Call the breadth of the water-line AB = 1/2B, the depth AE = *h,* and the area ABE = 1/2M, and let *m* be the ex­ponent of a parabola having the same area; then

⅛Ι∙⅛B∙Λ≡iM,

. ⅛M M

an "l~ ⅛BA- ⅜M~ BA — M

In the same manner, the exponent may be foιmd for the water-line, by supposing a parabola with its vertex as the greatest breadth, and passing through the points in which the water-line cuts the middle line. Suppose the exponent of this parabola = r, the length on the water-line = L, and, as before, the breadth = B ; also let the area of the water­line = W ; then

-L-i∙L∙⅛B∙=UW,

"\*dr = BL~W (6)·

Lastly, suppose the areas of the several water-lines, from the load water-line downwards, to decrease in the propor­tion of the abscissas to a parabola; and let the exponent *= s,* the depth from the water-line to the tangent of the midship section = A, the displacement = D, and the area of the water-line = W ; then

4ι∙WA = D,

and ' = Λ∖V∏- D

By calculating these different exponents for ships already built, and which have been found to possess good qualities, a very correct idea of their shape will be obtained, which, in making new constructions, may be referred to ; and after a very short practice the constructor will be enabled to de­termine, not only the principal dimensions, but the outlines of the body, before a drawing is begun.

A collection of such calculations was begun by Chap- man, and has since his time been considerably augmented. We now therefore know what the value of the exponents ought to be in the different classes of ships, for the services to which they are destined. It is always found that large ships are fuller than small ones, and in consequence have larger exponents ; and that merchant-men have larger ex­ponents than men-of-war of equal size.

The exponent of the line of sections in the Swedish navy, in ships of the line, varies from 2∙5 to 2∙7 ; of the midship section, from 5 to 3∙8 ; of the water-line, from 6∙6 to 5·9 ; and of the displacement, from 2∙2 to 1·8; of course the larger exponent belongs to the larger class of ships.

In frigates, sloops, and brigs, they are smaller ; the ex­ponent of the line of sections varies from 2∙3 to 2∙l ; of the midship section, from 3 to 1·9; of the water-line, from 5∙2 to 3∙25 ; and of the displacement, from 1·6 to 1·25. These exponents show that small ships have much larger dimen­sions in proportion to their displacements than large ones.

The above results were obtained from the displacements and breadths, not including the plank ; and the length is that of the construction water-line, which, in Swedish ships, is 1/84th less than the whole water-line between the rabbets, 7/10ths of which deduction is made from forward, and 3/10ths from aft. In finding the exponent for the water-line, its whole length between the rabbets is taken.

These calculations are equally applicable with the plank on as with it off ; in the first-mentioned case, the sections near the extremities will have, relatively to the midship section, a larger area, and there will therefore be scarcely any hollow at the ends of the curves, and it will not be im­proper to take the length of the water-line the whole length between the rabbets.

The following tables are given as an illustration of this method, in its application to English ships.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **Length on tne Water- line.** | **Breadth, extreme.** | **Depth from the Water­line to the lower edge of the Rab­bet.** | **Displace­ment, in­cluding the Plank.** | **Area of the Load**  **Water- section.** | **Area of the Mid­ship Sec­tion.** |
|  | **Feet.** | **Feet.** | **Feet.** | **Cub. Feet.** | **Sq. Feet.** | **Sq. Feet.** |
| Nelson | 203·3 | 53·5 | 23·5 | 165182 | 10027 | 1099 |
| Bulwark... | 180·3 | 49·0 | 19·8 | 105584 | 7706 | 791 |
| Endymion | 157·0 | 41·9 | 16·0 | 55807 | 5656 | 510 |

Then from the equations (a), (5), (6), and (7), the fol­lowing results may be obtained :—

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Nelson | **Value of *n*, the Exponent of the Line of Sections.** | **Value of m. the Exponent of the Mid- ship Sections.** | **Value of *r*, the Exponent of the Water­line.** | **Value of r. the Exponent of the Dis­placement.** |
| 2·836  2·851  2 300 | 6·9447  4·4141  3∙1796 | 11·8034  6∙8273  5·1235 | 2·3445 2∙2538 1·6088 |
| Bulwark |
| Endymion |

From this table of exponents we may judge with cer­tainty of the shape of the vessels. The Nelson, for instance, has a very full midship section, and an exceedingly full water-line ; but she is not relatively so full towards the ex­tremities as the Bulwark, and her displacement is not re­latively much fuller than that of the Bulwark. The Bul­wark has a small midship section, is full towards the ex­tremities, and has a very large water-section in proportion to her displacement. The Endymion is a very sharp ship of her class, has a small midship section, is rather clean to­wards the extremities, but her water-line is not very sharp ; its proportion to her displacement is very large.

The four exponents which have been described will, se­parately, only show the degrees of fulness in one direction ; but they may be combined in such a manner as to express at the same time the longitudinal and transversal fulness ; to effect which the value of the area of the midship section = —∙ BA must be substituted in equation (1), which gives

—^-r∙∕∙B∙A = D (ft);

*n* + 1 *m* -I- 1 v ,

also, by substituting the value of W = **~~r -p 1 \*~~~~n~~** equation (7), we have

⅛∙s-÷Ι∙LB∙A=D (e).

In these equations the products **~~∣ ‘~~ ~~r~~ ~~\_p j "~~ ~~j~~~~,∙ \_p 1~~**

show the relative fulness of the different ships in compari­son to the circumscribing parallelopiped. When the con­struction water-line is equal to the whole water-line, as was supposed in calculating the foregoing table,

*n m r s*

»-f-1 \*« -J- 1 - r + 1 *s* + 1

By this equation any error in determining the exponents may be detected ; and also by using the whole equations (*b*) and (*c*), errors in the dimensions or exponents will be detected.

By a method of interpolation, formulæ of very easy ap­plication have been deduced ; by which the depth of the centre of gravity of the displacement below the water-sec­tion, the height of the metacentre, and several other essen­tial elements, may be approximated to without the usually long calculations ; and thus most of the qualities of a ship which are determinable by calculation may be ascertained,