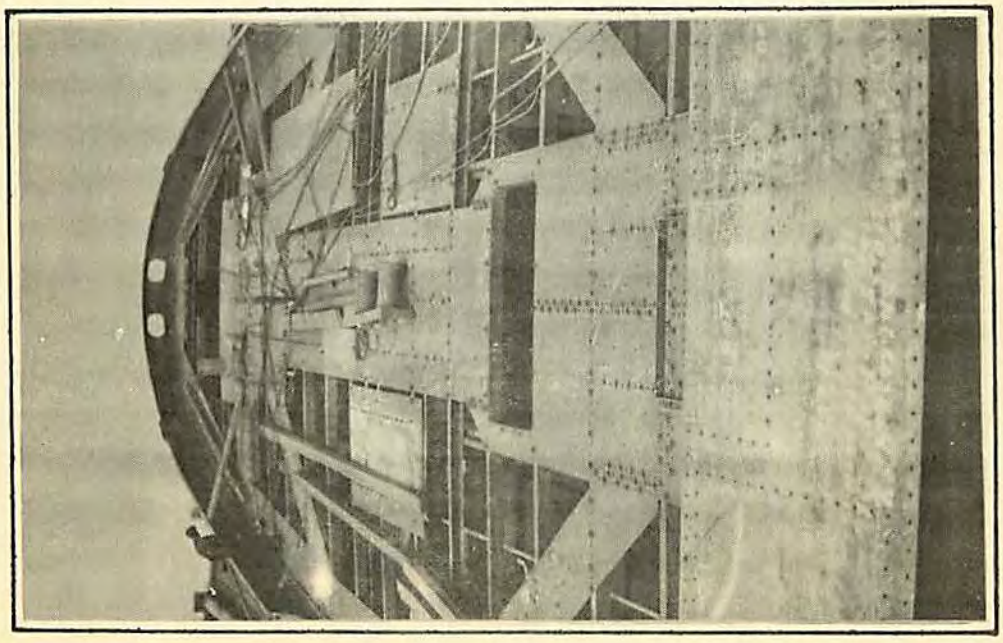


FIG.97(b). UPPER DECK AT STERN SHOWING BULWARKS, BEAMS, KING PLATE, TIE PLATES, AND TOWING BITT BED

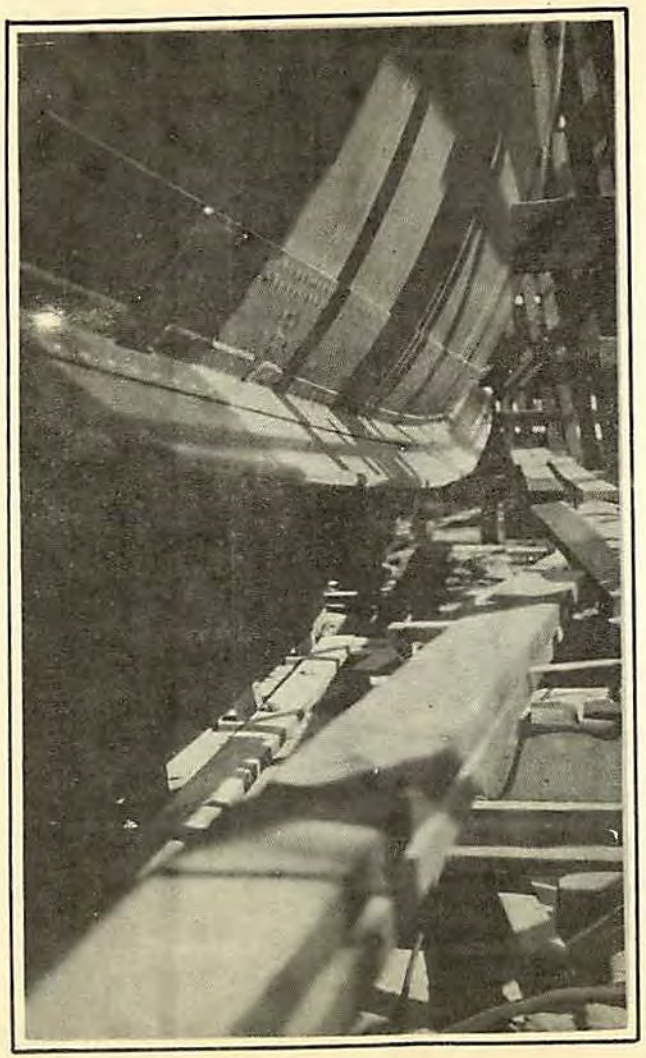


FIG. 99 BILGE KEEL

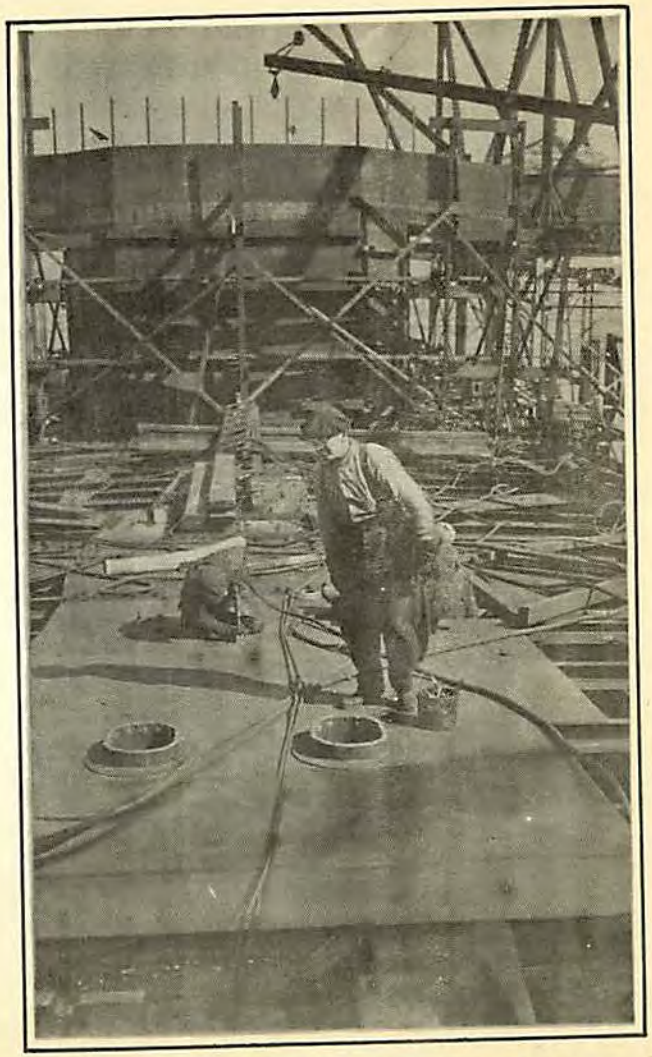


FIG. 98 UPPER DECK FORWARD SHOWING KING PLATE AND CHAIN PIPES

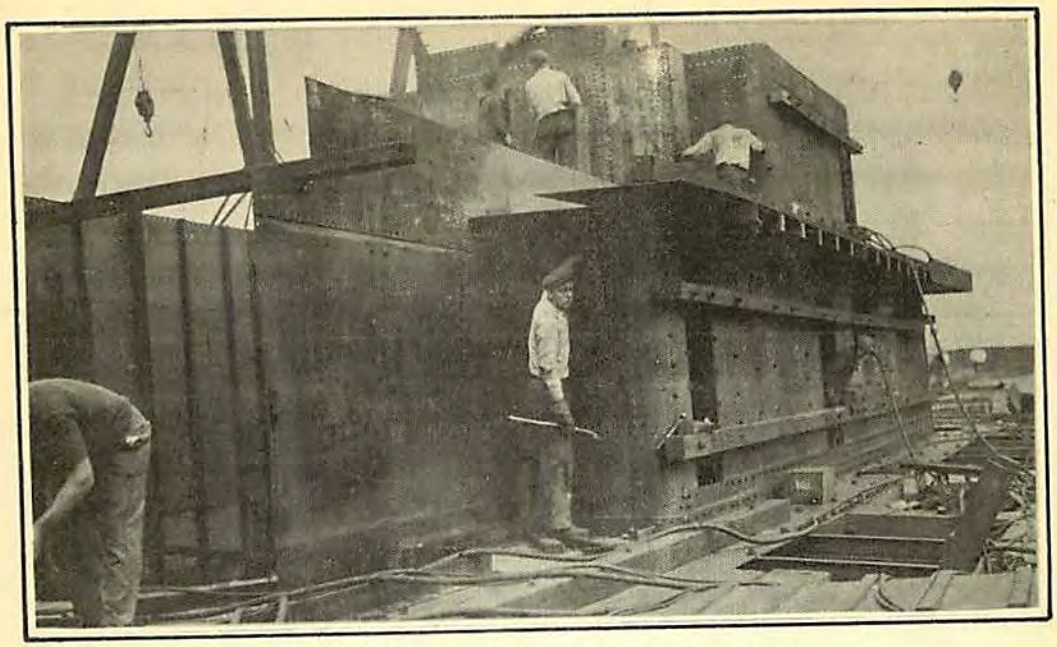


FIG. 100 ENGINE AND BOILER CASING

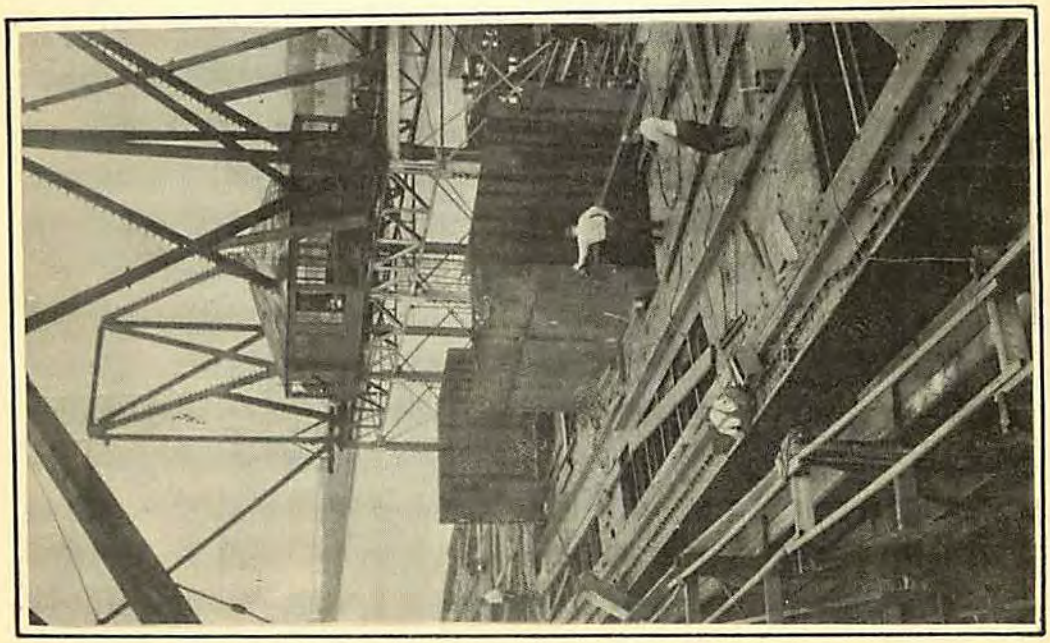


FIG. 101 ENGINE AND BOILER CASING ABOVE UPPER DECK

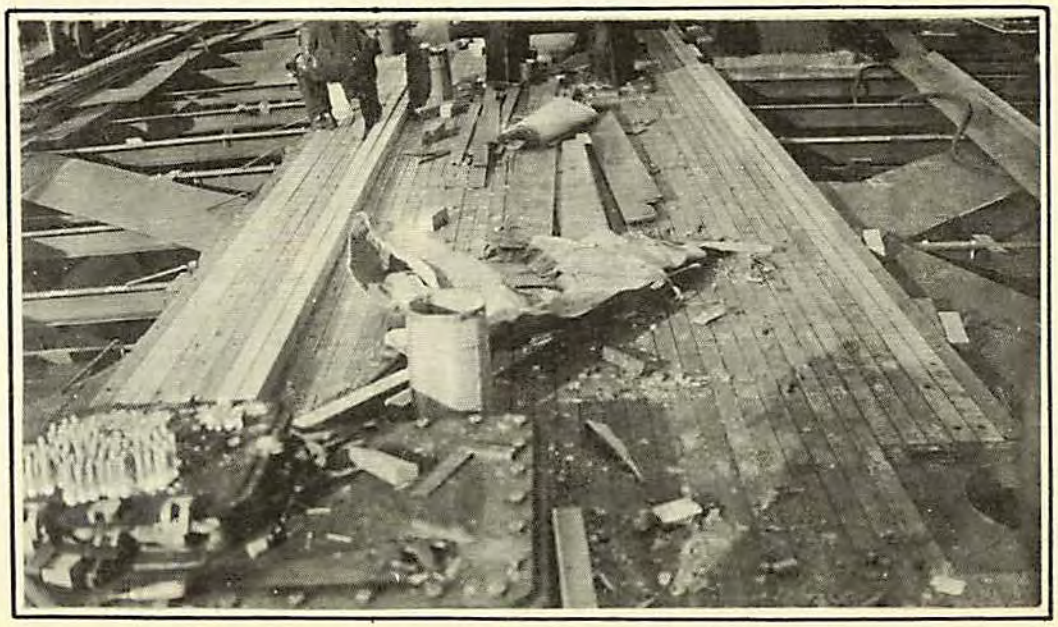


FIG. 102 LOOKING FORWARD FROM FRAME 112,
SHOWING WOOD DECKING BEING LAID

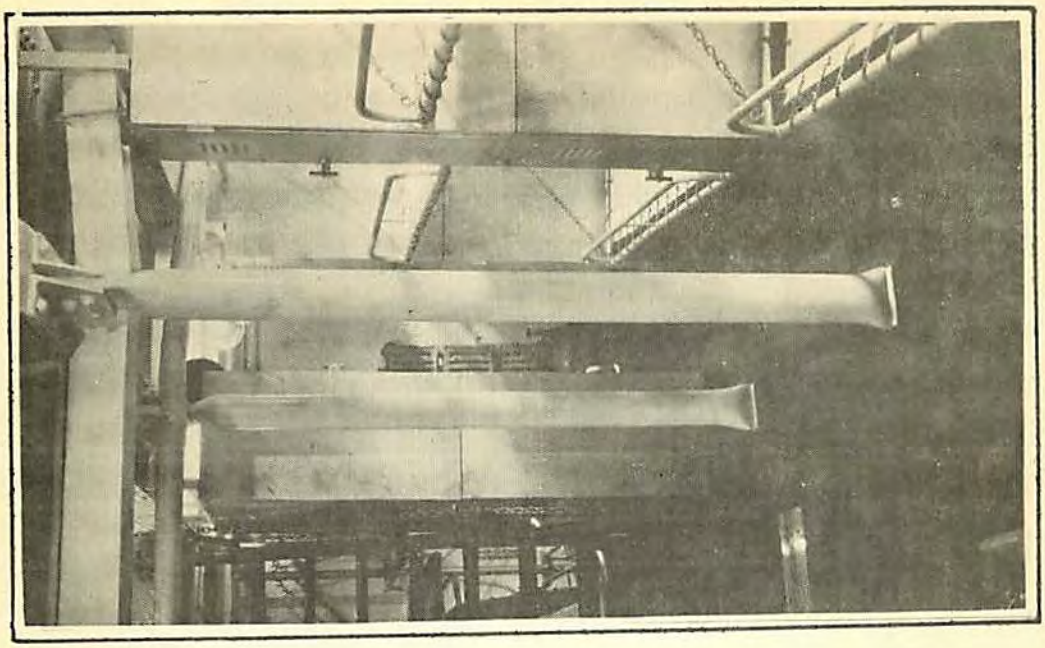


FIG. 103 FRAME 28, BERTH DECK, LOOKING AFT, PORT SIDE. PILLARS SUPPORTING GUN FOUNDATIONS, ANCHOR WINDLASS, ETC.

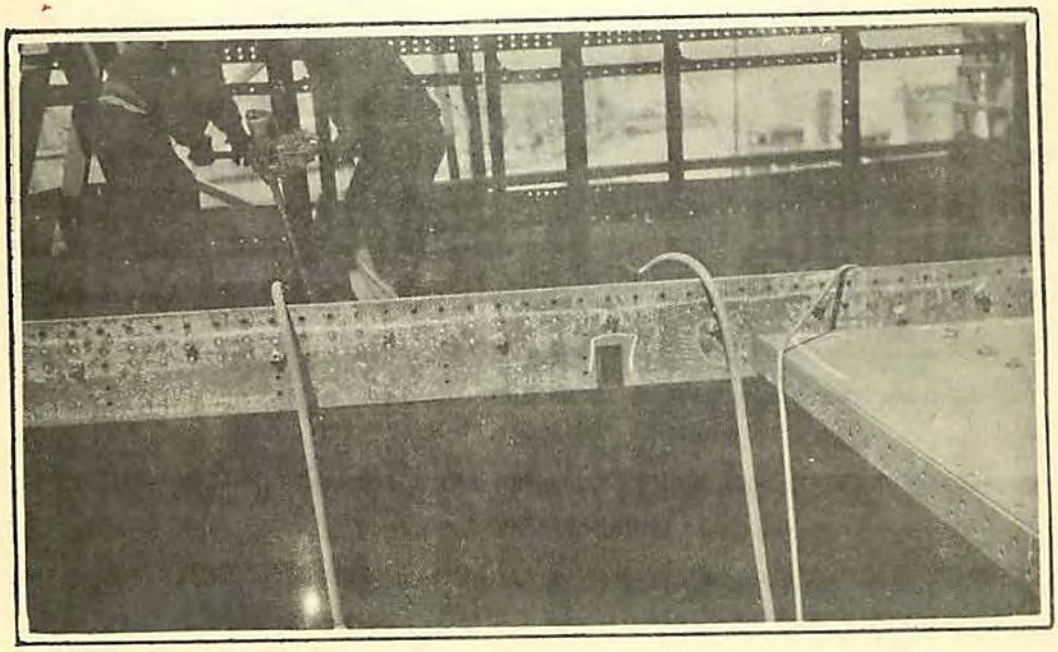


FIG. 104 COAMING PLATE OF RAISED MAIN DECK OVER BOILER FOR BEAM

ADVANCE When a ship is underway steady on a course and the rudder is suddenly put hard over, it is the maximum distance that the ship's center of gravity travels in her original direction.

