TRUE LENGTHS & ANGLES ~PLATE-8~

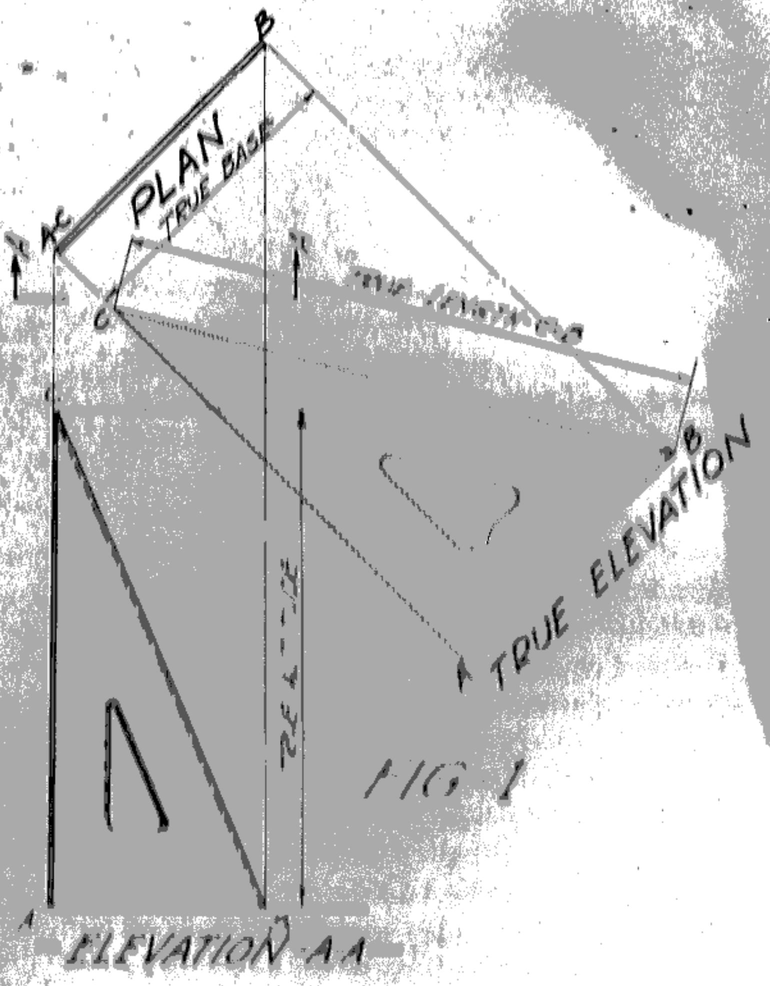
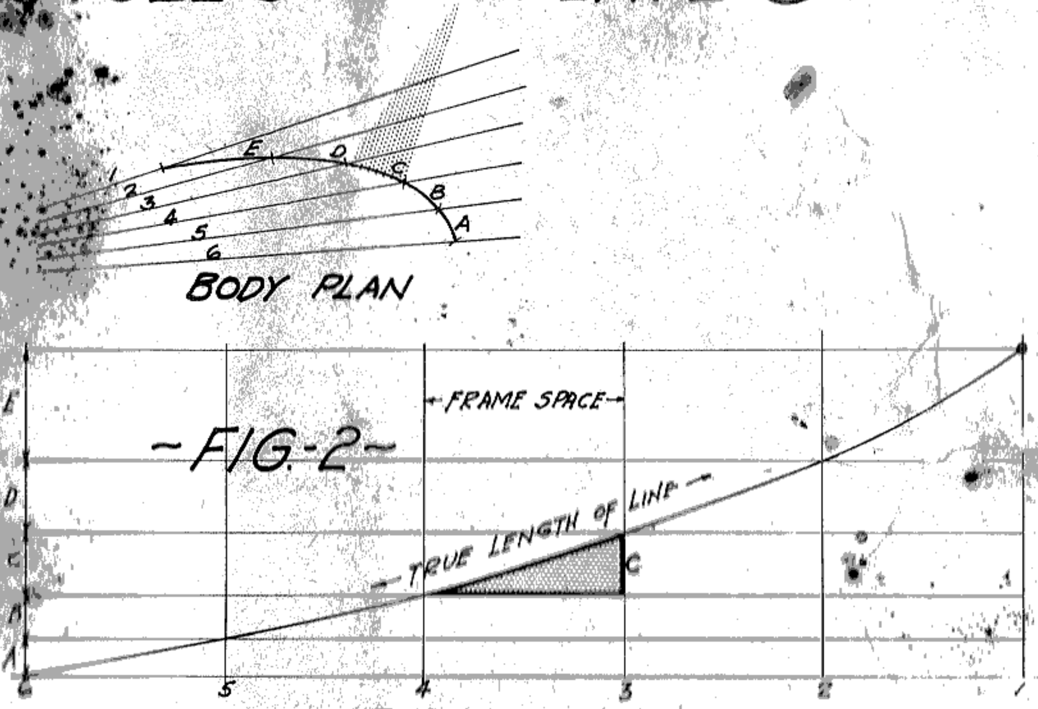
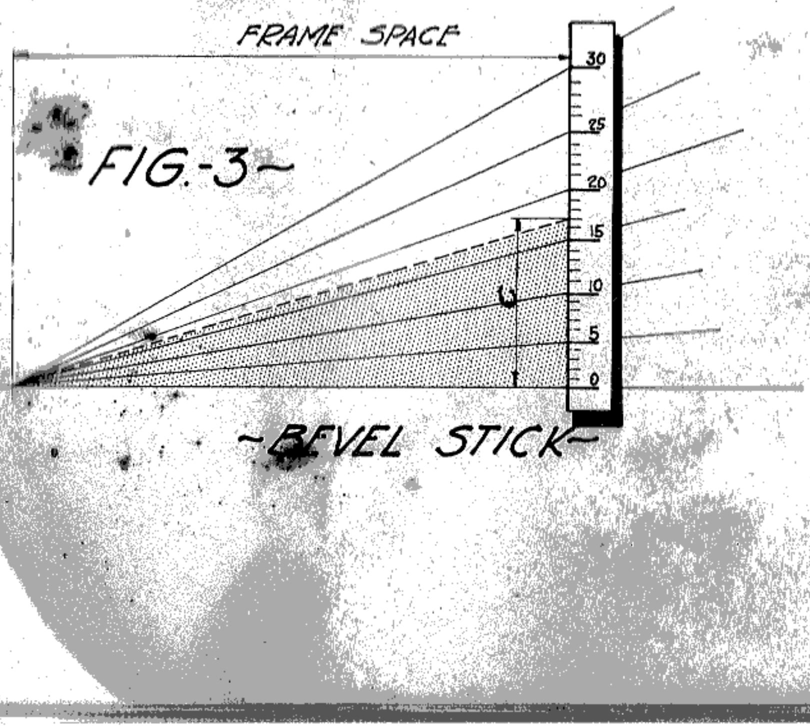


FIG. 1



~FIG-2~



~FIG.-3~

tween two frames on a body plan, say for instance, line C between Frames 3 and 4 on the body plan (PLATE 8, Fig. 2). We would first gather together our known dimensions. We can measure the distance C direct. Let us say, for instance, that this is 8″. We know from other plans on hand that the frame spacing between these frames is 30″. We know that the line C lies parallel to the plane of the paper and is, therefore, "true." We also know that the frame station planes are parallel and, therefore, the vertical distance between them (30″) is a line at right angles to the paper plane. We now have a proven right triangle whose base is 8″ and whose altitude is 30″, and with these two known figures we can get the altitude, which will be the true length of line C. In the development of shell plating, such a line as we see on the body plan (PLATE 8, Fig. 2) would represent the edge of a plate. One of the essentials to the development of a shell plate is the true lengths of its edges.

From the foregoing process it is not very difficult to see that the true lengths of all of the distances between Frames 1 and 6 are just a repetition of the process of finding the length between Fr. 3 and Fr. 4. In actual practice, this is done as follows: The spacing of the Frames 1 to 6 is laid down on a common base line, and ordinates erected at the frames. A thin stick is bent around the desired line on the body plan, and marked at every frame. Thus, the distance from 6 to 5 would be A, from 6 to 4 would be A plus B, and so forth on to Frame 1. This stick is then set against the base line, and each frame marked off in its proper order. A line faired through the spots on each individual frame will give us the true length of the line between Frames 1 and 6. We can now see that the increment between each frame forms a triangle as it did between Frames 3 and 4, which is shown outlined and shaded. This is also shown on the body plan.

