SAILING.

Centre of Lateral Resistance.

The centre of lateral resistance is the centre of application of resistance of the water; and as this varies in position with the speed of the ship, &c., it is not determinate, but a point is generally taken at the centre of the immersed longitudinal vertical middle plane of the vessel as sufficiently accurate.

Centre of Effort.

The point in the longitudinal vertical middle plane of a vessel which is traversed by the resultant of the pressure of the wind on the sails is termed the centre of effort; its position varies according to the quantity of sail spread, &c., but its position is determined approximately for purposes connected with designing the sails, all plain sail only being taken—that is, the sails that are more commonly used, and which can be carried with safety in a fresh breeze (see table, p. 200). They are as follows:—

In square-rigged vessels: the fore and main courses, fore, main, and mizen topsails, fore, main, and mizen topgallant sails, driver, jib, and sometimes the fore topmast staysail.

In fore and aft rigged vessels: the main sail, fore sail, and sometimes the second or third jib.

In calculating the position of the centre of effort by the following rules the sails are taken braced right fore and aft.

To find the perpendicular height of the centre of effort above the centre of lateral resistance.

Rule.—Multiply the area of each sail by the height of its centre of gravity above the centre of lateral resistance; take the sum of those products (or moments) and divide it by the total area of sail: the quotient will be the required result.

To find the lateral position of the centre of effort relatively to the centre of lateral resistance.

Rule 1.—Multiply the area of each sail whose centre lies to one side of a vertical axis passing through the centre of lateral resistance by the perpendicular distance of its centre from that axis, and add the products (or moments) together.

Rule 2.—Treat the other sails whose centres lie to the other side of the axis of moments in the same way as before, and add their products together.

The difference between the two sums added together, and divided by the total area of sail, will give the perpendicular distance of the centre of effort from the given axis.

Note.—The centre of effort will lie to that side which has the greatest moment of sail.

The following table shows the method in which the centre of effort is calculated.

Table showing Method of Calculating the Position of the Centre of Effort relatively to the Centre of Lateral Resistance.

Name of Sail	Areas	Distances of Centre of Sail		Moments		Heights of Centre of Sail Above	Vertical Moments
		Before	Abaft	Before	Abaft		
Jib	2040	138	—	281520	—	87·3	178092
Fore course	4050	78	—	315900	—	56·0	226800
„ topsail	4330	78	—	337840	—	109·5	474185
„ topgallant sail	1500	78	—	117000	—	158·8	238200
Main course	5488	—	12·5	—	67600	58·3	315286·4
„ topsail	5440	—	14·0	—	76160	117·3	638112
„ topgallant sail	1881	—	15·5	—	29155·5	172·0	324532
Driver	2831·5	—	100·5	—	284565·7	62·5	176968·7
Mizen topsail	2645	—	78·0	—	206310	99·5	263177·5
„ topgallant sail	902	—	79·5	—	71709	136·0	122672
	31027·5			105226·0	735500·2		2957975·6

$$\text{Hght. of Centre of Effort above Centre of Lateral Resistance} = \frac{\text{moment}}{\text{area}} = \frac{2957975{\cdot}6}{31027{\cdot}5} = 95{\cdot}3.$$

$$\text{Dist. of Centre of Effort before Centre of Lateral Resistance} = \frac{\text{moments}}{\text{area}} = \frac{1052260 - 735500{\cdot}2}{31027{\cdot}5} = 10{\cdot}2.$$

Ardency.

Ardency is the tendency a ship has to fly up to the wind, thus showing that the position of her centre of effort is abaft the centre of lateral resistance.

Slackness.

Slackness is the tendency a ship has to fall off from the wind, thus showing that the position of her centre of effort is before the centre of lateral resistance.

Relative Position of Centre of Effort and Centre of Lateral Resistance.

D = distance of centre of effort before centre of lateral resistance.

D_1 = distance of centre of effort above centre of lateral resistance.

L = length of load water-line.