AFTER BODY Refers to that portion of the ship's form abaft the midship section. (Fig.1)

AFTER PERPENDICULAR On a ship's lines, it is the line perpendicular to the base line intersecting the after edge of the stern post at the designed water line. (A.P. Fig.1).

AIRPORTS, PARTS OF Port frame, lugs, light frame, bolts, rubber gasket, dogs, battle port or "dead cover". A lug secures the battle port and may also secure the light frame. The port frame has elliptical holes for adjusting movement of the bolt to permit the light frame to close tightly.

AMIDSHIPS FRAME It is the frame of a vessel half way between the forward and after perpendiculars. (Fig.21).

ANGLE An abbreviation for angle iron or angle bar. (Fig.13).

ANNEAL To anneal is to subject a metal to a process of heating and cooling so as to increase its ductility and relieve internal stresses. Brass or copper is annealed by first heating and then dipping suddenly in water while still hot and allowing it to remain in the water until cooled off. Hammering copper hardens it; annealing softens it. Iron and steel are annealed by heating followed by SLOW cooling.

ANTI-ROLLING DEVICES are bilge keels, gyro-stabilizers, anti-rolling tanks, and devices for moving weight toward the ship's rising side. The methods of reducing the velocity or amplitude of rolling of a ship in a seaway are as follows: Bilge keels increase the friction; a gyro-stabilizer, by applying a gyro-scopic force to resist rolling; an anti-rolling tank introduces a flow of water out of phase with the roll; increase of weight away from the axis of the ship decreases the period of roll, but increases the energy of roll.

APRON A strong piece of timber bolted to the inner side of the stem of a small boat to provide a strong connection between the stem and the keel. (Fig. 49).

AREA OF SHIP'S BOTTOM equals 15.5 times the square root of W L where W equals the displacement in tons and L equals the length of waterline in feet.

ATHWARTSHIP Horizontally from side to side at right angles to the fore-and-aft center line of the vessel. (Fig. 11).

BALANCED RUDDER See **RUDDER** (Fig. 20 (a).

BALSA A tree which grows in South America, the wood of which is very porous. The fibre is soft and of milky white color. When dried its specific gravity is about 27% that of cork. It is used in making life belts, life rafts and in packing buoyancy compartments.

BARK Fore, main and mizzen masts; the two former square rigged and the mizzen fore-and-aft rigged.

BAR KEEL see **KEEL**

BARKENTINE Fore, main and mizzen masts; the fore mast is square rigged and the two others fore-and-aft rigged. Distinguished from a topsail schooner by having no gaff foresail, and generally a shorter lower mast.

BARNACLES Cirriped crustaceans which adhere to the underwater body of a vessel. They are rough, jagged, stationary shellfish, which grow attached to a ship's bottom in such quantities as to reduce

her speed. Their growth can be checked by poisonous copper paint, or by sheathing the bottom of a wooden vessel with sheet copper. A vessel must be regularly dry docked for their removal by scraping and then fresh paint applied. Putting a vessel into fresh water will kill barnacles.

BASE LINE The horizontal line which for vessels without drag, is usually coincident with the top of the flat keel and from which all vertical distances are measured. It is the intersection of the horizontal plane through the top of the keel with the center longitudinal vertical plane of the ship. It is parallel to the load waterplane. (Fig. 1,20,22). Figure 20 is a vessel without drag and figure 22 is a cutter with a two foot drag.

BATTENS are smooth, thin, flexible strips of wood or hard rubber bent or constructed to the curve of members that go into the fabrication of a ship as, for instance, the curvature of a transom frame. (Fig.75).

BATTENS, SHEERING Long wooden battens which are clamped to the frames in order to locate the edges of the strakes of shell plating in relation to the sheer of the deck.

BEAM BRACKETS see **BRACKETS**

BEAM A heavy timber or metal support which spans the hull of a ship or superstructure from side to side and on which the deck is laid. (see CAMBER). Beams afford athwartship strength. (Fig. 68,69, 80, 82, 85, 86, 87, 95,).

BEAM, DECK, MOLDING OF Refers to the vertical dimension of the deck beam.

BEAM, DECK, SIDING OF Refers to the horizontal dimension of the deck beam.

BEAM, HALF-DECK Athwartship supports of the deck plating or planking in a vessel. In the way of hatch openings they run from each side of the ship to the hatch coaming where they are secured by top and side clips, and fore-and-aft carlings built in. (Fig. 97 (b).

BEAM KNEES A block of wood cut from the joint of the root with the lower portion of a tree trunk, which is shaped in an angular or bracket shape and used for connecting the frames to the deck beams of a wooden vessel. Knees are also used for connecting the fore foot and the stern post to the keel of a wooden vessel.

BEAM, MAIN The beam at the point of maximum breadth of the vessel. (Fig. 21, 87).

BEAM, STRONG Same as **BEAM, MAIN**

BEAM PANTING An athwarthship beam fitted in the bow or stern of a vessel, fastened to the underside of the deck or to panting stringers, for the purpose of reducing tendency to pant. (see PANTING). (Fig. 18).

BEAM, TRANSOM The heavy deck beam over the stern post to which the transom frame and the cant beams are connected. (Fig. 17),

BED PLATE Several fore-and-aft members or girders connected together to support the feet of the engine columns, etc. It is fastened to the ship structure by holding down bolts. (Fig. 23).

BENDING SLABS In a shipyard are rectangular checkerboard cast iron blocks having holes of about one and one-half inches square, by means of which dogs and pins are used to clamp down shapes such as frames, as they are bent into shape.

BEVEL BAR A tool with steel jaws used for beveling frame angles. (see BENDING SLABS).

BEVEL BOARD A wooden board having marked on it the bevel of some member

of the ship structure, such as a frame, for ready reference in lieu of a blueprint.

BEVELED FRAME ANGLE The frame angle of a ship bent so that one toe is athwartship and the other bears along the shell plate. They are beveled so that the angle in the bosom is always greater than 90° and so they will face toward the midship section regardless of their location in the ship structure. (Fig.74).

BEVELED BARS are those whose angles do not make 90° .

BILGE KEELS Keels installed along the bilge outer plating, for the purpose of reducing the rolling of a vessel. They are also referred to as rolling chocks. (Fig. 99).

BINDING STRAKE A strake of plating having greater strength or thickness than the other strakes.

BLOCK COEFFICIENT A figure less than 1, to be applied to the product of the length, breadth, and depth of the hull of a vessel, to give a result equal to the actual volume of the ship. It usually applies to only the immersed portion of the hull. It is a measure of the fineness of a vessel, which is her difference from a box shape. It equals displacement in tons x 35 ÷ l x b x d. Where l equals the length, b equals extreme beam, and d equals the mean draft. For destroyers the block coefficient is about .50; liners and battleships about .60; cargo vessels, from .75 to .80; for electric drive cutters .49 and .378 for 165 ft. patrol boats.

BODY PLAN A series of cross sections taken at regular intervals at right angles to the fore-and-aft centerline plane of a vessel, showing end views of a ship, so arranged that the right side shows the ship as observed from ahead and the left side as observed from the stern. It shows the curvature of the rail and deck lines at the side and as straight lines it shows the bow, diagonals, buttocks, and waterlines. (Fig.15).

BODY POST is another name for the propeller post. It is the forward vertical member of a stern frame containing the propeller boss. (Fig. 20, 22, 88, 90, 93).

BOILER BRACKET A bracket or clip connecting the boiler and the ship structure. (Fig.65).

BOILER FOUNDATION Girders built up from plates and shapes, which are secured to the ship structure to support the boiler. (Fig.65).

BOLSTERS refer to the heavy rounded off portion of the outboard end of hawse pipes, to provide for smooth passing of the chain cable. (Fig.71).

BOLTING UP The securing in proper position of the parts of members going into the fabrication of a ship by means of bolts and nuts, preparatory to riveting. (Fig.100, 114.).

BOLTS FOR DECK PLANKING Usually galvanized iron flat head square neck bolts are used to fasten deck planks to deck beams. Lamp-wick grommets soaked in white lead seat against the bolt head and washer. Deck plugs or dowels close the holes in the deck planking. In laying deck planking in the Coast Guard ½" bolts are used. Fig.31).

BOSOM PIECE A short angle bar fitted in the throat or bosom of another angle bar for strength, or in the throat ends of two angles to connect them.

BOSS The curved enlarged casting which provides an outlet for the stern tube and propeller shaft. In the case of a single screw vessel it is the enlarged middle section of the propeller post. For twin screw vessels it is a casting, surrounded

by a boss frame and bossed shell plating, in the sector where the screw emerges through the side skin of the ship. (See PROPELLER POST and STERN FRAME (Fig. 20,22,88,89,90,91).

BOSS PLATES are the curved plates of that part of the shell plating which surround the propeller boss. (Fig.90).

BOSS, PROPELLER POST That part of the propeller post which is swelled out to receive the support of the stern tube. (Fig. 20,22,88,89,90,91).

BOUNDING BARS are the angles that connect the deck plating to the shell plating, bulkheads or coamings. They are the extreme connections between the bulkheads and the decks, sides, and bottom of the ship. (Fig.19,96).

BOW CHOCK PLATE A plate secured to the structure for the purpose of taking a bow mooring chock.

BRACKET END is a beam end forged in the shape of a bracket.

BRACKETS are plates used to connect frames to beams. They are usually triangular. (Fig. 23,32,74(a),79,86).

BREADTH, EXTREME is the breadth measured to the outside surface of the fenders, armor, or plating. (Fig.21,23).

BREADTH, MOLDED is the breadth of the ship at its widest point measured to the outside surface of the frames but inside the plating. It is spoken of as molded beam. (Fig 14(d),86).

BREAST HOOKS are used at the forward and after extremities of deck and hold stringers and bilge and side keelsons to connect and strengthen the two sides of the vessel. They usually consist of a horizontal made up of plating of the same thickness as the midship floor plating. When at the stern, they are called crutches. (Fig.18).

BULK is the volume of the underwater body.

BULKHEAD A partition wall of plating, running in an athwarthship or fore-and-aft direction, subdividing the interior of a ship into a compartment.

BULKHEAD BOUNDING BAR A bar used to connect a bulkhead to another bulkhead, to tank top, shell plating, decks, etc. (Fig.51, 52, 60, 67).

BULKHEAD LINERS are the plates fitted to the inner side of an outside strake of the hull plating in the way of a bulkhead, usually extending from the first frame forward of the bulkhead to the first frame abaft the bulkhead, and are placed there to add strength, compensating for the shell plating having been weakened by the numerous rivet holes of the bulkhead connection.

BULKHEAD STIFFENERS Beams or girders attached to bulkheads for stiffening. They are connected to tank tops, decks, and the shell by brackets. (Fig. 19, 51, 63).

BULKHEADS, VARIOUS KINDS ON SHIPS
Fore peak, after peak, boiler room, hold, center line, collision, deck, engine room, longitudinal, oil-tight, partial, plate, poop, structural, transverse, trunk, wash and watertight. (Fig.18, 51, 52, 82, 83).

BULWARK In steel vessels it is the strake of shell plating above the weather deck. Bulwark openings are provided for freeing ports and mooring chocks, and stanchions are required inboard to brace the bulwark to resist the force of seas. (Fig.111).

BUOYANCY, CENTER OF It is the center of gravity of the displaced water of a

floating object. It is the point through which the buoyancy acts vertically upward. (Fig.1 (a), 1 (b), 1 (c), 2).

BUOYANCY, FORCE always is equal to the weight and contents of the ship when it is afloat.

BUOYANCY of WATER is measured by the weight of the water displaced by the body.

BUOYANCY, RESERVE is the floating power or force contained between the load waterline and upper deck.

BUTTOCKS The lines formed by the intersection of vertical longitudinal planes with the forward and after surfaces of the ship's hull. (Fig.15).

BUTTS, PLATE Owing to the relative weakness of a butt joint in comparison to the plating, it is necessary to arrange the butts so as to minimize their effect. Plating of the ship is usually butted about midway between the frames, which allows for the fitting of butt straps on the inner side of the plating. The shifting of butts also brings about equalization of the different sections of the plating as regards strength. (Fig.16).

BUTT STRAPS are plates or straps placed over a butt seam to which the ends of the abutting plates are riveted. (Fig. 16).

CAISSON A watertight structure which, with the aid of compressed air, is used for raising sunken or stranded vessels. Also a structure which is sunk at the entrance of a drydock, of sufficient strength to withstand the pressure of water when the dock is emptied. Water is admitted to both until they are placed then the water is ejected.

CALK When used in connection with metal plating refers to the driving of the adjoining edges of metal plates together to stop or prevent leaks. The edge of the lower plate is planed first, then with the splitting tool the edge of the upper plate is upset in region of the lap joint, then with the setting-in tool the edge is driven in against the adjacent plate. Plating less than 3/16" cannot be calked. When used in reference to wooden vessels, calk refers to stopping the seams and butts of planking with one thread of cotton, three of oakum, and about an inch of marine glue.

CALKERS Men who swage metal into the seams between adjoining plates for the purpose of providing water-tightness or oil-tightness. Air driven tools are usually used for this purpose. For thinner plating, hand driven calking tools are used.

CAMBER The convex curvature given to deck beams of weather decks to facilitate drainage and increase their strength by the catenary effect of the arch. (Fig.23).

CAMEL A round spar or floating timber placed between the side of a ship and the fender piles of a wharf or dock.

CANT FLOOR A crooked floor forming both floor and cant frame.

CANT FRAMES Frames in the forward and after body of a vessel which are not perpendicular to the keel line. Such frames are arranged radially so as to be normal to the plating. At the stern they form the skeleton of the overhanging counter, being securely attached to the transom frame with heavy brackets. (Fig. 17,61,94).

CARGO NET A square net made from various sizes of manila rope which is made to form a mesh by running two sets of ropes at right angles to each other. Used in the Coast Guard over the ship's side to help persons aboard who are being rescued in heavy weather. Invaluable when a boat is capsized or in rescuing

from another vessel by buoy or life-raft hauled back and forth on a line.

CARLINGS are fore-and-aft beams to reinforce openings in deck for hatches, etc. (Fig. 104).

CARVEL refers to a method of small-boat building where the planks are fitted edge to edge and calked, forming a smooth surface. (Fig. 49,49 (a). (See CLINKER).

CAVIL A strong piece of wood forming a cleat on wooden bitts. (Fig.49).

CAVITATION Cavitation takes place at high speed through the inability of the water to flow into the propeller wheel as fast as it is forced out astern.

CEILING The wooden sheathing or planking covering the interior of the vessel.

CEILING, FLOOR The wooden planking fitted on top of the floors or double bottom.

CEILING, HOLD The heavy planking fastened to the inner edges of frames.

CELLULAR (see FRAMES) (Fig.11).

CEMENT, PORTLAND A heat treated mixture of powdered stone; when wetted it hardens. Use two to two and a half parts of sand to one part of cement.

CENTER OF BUOYANCY is the center of gravity of the immersed volume. It is the center of the resultant of the forces, caused by the action of water pressure on the ship. (Fig.1a,1b,1c,2).

CENTER OF FLOATATION is the center of gravity of the water plane at which the vessel is floating. It is used in making longitudinal stability calculations.

CHAIN CABLES, CARE OF Keep coated with asphaltum varnish. Navy Formula No.27.

CHAIN CABLES ON LAKE TYPE CUTTERS 1 3/4" stud link, 120 fathoms long.

CHAIN PIPE A cast or wrought iron or cast steel pipe leading from the upper deck bolster to the chain locker for the purpose of handling the anchor chain. At its lower end it is fitted with a half round in order to prevent chafe as the chain runs out. Chain pipes are set at an angle for the purpose of lessening noise incident to the chain running out. (Fig.98).

CHAMFER is a bevelled surface formed by cutting away the angle of two faces of a piece of timber. A chamfer is at 45° with each surface; a bevel may be at any angle.

CHAMFERED refers to the tapering off of the portion of one plate that is common to both butt and seam laps. This saves using a liner.

CHANGE OF TRIM is the sum of the change of draft both forward and aft. (See TRIM).

CHANNEL FRAME A particular shape of frame employed in ship building. (Fig.32).

CHECKS Cracks or openings in the grain of wood, caused by exposure to sunlight and to drying out.

CHOCK, ROLLING Is another name for bilge keel. (Fig.99).

CLINKER refers to a method of small-boat construction where the planks, except the garboard strakes, overlap the upper edge of the strake next below.

CLIPS Short lengths of angle bars used to connect the various members of the ship structure. (Fig.67).

COAMING A raised border around edges of hatches and doors. (Fig.24,97,97(a)).

COAMING PLATES are the plates of a hatch that form the raised sides above the deck. They are usually firmly connected to the beams, half beams, carlings, and other members of the deck framing. (Fig. 97, 104).

COEFFICIENT, CYLINDRICAL, LONGITUDINAL or PRISMATIC All of these refer to the same thing, namely, the ratio of the immersed volume of a ship to the product of its waterline length and the immersed area of the midship section. (Fig.15(b).

COEFFICIENT, WATERLINE is the ratio between the area included by waterline of a ship and the area of the circumscribed rectangle.

COFFERDAMS are narrow vertical athwartship compartments formed by placing two bulkheads close together. They provide a neutral or empty space to prevent leaks between the compartments which are forward and abaft of the cofferdam. (Fig. 40, C.D.).

COLLISION BULKHEAD is the watertight bulkhead, usually at the after end of the fore peak tank. (Fig. 19).

COMPOSITE CONSTRUCTION Here the keel, stem, stern post, and most of the shell are wood. Only the important strakes such as the garboard and sheer, are steel. However, all of the inner structure, frames, bulkheads, beams, etc. are steel. The bottom is then coppered. The copper is used in tropical waters to minimize fouling.

COUNTER The projection of the vessel abaft the after perpendicular is termed the counter or overhang. (Fig.17,22).

COUPLE A couple consists of two equal and opposite forces, not in the same straight line, acting on a body and tending to turn it. Illustrations of couples are the operation of the steering wheel of an automobile and that of the steering wheel of a vessel. (See Fig. 10 and Text).