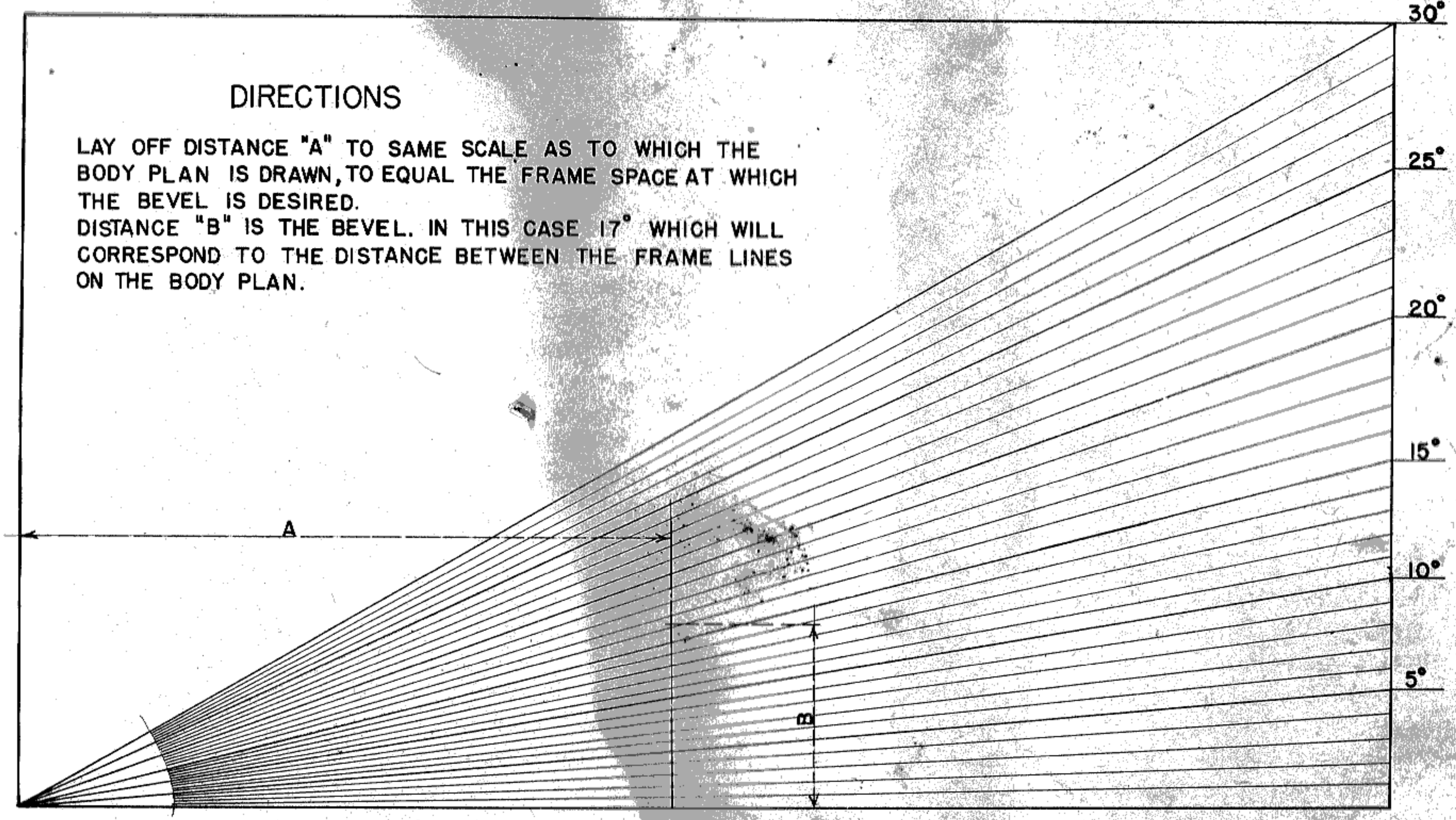
In actual development in the loft, the line is not drawn on the floor. After all of the spots are determined, a batten is bent through the stretchout, and the frame locations marked and identified on this batten. When the process is completed for both plate edges, the battens are laid away to be used in the development later.

From the stretchout in Fig. 2, something else becomes evident. We see that the greater the length of the lines between the frames, the greater becomes the apex angle of the triangles in the stretch-out. This apex angle is closely related to the bevel of the frame at this point, and the distance between the frame lines can be used to determine this angle.

We know that the angles of a right triangle are functions of the proportion between base and altitude. A right triangle with a one-inch base and three-inch altitude has the same indentical angles as one with a mile base and three-mile altitude. The angle at the apex of a series of right triangles all with the same altitude will increase or decrease as the base decreases. We thus see that by measuring the base we can measure the angle, and if we lay out a scale in degrees instead of inches, we can measure the angle direct from the body plan.

This scale in the mold loft is called a "bevel stick" or "degree stick," and is constructed as follows: With a protractor lay off segments of 5°, 10° and so on up to 30°. From the centroid of these segments lay off the spacing between the frames, and erect a perpendicular to the base line at this distance. Where the radians cross this perpendicular, mark off on a convenient stick the 5° increments, as shown on PLATE 8, Fig. 3. These spaces are then divided into five equal spaces to get the individual degrees. While this method of division is not entirely correct for the individual degrees, the error is of no serious consequence.

To measure the bevel of a frame, let us say Frame 4 in the body plan (PLATE 8, Fig. 2) we place the bevel stick (Fig. 3) on the body plan, and for the distance C we find 17°. As the frames in this direction are decreasing in width, this will be a closed bevel. Being closed it will decrease from 90°, and 90° minus 17° will give us 73° of closed bevel. Were we to measure the bevel on Frame 3, and the flange of the angle were toeing aft or increasing, the bevel would be open and would be larger than 90°. Therefore, adding the measurement gives us 90° + 17° or 107°.



BEVEL SCALE FOR DRAFTING ROOM USE

VI. Visual Fairing

WHEN A LINE runs in an easy and smooth curve with no undue humps or hollows, it is said to be flowing or fair. The art of drawing this sort of line is called in moft loft parlance fairing. Fairing is accomplished in the drafting room preliminary to the plan being sent to the loft. The lines are again faired in the loft to eliminate the errors of measurement caused by the small scale of the previous drawing. Two methods of fairing are employed, visual and geometric. Visual fairing is accomplished when the line is run pleasing to the designer's eye without resort to any calculation of the line's dimensions. Visual fairing is an art, as true as that of any of the great masters of painting. It is the art of Donald McKay, evidenced in the hull lines of his famous clipper ships; it is the art employed by Hershoff, and Burgess in the design of their cup defenders; and it is the art alive today practiced by Phil Rhodes and many of our present-day yacht designers in producing their creations of beauty and utility.

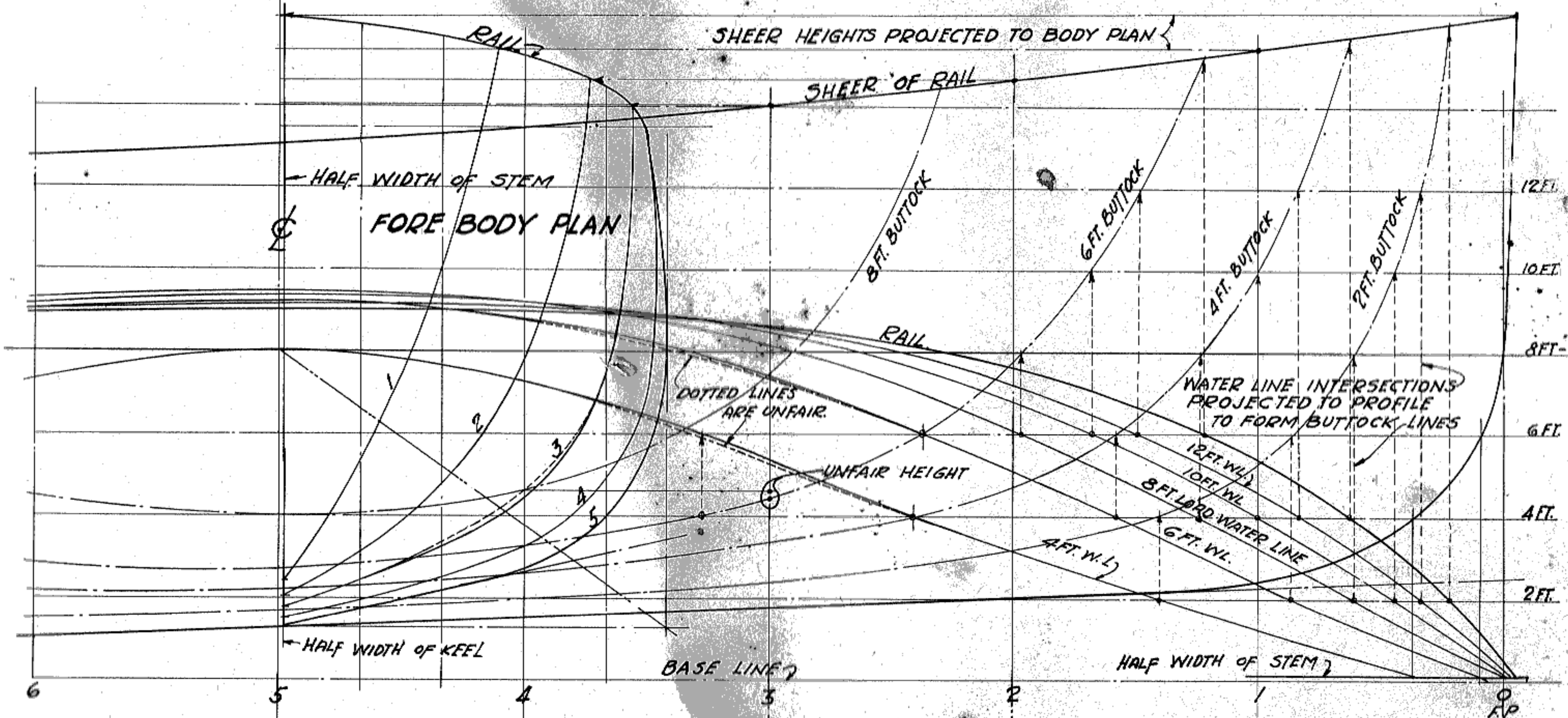
Geometric fairing uses the practice of employing mathematically produced curves such as the ellipse and parabola to determine just how a line should run. It is the practice most used in aircraft, although many parts of the modern steamship have their lines produced geometrically. It is becoming more and more common in the shipbuilding industry due to the modern demand for streamlining. It is limited mostly to the production of body sections in aircraft, the profiles and plan views of the fuselages and hulls being drawn to conform to streamline principles, pleasing to the eye. The width and depth dimensions of these views are used to limit the boundaries of the geometric curves producing the cross sections.