A = area of load water-line.

d = distance of centre of buoyancy of ship below load water-line.

d_1 = distance of centre of lateral resistance abaft the middle of the load water-line.

d_2 = distance of centre of buoyancy before the middle of the load water-line.

$$D = \frac{L(\frac{3}{4}d_1 + d_2)}{10(d_1 + d_2)}$$ for square-rigged vessels.

$$D = \frac{L}{10(d_1 + d_2)}$$ for cutter and fore and aft rigged vessels.

$$D_1 = \frac{4A}{5d}.$$

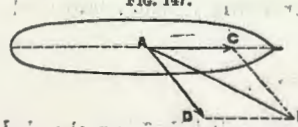
Note.—The centre of effort of the sails, to produce the best effect, must be higher or lower according as the ship is more or less full at the load water-line compared with the fulness of the body at the extremities below the water. Ships that are full at the load water-line and clean below at the extremities require the higher masts.

Real and Apparent Motion of the Wind.

By the real motion of the wind is meant its motion relatively to the earth, and by its apparent motion its motion relatively to the ship when she is sailing.

The apparent motion being the resultant of the real motion of the wind and of a motion equal and directly opposite to that of the ship.

Fig. 147.



In fig. 147 let AB represent in magnitude and direction the real motion of the wind, and AC the direction and velocity of the motion of the ship; through B draw BD parallel and equal to AC; join DA; then DA will represent in magnitude and direction the apparent motion of the wind.

In algebraical symbols let—

a = angle ADB made by the point from which the apparent wind blows with the course of the ship.

K = 180 − a = supplement of ADB, the corresponding angle for the real wind.

$r = \frac{AD}{DB}$ = ratio of velocity of apparent wind to that of the ship.

$r_1 = \frac{AB}{DB}$ = ratio of velocity of real wind to that of the ship.

$r = \{\sqrt{(r_1^2 - 1 + \cos^2 a)} + \cos a\}$.

When a is obtuse, $r = \{\sqrt{(r_1^2 - 1 + \cos^2 a)} - \cos a\}$.

$r = \sqrt{(1 + r_1^2 + 2r_1 \cdot \cos K)}$.

When K is obtuse, $r = \sqrt{(1 + r_1^2 - 2r_1 \cos K)}$.

$r_1 = \sqrt{(1 + r^2 - 2v \cdot \cos a}$.

When a is obtuse, $r = \sqrt{(1 + r^2 + 2r \cdot \cos a)}$.

$$\text{Sin } K = \frac{r}{r_1} \sin a. \qquad \text{Sin } a = \frac{r_1}{r} \sin K.$$

Effective Impulse of Wind.

D = direct impulse of wind on sails in lbs.

E = effective impulse of wind on sails in lbs.

C = component of effective impulse which produces leeway and tends to heel the ship over.

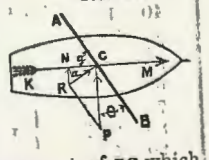
C_1 = component of effective impulse which moves the ship ahead.

θ = angle made by direction of apparent motion of wind with the plane of the sails (see fig. 148).

α = angle made by the plane of the sails with the ship's course (see fig. 148).

$$E = D \sin^2 \theta. \quad C = E \cos \alpha. \quad C_1 = E \sin \alpha.$$

Fig. 148.



In fig. 148 let PC represent in magnitude and direction the pressure of the apparent wind on the sail AB; through P draw PR parallel to AB; through C draw CR perpendicular to PR and cutting PR in R: then RC is the effective pressure of the wind on the sail AB, and RN perpendicular to KM is the component of RC which produces heel and leeway, while NC is the component of RC which propels the ship along.

Table of Direct Impulse of Winds in Lbs. per Square Foot, and Sails commonly set by the Wind.