CRANKY SHIP has a small metacentric height; not very stable. Weights are too high. The opposite of a stiff ship; one which heels easily.

CROSS SECTIONS are drawings showing transverse sections of a ship at various points throughout its length. (Fig.21,27).

CRUTCHES (See BREAST HOOKS).

CURVE OF TRANSVERSE METACENTERS A curve that shows the variation in value of the transverse metacentric height, corresponding to variations in draft and displacement.

CYPRESS is a fairly light, medium hard, cross-grained, and durable wood; good for inside and outside work. It is little affected by weather or rot.

DEAD FLAT That part of the vessel amidships throughout which a constant shape or cross-section exists, fore and aft. (Fig. 21,27).

DEAD RISE is the rise of the bottom or its slope from the keel outward to provide drainage toward the centerline of the vessel. It is also the amount that the flat portion of the bottom rises in the half-beam of the ship. (Fig.11).

DEAD WEIGHT is the weight of the cargo carried, usually expressed in tons.

DEAD WEIGHT, CARRYING CAPACITY is the difference between the displacement of a ship when light and when loaded to maximum draft allowed by law.

DEAD WEIGHT TONNAGE (See TONNAGE).

DEAD WOOD includes the portion of the hull at the junction of the body or propeller post and keel. (Fig.49.)

DECK DOWELS or PLUGS The cylindrical wooden plugs which are inserted in the tops of the holes in the planks which are bored for the deck bolts. They cover the bolt heads, are of the same material as the planks and their grain is kept parallel with that of the planks. (Fig. 31).

DECK LINES AT SHIP'S SIDE are lines showing the projection of the decks' edges on the body plan and sheer plan. (Fig.15).

DECK PLANKING is the wooden fore-and-aft deck covering. It is of yellow pine, Douglas fir, and sometimes of teak. (See WOOD). (Fig. 11,31,102).

DECK STRINGER refers to the especially heavy deck stringer plating, which connects the deck plating to the shell plating. It is connected by a heavy angle to the sheer strake. It is always fitted regardless, even though the balance of the deck is merely planked and not plate. (Fig. 81, 96, 97).

DENSITY (of water) is a measure of its weight per unit volume in terms of pure distilled water. That of fresh water is 1.000; that of salt water is 1.026.

DEPTH, MOLDED is the distance from the top of the upper deck beam at the side, to the base line of a vessel, half way between the forward and after perpendiculars of the vessel. (Fig. 21).

DEPTHS refer to distances measured vertically. They are also referred to as heights.

DESIGNER'S WATERLINE is that at which the vessel will float, with crew, ammunition, two-thirds fuel, water, stores, etc., or under average conditions for going into battle.

DIAGONALS are curves made by intersecting planes perpendicular to the planes of the stations and inclined to those of the waterline and buttocks, and are approximately perpendicular to the surface of the hull where they meet it. They are used to check the fairness of the ship's form. (Fig. 15).

DIAMETER, TACTICAL If a vessel in position "A" heading northward, puts her rudder full right, she will turn to the eastward, then southward. If "B" is the point of her southward path, directly east of "A" the distance "AB" is her tactical diameter. (See ADVANCE).

DISH PLATES are shaped cross-section plates that join the flat plate keel to the garboard strake, the stem and stern frame. (Figs. 57, 60).

DISPLACEMENT is the weight of the volume of the water the ship displaces when floating freely. It is expressed in long tons of 2240 pounds; a long ton is equal to 35 cubic feet of salt water or 36 cubic feet of fresh water.

DISPLACEMENT, CALCULATIONS OF Compute the volume of the underbody in cubic feet and divide by 35 to obtain tons in sea water and by 36 in fresh water. The result is in long tons.

DISPLACEMENT IN BRACKISH WATER may be obtained from that in fresh water by multiplying the displacement in fresh water by the density of the brackish water.

DISPLACEMENT, LIGHT is that of a vessel with batteries and outfit. It does not include ammunition or stores, water, fuel, crew and effects.

DISPLACEMENT, NORMAL is that of a vessel with batteries and outfit and only two-thirds fully loaded with stores, fuel oil, and water.

DISPLACEMENT, STANDARD is defined by the Reduction in Armaments Treaty as being the displacement of a ship ready for

sea, including armaments, ammunition, stores, equipment, outfit, fresh water etc., all weights on board, but without fuel or reserve feed water.

DISPLACEMENT, TONNAGE (See DISPLACEMENT).

DOCKING PRECAUTIONS Any tanks containing water or oil should, if possible, be full or empty. From the time the bow of the vessel crosses the sill of the dock going in and until the bow crosses the sill coming out, the propellers must not be turned over unless authorized by the docking officer. Great care must be exercised when jacking propellers to safeguard men working on staging in vicinity of propellers. While in dock, the commanding officer of a vessel is responsible for the closing overnight of all openings in the ship's bottom upon which no work is being done. When vessels are docked in cold or freezing weather, the valves, pipes, and similar fittings attached to the hull should be examined and any water remaining therein should be drained to prevent freezing and possible cracking. (1) Shift no weights while in dock, liquid or otherwise. (2) See that fire hose from ashore is aboard. (3) See that ship is on an even keel. (4) The keel should be horizontal, or not more than one foot in a hundred out of that trim. (5) There should be no free surface liquids. (6) Have docking plans available. (7) Have condensers cooled off. (8) See that there are men to handle lines. (See TEXT). (Also see UNDOCKING).

DOUBLE BOTTOM, CELLULAR Where a double bottom is divided into a number of rectangular compartments by floors and longitudinals. (Fig. 11).

DOUBLE BOTTOMS are spaces in the bottom of a vessel formed by an inner skin, laid on top of the floors, usually run out to the turn of the bilge. They are subdivided by watertight floors and longitudinals into a number of watertight compartments, thus localizing damage should the outer skin be pierced. The inner bottoms, also called tank tops, are watertight and provide floatation safety. Double bottoms are entered through manholes fitted in the inner skin. They may extend up the side to a deck. (Fig 11,23, 24,67).

DOUBLING PLATES are additional or doubled plates to give strength where holes have been cut, or where excessive strain or wear is expected, and are fitted in way of hawse pipes, anchor beds, holes for sea chests, etc. They are also placed forward for chafe of anchor chains, and aft in the vicinity of the stern post. (Fig. 71). (Extreme bow of Fig. 97).

DOWEL is a pin of wood or metal inserted in the edge or face of two boards or pieces of wood to secure them together. (See TENON).

DRAFT The draft at any point is the vertical distance from the surface of the water to the bottom of the ship.

DRAFT, DIFFERENCE IN PASSING FROM SALT TO FRESH WATER equals weight or displacement in tons divided by 35 times mean tons per inch immersion for the range of the depth involved. From fresh to salt water, use 36 instead of 35.

DRAFT MARKS Raised numerals which at their lower edge indicate a vessels draft. In U. S. service Arabic numerals are used except that Roman numerals are used where there are projections below the base line. Draft is measured in feet and inches. (Fig. 110).

DRAG When a ship is designed to have a greater draft aft than forward, she is said to have a drag in the amount that her draft aft is greater than it is forward. (Fig. 22, 41).

DRAINAGE WELLS are small pockets lo-

cated in the bilges to allow water to collect for pumping overboard.

DRIFT The amount two holes in connecting plates that lap are out of line and not concentric. Use of a steel pin called a drift pin to bring them in line is very bad practice. Reaming is resorted to if the holes are not too much out of line.

DROP STRAKES (See STEALERS).

DUTCHMAN is a piece or small patch of like material as the structure which is worked into a slack place to cover up bad work.

EQUILIBRIUM, NEUTRAL M G / B

EQUILIBRIUM, STABLE M G B

EQUILIBRIUM, UNSTABLE G M B

(M is the METACENTER)
(G the Center of Gravity)
(B the Center of Buoyancy)
(SEE FIGURES 1(a), 1(b) and 1 (c).

FACE PLATE A plate which is placed perpendicular to the web of a web frame, to compensate for the continuous plating attached to the flanges at the other edge. Face plates are also used in connection with stiffeners and girders. (Fig. 11,72).

FAIR UP LINES Refers to the fairing up of the lines of a vessel so that the defined surfaces will show no irregularities throughout their entire extent. (Fig. 15, 75).

FAIRWATER Plating fitted around the ends of shaft tubes, struts, etc., to prevent abrupt changes in streamline. They are usually in the shape of a frustrum of a cone. (Fig. 22, 91).

FANTAIL Refers to the elliptical after ends of upper decks. (Fig. 68, 97 (b)).

FAY To unite closely two members such as plates, in order to bring their common surfaces into intimate contact.

FILLETS Refers to metal inserted or filled in the bosom or inside corners of angles where abrupt changes in direction occur. Fillets are necessary in castings in sharp internal corners where cracks are apt to develope in the process of cooling.

FLAT PLATE KEEL (see KEEL).

FLOOR, INTERCOSTAL A floor composed of separate plates, intercostal between continuous longitudinals, and securely clipped to them. (Figs. 11,13,60).

FLOORS Vertical plates running athwartships on each frame, extending between the frame and reverse frame angles and from bilge to bilge. (Fig.11,13,51,52,55,58, 63).

FLOORS, DEEP Owing to the converging of the sides of a ship at bow and stern, floors are deeper there than in the main body. (Fig. 70).

FLOOR, TRANSOM The heavy floor like built up plating fitted athwartship over the stern post and attached thereto. (See TRANSOM FRAME). (Fig. 17).

FLOATATION, CENTER OF Is the Center of Gravity of the waterplane at which the ship is floating. (Fig.15(b)).

FORE BODY refers to the portion of the ship forward of the midship section. (Fig. 1, 15).

FOREFOOT The part of the stem that connects to the keel. (See STEM). (Fig. 53, 54, 57).

FOREFOOT CASTING (See STEM). (Fig.

53, 54).

FORWARD PERPENDICULAR (See PERPENDICULAR). (Fig. 1).

FOUNDATION, MAIN GENERATOR (Fig. 73, 84).

FOUNDATIONS, GUN, ANCHOR WINDLASS, ETC. (Fig. 24, 116).

FRAME The transverse or athwartship strength member of a vessel which acts as a stiffener, holds the outside plating in shape and maintains the athwartship form of the ship. The most usual types of frames in use are: (a) built up of two angles, riveted together back to back, (b) a solid frame built up of a bulb angle, channel or Z bar, (c) a web frame made up of a web plate with bars riveted on each egde. The frame angle bar is the one in contact with the plating and the reverse frame angle bar the inner one. (See FRAMES, REVERSE). (Fig. 27,55,58,68,78, 79, 86).

FRAME, BOSS is the frame that is bent to fit around the propeller boss which carries the stern tube and propeller shaft. (See BOSS; also BOSS, PROPELLER POST)(Fig. 20,22,89).

FRAME, CELLULAR SYSTEM The cellular system is a mixed system consisting of an intersecting network of transverse and longitudinal frames. The margin plate and vertical keel are continuous. This divides the bottom into a number of cells, providing many watertight subdivisions and a double bottom. (Fig. 11).

FRAME LINERS are strips of plate the width of the connecting flange of the frames, used as filling pieces in the wake of outside strakes.

FRAME, SPECTACLE is a single casting for supporting both the stern tubes and propeller shafts of twin or quadruple screw vessels. The two arms of the frame extend in pear shaped sections about 30 degrees downward from the horizontal from each side of the center line of the vessel, the outer limits of the sections being bossed to provide for carrying the propeller shafts.

FRAME STERN (See STERN FRAME).

FRAME TRANSOM The deep floor and frame fitting athwartship across the top of the stern or rudder post and fastened thereto, which acts as the support for the overhanging stern of the vessel. (Fig. 17, 94).

FRAME SPACING The distance fore-and-aft between frames. In the lake type cutters the spacing is 24 inches below the main deck and 48 above; in destroyers 21" and in light cruisers 36".

FRAME, WEB A built up frame consisting of a deep web plate to the edges of which single or double angle bars are riveted. They are placed at intervals, with regular smaller frames in between. They extend from the top of the double bottom to the upper decks as required. In areas where deck beams are omitted, such as boiler and engine spaces, they extend to an upper deck. Intercostal girders are usually run between web frames. (Fig. 11, 21, 72).

FRAMES, BELT (Same as WEB FRAMES). (Fig. 11, 21, 72).

FRAMES, DEEP (Same as WEB FRAMES).

FRAMES, ISHERWOOD SYSTEM The Isherwood system of framing a vessel has the frames running longitudinally with deep transverse web frames more widely spaced than in the Transverse system, and located so as to give the necessary stiffness to the longitudinal frames. Structurally the Isherwood system of framing is stronger in resisting hogging or sagging in a long vessel, such as an oil tanker, than the

Transverse framing system. However, in a vessel for which the ratio of length to beam is not great, the tendency for hogging and sagging is not so great. The slight increase in strength gained by the use of the Isherwood system is not so important as it would be in a long tanker with a lower length to beam ratio. (Fig. 21).

FRAMES, LONGITUDINAL SYSTEM In this system instead of closely spaced transverse frames, deep frames formed of plates and angles known as transverses are fitted at intervals of about ten feet. The shell and deck plating is supported by continuous longitudinals which pass through slots in the transverses but are cut at the bulkheads to which they are bracketed. (See FRAMES). The 328-foot Cutters are longitudinal construction; there are 19 longitudinals and 24 web frames. (Fig. 21).

FRAMES, REVERSE Are angle bars riveted to the frames in reversed position or back to back, for providing greater strength. In the double bottom region the reverse frame is the portion of the frame which is uppermost and is the angle bar which forms the upper limit of the floors. (See FRAME). (Fig. 11,23,55,58,79).

FRAMES, TRANSVERSE SYSTEM In this system, used for small vessels, closely spaced frames are run across the ship. Longitudinal strength comes from the shell plating, decks and keel structure, with one or more intercostal side keelsons or stringers. (Fig. 11,79,86).

FRAMES, TYPES OF BARS USED FOR Channel, Z, bulb angle, simple angle, frame and reverse frame angles.

FREEBOARD Is the vertical distance from the water to the weather deck edge at any point in the length of the ship.

FREE SURFACE LIQUID Liquid in a tank not completely filled. (See VIRTUAL CENTER OF GRAVITY).

FRESH WATER Weighs 62 1/2 pounds per cubic foot. A long ton is 36 cubic feet.

FROUDE'S LAW A law of comparison of similar ships. (See LAW OF COMPARISON).

FUTTOCK One of the sections which form the timber from which the frame in a wooden ship is made.

GARBOARD STRAKE is the first outside plate next to and fastened to the keel. (Fig. 11,21,23,60,64,89).

GIRDERS are longitudinal built up strength members, which are fitted underneath decks in areas where it is not feasible to place the number of stanchions required. Stanchions that are fitted are attached to the girders. (Fig. 22,24,65).

GIRTH is a band encircling a body. The GIRTH of a ship is the measurement around its body; the half-girth is taken from the center line of the keel to the upper deck beam end.

GRAIN Variations allowed are, for coarse grain wood, a slope of one grain to 10; medium grain, one grain to 15; and in close grain one to 20.

GRAIN, EDGE The grain of wood at right angles to the face of the board. Also referred to as VERTICAL GRAIN.

GRAIN, STRAIGHT The grain of wood running parallel to the face of the board.

GRAIN WOOD (VERTICAL GRAIN) is sometimes known as EDGE GRAIN. The grain is approximately at right angles to the face of the board.

GRATINGS are made of ash or oak. Mach-

inery space gratings are usually made up from iron bars.

GRAVING PIECES are small pieces of wood used to replace injured places in deck planks, etc.

GRAVITY, CENTER OF Is the point at which the total weight of an object is centered, and through which gravity acts vertically downward. (Fig. 1a, 1b, 1c, 2).

GROMMET Ring-shaped pieces of fibre such as rope yarn soaked in red lead for steel work and in white lead for wood work such as deck planking, which are used as packing under the heads of bolts and nuts to make them watertight. (Fig. 31).

GROUNDING, EFFECT OF has the resultant effect of raising the center of gravity and lessening the metacentric height. The changing of the position of "M", the metacenter, depends upon the amount of buoyancy lost.

GUDGEONS Lugs on the after side of the rudder post, with lignum-vitae or white metal bushings, which provide bearings for the rudder pintles. (Fig. 20, 22, 91).

GULLETING OF A RUDDER Scores are cut below and behind the pintles to allow a rudder to be shipped and unshipped.

GUSSET PLATES are angular plates, placed horizontally, for connection or strength. They often connect the ends of beams to the stringer plates. (Fig. 18).

GYRATION, RADIUS OF It is the effective radius of the inertia of the ship with respect to its center of oscillation. i.e.. the radius at which the mass is considered concentrated. Recalling that the moment of inertia of a section or area (such as a waterplane) is obtained by dividing it into a large number of very small areas and then multiplying each minute area by the square of its DISTANCE from the axis about which it rotates, and that the summation of all these products is the moment of inertia, THE MEAN VALUE OF ALL THESE DISTANCES IS THE RADIUS OF GYRATION. In computing the strength of materials, such as a column, use is made of the relation that the RADIUS OF GYRATION of a section in reference to the neutral AXIS through the center of gravity, is the square root of the quotient of the moment of inertia of the section referred to that AXIS, divided by the area.

GYROSCOPE A spinning wheel is suspended in double gimbals. Its first tendency is to resist forces tending to change its plane of rotation and when a weight is applied to the end of the revolving shaft of the wheel it causes precession. Precessional motion causes the spinning wheel to move slowly about an axis perpendicular to the applied weight.

HALF-BREADTH PLAN is the drawing showing the true shape of the waterlines. (Fig. 15).

HALF-BREADTHS are ordinates perpendicular to the vertical central longitudinal plane which divide a ship into halves. The half-breadth of a point on the form of a ship is the distance from that point to the vertical central longitudinal plane of the ship. (Fig. 15).

HATCHES (Fig.24).

HAWSE PIPES Heavy castings of iron or steel, terminating at upper and lower ends in bolsters, to prevent nipping of chain as it runs out when the anchor is let go (Fig. 71).

HEIGHTS refer to distances measured vertically; also referred to as depths.