The practice of full-size fairing on the loft floor follows a different procedure than that on a drawing board. On the board, the designer draws to a small scale the lines of his finished product. In the loft the loftsman again lays down the designer's lines and fairs them to the full size dimensions, correcting the designer's errors of fairing and dimension (which often are many), and prepares the lines for the take-off of templates for the manufacture of the project. A good loftsman is equally as important as a good draftsman; the loftsman's layout can be made more accurate, and his knowledge of development and fairing often discovers errors on the part of a draftsman who may not be a specialist in the one particular line of work involved in fairing.

In visual fairing, as applied to ship work, the designer lays down the limiting dimensions of his ship. The profile and plan are drawn to suit the designer's ideas and the service factors involved. The load waterline is drawn in on the plan and a buttock half way out between centerline and the greatest half beam is drawn on the profile. Between these lines the ship designer or naval architect sketches in his cross sections. These sections are then checked to insure that the hull has sufficient volume under her load waterline to produce the displacement necessary. The lines are then further faired, more waterlines and buttocks are run in to further limit the shape of the sections, and the finished plan is sent to the loft to be faired full size on the floor.

A similar procedure is followed by the aircraft designer. With the plan and profile of the hull or fuselage drawn, certain sections are selected through the body which will limit

~FORE BODY LINES - TUGBOAT - PLATE -9~



WATER LINES & BUTTOCKS OVERLAPPED.

the shape. For instance, in a high-speed plane the cockpit section will be made no wider than is necessary to enclose the pilot. The forward section will be designed to enclose the motor as much as possible, and the very rear section of the fuselage will be faired into the trailing edge of the rudder to produce perfect streamline flow. The body sections will be kept as small as possible to reduce frontal area, and the outlines of the fuselage faired to encompass these foregoing features. At the point of greatest section some geometric curve will be selected which can be drawn between the greatest half beam and the greatest depth. This curve may be in two sections, and may be different above and below the horizontal centerline. As an instance of this, the fuselage shown on PLATE 14 has a circular top for most of its length and the lower sections are elliptical.

Where visual fairing is resorted to, it can be done on diagonals alone without resorting to waterlines and buttocks. This type of fairing is illustrated in the lifeboat on PLATE 10, and will be taken up later in this work. Diagonals are also very good in checking the accuracy of the layout when mathematical fairing is used, and to other good advantage in aircraft work. All of the examples of visual fairing in this work will be confined to the shipbuilding industry with the exception of camber curves. Most of the examples of geometric fairing will be confined to aircraft work.

FAIRING SHIP LINES (PLATE 9)

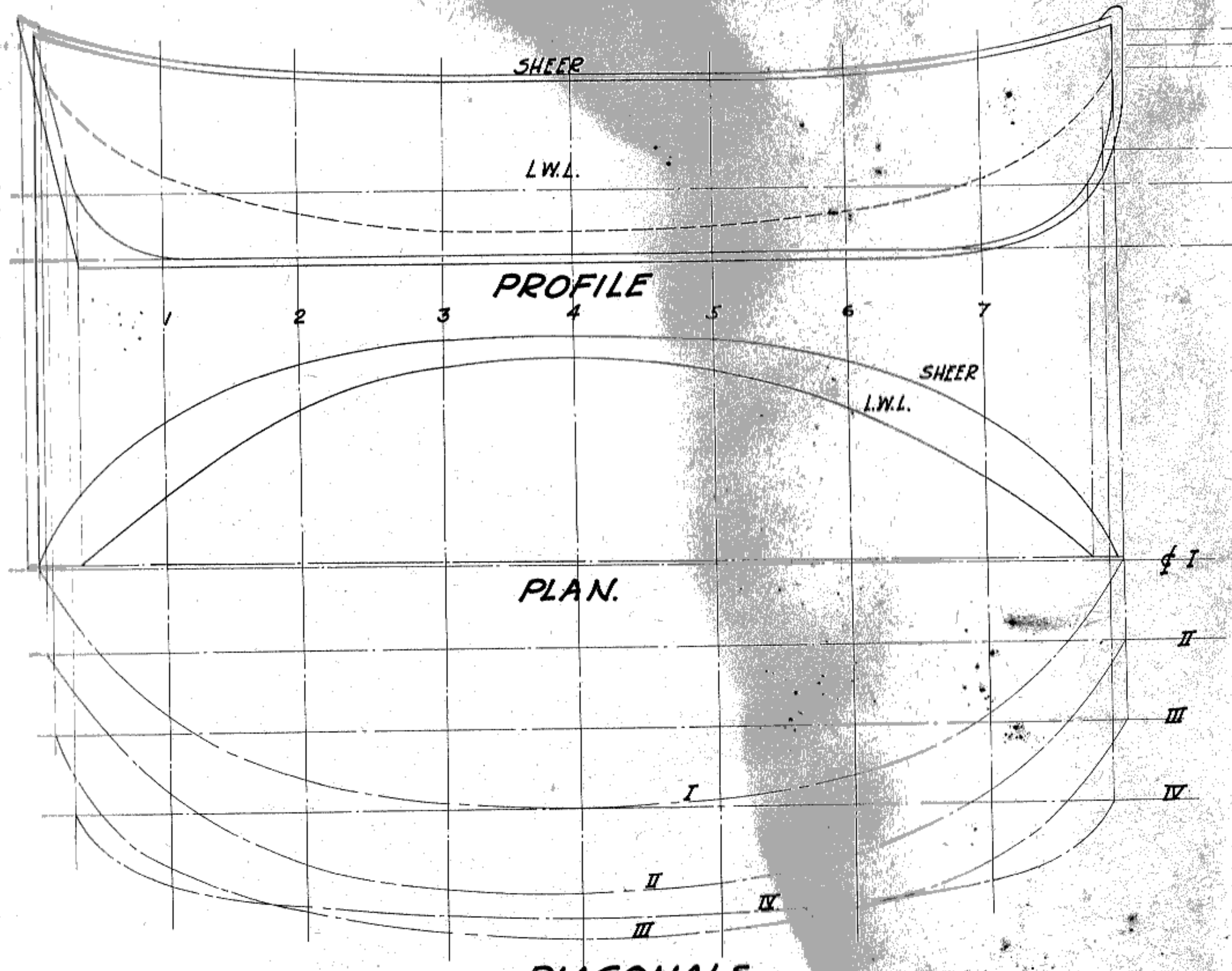
In fairing the design lines, as explained before, the naval architect lays down the elementary lines of the design. After he has checked his displacement he runs in more waterlines and buttocks, and after fairing his lines, he sends the results to the mold loft in the form of a drawing of the lines and a table of the offsets. Here in the loft, the body plan is laid down on the floor from the offset figures. The offsets given to the loft are the designed station figures, and not the final frame station lines of the ship. From the body plan the half widths of the waterlines are picked up and transferred to a set of perpendiculars drawn on the floor, which represent the station spacing. Prior to this, the loftsman has faired his lines through the points given for the stations in the body plan. He now bends his batten around the spots of the waterline half breadths and alters the batten wherever they appear unfair. If a point appears unfair along the batten, the nails are withdrawn at the unfair spot and the batten allowed to assume a natural curve between the points on either side of the unfair one. This is repeated for every waterline until they all appear fair. The body plan is now altered to conform to the new waterline points.

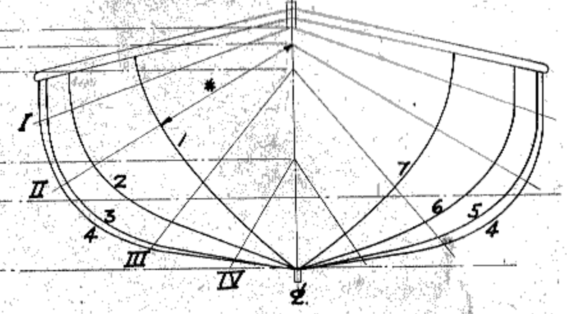
In the plan view, the lines of the buttocks are now drawn on the floor, and the waterlines are drawn in the profile. It can be readily seen from PLATE 9 that there is an advantage to equally spaced waterlines and buttocks. Where space is at a premium on the loft floor and the plan and profile are overlapped, these lines are coincident, and the labor of drawing two sets of lines is eliminated, as well as the confusion resulting from two sets of lines. Often the longitudinal measurements of the hull are reduced to half, thus making the curves steeper and enabling the loftsman to spot an unfair curve much easier. This method of laying down the measurements is called "contracted fairing."

Before the curves of the buttock lines are drawn in, the loftsman notes the intersections of the curve of the waterline with the straight line of the buttock. Let us take the 2-ft. line for instance. This line is crossed close to the stem by all of the waterlines as well as the line of the rail. In the plan view the same line represents the vertical view looking down on the 2-ft. buttock, just as it also represents the horizontal view of the 2-ft. waterline looking in at the profile. We thus see that if

FAIRING BY DIAGONALS

-PLATE-10-





* NOTE:- MEASUREMENTS ARE TAKEN ALONG LINE OF DIAGONALS BETWEEN ℄ AND INTERSECTION WITH STATION LINES AS SHOWN.

the ship were cut along the 2-ft. buttock a curve similar to that shown for a buttock in PLATE 2, would be produced. To produce this curve in profile, therefore, it is necessary to project these crossings up to the profile. The heights where the buttocks cross the station lines in the body plan are also set off on the respective stations in the profile. Battens are now run through these spots to prove the fairness of the buttock. This process is repeated for all the buttocks, just as it was for the waterlines.