Velocity in Knots per Hour	Impulse in lbs.	Name of Wind	Sails commonly set by the Wind
1	·0067	Light air	Courses, topsails, topgallant sails, royals, spanker, jib, flying jib, and all light sails.
2	·027		
3	·060		
4	·107	Light wind	
5	·167		
6	·240	Light breeze	
7	·327		
8	·427	Moderate breeze	
9	·540		
10	·667		
11	·807	Fresh breeze	Royals and flying jib taken in in a sea way to two reefs in the topsails.
12	·960		
13	1·13		
14	1·31		
15	1·50	Strong breeze	Single-reefed topsails and topgallant sails in much sea, two reefs in the topsails to taking in topgallant sails.
16	1·71		
17	1·93		
18	2·16		
19	2·41		
20	2·67		
22	3·23	Moderate gale	Double-reefed topsails to treble-reefed topsails, reefed spanker and jib.
24	3·84		
26	4·51	Fresh gale	Close-reefed topsails, reefed courses to taking in spanker, jib, fore and mizen topsails.
28	5·23		
30	6·00		
32	6·83	Strong gale	Reefed courses, close-reefed main topsail, fore staysail, mizen topsail to taking in the main sail.
34	7·71		
36	8·64		
38	9·63	Heavy gale	Close-reefed main topsail to storm staysails, or close-reefed main topsail only.
40	10·7		
45	13·5	Storm	
50	16·7		
60	24·0	Hurricane	
70	32·7		
80	42·7		
90	54·0		
100	66·7		

Impulse of Wind.

V = velocity of wind in knots per hour.
D = direct impulse in lbs. on one square foot.

$$D = \frac{V^2}{150} = V^2 \cdot 006667.$$

Speed of Similar Vessels under Sail.

V = velocity of ship. D = displacement of ship.
X = area of midship section. A = area of sails.
c and c_1 = constants obtained from similar vessels.

$$V = c\sqrt{\frac{A}{X}} = c_1\sqrt{\frac{A}{D^{\frac{2}{3}}}}. \qquad c_1 = \sqrt{\frac{V^2 D^{\frac{2}{3}}}{A}}.$$

$$c = \sqrt{\frac{V^2 X}{A}}. \qquad A = \frac{V^2 X}{c^2} = \frac{V^2 D^{\frac{2}{3}}}{c_1^2}.$$

Table of the Ratio of a Ship's Speed under Sail to Speed of Real Wind.

Ratio of Area of Sails to Augmented Surface	Relation between Course and Wind	Probable Ratio of Speed of Ship to Sp. of Real Wind
1	Course 5 points near wind	½
	Wind 2 points abaft beam	1
1½	Course 6 points near wind	1½
	Wind abeam	2
	Wind astern	3
2	Course 5 points near wind	2½
	Wind 2 points abaft beam	3
2½	Course about 6½ points near wind	3½
	Wind on quarter	4

Table of the Ratio of the Probable Speed of Vessels under Steam and Canvas to those under Steam.

Speed under canvas ÷ speed under steam	Probable speed under steam and canvas ÷ speed under steam	Speed under canvas ÷ speed under steam	Probable speed under steam and canvas ÷ speed under steam
·4	1·02	1·3	1·47
·5	1·04	1·4	1·55
·6	1·07	1·5	1·64
·7	1·10	1·6	1·72
·8	1·15	1·7	1·81
·9	1·20	1·8	1·90
1·0	1·26	1·9	1·99
1·1	1·33	2·0	2·08
1·2	1·40	—	—

Heeling Moment of Sails.

E = effective impulse of wind on sails in lbs. (see p. 199).
D = displacement of vessel in lbs.
C = height of centre of effort above centre of lateral resistance.
G = height metacentre above centre of gravity.
L = length of arm of righting couple at a given angle of heel.
M = heeling moment of sails.
α = angle made by plane of sails with course of ship (see fig. 148).
θ = angle of heel of vessel.

$$M = C \cdot E \cdot \cos \alpha \cdot \cos \theta.$$

The steady angle of heel of a vessel due to M will be that at which

$M = D \cdot G \cdot \sin \theta$ (for small angles of heel),
$M = L \cdot D$ (for any angle of heel).

In the two last formulæ the reduction in the effective heeling power of the wind due to the sails being inclined from the upright position has been neglected, but if necessary the diminution of the effective pressure of the wind may be taken to vary as the sine squared of the angle of incidence of the wind with the plane of the ship's sails, or as the cosine squared of the angle of heel.

Note.—In a general sense the moment of sail is usually understood to be the product of the area of all plain sail into the height of the centre of effort above the centre of lateral resistance, as the pressure of wind is generally taken as one pound in the square foot; and the product of the weight of the ship in lbs. into the height of the metacentre above the centre of gravity, divided by the moment of sail, is taken as a measure of her efficiency to resist inclination under canvas.