HELICOIDAL SURFACE (SCREW PROPELLERS) is a surface generated by a line, set at an angle to an axis, which revolves about this axis at a constant speed and at

the same time advances along the axis at a constant speed. (Fig.90, 91, 93).

HOLDERS-ON OR BACKERS-UP The men who place the heated rivets in the holes and firmly hold a heavy hammer or dolly bar against the rivet heads while the riveters are forming the points.

HOLYSTONES Heavy cubes of sandstone, used with sand and water to grind down wooden deck planking to a clean, smooth surface. So called because they were, during early periods, most frequently used on Sundays.

HOGGING The tendency of the ends of a vessel to droop until they are lower than the middle portion.

HORSING is calking with a large maul or beetle.

INBOARD PROFILE It is a plan showing the longitudinal, vertical section of the ship through the center line. (Fig. 40,41, 42, 43, 44, 45, 46).

INCLINING A SHIP TEN DEGREES The metacenter and the center of gravity do not change position. The position of the center of buoyancy does change.

INCLINING EXPERIMENT The ship is inclined by the use of weights which are moved across an upper deck to produce an inclination of not over ten degrees, and the distance from the center of gravity to the metacenter is computed by means of the relationship which exists between this distance and the distance a suspended plumb line moves as a result of the inclination. When G M, the metacentric height, is obtained it is possible then to get the distance of G above the base line, i.e., to locate the center of gravity. (See TEXT). (Fig 2d, 6).

INITIAL STABILITY The metacentric height, G M, as obtained by small inclinations of the vessel, is a measure of its initial stability. It indicates the resistance offered by a ship to inclination from an upright position.

INTERCOSTAL Interrupted or noncontinuous members running between continuous ones, such as an intercostal side keelson running between continuous floors. (Fig. 11, 23).

IRON An element which rarely occurs in the free state. It is obtained by the reduction of its ores. Iron usually occurs as oxides called Maganite, Hematite, Gothite, etc. The iron ore is reduced in the blast furnace with carbon and the product obtained is called pig iron.

IRON, CAST is usually remelted pig iron. It is divided into two classes, namely gray and white.

IRON, PIG as produced in the blast furnace it contains 2% to 4½% of carbon together with varying percentages of Silicon, Sulphur, Phosphorus and Manganese. The carbon exists partly in solution called hardening carbon, and partly in the graphite state.

IRON, WROUGHT is nearly pure iron, containing less than 3% carbon. It is produced by reducing the carbon content of pig iron by burning it out, as in puddle iron, or by employing burning charcoal, as in the sinking process, the latter producing charcoal iron.

ISHERWOOD SYSTEM A system of framing in which longitudinal frames and widely separated transverse deep frames of great strength are used. (See FRAMES, ISHERWOOD SYSTEM). (Fig. 21).

JOGGLED A frame or plate is joggled when it is offset to provide a landing edge for an adjoining member such as a shell plate to land on a joggled frame. The advantage of joggling is that it does

away with the necessity for using a liner between the frame and plate. Deck plating is invariably joggled. (Fig. 21).

JOINTS, OIL-TIGHT, HOW MADE (1) By calking both edges. (2) By closer spacing of rivets. (3) Use of oil stops. (4) Welding.

JOINTS, RIVETED (AS COMPARED TO WELDED JOINTS) (1) Stronger. (2) More elastic. (3) Strength of joint may be calculated. (4) Easier to replace a damaged plate.

JOINTS, RIVETED vs WELDED; STRENGTH DEPENDS ON (a) RIVETED: (1) Number of rows of rivets. (2) Kind of material in the rivet and in the plating. (3) Diameter of rivets relative to thickness of plates. (4) Distance rows of rivets are from edge of plate and space between rows. (5) Workmanship. (b) WELDED: (1) Material of welding rod. (2) Width of weld parallel to the plane of the plates joined. (3) Thickness of weld perpendicular to the plane of the plates joined. (4) Whether or not the plates joined are in the vertical or horizontal plane. (5) Method of making the weld. (6) Skill of welder.

JOINTS, TYPES OF AS TO TIGHTNESS (1) Oil-tight; (2) Watertight; (3) Non-watertight.

JOINTS, WATERTIGHT; HOW MADE (1) By closer spacing of rivets. (2) Calking. (3) Use of stop waters. (4) Continuous welding.

KEEL The lower midship longitudinal member of a vessel. In building a ship the keel is first laid. There are two types of keel. The BAR KEEL has a fore-and-aft bar external to the molded shape of the ship and to which the garboard strakes are flanged. This type of keel is strong and reduces rolling and leeway, but increases the draft of the ship, is hard to keep tight and is liable to injury. The other type, the FLAT PLATE KEEL, is made up of long horizontal plates which are flanged and riveted to the garboard strakes. The flat keel plates are joined together by butt straps. (Fig. 57,59(a); BAR KEEL, (Fig. 37); SIDE BAR KEEL, Fig. 11).

KEEL, BILGE A long narrow fore-and-aft steel plate or deep bulb angle, normal to the shell plating at the turn of the bilge. It is riveted to the shell plating except in certain oil-tight areas etc., where it is welded. Its purpose is to restrict the rolling of the ship without restricting its passage through the water. Bilge keels are sometimes called "rolling chocks", especially so abroad. They should follow the streamline of the water closely. (Fig. 99).

KEEL BLOCKS Blocks of wood built up on building ways and in drydocks to receive and support the keels of vessels. (Fig. 50).

KEEL, FLAT PLATE (See KEEL above).

KEELSONS Are longitudinal girders in the bottom region of a ship. They are connected to shell plating by angle bars and are placed normal to the curvature of the plating. They run closely parallel to the center vertical keel. Those nearest to the keel are called SIDE KEELSONS and those near the bilge are termed BILGE KEELSONS. In the region of the floors they are made up with deep plates, to match the same height as the floors and are fitted in between adjacent floors. (Fig. 11, 23).

KEEL STRUCTURE; CONSISTS OF (1) Outer flat plate keel. (2) Inner flat plate or dished plate keel. (Note: cutters have only one plate in the flat keel; it is dished near both forward and after ends and flat in the central portion). (3) Vertical keel plate. (4) Outer angles, the angle bars at the lower extremeties of the vertical keel which secure the verti-

cal keel plate to the flat plate keel. (5) Inner angles, which are at the upper extremeties of the vertical keel. (Fig. 13, 24, 56, 59, 60, 62).

KEEL, VERTICAL (See KEEL STRUCTURE above).

KING PLATE A wide center line deck plate to which the tie plates fasten and from which the tie plates run radially outward where they tie to the deck stringer plates. This type of partial steel deck plating is used on Coast Guard Cutters in conjunction with wood deck planking which is laid on top of the steel plates. They are also called center line plates. (Fig. 97, 98).

KING POST or SAMSON POST The vertical post (not a mast) used to support a derrick boom. They are often placed off the center line of a vessel.

KNEES In wooden shipbuilding; a piece of wood cut from a tree near where the root joins the trunk, so that the grain makes a right-angled change of direction. Such pieces join deck beams to their respective frames and preserve the angle between the two. (Fig. 49).

KNEE BEAMS Deck beams which are forged up so that their ends act as knees for joining them to the frames. The end of the beams are split at the forge shop and the lower half of each is turned down. Gusset plates are riveted in place to provide a wide bearing surface for riveting to frames.

KNUCKLE The line at the apex of the angle dividing the upper from the lower part of the counter of a vessel. They are also sometimes placed at changes in direction of plating, especially when the change in direction is abrupt. (Fig. 17).

LAPSTRAKE In wooden shipbuilding; where the top plank always laps on the outside of the plank next underneath, as Clinker construction. In a steel vessel the plates may lap in the same manner over the next lower strake. (Fig. 14 (d)).

LAW OF COMPARISON Froude's Law. For similar ships running at speeds in the ratio of the square root of their lineal dimensions, the resistances are in the ratio of the cubes of the linear dimensions. The speeds above referred to are termed the corresponding speeds. This law makes it possible to predict the speed and resistance of ship forms from results secured by towing in a model basin.

LAYERS-OUT Are men in a shipyard who mark plating from the templates or patterns for the punching of rivet holes.

LAYING DOWN LINES ON MOLD LOFT FLOOR It is drawing the shape of a vessel full size on a large floor in the mold loft. Use is made of descriptive geometry in fairing the lines in all three projections. (Fig. 75).

LAYING OUT Noting on plates etc., the markings for shearing, punching, bending, flanging, beveling, rolling, etc. Templates used are taken from the mold loft floor or directly from the ship.

LENGTH OVER ALL Is the length between ~~the forward and after perpendiculars~~ total measured from the foremost to the aftermost points of a vessel's hull. (See PERPENDICULARS). (Fig. 1, 15).

LIGHTENING HOLES Are holes cut in webs of built-up members, such as floors etc., to reduce the weight, without specially reducing the stiffness or strength of the member. Metal taken out near the neutral axis of a member often does not effect its strength. Such holes in floors also permit the passage of a man for inspection and painting.

LIGNUM-VITAE A hard, oily wood, used as a bearing surface for propeller shafts in stern tubes.

LIMBER HOLES Are cut in the lower port-

ion of floor plates in order to permit water drainage in bilges.

LINER A piece of metal used for the purpose of filling up a space between bars and plates. (See FRAME LINERS and LINERS, TAPERED).

LINER, BULKHEAD A diamond-shaped plate between the shell plating and the outer flange of a bulkhead bounding bar. (See BULKHEAD LINERS).

LINERS, TAPERED Wedge-shaped pieces which are used to fill in between plates and frames where lap joints are employed and neither the frames nor the plates are joggled.

LOAD WATER LINE (L. W. L.) Refers to the line of intersection of the ship's form with the plane of the surface of the water when the ship is floating with her designed load on board. (Fig. 15).

LOFTMEN Lay down plans to full scale on mold loft floor of a shipyard.

LONGITUDINALS Strongly built fore-and-aft girders, made extra heavy through the main part of the vessel and reduced somewhat at each end. They are continuous when they pass solid through frames, floors or other structural members, and are intercostal when the other members passing through them are continuous. Longitudinals are usually continuous in warship construction and intercostal in merchant vessels. (See FRAMES, LONGITUDINAL SYSTEM). (Fig. 11, 21, 23).

LOUVER An air duct so constructed that the inner and outer partial covers overlap by virtue of being fitted diagonally so as to allow free passage of air but to obstruct the view and deflect water.

LUG PIECE A small section of angle bar used to attach keelsons, girders, etc., to other strength members.

MANHOLES (Fig. 25, marked M.H).

MANGER PLATE The plate forming the main part of a breakwater installed in the bow to deflect seas that are shipped.

MARGIN PLANK The plank forming the boundary of the deck planking.

MARGIN PLATE The plate connection at the turn of the bilge between the inner bottom and the outer bottom; it is normal to the shell plating. This arrangement applies where the double bottom does not extend above the bilges. The ship's frames are tied to the plate of the inner bottom by means of a bracket. (Fig. 11, 23, 63, 76).

MAST CAP Two bands welded together, one section of which is large enough to fit over the masthead, the other a loose or sliding fit for receiving the lower section of the topmast. Eyes are welded on the forward and after sides to take the shackles of the stays.

MAST HOLES The holes in decks through which the mast passes.

MAST PARTNER The steel plate with a collar which is worked around the mast hole in the deck to form a side support for the mast. Wooden wedges are driven in tightly between the steel circular coaming and the mast. (Fig. 37 (B)).

MAST WEDGES (See MAST PARTNERS).

METACENTER is sometimes defined as the point about which the center of buoyancy appears to swing when the ship rolls easily or is given small inclinations. When a vessel is given an inclination of 10° or less, M, the metacenter, is the point where the vertical through the center of buoyancy of the vessel in the INCLINED position cuts the longitudinal vertical plane of the vessel. The longitudinal vertical plane passes through the center

of gravity and the center of buoyancy of the vessel when it is in the upright position. The metacenter is the maximum point to which the center of gravity may be raised without the vessel becoming unstable. It is the point in a floating body slightly displaced from equilibrium through which the resultant upward fluid pressure always passes. (See TEXT). (Fig. 1 (a), 1(b), 1(c)).

METACENTRIC HEIGHT The distance from the center of gravity to point M, the metacenter. It represents the initial stability of a vessel. It is obtained from the relation BM = Moment of Inertia of the waterplane divided by the displacement in cubic feet. Also the height of the metacenter above the base line equals $A \times H$ plus $c \times \frac{B^2}{H}$, where H is the draft in feet, B is the beam, c the constant and A is the coefficient of fineness. (Fig. 1 (a)).

MIDDLE BODY The portion of the ship adjacent to the midship section. (Fig. 11).

MIDSHIP SECTION The vertical transverse section located half way between the forward and after perpendiculars. It is usually the largest section of the ship in area.

MILL SCALE Scale or oxide which is present on all plating after being rolled at the mill. It is removed by sand blast or by pickling in one part of hydrochloric acid to nineteen parts of water.

MOLD A pattern, or form, generally built up of thin wood to show the true shape of any part of a vessel's structure; for instance, shell plating and floors, etc. It is generally a representation of one surface, plane or curved.

MOLDING This term applies to depths of such members as floors, keels, keelsons, sternposts, stems, etc. The dimension being normal to the length.

MOLD LOFT A large floor space on which the lines of a vessel are laid down full size and from which the templates for structural members are made. After the lines are laid down it is necessary to fair them. (Fig. 75).

MOMENT OF INERTIA The summation of the products of small elementary areas of a section or area by the squares of the respective distances from their centers of gravity to an axis assumed for calculation purposes. (See TEXT).

MONEL METAL An alloy of about two-thirds nickel to one-third copper. It is very tough, strong and non-corrosive.

MONKEY TAIL or MONKEY TILLER A curved bar fitted to the upper and after end of a rudder for the purpose of providing a means of attaching the rudder pendants. In an emergency it may be used for fastening the jury wheel ropes for steering. (Fig. 92).

MOORING PLATE An oval casting or frame inserted in the bulwark plating to provide a chock or opening through which mooring lines are passed.

MOTOR SYNCHRONOUS An A.C. motor, the speed of which bears a fixed relation to the frequency of the circuit independent of the load on the motor. It is brought up to the synchronous speed by external means before the field winding is energized. This type of motor provides a method of reproducing the movement of mechanical devices at any distance. It can be used to show in a pilot house the movements of the ship's engines.

MOULDED BREADTH In the lines of a ship, the width of the vessel where she is widest, at the midship section.

MOULDED DEPTH (See DEPTH, MOULDED).

NAVAL ARCHITECT One engaged in design, construction and alteration of vessels.

NAVAL CONSTRUCTOR One responsible for the building and maintenance of vessels.

NEUTRAL AXIS Considering a beam under transverse stress, the particles on one side are under compression while those on the other side are in tension. At the middle point between, there exists a small longitudinal area where there is shear but neither compression nor tension. The center line of this area is called the Neutral Axis. (Fig. 30).

NEUTRAL AXIS OF A SECTION Passes through the center of gravity of the section.

OAKUM Hemp or jute fiber, treated with pine tar, often made from old rope, unlaid and loosened up.

OFFSET Refers to ordinates of ship's curves. (Fig. 15).

OIL STOPS are pieces of canvas soaked in pine tar and shellac.

OIL TANKS usually extend across the ship athwartships; they are equipped with a center line bulkhead permitting a certain circulation at the foot. One-half way from the center line to each ship's side are swash bulkheads. (Fig. 21, 23, 27, 66, 77).

ORLOP DECK is the name often given a lower deck not extending the full length of the ship. It also applies to the lowest deck of a ship having four or more decks.

OSCILLATION The roll of a vessel from maximum angular position on one side to the corresponding position on the other side.

OUTBOARD PROFILE Drawing showing vessel's profile, deck lines, masts, yards, stem, keel, stern frame, etc. (Fig. 15).

OVERHANG is the projection of the vessel abaft the after perpendicular. It is also called the counter. (Fig. 17, 22).

OXTER PLATES are located where the stern frame joins the counter. Specially forged and formed plates are required. (See PLATES, OXTER). (Fig.22,37D,90).

PAINT, BOTTOM, ANTI-CORROSIVE The first coat of paint for a ship's bottom, after cleaning and scraping off barnacles and loose paint in drydock; use Navy 14 RB or 14 RC. Allow eight hours minimum to dry.

PAINT, BOTTOM, ANTI-FOULING Is applied after the anti-corrosive bottom paint. Use Navy 15 RB or 15 RC. Allow minimum of six hours to dry. Care must be taken to see that no zinc plates are painted.

PAINT, BOTTOM, BOOT TOPPING use Navy #2 for black hulls and Navy #3 for white and gray hulls.

PAINT, COFFERDAMS AND PIPE TUNNELS use inside white.

PAINT, INTERIOR OF WATER TANKS FOR DRINKING, CULINARY, AND FEED WATER paint with brown metallic paint, Navy formula 26; two coats.

PAINT, PRIMING COAT for new steel and iron underwater body of hulls; zinc oxide and spirits of turpentine. Also used to touch up bare spots.

PAINT, FOR STEEL HULLS IN FRESH WATER use red lead only.

PAINTING, BILGES use red lead except in cofferdams and tanks and do not use on a fuel oil bulkhead in the bilges.

PAINTING, FUEL OIL TANKS do not use paint even when new. During construction a rust preventative non-volatile oil, such as fish oil, is applied.

PAINTING, HULL OUTSIDE, NEW VESSELS American Bureau of Shipping requires that outside steel work shall not be painted until shortly before the vessel's launching. This requirement is for the purpose of weathering off the mill scale. Then at least two coats of good oil paint are to be applied.

PANTING a tendency to flexibility of the bow region of the ship, or near the stern; moving in and out of the plating when the vessel is in a seaway.

PANTING BEAMS are beams fitted in the fore-and-aft peaks of a vessel to prevent panting. (Fig. 18).

PANTING STRINGERS are installed near the bow in order to reduce the tendency of a vessel to pant. (Fig. 18, 69).

PARTNERS are pieces of wood, angles, or other metal bars, fitted upon or between the deck beams, under capstans, winches, etc., and around masts for support and strength. (See MAST PARTNERS).

PATCH, HARD is a piece of plate riveted to another plate, over a hole or break, and is made watertight by calking.