Let us assume, for instance, that the spot off on Station 3 for the 6-ft. buttock, as measured from the body plan, cannot be made to fair. We would also note that the intersection of this buttock with the 4-ft. waterline will not exactly make a fair curve. In this case the batten is allowed to run fair, and Station 3 in the body plan is altered to allow the buttock to run fair in the profile. Now we note that there appear to be unfair spots in the waterlines in the proximity of this station, so the 4-ft. and the 6-ft. waterlines are also altered from the new station line in the body plan to make all lines come fair. The dotted lines show the effect of the unfair spot in the height of the buttock. The full lines are fair. While this plate only shows the forebody lines, the after lines are treated in a similar manner. Where it is only possible to lay down half the length of the ship on the floor the overlap of the lines fore and aft should encompass several stations.

FAIRING BY DIAGONALS (PLATE 10)

On small boats and on some types of aircraft work where it is desired to simplify the fairing, the use of diagonals alone is resorted to. These can be used only to advantage where the sections follow a more or less circular form. The designer sketches the sections he desires in the body plan, and at random draws diagonals that will fall more or less normal to all the sections. The endings of these diagonals in the plan are determined by the intersection of their heights on the centerline of the boat in the body plan. The heights are projected from the body plan to the profile, and where they meet the slope of the ends of the boat, they are projected down to the plan.

The offsets for the diagonals in the plan are measured from the body plan *along* the run of the diagonal. These are now laid out in the plan in the same manner that waterlines would be. It is often necessary to lay each diagonal off on a separate datum to keep the diagonals from overlapping. The body sections are altered if necessary, should the diagonals appear unfair in any point.

FAIRING THE SHELL PLATE LINES (PLATE 11)

The shell of a steel vessel is composed of numerous plates, whose lengths follow the longitudinal dimensions and whose widths follow the girths around the vessel's beam. The longitudinal joints between these plates follow in continuous lines fore and aft, but the girth joints or butts are staggered so as to not fall in the same frame spaces in adjoining plates. In most systems of plating, the longitudinal seams are visible; and if these do not run fair the look of the vessel is spoiled. It is not within the province of this work to go into the whole science of plating a vessel, but the fairing of the seams will be dealt with.

When the lines of the vessel are faired in the loft and the finished offsets are returned to the drafting room, a wooden scale model of the vessel's hull is constructed. The model is made as accurate as possible, and all station and frame lines are drawn across it. The midship arrangement of the plating is determined, and the girth of these laid off on a body plan which is made to the same scale as the model. The run of the plating lines are drawn on this small body plan to suit definite rules that are in vogue for this procedure. The lines both in the fore and aft body should be made to run just as straight as

SHELL PLATE LINES ON BODY PLAN ~PLATE-11~

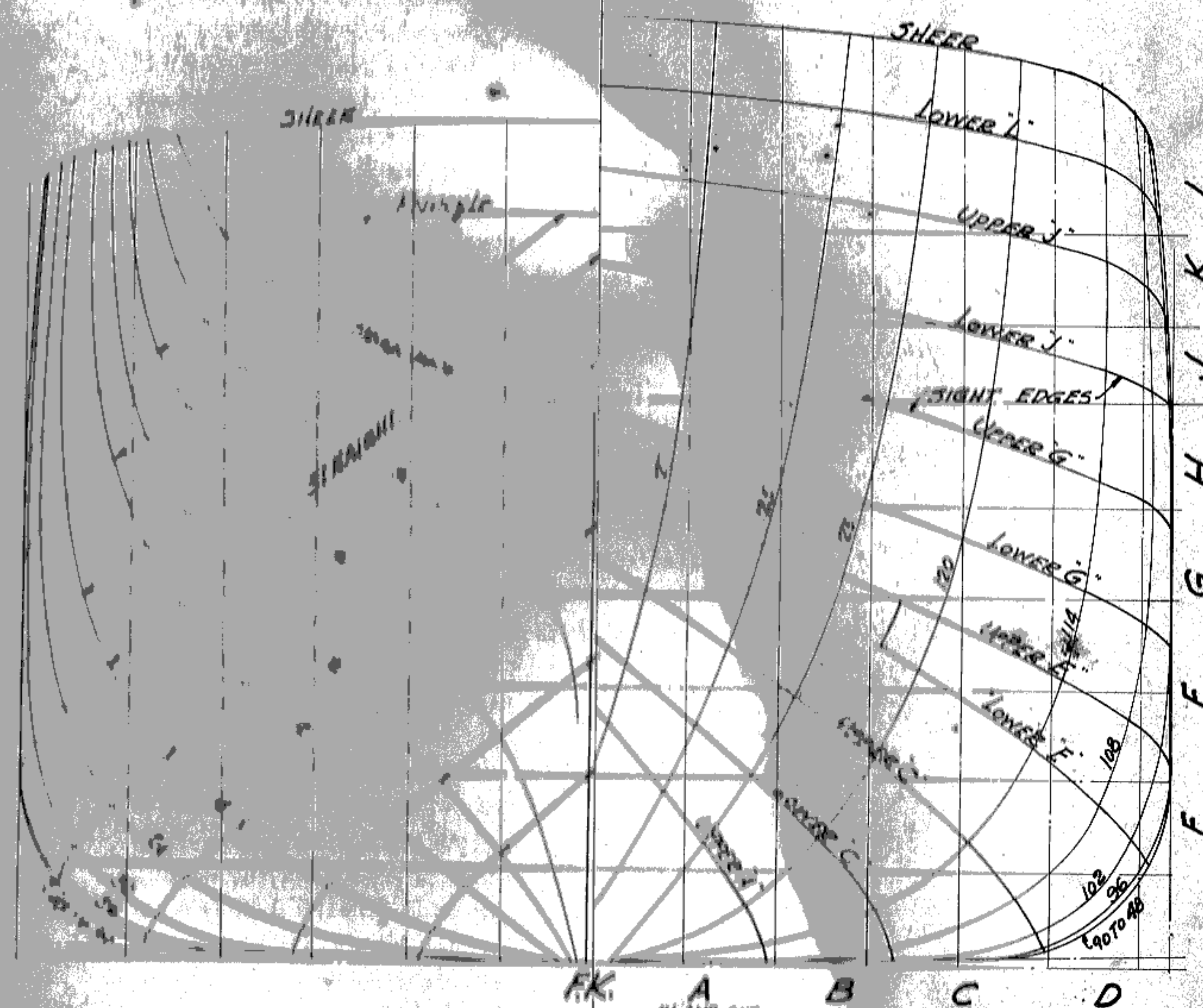
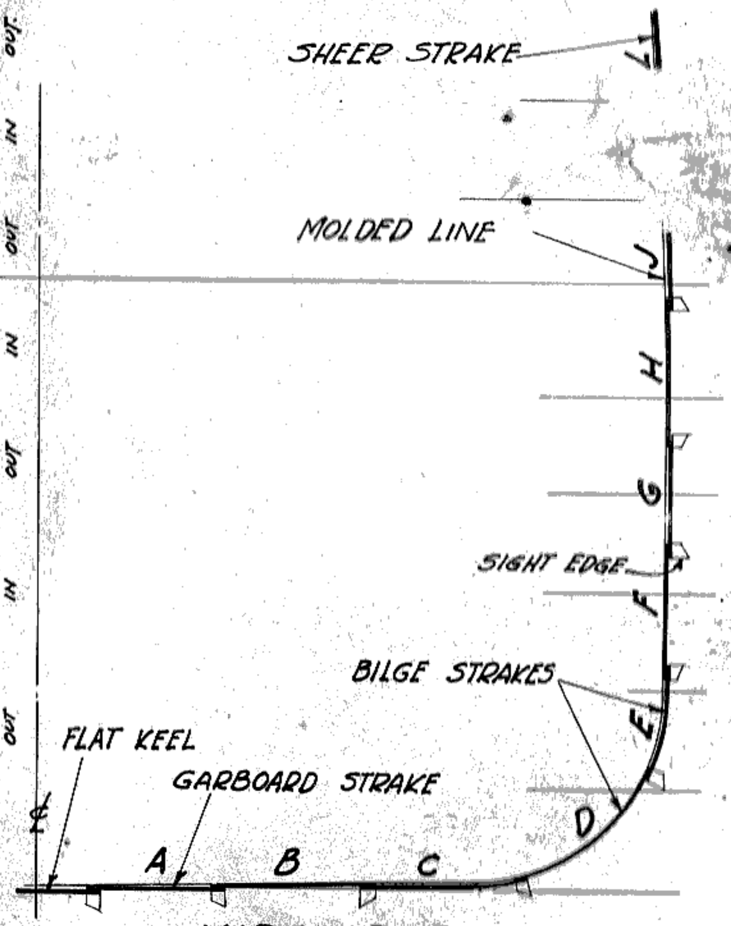