Area of Sail.

To determine accurately the quantity of sail suitable for any vessel to carry, make the moment of sail equal to the moment of stability at a definite angle of heel; but the following rule may generally be taken as sufficiently approximate:—

A = quantity of sail suitable to a given vessel.
D = displacement of vessel in lbs.
M = height of metacentre above centre of gravity.
H = height of centre of effort above centre of lateral resistance.
θ = angle of heel in circular measure suitable to given vessel taken from the following table.

$$A = \frac{D \times M \times \theta}{H}$$

Table of Angle of Steady Heel for Different Classes of Vessels.

Class of Vessel	Angle of Heel	Circular Measure
Frigates and large merchant ships	4°	·070
Corvettes	5°	·087
Schooners and cutters	6°	·105
Yachts	6° to 9°	·105 to ·107

Table of the Area and Moment of Sails of some of Her Majesty's Screw Vessels.

	A	B	C	D	E	F		G	H
						ft.	in.		
Achilles	30133	22·6	3·11	95·99	23·33	26	10	1·517	3·088
Bellerophon	23792	19·34	3·15	85·64	26·1	24	8½	2·03	3·28
Favourite	16206	20·62	5·01	105·4	21·2	21	4	1·00	3·40
Hercules	28882	21·62	3·26	118·42	18·9	24	0¾	1·38	2·69
Inconstant	26034	27·57	4·61	147·9	15·1	23	10½	1·42	2·80
Iron Duke	25054	23·92	4·25	128·96	17·3	22	0	·66	3·012
Monarch	27700	22·52	3·35	129·12	17·3	24	1½	·76	2·37
Minotaur	32377	24·23	3·10	74·50	30·0	26	8½	1·999	3·879
Penelope	17168	22·32	3·93	84·35	26·6	16	6½	1·35	3·52
Prince Consort	22459	18·85	3·36	43·28	51·7	25	5	2·15	6·01
Sultan	28258	20·42	3·07	112·84	19·8	26	0	2·35	2·64
Swiftsure	25095	21·95	3·82	116·0	19·3	24	10½	1·8	3·05
Valiant	21426	17·49	3·18	59·10	37·9	25	8	1·89	4·61
Vixen	7860	22·98	6·39	74·67	29·9	11	2½	·95	4·21
Warrior	28809	23·07	3·16	63·22	35·4	26	5½	2·285	4·678

In the above table—

A = area of plain sail in square feet.

B = proportion of sail to one foot of midship section at load draught.

C = proportion of sail to one ton of displacement at load draught.

D = moment of sail about centre of lateral resistance divided by displacement in tons into the distance between the metacentre and the centre of gravity in feet.

E = weight of the ship in lbs. multiplied by the distance between the metacentre and the centre of gravity, and the product divided by the moment of sail about the centre of lateral resistance.

Note.—This is a measure of the power of a ship to resist inclination under her canvas.

F = mean load-draught of water in feet and inches.

G = distance of centre of gravity below load water-line in feet.

H = height of metacentre above centre of gravity in feet.

Effect of Gust of Wind on a Ship's Sails.

The effect of a sudden gust of wind upon a ship's sails is, as a rule, to heel her over to an extreme angle of heel of about twice the steady angle at which the same constant pressure of wind would keep her.

In fig. 149 let ABC be the ship's curve of statical stability, and DE her curve of varying moments of sail—that is, the ordinates which express the moment of sail at the different angles vary as the cosine² of the angle of heel.

Fig. 149.

If the wind is steadily applied the ship will remain inclined at a steady angle of heel of 20°, determined by dropping an ordinate at the point of intersection E of the two curves: but in the case of the same pressure of wind being suddenly applied she will heel over beyond the steady angle of heel, and she will oscillate for a time about that angle, the reason being that an amount of mechanical work has been done in heeling her over to 20°, which is represented by the area ADEH, whereas the work absorbed is only equal in area to AEH; hence mechanical work has been accumulated equal to the area AED. The ship will therefore continue to heel over till this work has been absorbed; this will occur at 40°, when the area EKL is equal to the area AED, or, in other words, when the area ALM—the dynamical stability at 40°—is equal to the area ADEM she will commence a return oscillation under the influence of a righting moment, represented by KL.