PATCH, SOFT is a plate put over a break, crack, hole or thin place, in another plate. It is fastened on with tap bolts or tap rivets, and is made water-tight by use of a stop-water of red lead putty, or a fibrous packing, such as painted canvas or burlap.

PAYED Deck seams are payed by pouring melted marine glue into them after calking. (See DECK PLANKING).

PEAK OF A VESSEL is the narrow part of the vessel's hold near the stem and stern. (Fig. 18, 25).

PEAK TANKS Are tanks in the forward and after extremities of a vessel, used to carry fresh water and to change the trim as necessary. The fore peak is in the bow and the after peak in the stern. Collision bulkheads are invariably abaft the forward peak tank and forward of the after peak tank. (Fig. 70).

PERIOD OF ROLL The time occupied in performing a double oscillation. (See OSCILLATION).

PERPENDICULARS the forward perpendicular, called F.P., is the perpendicular to the base line, passing through the intersection of the forward part of the stem and the designers waterline. The after perpendicular called A.P., is the perpendicular to the base line passing through the intersection of the contour of the sternpost and the designer's waterline. (Fig. 1, 15).

PERPENDICULARS: LENGTH BETWEEN It is the distance from the forward perpendicular or F.P., to the after perpendicular, or A.P., and it is used by Naval architects in connection with the design of the ship. (Fig. 1, 15).

PERPENDICULAR, MIDDLE is a line perpendicular to the base line taken midway between the forward perpendicular and the after perpendicular. It is called, M.P.

PICKLING the removal of mill scale by placing steel plating in an acid bath. (See MILL SCALE).

PIGMENTS the solid portion of paints which is carried by the vehicle such as oil, turpentine, etc. They are usually one of the following: White lead, red lead, oxide of zinc, oxide of iron, Van Dyke brown, Venetian red, Indian red, vermilion, Prussian and Chinese blue, ultramarine blue, lampblack, and lakes. Extenders which reduce the spreading power and increase the thickness of paint such as silica, aluminum, silicate and calcium carbonate are used.

PILLARS are the vertical supports of decks and are placed under the beams and girders. Being vertical ties, as well as deck supports, they are riveted at both head and heel. In the Coast Guard they are usually tubular. They may be solid round bars, channel bars riveted back to back, etc. (See STANCHIONS). (Fig. 24,116).

PINTLES The pins or bolts which hinge the rudder by engaging gudgeons on the rudder post or stern post. They are cylindrical in shape in the way of the gudgeons up to the rudder lug and are given a conical taper through the rudder lug and above the lug a thread is cut for the nut. The tapered shoulder when set up by the nut holds the pintle in the lug. The weight of the rudder is carried by means of the rudder stock bearing above. The pintles handle only the side pressure. They are frequently fitted with a brass sleeve in the way of the gudgeon which has a white metal bearing. The upper pintle usually has a head turned on its bottom to prevent the rudder unshipping by an upward movement. (Fig. 20, 22, 91).

PIPING STANDARD COLORS (Fig. 28).

PITCH The distance the propeller will advance in one revolution. (See PROPELLER PITCH).

PITCH POCKET The pitch occuring between the annular growth rings where shakes occur in a tree, sometimes called pitch streaks.

PIVOTING POINT The vertical axis about which a ship turns when the rudder is put over. It is usually one-third of the length of the ship abaft the bow.

PLANES THE LINES OF A VESSEL ARE TAKEN FROM (1) Waterplanes, (2) Stations, (3) Buttocks. (Fig. 15).

PLANKING DECK, LAKE-TYPE CUTTERS Three inches on each side, laid edge grain. Bolts galvanized iron, ½". (See DECK PLANKING). (Fig. 102).

PLANS (THE THREE PLANS OF A VESSEL) (1) Half breadth. (2) Body. (3) Sheer. (Fig. 15).

PLATE usually refers to mild steel plates used for decks, bulkheads, and shells of vessels. It is referred to by thickness or by pounds per square foot. A plate 1" thick weighs 40.8 pounds. (Fig. 71, 77, 80, 81, 95).

PLATE, BOSS Furnaced plates, considerably thicker than shell plating, which are fitted around the propeller boss, and around the spectacle frames in way of the stern tubes. (Fig. 91, 93).

PLATE, BUTTS Owing to the relative weakness of a butt joint in comparison with the plating, it is necessary to arrange the butts so as to minimize this effect. Plating of a ship is usually butted about midway between frames to provide for riveting and in the case of the flush type this allows for the fitting of butt straps on the inner side of the plating butts. The shifting of butts also brings about an equalization of the plating as regards strength. (Fig. 16).

PLATE, OXTER The shell plate which is immediately below the transom and which is riveted to the stern frame. It is an extra heavy plate. (Fig. 22, 37 (d), 90).

PLATE, STEALER a plate that combines two strakes and continues toward the bow or stern as a single strake. (Fig. 48).

PLATE, WEB the girder plate that forms the main part of a web frame. Angle bars fasten on each edge. (See WEB FRAMES). (Fig. 21).

PLATEN a work table, the upper surface of which lies in a true plane.

PLATING JOINTS (1) Butt. (2) Lap. (3)

Joggled; used for steel deck plating only. (Fig. 11,14,21).

PLATING SYSTEMS (a) CLINKER. Same arrangement as in small boat construction. Tapered frame liners are used.

(b) FLUSH SYSTEM. Edges form butt joints providing a flush surface. Seam straps and butt straps on the inner side secure the plates together. (Fig. 22).

(c) IN AND OUT In this system the edges of the outside plating form lap joints, both edges being alternately inside and outside. Frames are joggled in the way of the outside strakes or else frame liners of the thickness of the plating have to be fitted between the frames and the outside strakes. (Fig. 11, 19, 27, 71, 107).

PLIMSOLL MARK is the mark on the side of a merchant ship at the midway section indicating maximum draft, according to seasons, in various salt and fresh waters, to which ships may be loaded without voiding their insurance.

PONTOONS are used to assist in floating vessels or other submerged bodies. They are flooded with water, sunk in the proper position and secured, then pumped out.

PORT, AIR Parts of see Fig.38. (See AIRPORTS, PARTS OF).

PORT, BULWARK, OR FREEING openings about the size of a manhole fitted with flap doors to provide quick drainage of seas breaking over into enclosed bulwarks or wells.

PROFILE PLAN (See SHEER OR PROFILE PLAN).

PROPELLER a propulsive device consisting of a boss, or hub, carrying radial blades, from two to four in number, the rear or driving faces of which form portions of an approximately helical surface and the axis of which is the center-line of the propeller shaft. A single propeller is the most efficient. A two-blade propeller is more efficient than one with a greater number of blades but is not used owing to the large diameter required and the fact that it would be badly out of balance if one blade was lost. (Fig. 90, 91).

PROPELLER BACK is the forward surface of the propeller blade when the ship is going ahead.

PROPELLER BLADE is a solid, having for its driving surface a portion of a helicoidal surface.

PROPELLER DIAMETER is the diameter of the circle cut by the tip of the propeller blade.

PROPELLER FACE is the after or driving surface of the propeller blade, when the ship is going ahead.

PROPELLER FOLLOWING EDGE is that opposite the leading edge.

PROPELLER LEADING EDGE is the edge of the blade which first cuts the water, when going ahead.

PROPELLER PITCH is the axial advance of one revolution considering the propeller working in a fixed nut.

PROPELLER PITCH, NOMINAL the distance (measured parallel to the axis of rotation) between similar positions of a point on the driving face of a propeller blade in successive revolutions. When the driving face of a propeller blade lies entirely in true helical surface the blade is said to have a uniform pitch. When the pitch at the following edge is greater than at the leading edge, the blade is said to have axially increased pitch. When the pitch near the tip is greater than near the hub the blade is said to have

radially increasing pitch.

PROPELLER PITCH, VIRTUAL the pitch of a theoretically perfect blade of no thickness which would act as does the actual blade. The pitch of the back of a propeller blade varies greatly from that of the face of the blade. Inasmuch as the back exercises a material influence upon propeller performance correct conclusions are impossible unless proper allowance is made therefor. The virtual pitch as above defined meets this requirement.

PROPELLER POST is the vertical post at the stern of a single or triple screw vessel, through which the center propeller shaft passes. (Fig.20,88,89,90,91,93).

PROPELLERS are usually made of manganese bronze containing 58% copper, 40% zinc, 1% manganeze, tensile strength, 65,000 pounds per square inch.

PROPELLER SLIP ANGLE the angle between the plane of the blade face and its direction of motion.

PROPELLER SLIP, APPARENT the value of the fraction: propeller speed minus speed of ship, divided by propeller speed.

PROPELLER SLIP OR SLIP RATIO; APPARENT TRUE SLIP The ratio of speed of slip to speed of propeller or, expressed in the form of a fraction, propeller speed minus speed of advance, divided by propeller speed.

PROPELLER SPEED RATIO the speed of advance divided by the speed of propeller.

PROPELLER STRUTS (See SHAFT STRUTS). (Fig. 114).

PROPELLER SURFACE is termed helicoidal, it being a surface generated by a line set at an angle to the axis.

PROPELLER THRUST the effort delivered by a propeller in pushing a vessel ahead.

PROPELLER THRUST, DEDUCTION the actual thrust of the propeller minus the tow rope resistance of the ship or the net thrust of the propeller.

PROPELLER TIP is the point farthest from the hub or axis.

PROPULSIVE EFFICIENCY the ratio of effective to indicated (or shaft) horse power.

PROTECTIVE PLATE a term applied to the plate fitted in the way of the hawse pipe for protection against blows from the flukes of the anchor. (See DOUBLING PLATE). (Fig. 71,97).

PUMP SUCTIONS in the midship and dead flat sections of a ship and where there is not a sharp rise in the floor or bottom, three suctions are required, one at the keel and one at each side to make sure of clearing the ship when she has taken a heavy list. In the ends of a ship and where there is a sharp dead rise only one suction need be installed near the keel. (Fig.37).

PUMP WELLS a tank formed either independently or by the structural members of the ship in which the pump strainer on the end of the suction line is installed. The hot well may be an independent tank and is used to collect the condensate water. Other wells are usually depressions in the inner bottom and into which the bilge water drains.

PUNT a heavily built boat of rectangular shape used by men employed in painting, cleaning or repairing a ship's topsides when in sheltered waters.

QUADRANT a casting, forging or built up frame in the shape of a sector of a circle attached to the rudder stock and through which the steering gear leads or wheel ropes turn the rudder.

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PLATEN a work table, the upper surface of which lies in a true plane.

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QUARTER is the curved portion of the ship on either side of the extreme stern. It is the overhang abaft the athwartship transom which rests on top of the rudder post. (Fig. 22, 97 (b)).

RABBETS are grooves in the side of the keel, stem, or stern frame, for receiving the strakes of plating. (Fig. 53, 54).

RABBETTED means recessed so the outer surface will be flush with the outer surface of the member into which the member is recessed. For example, the shell plating may be recessed or rabbetted into the keel so the outer surface of the shell plate will be flush with the outer surface of the keel. (Fig. 53, 54).

RADIUS OF GYRATION (See GYRATION, RADIUS of).

RAKE Masts are raked mainly for appearance. There is a slight streamline gain. It is desirable to set the masts plumb on cargo vessels in order to avoid offsetting the derrick table.

REEFING HOOKS are used for reefing oakum out of seams.

REEFING IRONS are used for cutting or reefing the pitch or marine glue out of seams.

REAM To open the seams of the planking by means of a reaming iron in order that the oakum may be more readily driven in.

RESERVE BUOYANCY The difference between the amount a vessel would displace if she were water-tight and totally submerged, and the amount she actually does displace at her designed draft.

RESISTANCE, CENTER OF LATERAL That point through which a single force could act producing an effort equal to the total lateral resistance of a vessel. The center of lateral resistance is ordinarily assumed to be coincident with the center of gravity of the central immersed longitudinal plane.

RESISTANCE, EDDY-MAKING Resistance due to the formation of eddies at the stern usually resulting from the abrupt termination of the after ends of waterlines, from the action of propellers and rudders, and from the addition to the hull of projections such as struts, docking keels, etc.

RESISTANCE TO A SHIP'S MOTION (1) air (2) friction, (3) waves, (4) eddies, (5) stream line, which consumes energy by diverting the lines of water out of their normal positions as they are crowded together to get around the bow of the vessel.

RESISTANCE, TOW ROPE the total resistance overcome in towing a ship or model. It equals the sum of the frictional, eddy making and wave making resistance.

REVERSE FRAMES (See FRAMES, REVERSE).

RIBBANDS, FORE-AND-AFT pieces of timber arranged longitudinally around the building ways outlining the form of the ship at different levels and having the frame stations marked on them. When a frame is erected it bears against the ribbands which hold it in its correct athwartship position and by setting it to the ribband frame station mark, it assumes its proper fore and aft position. (Fig. 52, 60, 82).

RIDER a plate or girder fixed to the inner side of the framing at the center line for extra strength.

RIDER PLATE is the name applied to the center strake of inner bottom plating attached to the top of the center vertical keel. It is usually heavier than the balance of the inner bottom plating. (Fig. 11, 73, 74).

RIGHTING ARM G.Z. the horizontal distance measured in feet from the center of

gravity to the vertical, drawn upward through the center of buoyancy of a slightly inclined vessel. (G.Z. is perpendicular to B'M the vertical).

RIGHTING COUPLE Gravity acts downward through the center of gravity, and buoyancy upward through the center of buoyancy; they are equal and opposite and are termed the righting couple. (See COUPLE). (Fig. 1 (a).

RIGHTING MOMENT the product of the displacement and length of the righting arm. The displacement being expressed in tons, and the righting arm in feet, the righting moment is therefore expressed in foot tons. (Fig. 1 (a).

RIVETER, HYDRAULIC usually a large C shaped cast steel frame with a hydraulic ram fitted at the open end which carries the rivet set.

RIVET HEAD The head before the rivet is driven; the POINT is formed on the opposite end when the rivet is driven. The heads most commonly used are the pan, the button, and the countersunk.(See RIVETS in text). (Fig.48 (a)).

RIVET HEATER, ELECTRIC a specially designed transformer with one or more openings for the rivets in the secondary winding. The rivets when placed in the openings complete the secondary circuit.

RIVET HOLES, DRIFTING OF When the rivet holes in two adjoining plates are not in the same line normal to the surface of the plate, a drift pin should never be used to rupture the plating to permit the rivet to go through.

RIVET HOLES, PUNCHING OF Plate up to one inch may be punched and always FROM the faying surface. For more than one inch plate the holes are punched smaller and then reamed out or drilled.

RIVETING, BULL a term applied where rivets are driven by power machine, usually air or hydraulic.

RIVETING, CHAIN a term applied to two or more rows of rivets that have their centers opposite each other. A line drawn perpendicular to the edge of the plate through the center of a rivet in one row will pass through the centers of the corresponding rivets in the other rows. (Fig. 16).

RIVETING CREW (1) heater, (2) passer, (3) holder on, (4) riveter.

RIVETING, DOUBLE a term applied when a connection is made with two rows of rivets. In double riveting butt joints there are two rows of rivets in each plate. (Fig. 16).

RIVETING, OIL-TIGHT (1) rivets are closely spaced, (2) rivet holes should be drilled or else small holes punched and reamed out, (3) rivet spacing of 3 to 3½ diameters is used.

RIVETING, SINGLE a term applied where a connection is made with one row of rivets. (Fig. 16).

RIVETING, STAGGERED A term applied to two or more rows of rivets where the centers of the rivets in one row are one-half the pitch of spacing ahead of the other row. (Fig. 78).

RIVETING, THREE-PLY a term applied to where three thicknesses of material are connected by one rivet.

RIVETING, TREBLE a term applied when a connection is made by three rows of rivets. In treble riveting butt joints there are three rows in each piece connected. (Fig. 16).

RIVETS should be of the same material as the parts they connect but with greater ductility. Mild malleable steel is

mostly used. (Fig. 48 (a)).

RIVETS, BUTTON POINT are used mostly where the driving is by power. (Fig. 48 (a)).

RIVETS, COUNTERSUNK POINT are used for flush work and where water-tight or oil-tight work is hard to get to as in staples and bounding bars. (Fig. 48 (a)).

RIVETS, HAMMERED POINT are used mostly for internal work. (Fig. 48 (a)).

RIVETS, OVERHEATING OF Rivets should be heated until just before they give off sparks. (See TEXT under INSPECTION DATA).

RIVETS, SIZE The diameter of the shanks before driving are from ¼" to 1-¼". For 10-lb. plate use 5/8" rivets; for 20-lb. plate use 7/8" rivets, etc.

RIVETS, SPACING A term applied to the distance between the centers in a row of rivets. The distance usually consists of a multiple of the rivet diameter and depends on whether oil-tightness, water-tightness or strength is to be the governing requirement. Rivet spacing for water-tight work is 3½ to 5 diameters. The spacing of rivets in rows abreast of each other is termed chain riveting, rivets not so placed as "zigzagged" or "staggered".

RIVETS, TACK are used to keep the inner and central surfaces, or faying surfaces, of doubling plates together and touching throughout.

RIVETS WITH CONE NECK are used only where holes in plating are punched. (Fig. 48 (a)).

ROLLING CHOCKS (See BILGE KEEL). (Fig. 99).

ROLLING OF THE SHIP The oscillation is caused by the slope of the wave and consequent moving of the center of buoyancy and the tendency of the vessel to assume a position perpendicular to the sloping wave surface. (See OSCILLATION). An oscillation is half the period of roll. The time required to roll from starboard to port and back to starboard is the PERIOD OF ROLL. (Fig. 29).

ROLL OF VESSEL, FACTORS THAT BREAK THE SYNCHRONISM OF (1) Friction of the ship's sides against the water. (2) Amplitude of each successive roll increases until the oscillation requires more than the normal period of time. (3) Waves seldom follow at constant intervals.

ROLL OF VESSEL; HOW DAMPENED (1) bilge keels, (2) gyro-stabilizers, (3) anti-rolling tanks, (4) weights moved upward, (5) weights moved outboard. (6) adjustable fins.

ROLL OF VESSEL IS DEPENDENT UPON (1) metacentric height, (2) displacement, (3) natural period of roll which is effected by No.1 and No. 2, and also by the radius of gyration.