PLATE LINES



MIDSHIP PLATING

SHELL PLATE LINES ON BODY PLAN ~PLATE-11~

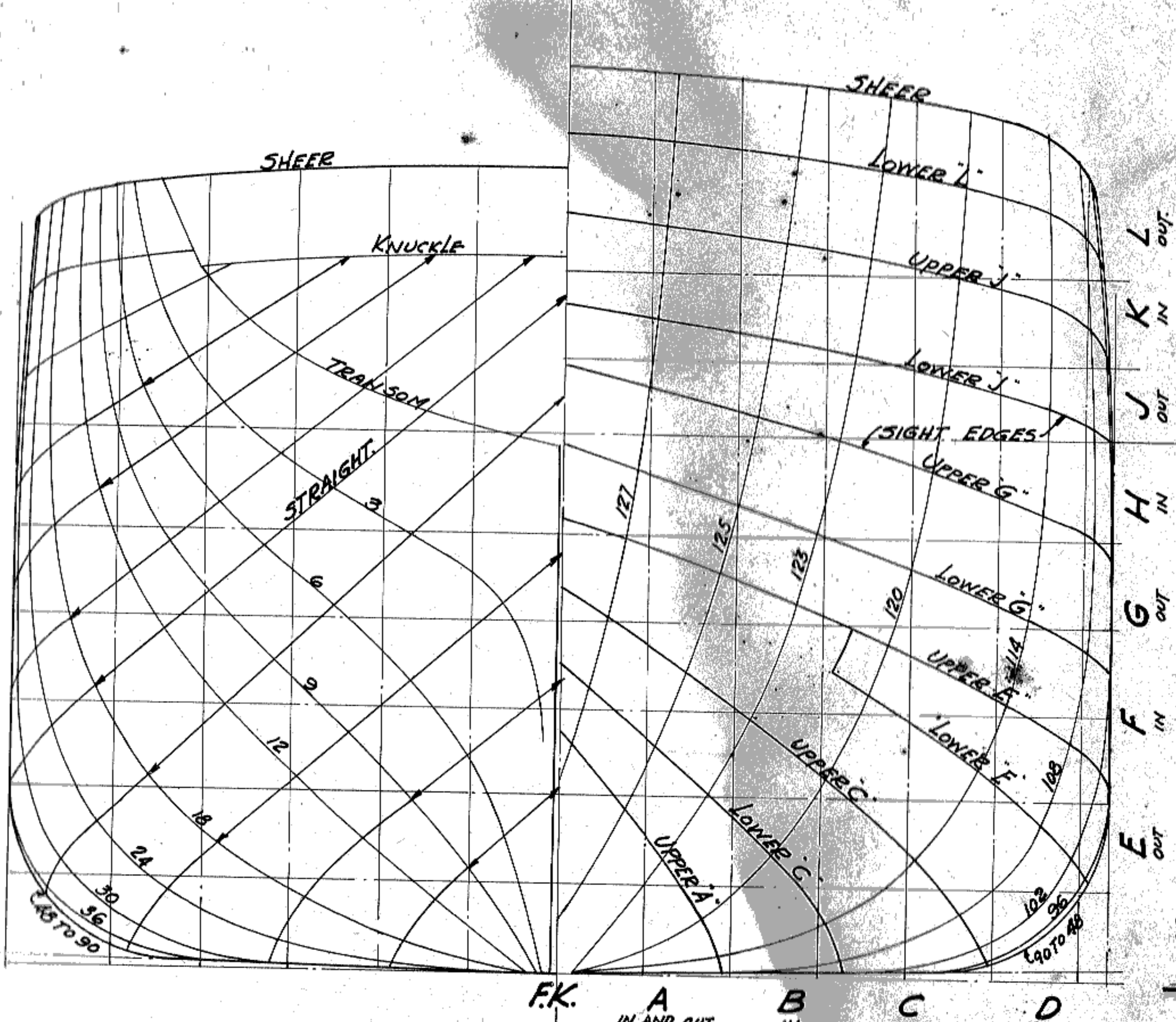
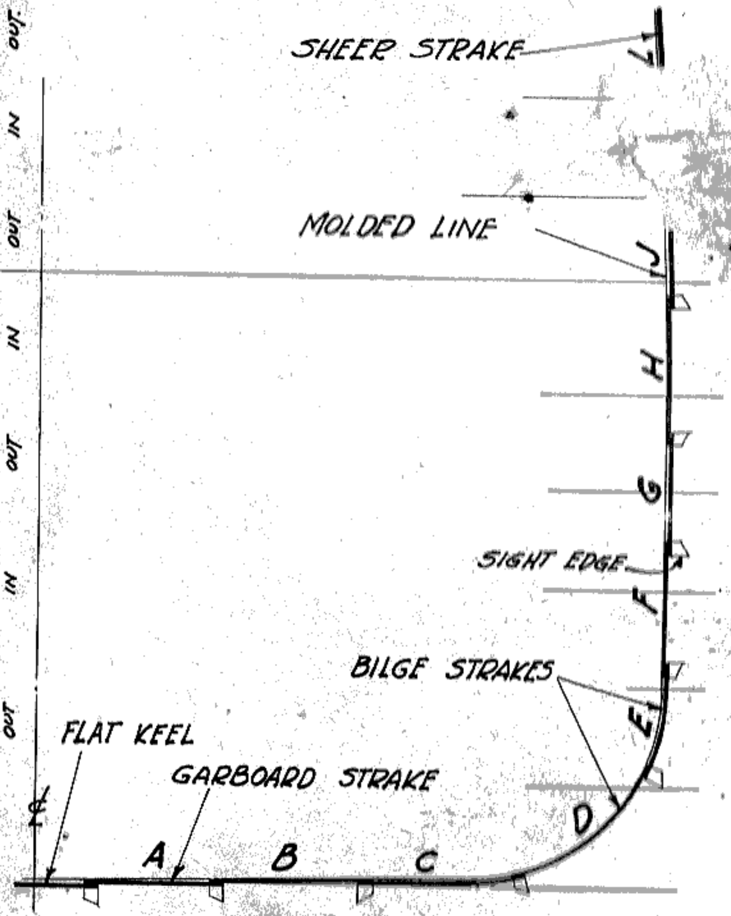


PLATE LINES



MIDSHIP PLATING

possible on the body plan and yet appear fair on the model. This is accomplished as follows:

After the lines are laid in on the body plan, strips of paper about a quarter of an inch wide are prepared. Starting from the centerline of the ship at the keel, the stations are girthed by first marking a point on the paper strip at the centerline and then slowly working it around the station, marking the location of every plate line as it is crossed. When the sheer line of the ship on the body plan is reached, the paper is laid aside, and the same thing done for another station, until all the stations are measured or girthed. By this time the mold loft will have given the drafting room the actual girths from the full size body plan, for comparison with the girths obtained from the small scale one.

The girths of the stations are obtained in the loft by driving a series of small nails in the frame station line on the floor and stretching a steel tape around them, measuring from centerline to the sheer. Up to this time we have been dealing with molded lines. These are the lines as laid down on the floor, and represent the inside of the shell plating. An examination of the midship plating arrangement on PLATE 11 will show how some of the plates will lie entirely away from the molded line, due to the thickness of the inner strakes of plating.

After the paper strips representing the girth at the various stations are checked from the loft figures, the location of the sight edges of the plating are marked on the model, and battens are tacked to these marks with small bank pins. Any unfair spot in the run of the batten is adjusted, and the new girth transferred back to the scale body plan. This is repeated until all plate lines run fair to the satisfaction of the designer. In running the plate lines, care must be taken that no edge will cross a stringer or tank margin at too sharp an angle. In this case the line must be jogged or discontinued in a fair line and jumped across the line of interference, and then continued fair from that point on. As the ends of the vessel are approached the girths become smaller, and it is often necessary to reduce the width of a strake by either dropping out a plate sight edge altogether, or by working in another plate which will carry on the line for a distance and then drop it off. This sort of plate is termed a "stealer" in shipyard parlance.