Time and Knot Table.

The number in this table corresponding to the time in which a vessel passes over the measured knot is her rate in knots per hour.

Secs.	2 min.	3 min.	4 min.	5 min.	6 min.	7 min.	8 min.	9 min.	10 min.	11 min.	12 min.	13 min.	14 min.
0	30·000	20·000	15·000	12·000	10·000	8·571	7·500	6·667	6·000	5·455	5·000	4·615	4·286
1	29·752	19·890	14·938	11·960	9·972	8·551	7·484	6·654	5·990	5·446	4·993	4·609	4·281
2	29·508	19·780	14·876	11·921	9·945	8·531	7·469	6·642	5·980	5·438	4·986	4·604	4·275
3	29·268	19·672	14·815	11·881	9·917	8·511	7·453	6·630	5·970	5·430	4·979	4·598	4·270
4	29·032	19·565	14·764	11·842	9·890	8·491	7·438	6·618	5·960	5·422	4·972	4·592	4·265
5	28·800	19·459	14·694	11·803	9·863	8·471	7·423	6·606	5·950	5·414	4·965	4·586	4·260
6	28·571	19·355	14·634	11·765	9·836	8·451	7·407	6·593	5·941	5·405	4·959	4·580	4·255
7	28·346	19·251	14·575	11·726	9·809	8·431	7·392	6·581	5·931	5·397	4·952	4·574	4·250
8	28·125	19·149	14·516	11·688	9·783	8·411	7·377	6·569	5·921	5·389	4·945	4·568	4·245
9	27·907	19·048	14·458	11·650	9·756	8·392	7·362	6·557	5·911	5·381	4·938	4·563	4·240
10	27·692	18·947	14·400	11·613	9·730	8·372	7·347	6·545	5·902	5·373	4·931	4·557	4·235
11	27·481	18·848	14·343	11·576	9·704	8·353	7·332	6·534	5·892	5·365	4·925	4·551	4·230
12	27·273	18·750	14·286	11·538	9·677	8·333	7·317	6·522	5·882	5·357	4·918	4·545	4·225
13	27·068	18·653	14·229	11·502	9·651	8·314	7·302	6·510	5·873	5·349	4·911	4·540	4·220
14	26·866	18·557	14·173	11·465	9·626	8·295	7·287	6·498	5·863	5·341	4·905	4·534	4·215
15	26·667	18·461	14·118	11·429	9·600	8·276	7·273	6·486	5·854	5·333	4·898	4·528	4·210
16	26·471	18·367	14·062	11·392	9·574	8·257	7·258	6·475	5·844	5·325	4·891	4·523	4·206
17	26·277	18·274	14·008	11·356	9·549	8·238	7·243	6·463	5·835	5·318	4·885	4·517	4·201
18	26·087	18·182	13·963	11·321	9·524	8·219	7·229	6·452	5·825	5·310	4·878	4·511	4·196
19	25·899	18·090	13·900	11·285	9·499	8·200	7·214	6·440	5·816	5·302	4·871	4·506	4·191
Secs.	2 min.	3 min.	4 min.	5 min.	6 min.	7 min.	8 min.	9 min.	10 min.	11 min.	12 min.	13 min.	14 min.

TABLE GIVING THE DIMENSIONS OF MASTS AND SPARS OF SOME SCHOONER-RIGGED SCREW STEAMERS.