ROSES perforated metal plates, fitted over the outside of injection sea cocks in order to prevent the entrance of weeds or other foreign substances into the ship's piping system or pumps. Also a perforated nozzle for delivering water in a fine jet.

ROT the presence of rot in wood is indicated by a decided softness of the wood where it is discolored. Discoloration of heart wood or stained heart should not be confused with the rot or rotten streaks.

ROTATION, AXIS OF when a vessel rolls, the axis of rotation is the longitudinal axis about which the movement takes place.

ROVEN COTTON is used for calking the seams of small boats.

RUBBING STRIP OR SHOE a plate rivet-

ed to the bottom of a keel, to afford protection in docking and grounding. Also a strip fastened to the outside of a fender or to the shell plating where the contact is likely to occur.

RUDDER ANGLE the most efficient rudder angle is about 35 to 36 degrees.

RUDDER, BALANCED The part of the balanced rudder forward of the axis is from 2/5 to 1/3. (Fig. 20 (a)).

RUDDER, TYPE MOSTLY USED IN COAST GUARD (See Fig. 22, 92, 93).

RUDDER, BALANCED, ADVANTAGES OF (1) requires less power for steering, (2) when pressure applied to the steering wheel is released, a balanced rudder quickly returns to midship position. (See RUDDER, BALANCED). (Fig.20 (a)).

RUDDER BEARING a fitting usually constructed in two parts which are bolted together around the head of the rudder stock. The upper portion of the bearing is usually fitted with an annular groove and a flat ring floating in oil upon which the rudder carrier turns. The middle portion, which is usually lined with white metal, forms a side bearing for the rudder stock, and the bottom portion, which is composed of a wide flange, provides for attachment to the top of the rudder trunk or deck. (Fig. 22).

RUDDER CARRIER a fitting usually constructed in two parts which are bolted together around the rudder stock and which forms a means of transferring the weight of the rudder to the rudder bearing. The upper portion of the carrier consists of a sleeve that forms a close fit around the stock which is usually turned to a larger diameter at the top and bottom of the carrier sleeve to form shoulders. The upper shoulder aids in transferring the weight of the rudder through the carrier to the bearing and the lower shoulder prevents the stock from slipping up through the carrier. Set screws or a key and keyway are usually fitted to insure that the carrier turns with the stock. The lower portion of the carrier consists of a flange having a flat bearing surface that works on an annular ring floating in oil in a groove on the top of the rudder bearing. (Fig. 22).

RUDDER HEAD is the upper continuation of the rudder above the blades, to which the rudder stock is attached.

RUDDER KEEPER a term applied to wedge shaped pieces of metal that are fitted between and prevent the nuts on the coupling bolts from working loose.

RUDDER POST OR STERN POST is the vertical post at the stern to which the rudder is hinged. In single screw vessels it is the after vertical post of the stern frame on which the rudder is carried and in sailing ships or in vessels with two or four propellers it is the single post on which the rudder hangs. (Fig. 20, 22, 88, 91, 92, 93).

RUDDER REQUIREMENTS Large enough to control vessels at slow speeds and of sufficient size to be effective without the use of a large amount of rudder.

RUDDER STOCK is the vertical shaft which secures on the forward upper side of the rudder. The upper continuation of the stock is called the rudder stock head. (Fig. 20, 22, 92).

RUDDER STOPS limit the angle to which the rudder may be put over. Lake Type Cutters have stops at 39°.

RUDDER, THE EFFECT OF (1) turns vessel, (2) vessel first heels inward and then likely outward, (3) vessel moves bodily sideways outward, (4) slows vessel.

RUN The underwater portion of a vessel aft of the midship section or dead flat.

SADDLES Are foundations made up of plates cut to a curved shape to fit snugly against the boiler shell, tanks etc. The edges are reinforced by angles and successive saddles are connected at their outer sides by longitudinal plates. The assembly is securely fastened on top of the floors or inner bottom, as the case may be. (Fig. 73).

SAGGING is the tendency of a vessel to droop or sag near the midship area until the center sags below the ends.

SALT, OR SEA-WATER weighs 64 lbs., per cubic foot and has a volume of 35 cubic feet per long ton.

SAMSON POST OR KING POST a strong vertical post used to support a derrick boom.

SAPWOOD is that nearest the bark. It constitutes a woody cylinder between the bark and the heartwood and carries the sap fluid. Sapwood in unseasoned lumber molds or stains rapidly when stowed in confined spaces. Bright sap in seasoned lumber is not considered a defect.

SCANTLINGS are the various shapes entering into the construction of a vessel such as frames, beams, stringers, longitudinals, and plating, etc. (Fig.52,55).

SCARPH is a joint in which a portion of two adjoining members is cut away so that they may overlap each other without increasing the width of either. Example: the stem is scarphed in figure 54.

SCREW PROPELLER is made up of a number of propeller blades, spaced at equal angles about the axis, and the hub which forms the inner limits of the propeller blades. The hub provides the means of securing the propeller to the shaft. (Fig. 22, 90, 91 93).

SCREWS, DIRECTION OF ROTATION the greatest efficiency for twin screw operation is with both propeller wheels turning outboard.

SCRIVE BOARD a portable platform made of soft, clear, planed lumber on which a full size body plan of a ship is drawn, the lines being cut into the surface of the wood in small "U" shaped grooves by means of a scriving knife, to prevent them from being obliterated. The scrive board is set up in some convenient spot and used as a ready reference for the shapes of frames, floors, etc., or to take dimensions from.

SCUPPERS drains from decks to carry off accumulations of rain or sea water. The scuppers are placed in the gutters or waterways on open decks and in corners of enclosed decks, and connect to pipes leading overboard. The flap valve at the bottom is also often called a scupper.

SCUTTLE a small opening, usually circular in shape, and generally fitted in decks to provide access, as a manhole, for stowing fuel, water, and small stores. A cover or lid is fitted so that the scuttle may be closed when not in use. Also applied to the operation of opening a sea valve or otherwise allowing the sea to enter a ship for the purpose of sinking her.

SEA CHEST A term applied to a casting fitted to the shell of a vessel for the purpose of supplying water from the sea to the condenser and pumps, and also for discharging water from the ship into the sea. Chests on suction lines should be fitted with strainers or gratings and when these gratings cannot be removed while the ship is in the water, a steam pipe should be led to the chest for the purpose of blowing out refuse. It is desirable to have as few sea chests as possible, and with the exception of the main injection and discharge to the condenser, two or more leads may operate from one chest. (See ROSES).

SEA COCK, SEA CONNECTION a sea valve secured to the bottom of a vessel for use in flooding the ballast tanks, magazines, supplying water to the fire pumps and sanitary pumps and for other purposes. While these sea valves are sometimes called sea cocks, the ordinary type valve is used.

SEAMS are the horizontal edges of shell plating.

SEAM STRAPS a term applied to a narrow strip of plate serving as a connecting strap between the butted edges of plate seams. The vertical strap connections at the ends of plates are called BUTT straps. (Fig.16).

SECTION A drawing showing the internal arrangement of a ship as it would appear if cut by a plane, usually longitudinally or transversely. (Fig. 21).

SETTLING TANKS Oil tanks used for separating water from oil. The oil is allowed to stand until the water has settled to the bottom, when the latter is drained or pumped off.

SHAFT ALLEY, LAKE-TYPE CUTTERS (See Fig. 64, 74).

SHAFT STOOLS The seatings to which the line shaft bearings are attached. In addition to supporting the weight of the shafting they resist any side bending tendency due to vibrations or thrust on the shaft. The overturning force is not nearly so serious as in the thrust block. (Fig. 41).

SHAFT STRUT A bracket supporting the after end of the propeller shaft and the propeller in a twin or multiple screwed vessel having propeller shafts fitted off the center line. It usually consists of a boss, fitted with a bushing to form a bearing for the shaft and is connected to the side of the ship by two arms of pear-shaped section. The inboard ends of the arms are fitted with palms for attachment to the vessel. (See STRUTS). (Fig. 114).

SHAKES are splits, cracks or fissures in wood.

SHAPES are bars of rolled mild steel or of nonferrous metals, having certain forms of cross section throughout their entire length. The forms of cross section used are such as lend to strength and rigidity in fabrication. (Fig. 55).

SHEER OF A SHIP is the longitudinal curve of the upper deck or rail showing the freeboard at stem and stern over that amidships. (Fig. 15, 113).

SHEATHING is covering the steel plating of a ship's bottom with wood, then with sheet copper. Used in the tropics. (See COMPOSITE CONSTRUCTION).

SHELL PLATING (See PLATE).

SHEER LINES are those showing the curvature in a vertical plane of lines of rail, deck edge, and deck at center. (Fig. 15).

SHEER or PROFILE PLAN It is a side profile or elevation showing the keel, stations, waterlines, stem and stern, deck lines, and the true shape of the buttocks.

SHEER STRAKE is the uppermost strake of the outside planking, or shell plating of a vessel. (Fig. 11, 19, 21, 71).

SHIFTING BEAM A term applied to a portable beam fitted in a hatchway for the purpose of supporting the hatch covers. The ends of the beams are fitted in slotted carriers attached to the insides of the hatchway coamings.

SHIM A piece of wood or iron let into a slack place in a frame, plank, or plate to fill out a fair surface or line.

SHIP, LONGITUDINALLY FRAMED A ship constructed of widely spaced, deep or

belt frames which support a relatively large number of smaller fore and aft longitudinals. The 328 foot cutters will be longitudinal construction with 19 longitudinals and 24 web frames. The longitudinals are attached to the webs by welding and by a 3" x ¼" flat bar stiffener. Strong connections to bulkheads are provided.

SHIP, TRANSVERSELY FRAMED A ship constructed of a large number of relatively small closely spaced athwartship frames reinforced in the bottom by vertical floor plates, in conjunction with widely spaced fore and aft deep girders such as the keel, longitudinals, keelsons, and side stringers. This is the usual type of a Coast Guard cutter. (Fig. 23, 27).

SHIP, UNSTABLE One that has too small a distance between the center of gravity and the metacenter, i.e., metacentric height, and not sufficient extra freeboard to overcome this.

SHOE (See RUBBING STRIP OR SHOE). (Fig. 35, 36).

SHORE A wedged timber or brace, the upper end resting against the object to be supported. (Fig. 35, 36).

SHOLES are the wedges under the heels of shores, etc. (Fig. 35).

SIDING OF A FRAME is its scantling or width in a fore and aft direction.

SKEG is the extreme after part of the keel of a vessel, the portion of the stern frame that supports the rudder post. (See SOLE PIECE). (Fig. 22, 91).

SKIN RESISTANCE of a ship moving through the water represents from 60% to 80% of the total resistance. The other components are streamline, wave making, eddy and air resistance.

SLEEPERS Timbers placed on the top of piling for supporting the cribbing, keel and bilge blocks of ways. (Fig. 50).

SLIP (APPARENT) Equals the difference between the speed of the ship and the speed of the screw. It includes wake effect.

SLIP OF PROPELLER The action of a screw propeller may be likened to the rotation of a screw in a threaded bolt, where the motion in rotation is accompanied by a corresponding motion in translation. In case of a propeller, slip is the difference between the motion of translation which would nominally accompany a screw rotation and the translation which actually does occur when the propeller is rotated in the water. The slip for the greatest efficiency is about 20%.

SLIP FOR COAST GUARD CUTTERS is usually about 15%.

SLIP RATIO speed of propeller minus speed of advance divided by speed of propeller. For example: $\frac{20 - 18}{20} = .1$

Consider the speed of the propeller as if it were moving in a fixed nut.

SLIP, TRUE is without wake effect.

SLUICE an opening in the lower part of a bulkhead fitted with a sliding water-tight gate or door having an operating rod extending to an upper deck. Such openings are advantageous in center line bulkheads, as in case of damage to one side of the ship the water may be quickly admitted to the other side before the ship is dangerously listed.

SOLE-PIECE OF STERN FRAME The lower fore-and-aft piece of the stern frame connecting the propeller post and stern post. (See SKEG). (Fig. 91).

SOLE PLATE A term applied to the top plate of a foundation to which the base of a machine or piece of equipment is

bolted. (Fig. 73).

SPACING OF FRAMES In cutters the spacing below the waterline is 24 inches; above waterline, 48 inches. For destroyers, 21 inches.

SPADE OR UNDERHUNG RUDDER It is shaped like the blade of a spade. The area of the blade forward of the axis compared to that abaft the axis is less than for the balanced rudder.

SPECIFICATIONS for painting the underwater body should stipulate eight hours minimum for drying of anti-corrosive paint No.14 RB or RC and six hours minimum for drying of anti-fouling paint No.15 RB or RC.

SPECIFIC GRAVITY Distilled water is usually employed as the standard of unity in computing the specific gravity of a substance. Distilled water weighs 62.4 lbs., per cubic foot. For example a cubic foot of cork weighs 15 lbs. Its specific gravity would be: 15÷62.4 =.240 specific gravity.

SPECTACLE FRAME The casting containing the hole through which a tail shaft in twin screw vessels passes. It is installed at the point where the propeller shaft emerges from the skin of the ship. (See FRAME, SPECTACLE). (Fig. 38).

SPIKE IRONS are narrow calking irons used to calk around bolt heads, spikes, and other close spaces.

SPLITS OR CHECKS are openings in the grain of wood caused by shrinkage of the material in process of drying. Splits in the end of a board ordinarily must not exceed one inch in length for each inch of width nor deviate more than one inch in one foot.

STABILITY is the quality by virtue of which a vessel rights itself when inclined and is expressed as a moment of force, in foot tons. It equals the displacement weight in long tons times the righting arm in feet. Stability varies as the square of the breadth and inversely as the draft. (See RIGHTING ARM and the chapter on STABILITY).

STABILITY CURVE A curve showing the righting arm values for all angles of inclination. (Fig. 1 (e)).

STABILITY DEPENDS UPON (1) Underwater shape, (2) Distribution of underwater shape, (3) Distribution of all weights on board.

STABILITY, DYNAMICAL is the force exerted or work done to deflect a vessel from its upright position. Its moment is usually expressed in foot tons.

STABILITY, EFFECT OF FREE SURFACE LIQUIDS ON is a virtual rise of the center of gravity thereby lessening the metacentric height with the consequent loss of stability. In the partial flooding of a compartment below the waterline, which is not vented, a compressed air space will be entrapped above the free surface of the water. The water will rise in the space until the air pressure inside exactly balances the pressure head of the outside water. If a compartment is partially below the waterline, free surface liquid will flow in up to the height of the outside water level. In the former case the water movement is less, due to the compression of the air above the water. (Note: If the damage is located near the bottom of a compartment and it can be sealed, air pressure put on the compartment will force the water out). (See FREE SURFACE and VIRTUAL CENTER OF GRAVITY).

STABILITY, HOW EFFECTED BY STRANDING the upward pressure of the ground on the ship's bottom may be considered as lessening the ship's weight, thus raising her center of gravity with the

consequent decrease of "GM", the metacentric height, thereby reducing the stability.

STABILITY, HOW REGAINED AFTER COMPARTMENTS ARE FLOODED by counter flooding and thus adding weights on the opposite side with trimming moments of equal but opposite values.

STABILITY IN DAMAGED CONDITION is the stability which remains after the flooding of one or more compartments with consequent loss of displacement and possible change in character of area of waterplane. Note the change in the period of roll. The change in the period will be accompanied by loss of metacentric height, G.M. The period of roll varies inversely as the square root of G.M., or G.M. varies inversely as the square of the period. Thus, if before damage the period of roll was 8 seconds and after damage it doubled to 16 seconds the G.M. has been lessened to one fourth of its original value. ($8^2 = 64$; $16^2 = 256$; 64 is ¼ of 256).

STABILITY, INITIAL the resistance offered by a ship to inclination from the upright and measured by the metacentric height, G.M. Beam has the greatest effect on initial stability, for BM =

$$\frac{\text{Moment of Inertia}}{\text{Volume of Displacement}}$$

while moment of inertia varies as the beam cubed. Initial stability of a vessel is dependent on height of center of gravity, freeboard, speed and height of the metacenter which depends on the height of B center of buoyancy, form of underbody and value of B.M., which is, as mentioned above, dependent on the beam.

STABILITY, LONGITUDINAL refers to the stability for longitudinal inclinations. For the reason that vessels are invariably stable for longitudinal inclinations (pitching) little attention is given to longitudinal stability.

STABILITY, MAXIMUM is the angle of inclination at which the righting arm, or the tendency of a vessel to regain the upright position, is at a maximum. (Fig.1(e).

STABILITY, RANGE OF is the angle through which a ship must be inclined to reach the point at which the stability vanishes, i.e., the point where GZ, the righting arm, becomes zero. (Fig 1 (e).

STABILITY, STATICAL the effort which a ship makes, when held steadily in an inclined position, to return to her natural upright position of equilibrium. The righting moment, the product of the vessel's weight by the righting arm, is the measure of the statical stability of a vessel.

STABILITY, TRANSVERSE refers to stability for transverse inclinations.

STABILITY, VANISHING ANGLE OF · As inclinations are increased, the value of "GZ", the righting arm, increases; however, as "G" and "M" approach, the stability lessens and the point of vanishing stability is reached when "G" and "M" coincide. (Fig. 1, (e).

STABILIZERS There are several types: anti-rolling tanks, gyro-stabilizers, moving weights, adjustable fins and bilge keels. In the gyroscope system, which makes use of the gyroscopic properties of a rotating wheel, a pilot gyro controls a precession motor which in turn controls the precession of the main gyro about the athwartship axis. The resultant reaction of the precession is opposition to the heeling movement. The resistance offered bythe gyro to rotation of its axis dampens the rolling of the vessel in which it is installed. (See Gyroscope). Anti-rolling tanks usually consist of large tanks on either side of the ship, connected by a pipe at the bottom and by an air passage, regulated by a valve, at the top. One tank is filled along with the connecting bottom pipe. The air valve is then adjusted so that when the vessel rolls the motion of the water

is one fourth period behind the roll of the vessel. Considerable use is made of anti-rolling tanks, especially on German vessels, including two of their large liners. Adjustable fins are a Japanese installation. Fins, which are mounted on the end of shafts, the inboard ends of which are geared together, project downward and outward through the skin of the ship, at the turn of the bilges. A gyro controlled steering engine rotates the shafts so that the leading edges of the fins on the side moving down are turned up and the leading edges of those on the side moving up are turned down. Alongside the dock and in shallow water the fins are retracted within the hull. They are about 60% effective in reducing roll.