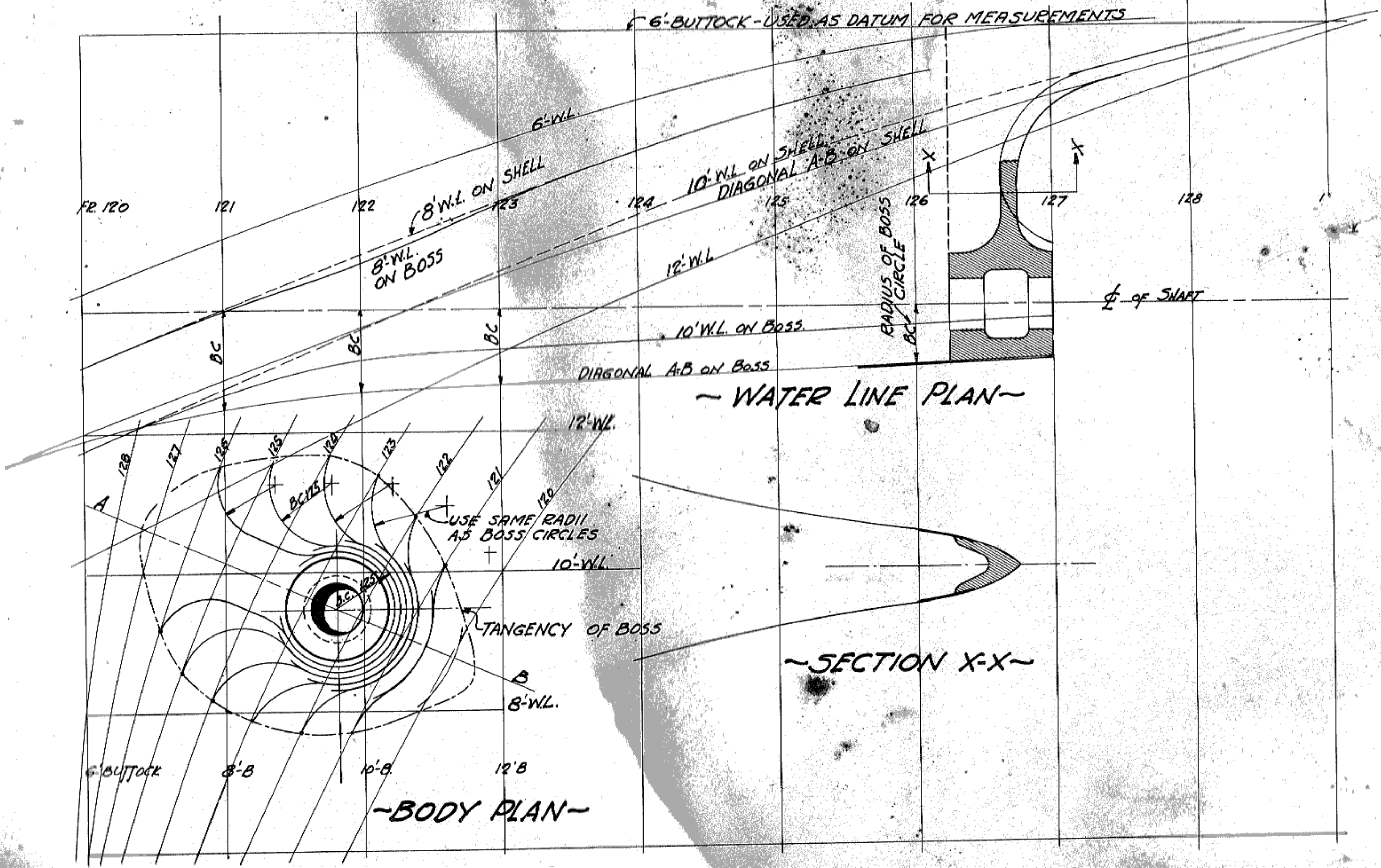
When the model is finally faired, the dimensions of the sight edges on convenient waterlines or buttocks is given to the loft by the drafting room, and these are again faired on the full-size body plan and any unfairness reported back for adjustment of the lines on the model, if they are serious. The loft is now ready to begin the development of the shell plating, the procedure of which will be dealt with later in this book.

FAIRING THE BOSS PLATING (PLATE 12)

A twin-screw vessel will have her propeller shafts come out of the hull at some distance off her centerline. It is evident that some method of fairing this appendage must be used. This is accomplished by first determining the diameter of the casting which will house the end of the stern tube. From the radius of this diameter, the circle of the bossing is drawn on the body plan. A diagonal, *A-B*, is now drawn through the center of this circle in such a way that it will lie as close as possible, perpendicular to the greatest number of frames which will encompass the bossing. The molded line of the frames along this diagonal is laid down in the plan, and the line from the boss casting is faired back into the shell as shown by the line noted "Diagonal *A-B* on boss." This line should run straight as far as possible, to make the plating easy to fabricate. The radius of this plating is now measured from the centerline of the shaft at every frame and laid down in the body plan. The same radius used to draw the boss circle

PROPELLER BOSSING

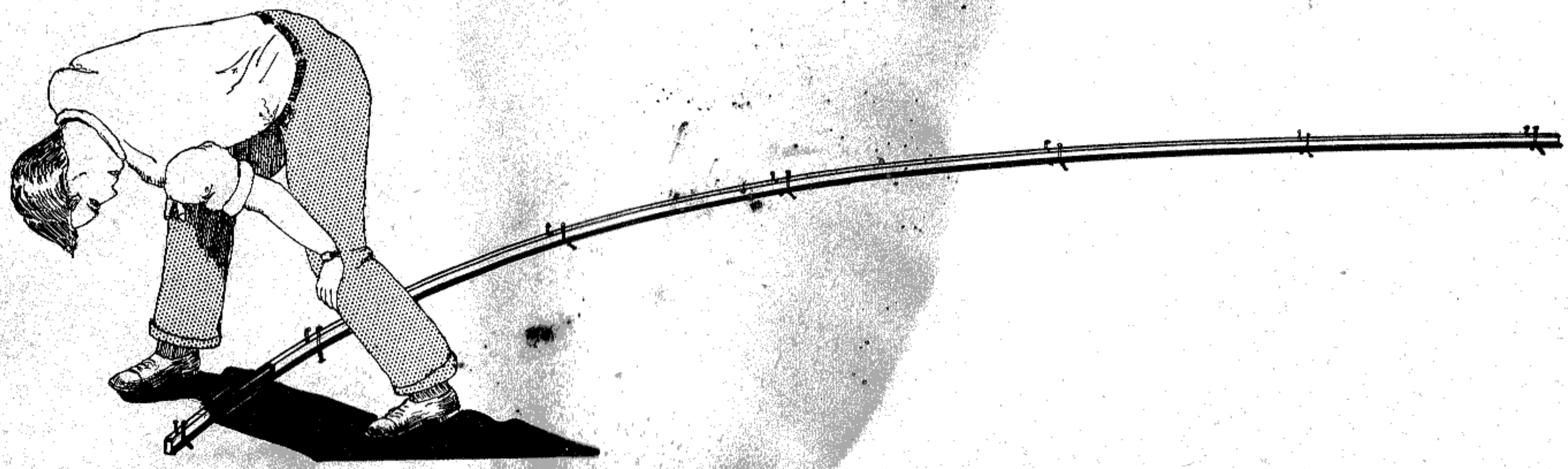
~ PLATE -12 ~



(BC) is used to lay in the fillet to the shell, drawing the arc tangent to the frame line and the circle of the bossing.

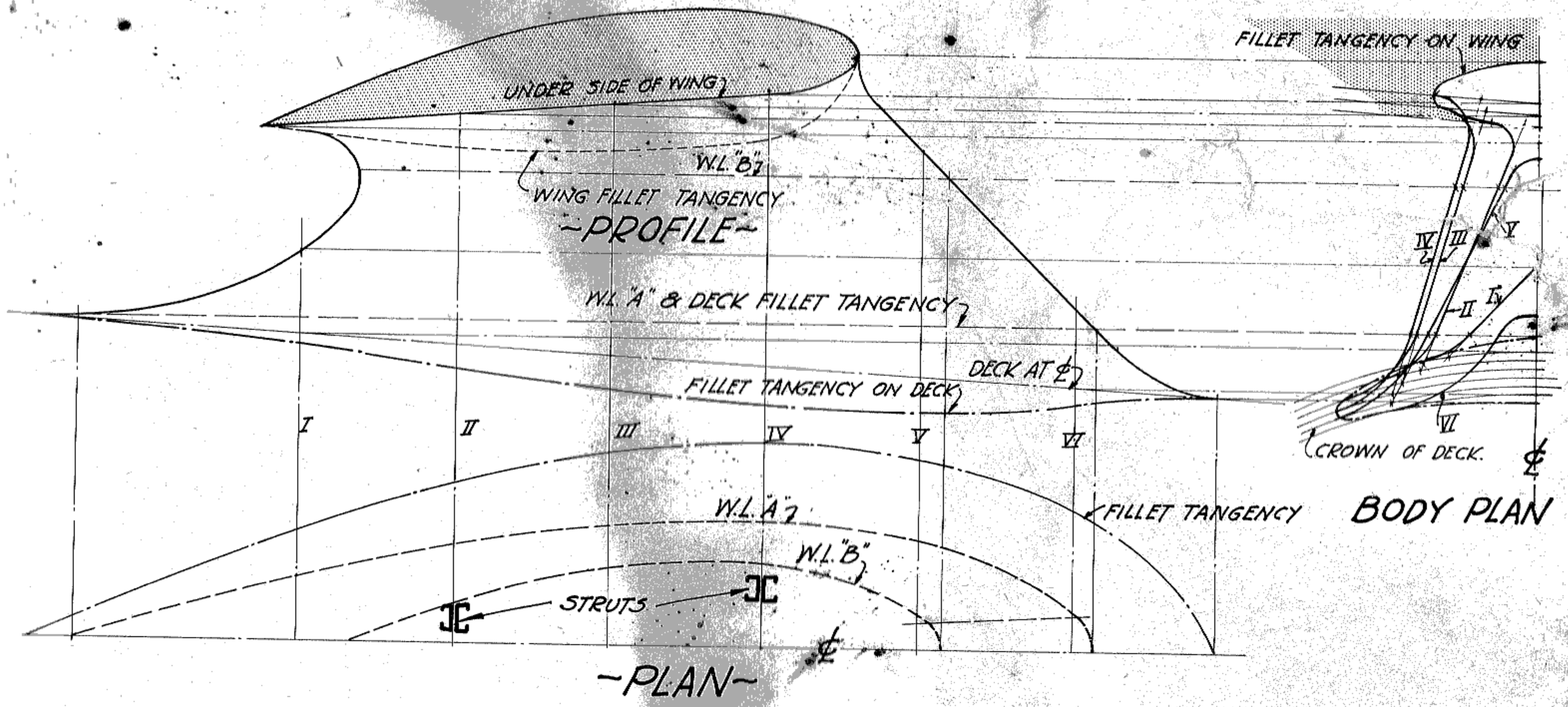
The first frame forward of the boss casting (Fr. 126) cannot be laid down in the body without some preliminary fairing. The aft end of the strut carrying the boss casting into the hull will have to be faired to a fine edge to eliminate unnecessary resistance; in other words, it must be streamlined. Halfway between the shell surface and the boss circle at the end of the boss a diagonal *Y-Y* is laid down on the body plan at right angles to the boss diagonal, *A-B*. The distances above and below the diagonal are picked up and set off on the frames in their proper order. From section *X-X* the ending of the boss casting is determined and the casting is faired into the hull. The width of the section at Fr. 126 after the boss casting has been faired will determine the locations of the lines on the body plan. These are drawn parallel to the boss diagonal *A-B*, and are faired into the shell and the bossing with a radius equal to the boss circle radius at Fr. 126.

Several other diagonals should be passed through the bossing to make sure that the bossing is fair in all directions. In some instances the centerline of the shaft does not run parallel to the centerline nor the base line, as the one illustrated in Plate 10 does. In this case the centers of the shaft are laid down for each respective frame from dimensions picked up in the plan and profile, and the boss circles are drawn from these points in the body plan. After the boss circles are drawn, the procedure is the same as has been previously described. The waterlines and buttocks passing through the bossing should also be run in the plan and profile to determine their fairness after the bossing has been faired preliminarily.



-CABANE FAIRING-

-PLATE-13-



VII. Geometric Fairing

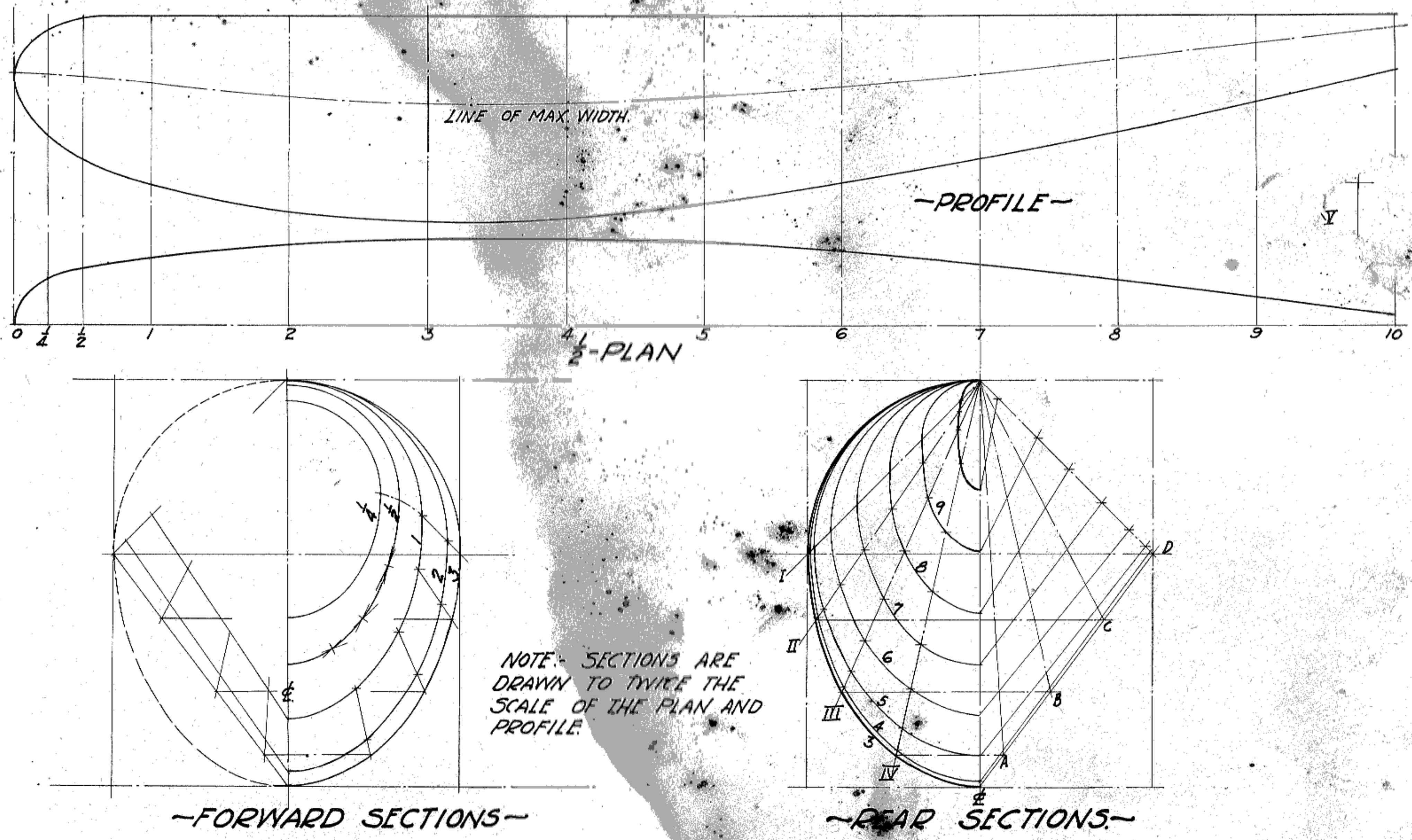
GEOMETRIC FAIRING, as was mentioned in the last chapter, employs curves produced by mathematics rather than those which are run in pleasing to the eye. All mathematically produced curves are laid down by first constructing some sort of layout either with straight lines, arcs of circles, or in some cases a combination of both. All curves produced by the selfsame method are said to belong to one family. While the names and formulas for these various mathematical curves are interesting to know, in this work we will be content with the knowledge of how they are produced on the drafting board or the loft floor. We have seen on Plate 6 how quite a number of the geometric curves were produced. Let us take as an instance of curve families the ellipse (PLATE 6, Fig. 1). The major axis of this sort of figure could be ten times the length of the minor axis, yet an ellipse would be produced by the method shown. The major axis might be only one and a half times the minor diameter, yet the figure produced by the method shown would still be an ellipse and would belong to the ellipse family, just as the stout Willie Smith and his thin brother John both belong to the Smith family.

From the foregoing we see that we can produce an infinite variety of curves of the same family, depending only on their limiting or control dimensions. In the case of the ellipse the limiting dimensions were the major and minor axes. As a case of simple geometric fairing, let us take the case of the envelope of a dirigible airship. We have to build the envelope as a many sided polygon for structural reasons, but were it not for this the envelope could be built cylindrical, just as it is in some of the non-rigid types. To fair this envelope, it would be necessary to establish only one line. This line would be the half diameter or radius about the straight fore and aft centerline. If all the radii at every station were to be limited in extent by this line, the envelope would be fair without running another line.

We could similarly fair this same envelope in elliptical sections by establishing a symmetrical profile about the fore and aft centerline and a symmetrical plan view about the same center. Thus, with the one acting as the limits of the major axis and the other as the limits of the minor axis, the stations would be automatically fair by producing ellipses to the limiting dimensions. We could go still further by dividing the profile above the fore and aft centerline and that below it into two different curves, and produce different half ellipses above and below the line for the various sections. We could also use a radius for the sections above the centerline and an ellipse below it or vice versa. The possibilities of this type of fairing are unlimited as long as we employ the same family of curves for the same portion of our transverse sections.

Just as we employed combinations of geometric curves for fairing, we could also employ a series of curves and straight lines. Let us take as an example of this type of fairing the Cabane on PLATE 13. The cabane is the portion between the fuselage of an airplane and its elevated wing. Here two waterlines are established; waterline *A* and waterline *B*. These are limited by the extent of the struts supporting the wing, and the cabane must be faired around them to reduce the air resistance of these struts. The waterlines are laid in to suit the

~FAIRING LINES - AIRPLANE FUSELAGE - PLATE-14~



designer's ideas and good streamline flow. The lengths of these are determined from a previously drawn profile. The stations *I* to *VI* are established to suit the conditions on the plane, and the half widths of these are laid in on the body plan as shown. Straight lines are now laid in between the points picked up between the wing and the hull or fuselage. The sharp corner recesses between the hull and the cabane, and between the wing and cabane are aerodynamically bad. That is, there are eddy currents formed in these corners which cause added resistance to the plane in flight, and these can be eliminated to a great extent by fitting fillets in the corners. To do this, the extent of the fillet has to be determined. The designer selects waterline *A* as the tangency point of the lower fillet, and fairs a line below the wing for the upper fillet. Radii are now used to draw arcs tangent to the straight lines of the cabane sides and the under side of the wing, and also to the hull surface. The corresponding tangency points of the fillets on the wing and hull should now be checked for fairness by running lines through the tangency points on these surfaces.

In our previous example of fairing a lighter than air ship's envelope, we dealt entirely with a straight fore and aft center-line. The airplane designer calls this line the "center-line of thrust." On PLATE 14 we have an example of fairing similar to this, where the centerline of thrust would not run at the same plane as the maximum width. In this case, the designer wanted his fuselage to run in a true straight line, and he made it so when he drew the profile. He selected a true radius as the top of his fuselage and an ellipse below. His point of maximum width was determined to be at Station 3, and the plan was drawn to suit this condition. Due to the fact that the top sections are cylindrical and all are perfect circles, the line of maximum width is drawn in the profile as shown by the dot-and-dash line. Actually, in the body plan this line was laid in straight between the intersection of the vertical center-line and the top, and a horizontal line across Station 3 at the point of greatest width. We now have as limiting dimensions the profile and the plan to work the rest of our stations from. The rest of the sections at the stations are produced by "conic projection," and we will go back to PLATE 6, Fig. 5 to see how this is accomplished.