STABLE SHIP is one with sufficient distance between the center of gravity and the metacenter, which condition provides sufficient righting arm to enable the vessel to regain her upright position after being inclined by external forces.

STANCHIONS support deck beams and girders. They are usually flanged at the top to the beam angle and secured at the bottom to the deck plating, directly over the beam below, or directly to the beam below by a flanging or angle. (See PILLARS). (Fig. 24).

STAPLES are irregularly shaped plates fitted around such members as stringers, frames, beams, and pipes to provide watertightness or to connect such members to the shell or bulkhead, as the case may be. (Fig. 14 (a), (b), (c)). (See WELDED COLLARS).

STATIONS are planes passing perpendicular to the longitudinal centerline plane and to the waterline planes of the ship. Stations are numbered aft from the bow. (Fig. 15).

STEADYING A STIFF SHIP, MEANS OF (1) bilge keels, (2) anti-rolling tanks, (3) gyro-stabilizers, (4) weights moved upward and outward, (5) adjustable fins.

STEALERS It is noted how fast the girth, measured from the keel to the upper deck, lessens as the bow or stern are approached. This results in reducing the number of strakes of plating at the bow and the stern, and where two strakes are merged into one, a stealer is said to be wrought. As the girth of a vessel lessens at the ends, some strakes must be dropped. Such strakes are called lost strakes or stealers. (Fig. 48).

STEAM LINES are high pressure lines which are made of copper.

STEEL is primarily an alloy of iron and carbon, the carbon content ranging from a trace to nearly two percent. It is capable of being cast into ingots or molds and rolled or worked into various shapes.

STEEL, ANCHOR CHAIN Up until recent years was made of wrought iron. Cast steel has been used more recently. The latest development is nickel steel. It is more uniform and stronger than cast steel. Nickel steel anchor chain is called "di-lock" chain. A recent improvement is replacement of the cumbersome U-type shackles by shackles which have practically the same dimensions as ordinary links, and swivels have been placed on the chain in positions where there is small probability of their coming on the wildcat during heaving.

STEEL CASTINGS are used for shapes such as stern frames, outer stern tubes, struts, bed plates, anchors, wildcats, capstans, hawse pipes, and gun mounts. Steel castings have practically replaced forgings.

STEEL, CHROME-NICKEL is a nickel steel to which about 1% of chromium is added.

STEEL, FORGED is used for propellers, crank shafts, connecting rods, rudder

stocks, stem and stern posts. CAST STEEL is also used for stem and stern frames, and stems are frequently made up of a combination of cast and forged steel.

STEEL, FOR WHAT TESTED (1) tensile strength, (2) ductility (elongation).

STEEL, HARD is a steel harder than medium steel and thus less ductile. It fatigues more quickly under repeated stresses.

STEEL, MEDIUM is harder and stronger than mild steel and will appreciably harden when suddenly cooled by quenching.

STEEL, MILD is soft, having a carbon content of not over 2% and it will not harden when suddenly cooled by quenching. STEEL generally used in shipbuilding is OPEN HEARTH MILD STEEL.

STEEL, NICKEL usually contains about 3% nickel, the addition of which causes greater toughness thus increasing the percentage of elongation. (See STEEL, ANCHOR CHAINS).

STEEL OR SHELL PLATING open hearth mild steel which is strong, elastic and tough, with sixty thousand pounds per square inch tensile strength and fifty thousand, sheering strength. (See STEEL, MILD).

STEEL, SHEET Steel plates weighing less than 5 pounds per square foot are called SHEETS.

STEEL USED IN SHIPBUILDING (See STEEL, MILD).

STEM OR STEM POST The bow frame forming the forward extremity of the vessel. By scarphing and riveting it is securely connected at its lower end to the keel. (See Fig. 53,54,57,71).

STERN BEARING, CLEARANCE OF The Bureau of Construction and Repair, U.S.N. Manual, shows lignum-vitae bearings for a 10-inch shaft should be renewed at .185".

STERN FRAME a heavy casting or forging for the purpose of supporting the rudder and propeller shaft in a single screw vessel. It also serves as a frame for rigidity, connecting the converging sides of the ship at the stern. (Fig. 20, 22, 91).

STERN POST (See RUDDER POST).

STERN TUBE The bearing supporting the propeller shaft. It is usually made up of a hollow cast iron or steel cylinder fitted with brass bushings which are lined with lignum-vitae strips for bearing surfaces. The propeller shaft, enclosed by a brass or bronze sleeve, which is shrunk on the shaft, bears on the lignum-vitae. Water enters the stern tube through the grooves in the lignum-vitae and acts as a lubricant. (Fig. 20, 26, 91).

STERN TUBE BEARING a common bearing surface for stern tubes consisting of lignum-vitae blocks or strips. (Fig. 26).

STERN TUBE BUSHING a hollow brass cylinder with an outside diameter equal to the inside diameter of the stern tube. There are usually two bushings, one inserted in the forward end of the stern tube and the other in the after end. (Fig. 26).

STERN TUBE GLAND A term applied to a short hollow cylindrical casting having a flange on one end and used for compressing the packing of the stuffing box. (Fig. 26).

STERN TUBE STUFFING BOX A term applied to the receptacle for packing around the propeller shaft in the forward end of the stern tube.

STIFFENERS are angles or other shapes fastened at intervals on bulkheads to stiffen them. (Fig. 19, 83).

STIFF SHIP The tendency of a vessel after being inclined by an external force to regain the upright position by rapid movement. The degree of stiffness is directly affected by the value of the vessel's metacentric height. A stiff ship is one that has a considerable distance between the center of gravity and the metacenter, resulting in the ship returning too quickly to the upright position.

STOCK, RUDDER The vertical cast or wrought steel shaft on the forward upper side of the rudder which rotates it.

STOP WATER Pieces of canvas soaked in red or white lead, placed between the faying surfaces of plates and shapes where water is apt to work its way through. The term is also applied to a wooden plug driven in through a scarph joint to stop water from leaking into a vessel.

STRAKE A term applied to a continuous range or row of plates. The strakes of shell plating are usually lettered upward starting with "A" at the bottom row. (Fig. 14, 19).

STRAKE, BILGE A term applied to a strake of outside plating running in the way of the bilge. (Fig. 11).

STRAKE, BOTTOM Any strake of plating on the bottom of a ship that lays between the garboard and bilge strakes. (Fig.11).

STRAKE, DOUBLING A term applied to a strake made up of two thicknesses of plate. A sheer strake and topside plate are sometimes doubled amidships for extra strength. (Fig. 71).

STRAKE, DROP A term applied to a strake that is terminated before it reaches the bow or stern. The number of strakes dropped depend on the reduction of girth between the midship section and the ends of the vessel. (See STEALERS).(Fig. 48).

STRAKE, GARBOARD The strake of the shell plating adjacent to the keel. This row of plates acts in conjunction with the keel and is made heavier than the other bottom plates. (Fig.11).

STRAKES The most important strakes are: (a) GARBOARD, next to the keel, (b) BILGE, at the turn of the bilge, (c) SHEER, the uppermost side plate. The strake next above the garboard is A, the other strakes being designated B, C, D, etc. Connection between plates in adjoining strakes is a SEAM; that between adjoining plates in the same strake a BUTT. Under HOGGING conditions the sheer strake plating is under tension and the lower side plating is in compression. The opposite conditions exist for a SAGGING condition. The above named important strakes are of heavier plate to withstand the alternate tension and compression stresses, incident to progress through waves. (See Table II and Fig. 11).

STRAKES, INNER A term applied to the inner strake of an "in an out" system of shell plating. They are the strakes adjacent to the molded frame line. (Fig. 11).

STRAP, BUTT If the edges of two plates are butted together and they are connected by a third piece, the connecting piece is a BUTT STRAP. In the case where two seams are butted, the connecting third piece is a SEAM STRAP. If the third piece or strap is on only one side of the plates joined it is a SINGLE STRAP; if on both sides, a DOUBLE STRAP.(Fig. 119).

STREAMLINES (See WAVE RESISTANCE).

STRENGTH OF BULKHEADS (1) Stiffen the hull, (2) Support the hull structure when in dry dock, (3) Separate body into compartments, (4) Provide for localizing damage.

STRESS The intensity of the force which tends to alter the form of a solid body; also the equal and opposite resistances offered by the body to a change of form.

STRESSES OF GIRDERS The stresses of ship girders are greatest at the mid-length. To save weight, reductions in size of such members, in gradual steps, are effected beyond the middle half-length of the ship.

STRESSES, POUNDING Stresses induced in a vessel as she rides through the waves by the beating of the water against her bottom. Pounding stresses are of special moment in flat bottom vessels of shallow draft.

STRESSES, STRUCTURAL are the stresses resisted by the entire ship structure. The greatest stresses occur in the parts of members most remote from the NEUTRAL AXIS, namely in the deck and bottom plating.

STRESSES, TRANSVERSE The transverse stresses of a vessel are much less than the longitudinal stresses. Rolling greatly increases the transverse stresses. With unequal distribution of weights, and when a ship is in dry dock, heavy torsional stresses may be exerted on beams and transverse bulkheads.

STRINGER PLATE A term applied to the outboard strake of plating on any deck. (Fig. 81, 96, 97, 97 (b)).

STRINGER ANGLE BAR A term applied to the angle bar connecting a deck stringer plate to the outside plating of the bulwark. They are usually made up of short lengths running between frames. A continuous angle bar connecting the inner flange of the frames to the stringer plate is sometimes called a stringer bar. (Fig. 23, 96, 97).

STRINGER, INTERCOSTAL A stringer made up of plates cut to fit between frames. Each plate is attached to the frames and shell plating by short angles or bar clips. The plates are usually made deep enough to allow a continuous bar to be attached to the inner edge of the frames. (See STRINGER, SIDE). (Fig.25).

STRINGER, PANTING A fore-and-aft plate, angle, or built up girder fitted in between the side stringers in the bow and stern. Its purpose is to reduce the in and out vibrations or panting of the frames and plating. (Fig. 18, 69).

STRINGER, SIDE A term applied to the fore-and-aft girder supporting the side plating and located between the bilge and the lower decks. The stringer may be intercostal and attached directly to the shell plating, or it may be continuous and attached to the inner flanges of the frames. (Fig. 11, 74, 81, 97 (a)).

STRIP, EDGE Narrow fore-and-aft strips of plate fitted along the inside of plate seams, in the flush system of plating. The edge strips are continuous whereas the vertical frame liners are intercostal.

STRONG BEAM (See BEAM, MAIN or STRONG).

STRUCTURAL ERECTION OF SHIP The keel is first laid on the keel blocks, then the bottom plating out to the turn of the bilge on each side, then the transverse and longitudinal framing inside and on top of the double bottom, next the bulkheads, and from this point the fabrication progresses from inboard out. After the shell plating is finished up to the upper deck, the stem and stern frames are set up, etc.

STRUCTURAL MEMBERS; FABRICATION OF From the full sized lines of the ship as laid down on the mold loft floor, patterns (templates) are made up of the various plates and structural shapes. From these the part is cut or shaped to size, openings cut as indicated, rivet holes punched or drilled and the members placed in readiness for fabrication into the ship.

STRUCTURE OF BULKHEAD Consists of

strakes of plating, reinforced by stiffeners, certain ones of which are secured at their ends by brackets, joined to the decks, shell plating, other bulkheads, and to structural members with which it makes contact. All openings in the bulkhead are strengthened by doubling plates.

STRUCTURE OF DECK Consists of plating laid in strakes fore-and-aft, supported by transverse deck beams which are bracketed to the ship's frames. Upper decks on cutters are made up of a wide center line fore-and-aft King plate, a horizontal deck stringer plate running around the periphery of the ship's side, and diagonal tie plates which connect the King and stringer plates, all being supported by athwartship deck beams which are secured to the ship's frames by triangular brackets. Deck planking is then laid over the entire deck (except areas such as gun foundations, towing bitts, etc.) outward to the waterway angle bars which limit it at the inner side of the waterway. The stringer angle bar ties the sheer strake of the shell plating to the stringer plate, at the outer limit of the waterway.

STRUCTURE OF HULL Made up in the following forms: Plates, shapes, castings, forgings and rivets. Forgings are used for simple forms whereas castings are necessary for complicated ones. Corrosion resisting steel is used wherever the local need justifies the higher cost. (See STEEL, MILD).

STRUT, SHAFT Is a one-piece V shaped casting, the legs of which flange on the outside of the shell plating, just forward of the propeller, to support the shaft of twin and quadruple screw vessels. Struts have a boss and stern tube and are fitted with sleeves and lignum-vitae bearings. The strut supports the shaft vertically and laterally but does not take the shaft thrust. (See SHAFT STRUTS). (Fig. 114).

STUFFING BOX, BULKHEAD A fitting attached to a bulkhead where it is desired to pass a rod, pipe, or shaft through without destroying the steam, air or water-tightness of a bulkhead. A hole of the proper size is bored through the fitting and a receptacle, for packing concentric with it, is bored part way through. The packing is held in place by a gland.

STUFFING BOX, DECK A fitting similar to a bulkhead stuffing box and attached to a deck where it is desired to pass a rod, pipe, or shaft through without destroying the steam, air, or water-tightness of the deck.

STUFFING BOX, RUDDER STOCK A stuffing box fitted where the rudder stock pierces a flat or deck. According to where it is located, its purpose may be either to prevent the sea from coming up or water on deck from going down. (Fig. 20 (a), 22).

SUPERSTRUCTURE A structure built above the uppermost complete deck, a pilot house, bridge, galley house, etc. (Fig. 100).

SURFACE, FAYING The faying surface, or side which is to be placed against the member to which it is riveted, is the side from which plates should be punched, drilled or sheared, in order to avoid having burrs come between the surfaces.

SURFACE LIQUID, FREE Consider a partly filled tank with its free surface liquid. As the ship is inclined, the volume of liquid added to the low side of the tank does not depend upon the amount of liquid in the tank but on the angle of inclination, (i.e.) the upsetting moment is independent of the amount of liquid in the tank. Also the effect of free surface on INITIAL STABILITY is independent of the shape of the tank. Thus it is noted that only the Moment of Inertia of the free surface, and not the amount of liquid in a tank, effects the metacentric height and stability. The presence of free sur-

face liquid invariably lessens the metacentric height and the stability.

SWASH PLATE or SWASH BULKHEAD A term applied to a vertical plate or bulkhead, with openings fitted, either athwartships or fore-and-aft, in a tank for the purpose of retarding the flow of free surface liquid therein. They are especially necessary in fuel oil tanks and water tanks that are apt to be only partly full, as the unrestricted and dynamic effect of moving liquid against the sides of the tank would otherwise damage the boundaries. (Fig. 37, 37 (c), 66).

SWEET LINE A term applied to a curved line when it is smooth and without humps or abrupt breaks. A FAIR line.

SYMBOLS, CONVENTIONAL BLUEPRINT See Fig. 126.

SYSTEMS, PLATING (1) CLINKER, (2) FLUSH (3) IN AND OUT or RAISED AND SUNKEN: (a) Raised and Sunken system with liner, (b) Raised and Sunken system with joggled shell plates, (c) Raised and Sunken system with joggled frame bar. (See PLATING SYSTEMS).

TACK WELDING is welding that is intermittent and non-continuous. It is used in non-watertight work and as a preliminary to continuous welding in new work.

TACTICAL DIAMETER The horizontal distance from the point of the original course where the rudder is put over to the position where a ship has turned through 16 points of the compass. (See DIAMETER, TACTICAL).

TAFF RAIL A term applied to the rail around the top of the bulwark or rail stanchions on the after sector of the weather deck, be it upper, main, or raised, quarter or poop. (Fig. 111, 112).

TANKS, ENTERING OF Any tank or compartment which has been closed or sealed for a period of time should be thoroughly examined into before entering. See TEXT for rigorous treatment of tanks which are known to have contained oils, fuel oil, gasoline, kerosene etc. Other spaces, least suspected, may contain inflammable gas which has seeped into them. Explosive gas may be verified by an approved hydrocarbon vapor indicator or by having samples tested by a chemist. If closed or sealed compartments have been painted with linseed oil paint they may contain carbon monoxide. After determining that explosive gasses are not present, before entering, the space must be thoroughly ventilated. The suction should always be placed as low as possible and the discharge led to an adequate open air space, free from danger of ignition. Never force fresh air into such a closed space. When safe for entering, men inside are to maintain direct communication with a man stationed outside the space. Flame safety lamps only are to be carried into the space and they are to be under constant observation. The men are to be withdrawn if any unsatisfactory conditions, such as lack of oxygen purity or safety of the air arise, as indicated by the lamp not burning properly. Men entering such spaces are to be searched to see that they carry no automatic lighters or matches and that their shoes carry no nails or clothing any metal attachments, which may strike a spark. No scrapers or cleaning gear may be taken inside such a space except rubber, wood, copper, brass or fiber. Keep fire apparatus close at hand. In case of emergency when it is necessary to send a man in a space not known to be free of gas, he shall be equipped with an oxygen rescue breathing apparatus and a line is to be securely fastened to him and held by the guard outside of the space.

TANK FOUNDATION A term applied to the seating supporting a tank and given the name of the tank which it supports.

as Feed Water Tank Foundation.

TANK, PEAK Transverse bulkheads are built near each end of the ship to prevent water from flowing into the larger compartments should the ends of the ship become damaged. This provides V shaped trimming tanks which are filled with water to alter the longitudinal inclination of the ship. (Fig. 25,26,70).

TAPERED LINER a liner made of a strip of plate having a triangular cross-section.

TEE BAR a rolled shape, generally of mild steel, having a cross-section shaped like the letter "T". In ship work they are used for bulkhead stiffeners, bracket and floor clips, etc. The size is denoted by dimensions and weight per running foot.

TEMPLATE A mold or pattern made to the exact size of any part of a structure. All templates are marked for rivet holes, lightening holes, size of laps, etc.