On this plate and figure we have the arbitrary curve *BD*, which has a half width at the centerline of thrust of *BX*, and a depth below the centerline of *XD*. Let us assume that this is the section of maximum area through our fuselage. At the tail end we have another arbitrary curve, *AE*, whose half width at the centerline of thrust is *AX*, and whose depth is *XE*. This curve has to be of the same family as *BD* to use this method of fairing, which is called "Fairing by Conic Projection." We now divide curve *BD* into six equal spaces, and lay in the diagonals *I, II, III, IV* and *V*. While we have spaced these equally, they might have been laid in at random had we so desired.

We now lay in our half width *BX* to the right-hand side of our vertical centerline, *XD*. We do likewise with the half width *AX*. From each point we draw the straight line *DB* on the right, and *EA* likewise. Let us now to proceed to develop the intermediate sections. From the points where the diagonals crossed our line *BD* we project horizontal lines to the right until they intersect the straight dot-and-dash line, *DB*. These intersections are at points *a, b, c, d* and *e*. From these intersections straight lines are drawn to point *X*. The half width of any intermediate section is laid in as *XC* to the right and *CX* to the left. The depth is laid in as *XF*. To the right the dot-and-dash line is laid in as *FC*.

Where the radians from points of intersection of the diagonals on line *BD* were projected to point *X*, intersect the dot-and-dash line on the right, *CF*. Horizontal lines are projected

~SEAPLANE FLOAT LINES PLATE-15.~

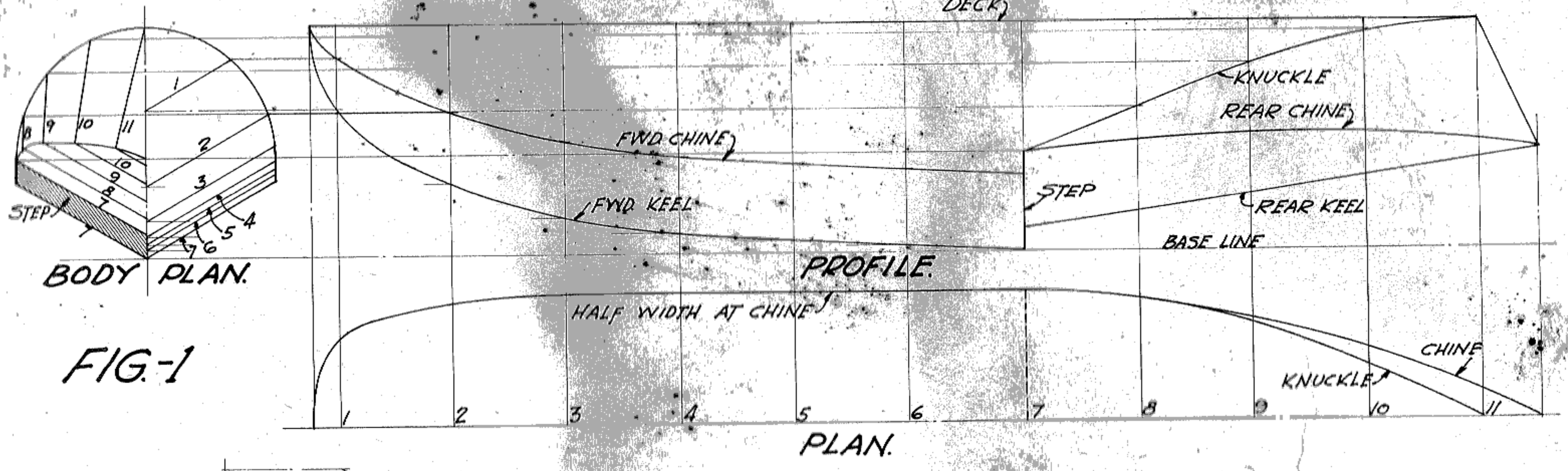


FIG.-1

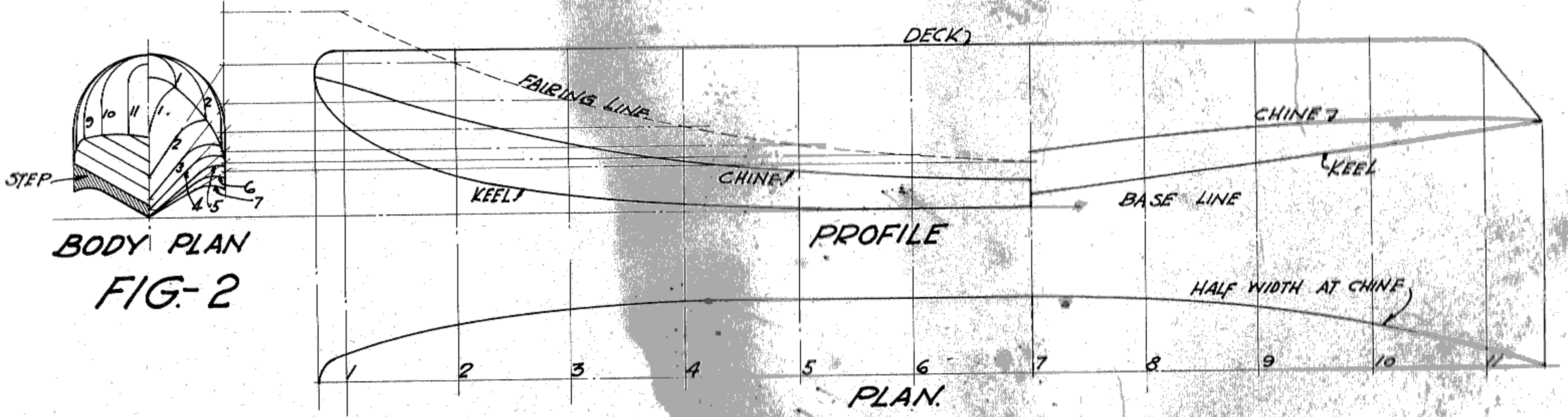


FIG.-2

across to the left again, and where they cross the original diagonals at points *f*, *g*, *h*, *i* and *j* will be the new line. To further clarify this, let us take diagonal *III* as an example. The intersection with *BD* is projected across to the straight line *DB* at *c*, and thence up to *X*. Where it crosses *FC* on the right it is projected back horizontally until it meets diagonal *III* again at *h*. All of the directions of the projection series are shown by arrow heads on the drawing.

Another way of projecting sections is called "Fairing by Triangulation" (PLATE 6, Fig. 6). Here we have a curve *AC*, whose limiting dimensions are the distances *AB* and *BC*. The distance *BD* is laid above the line *BC* as shown, equal to the length of *AB*. The horizontal lines *a-b*, *c-d* and *e-f* are laid out perpendicular to *AB*, either equally spaced or at random, as desired. The intersections of these lines with the parent curve *AC* are projected upward to the line *CD*. Any curve may be generated from this parent by laying out a new width *BE*. Another line which is shown dotted is carried up to point *D* from the new point *E*. The intersecting points on the line *CD* are now projected across horizontally until they meet the new dotted line. Projections down from these points to the former horizontal lines will give the points on the new curve. This method of fairing can only be used where the distance *AB* will remain constant throughout the extent of the body to be faired. It will find most favor in fairing fillets, which have one limiting dimension constant and the other varying.

The seaplane float generally offers another good example of geometric fairing. PLATE 15 shows two good examples of this sort. Fig. 1 of this plate shows a small float whose deck has a constant circular section throughout its length. The tail of the float aft of the step has been streamlined by simply cutting off a curved slab from the main body on each side of the centerline. This is done by fairing the chine line aft of the step either visually or geometrically. To enhance the appearance only, the tail end has been given a slight rake forward. This necessitates another line being faired for the knuckle. The after sections are thus given a slight rake inboard, due to the non-alignment of chine and knuckle. If both of these lines were coincident the aft sections between the chine and knuckle would be vertical and the sternpost at the tail would be perpendicular to the base.

The forward sections of this float and those aft of the step on the bottom all have the same angularity to the base line. To draw the chine line forward, the half width of the chine is formed by the angularity of the bottom of the float projected outward until it intersects the arc of the deck. To draw the angularity is projected outward and the projection of the chine half width laid down on these lines at the various stations. All the angularities are of course projected outward from the centerline, at their proper heights above the base line. These intersections of the chine projected back to the profile will give the shape of this line in that view.

Fig. 2 of PLATE 15 shows a more complicated float. While that shown in Fig. 1 could be built from flat sheet stock without any hammering, the one shown in Fig. 2 would entail hammered or "bumped" plating, as it is referred to in an aircraft factory. This float has been designed around a predetermined profile and plan view. The forward bottom is faired by a phantom fairing line which has been laid down on the line of maximum beam. As the bottom angle varies throughout the length, the fairing line provides a limiting dimension to the straight rise of the bottom. The flam inboard of the chine is faired by using a true radius, much in the manner of a fillet. The bottom aft is faired from the keel rise to the half width of the chine, as was done in the float in Fig. 1. As all the sections through the float at any point have a true radius to the deck, these radii are limited by the half width of the chine as shown in the plan.

FLYING BOAT LINES. PLATE-16-