TEMPLATE PATTERN A wood frame, or paper cardboard outline of a part of a ship showing the shape of the part with location of holes, and giving by means of notes made thereupon dimensions and information as to the fabrication of the part. (Fig. 75).

TENDER SHIP is one whose metacentric height, "G M" is too small. To correct, place weights lower down, thus lowering the center of gravity.

TENON is the end of a piece of wood cut into the form of a rectangular prism, designed to be set into a cavity of a like form in another piece, which is termed a mortise.

TENSILE STRENGTH The measure of a material's ability to withstand a tensile or pulling stress without rupture. Tensile strength of a material is usually measured in pounds or tons per square inch of cross-section.

TEST HEAD The head or height of water in a test pipe corresponding to the pressure prescribed as test for bulkheads, tanks, compartments, etc. Test heads are prescribed to insure satisfactory oil or water-tightness and also as tests of strength.

THICKNESS OF PROPELLER BLADES Thick blades give good results for slow turning propellers. To correct for CAVITATION blades are made as thin as advisable.

THOLES are pins in the gunwale of a boat which are sometimes used in place of ordinary rowlocks. (Fig. 49).

THRUST the net reaction of a propeller or wheel tending to force the vessel through the water.

THRUST BLOCK (See THRUST BEARING).

THRUST BEARING A bearing designed primarily to take the propeller thrust from the shaft and transfer it to the structure of the ship.

TIE PLATES A term applied to long narrow plates laid radially from the fore-and-aft center line deck plate for the purpose of tying deck beams and stringer plates together where there is only a partial deck plating. (Fig. 81, 97, 97 (b)).

TONGUE AND GROOVE A term applied where the edge of one plank is cut away to form a tongue and that of another is recessed to form a groove. The tongue of the one plank is fitted in the groove on the other.

TON, LONG refers to 2240 pounds, or to 100 cubic feet of a ship's cubical capacity. In building parlance only long tons are dealt with.

TONNAGE, DEAD WEIGHT The number of

tons of stores, fuel and cargo, a ship can carry without exceeding her draft marks.

TONNAGE, GROSS The total internal capacity of a ship below the main deck in tons of 100 cubic feet. Applies to vessels and not to cargoes.

TONNAGE, NET a vessel's gross tonnage minus deductions for space occupied by the crew's quarters, machinery for navigation, the engine room, fireroom, storerooms, and fuel. A vessel's net tonnage expresses the space available for the accommodation of passengers and the storage of cargo.

TONS, NET REGISTER The tonnage remaining after deducting from the gross tonnage the internal capacity occupied by engines, boilers, fuel, crew space, etc. Net register tonnage is the tonnage of the cargo spaces, 100 cubic feet to each ton.

TONS PER INCH refers to the number of tons required to increase the vessel's draft one inch. A curve shows its value for each draft. (Fig. 15 (b)).

TONS PER INCH IMMERSION is equal to $\frac{A}{12 \times 35}$ (for salt water) where A is the area in square feet of the waterplane under consideration. (Use 36 for fresh water). (Fig. 15 (b)).

TOPSIDE PLATING A term applied to the shell plating above the waterline.

TOWING MACHINE A machine which automatically, according to the strain on the rope, reels in or out a towing hawser. It acts as a shock absorber preventing sudden tension and danger of parting. The drums are designed to reel up and stow the hawser.

TRANSOM FRAME It houses a deep athwartship floor termed the transom floor. It secures to the upper limits of the stern post and forms the support for the radial cant frames and counter of the vessel. (Fig. 17).

TRANSVERSE At right angles to the ship's fore-and-aft center line plane. In an athwartship direction.

TRAP is a lowered section in a pipe which retains a sufficient quantity of water to prevent the passage of gas or odors.

TRIM is the difference between the draft at the bow and that at the stern. Weights or flooding unsymmetrical to the longitudinal center line plane of the underbody will cause a LIST. (See TRIM, CHANGE OF).

TRIM, CHANGE OF is the sum of the changes of draft forward and the draft aft.

TROCHOIDAL WAVE A wave, the contour of which is the curve traced out by a point on the radius of a circle, when the circle is rolled on the underside of a horizontal line. This is the wave contour which is usually adopted for use in connection with calculations of the bending moments of a vessel among waves. (See WAVE PROFILE).

TRUNDLE HEAD The circular portion of the capstan head designed to take the ends of the capstan bars for turning.

TRUNK A vertical or inclined shaft formed by bulkheads or casings extending one or more deck heights, for direct access and ventilation. (Fig. 41).

TRUNK DECK VESSEL A vessel having a long continuous opening or hatch in the weather deck. The longitudinal coamings of this hatch are carried up about a deck height above the weather deck and connected at their upper edges by a flat deck.

TUMBLE HOME The decreasing of a vessel's beam above the waterline as it approaches the rail. (The opposite of FLARE).

TUNNEL PLATING The plating composing the structure of a tunnel. (Fig. 72).

TURNING CIRCLE The approximate circle described by a vessel in turning when the helm is put hard over. (See DIAMETER, TACTICAL).

UMBRELLA A metal shield in the form of a frustrum of a cone, riveted to the upper outer casing of a smoke stack to keep out the weather.

UNDOCKING, PRECAUTIONS (1) Close all air ports and other openings. (2) Stand by all valves to watch for leaks while vessel is being floated. (3) After undocking observe for leaks in repaired areas or in parts of the hull which have been opened. (4) Do not turn over main engines until check is made to insure that propellers are clear and not until the bow of the ship is clear of the dock sill. (See DOCKING PRECAUTIONS).

UNDERWATER BODY is that portion of the hull which is normally completely immersed. It includes the hull up to the deck at or next below the normal waterline.

UNDERWATER BODY VOLUME OF A VESSEL, COMPUTATION OF Run vertical planes athwartships at regular intervals and compute, by Simpson's rule, the areas of these sections. Likewise run and compute areas of sections cut out by fore-and-aft horizontal planes at regular intervals. Then using the areas of the vertical sections as ordinates, with the areas of the horizontal planes perform another Simpson rule calculation. The answer will be the volume in cubic feet.

UPSETTING MOMENT In the case of an unstable vessel it is the product of the displacement and the upsetting lever arm. The displacement is expressed in long tons, and the lever in feet which gives the upsetting couple in foot tons.

UPTAKE A large duct which connects the boilers to the smokestack. (Fig.40, 41).

VALVE ALARM Any valve which automatically gives an alarm.

VALVE, FLAP or STORM A simple form of check valve at the bottom of a scupper pipe which permits water to discharge from the scupper overboard but prevents sea water from backing up the pipe.

VALVES, SEA Valves located at or near the outside plating of a vessel to supply sea water to the fire pumps and for flooding the ballast tanks, magazines, etc., also for discharging water overboard from bilge pumps, ballast pumps, condenser circulating pumps, boiler blows, etc.

VALVE, SHIFTING A small sized valve placed on condensers, pipes, or in general other low pressure members to allow the escape of air trapped by pockets, the valve closing automatically to prevent inflow from the atmosphere.

VALVE, SLUICE A valve secured to a bulkhead usually without any connecting pipes, for use in allowing water to flow to and from adjoining compartments.

VANISHING POINT is the point of inclination at which a vessel's righting arm becomes zero. The vessel is doomed to capsize before this point is reached. (Extreme right of Fig. 1 (e)).

VENTILATORS, BELL-MOUTHED or COWL Terminals on open decks in the form of a 90° elbow with enlarged or bell-shaped mouths, so formed as to obtain an increase of air supply down ventilation

pipes.

VENTILATORS, GOOSE-NECK or SWAN-NECK Terminals consisting of 180° bend used on ends of exhaust pipes or air vents and so shaped as to make the clogging of the outlet difficult.

VERTICAL KEEL (See KEEL, VERTICAL).

VIRTUAL CENTER OF GRAVITY The point at which the weight of a liquid with a free surface may be considered to be concentrated when taking into account its effect upon the initial stability of a vessel. The virtual center of gravity of a free surface liquid is in a vertical line directly above the center of gravity of the vessel and usually is equivalent to the weight being projected well up on the mast. The distance between the actual and virtual centers of gravity equals the moment of inertia of the free surface divided by the volume of the liquid. (See FREE SURFACE LIQUID). (See "g" Fig. 5).

VOID SPACE is any unoccupied space in a vessel, which will permit water to enter in the event of leakage, etc.

WAKE The disturbed water left behind a moving vessel. It is at and immediately abaft a vessel's stern and follows the vessel with differing velocities at various points as she moves ahead.

WAKE CURRENT, EFFECT OF It increases the speed of the vessel.

WAKE GAIN The increase in the effective thrust of a propeller for a given power delivered thereto, by virtue of the forward motion of the water forming the wake behind the vessel's hull. It is the amount the speed of advance over the ground is greater than the speed through the wake.

WANE Is an inequality in a board or plank, caused by its being sawed from the outer portion of a log. It is bark or lack of wood on the edges of lumber from any cause.

WASH PLATES Plates fitted fore-and-aft between floors for the purpose of checking the flow of bilge water when the vessel is rolling.

WATER Fresh water weighs 62.4 pounds per cubic foot. Salt water weighs 64 pounds per cubic foot. There are 36 cubic feet in one long ton of fresh water; 35 of salt water.

WATERLINES are the curves representing the intersections of planes drawn parallel to the designer's waterline with the underbody skin of the ship. The zero waterline is at the base line. The designer's waterline is the waterline when the ship is floating at its designed draft. (Fig. 15).

WATERLINE COEFFICIENT The coefficient of fineness of a waterline is the ratio between its area and that of its circumscribed rectangle.

WATERPLANE A plane coincident with or parallel to the surface of the water and limited by the line of its intersection with the vessel's hull. (Fig. 15).

WATERPLANE AREA The area of the waterplane at which the ship floats.

WATER-TIGHT FLATS are the upper sides or top plating of deep water ballast tanks or other compartments which are required to be perfectly water-tight. (Fig. 41).

WATERWAY On steel ships with planked decks it is the gutter formed along the deck stringer plate by the sides of the waterway bar and the stringer plate angle bar. On wooden ships it is the margin plank running along the outer edges of the decks and adjacent to the inside faces of the frames. This timber is al-

ways thicker than the regular deck planking. (Fig. 23, 96).

WATERWAY BAR A term applied to an angle bar attached to the deck stringer plate forming the inboard boundary of a waterway and serving as an abutment for the wood deck planking. (Fig. 23, 96).

WAVE PROFILE In the case of the bow wave, which, for a given speed and ship assumes a fairly constant size, shape and position relative to the ship's length, it is the wave outline against the ship's side. Its profile conforms closely to a mathematical curve and is used in strength calculations. (See TROCHOIDAL WAVE).

WAVE RESISTANCE Is composed of the following: (1) The bow wave which consumes, for high speeds, one-half of the ship's power. (2) The stern wave, which is similar to the bow wave, and is the resultant of a normal bow and stern wave. (3) Eddy resistance which is due, in the case of a vessel, to the formation of eddies behind the stern post or struts. In the case of a square barge, there are also eddies at each of the corners. The resistance due to distortion of the stream lines manifests itself in the making of eddies and waves.

WAYS A term applied to the tracks and sliding timbers used in launching a vessel. Also applied in a general sense to the building slip or ways upon which a vessel is constructed. (BROADSIDE LAUNCH WAYS, Fig. 37 E). (Fig. 50, 56).

WAYS, BUILDING Deep piling support the keel blocks and ground ways, the former support the ship during building and the latter carry the weight during launching. A working platform is constructed on both sides of the keel blocks. Curvature of the platform conforms to that of the ship's bottom. Shoring supports the ship upright.

WAYS, GROUND The stationary timbers or tracks laid upon piling or foundation cribbing, upon which the sliding ways supporting a vessel to be launched travel. (Fig. 50).

WAYS, LAUNCHING Two sets of heavy timbers are arranged longitudinally on piling so as to be under the bottom of a ship, with one set on each side of the keel, and sloping toward the water. The space between the tracks is about one third of the ship's beam. Each set is composed of two separate members with the adjoining surfaces well lubricated with oil and tallow. The lower member is the ground ways and remains stationary, while the upper members are termed the sliding ways and cradle. Upon the removal of the shores and the lifting of the ship off the keel blocks, by driving wedges between the sliding ways and the cradle, the ship is launched. The cradle and sliding ways are removed after the ship is waterborn. (See BROADSIDE LAUNCH WAYS, Fig. 37 E). (Fig. 106, 108).

WEB The plate strength member of a beam or girder, between the flanges, which acts to hold the flanges in place and to resist the internal sheer stresses of the girder. (Fig. 21).

WEB FRAMES are continuous floors or deep frames in the side regions of a vessel to provide extra strength lost by omission of deck beams, etc. In web frames the full depth of the web plate is maintained, throughout the entire girth of the frame. (Fig. 21, 72).

WEDGE OF EMERSION AND IMMERSION When a vessel pitches, the triangular-shaped section forced into the water on the inclined side is called the wedge of immersion aud must be balanced by a similar triangular-shaped section at the other end of the vessel called the wedge of emersion. (Fig 1 (a), 1(b), 1 (c)).

WEDGES Wood or metal pieces shaped in

the form of a V, used for driving up or separating members. They are used in launching to raise a vessel up on the cradle from the keel blocks. (Fig. 35, 36, 108).

WEIGHTS, MOVEMENT OF, EFFECT ON STABILITY If weights are removed from an upper deck and stowed below in the hold, the displacement and trim remaining the same, (a) the center of gravity will be lowered, (b) the position of the center of buoyancy will be unchanged, (c) the position of the metacenter will remain unchanged, (d) the metacentric height will increase.

WELDED COLLARS The boundaries of water-tight members such as at the junction of a fore-and-aft water-tight bulkhead and a deck beam, in riveted construction, is accomplished by stapling around the beam. In welded construction the stapling is replaced by a COLLAR PLATE which is welded around the intersecting shape.

WELDED JOINTS There are three classes of welded joints: (1) Continuous bead, (2) Intermittent bead, (3) Tack welding. Advantages of welded joints are: (1) No weakening holes necessary in members joined. Rivet holes reduce the cross-sectional area; (2) Saving in weight and cost; (3) Calking unnecessary for water-tight joints; (4) Simplifies construction by doing away with many bounding angles, angles, clips, straps, etc. Modern welding has by introduction of covered cathodes provided ductile welds. Welding is now equal to if not superior to riveting and is gradually displacing the latter. It is bringing about radical changes in scantlings and in the order of fabrication or assembly of new vessels. (See JOINTS, WELDED). (Fig. 119).

WELDING The art of joining or uniting two pieces of iron, steel, or other metal. Gas, electricity, and "Thermit" are used for welding in ship work. (Fig. 119).

WELDING, AUTOGENOUS The process of fusing and uniting metals by the application of intense heat, without compressing or hammering. Steel, cast iron, copper, brass, bronze and aluminum can be welded.

WELDING, ELECTRIC Welding by the use of electric current.

WELDING, GAS Welding by a flame produced from gas and oxygen.

WELDING, TACK Consists of individual beads, usually about ½" long, spaced several inches or feet apart depending on its use. (See TACK WELDING).

WETTED SURFACE The area of the immersed surface of the hull. It may or may-not include the wetted surfaces of the appendages. (Fig. 15 (b).

WINGING WEIGHTS refers to the moving outward toward the ship's side of weights already on board. It increases the moment of inertia of the waterplane and lengthens the roll period of the vessel.

WING TANKS Tanks located outboard and usually just under the weather deck. They are sometimes formed by fitting a longitudinal bulkhead between two uppermost decks.

WOOD DEFECTS are splits, checks, worm and bee holes, crooked grains, shapes, sapwood, heart centers, knots, wane, extreme curvature, etc. (See TEXT).

WOOD FOR SHIPS, DECK PLANKING There are three kinds used: (a) yellow pine from the Gulf; (b) Douglas fir; (c) teak. For booms, spars and masts, Oregon pine and spruce are used.

WOOD, USES OF (1) Hackmatack is a strong wood used for knees and frames of wooden vessels. (2) Lignum-vitae is an oily, cross-grained, hard, strong wood with fibers running radially and tangentially. (3) Oak, white, is strong and dur-

able, good for frames and beams and can be bent when steamed. It is not suitable for steel vessels as it contains an acid which attacks steel. (4) Yellow pine (long leaf or Southern pine) is a hard and strong wood extensively used for decks. (5) Pine (short leaf) resembles long leaf but is inferior. (6) Pine (white) is a light wood, very strong and easily worked. (7) Spruce is light, strong, tough and more durable than white pine; used for spars, oars, etc. (8) Teak is a heavy strong wood. It is suitable for exposed places on shipboard such as railings and will not rust steel on contact.

WOOD, MODEL There is constructed a half model in wood of the vessel being built, scale usually ¼ inch = 1 foot. On it are shown location of the frames, shell plating and butts, intersections of bulkheads and decks with the shell, airports, outboard fittings, and docking keels. Lengths of scantlings are taken from the model for ordering steel. Data for ordering the shell plating is taken from the shell expansion plan.

WROUGHT IRON is used in ships for straps, blocks, small anchors, and anchor chains.

YIELD POINT The maximum tensile strength which may be impressed upon a material without straining it beyond its elastic limit. When a material is stressed beyond that point a permanent set occurs so that when the stress is removed the material fails to regain its original shape.

YOKE A frame or bar having its center portion bored and keyed or otherwise constructed for attachment to the rudder post. The connecting rods from the steering engine or the leads from the wheel ropes are connected to each end of the yoke for the purpose of steering.

Z BAR A rolled shape, generally of mild steel, having a cross section shaped like the letter Z. In ship work they are used for frames and bulkhead stiffeners. The size is denoted by dimensions of cross sections and weight per running foot.

ZINC PROTECTORS are fitted on: (1) sea valves below the waterline, (2) where there are any brass or composition valves or nonferrous metals, (3) stern post, (4) rudder, (5) stern frame, (6) skeg of iron or steel vessel having a bronze propeller, (7) struts.

NOTE DECK ARRANGEMENT OF THE 328' CUTTERS: Fire Control Platform, Navigating Bridge, Superstructure Deck, Upper Deck, Main Deck, Second Deck and Platform Deck.

The boat shown on the superstructure deck of Fig. 39 has been replaced by a "seabright skiff" type motor boat.

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