SPECIES OF MASTS AND SPARS	Length, 150 ft. Breadth, 26 ft. Tonnage, 483. Schooner-rigged *				Length, 130 ft. Breadth, 20 ft. Tonnage, 251. Schooner-rigged				Length, 108 ft. Breadth, 17 ft. 6 in. Tonnage, 159 Schooner-rigged				Length, 76 ft. Breadth, 15 ft. Tonnage, 80. Fore and Aft Schooner			
	Fore Mast		Main Mast		Fore Mast		Main Mast		Fore Mast		Main Mast		Fore Mast		Main Mast	
	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.
	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.
Lower mast. From deck to hounds	42 6	15	44 0	14½	39 0	15	41 0	14	37 0	14	38 0	13	26 3	12	28 6	11
Head	10 0	—	10 0	—	8 0	—	8 0	—	7 6	—	7 6	—	—	—	—	—
Topmast. Length to stops	21 0	10	36 6	9	16 0	7	28 0	7	26 0	9½	27 0	9	20 0	—	20 0	—
Pole	—	—	3 6	—	—	—	4 0	—	3 0	—	3 0	—	3 0	—	4 0	—
Topgallant mast. Length to stops	12 6	—	—	—	10 0	—	—	—	—	—	—	—	—	—	—	—
Pole	3 0	—	—	—	4 0	—	—	—	—	—	—	—	—	—	—	—
Lower yard. Whole length	60 0	10½	—	—	46 0	8	—	—	41 0	9½	—	—	—	—	—	—
Yard arms, each	3 0	—	—	—	2 0	—	—	—	2 6	—	—	—	—	—	—	—
Topsail yard. Whole length	44 6	8	—	—	34 0	7	—	—	24 0	8	—	—	—	—	—	—
Gaff topsail yard. Whole length	—	—	14 0	5	—	—	18 0	6	—	—	19 0	11	11 0	4	13 0	4½
Yard arms, each	4 0	—	2 0	—	2 6	—	1 6	—	2 0	—	2 0	—	1 0	—	1 6	—
Topgallant yard. Whole length	29 0	5¾	—	—	21 0	5	—	—	—	—	—	—	—	—	—	—
Yard arms, each	2 0	—	—	—	1 6	—	—	—	—	—	—	—	—	—	—	—
Gaff. Whole length, fly included	31 0	6¼	34 0	6¾	19 0	6	27 0	7	25 0	7½	26 6	7½	17 0	5½	18 6	5½
Fly	2 0	—	2 0	—	2 0	—	2 0	—	2 6	—	3 0	—	1 3	—	2 0	—
Spanker boom	—	—	53 0	11	—	—	45 0	10	—	—	28 0	7	—	—	28 0	7
Bowsprit, exclusive of housing	28 0	10½	—	—	13 0	12	—	—	21 0	11	—	—	14 6	9	—	—
Jibboom „ „	—	—	—	—	15 0	5	—	—	—	—	—	—	—	—	—	—
Housing	—	—	—	—	10 0	—	—	—	—	—	—	—	—	—	—	—
Distance before rudder post †	114 0	—	45 6	—	92 6	—	41 0	—	81 6	—	34 3	—	57 0	—	24 0	—

* Sloop of war. † On load water-line.

TABLE OF FACTORS USED TO DETERMINE THE LENGTHS OF MASTS AND SPARS FOR FULL-RIGGED SHIPS.

SPECIES OF MASTS AND SPARS	Clipper Ships		Screw Vessels				
			Ironclad Frigates		Wood-sheathed Corvette	Troop-ship	Merchant Steamer
	Ex. 1	Ex. 2	Ex. 1	Ex. 2			
Main mast hounded = breadth of vessel ×	1·389	1·403	1·141	·947	1·238	1·217	1·440
„ „ headed = hounded length ×	·254	·282	·302	·333	·288	·259	·248
Fore „ hounded = main mast hounded ×	·910	·911	·908	·944	·904	·946	·958
„ „ headed = hounded length ×	·281	·309	·315	·353	·298	·273	·259
Mizen „ hounded = main mast hounded ×	·905	·911	·823	·889	·875	·893	·843
„ „ headed = hounded length ×	·246	·239	·239	·260	·219	·222	·215
Main topmast hounded = breadth of vessel ×	1·086	1·125	·987	·808	1·000	·945	·976
„ „ headed = hounded length ×	·211	·185	·155	·141	·155	·172	·167
Fore „ hounded = main topmast hounded ×	1·000	1·000	1·000	1·000	1·000	1·000	1·000
„ „ headed = hounded length ×	·211	·185	·155	·141	·155	·172	·167
Mizen „ hounded = main topmast hounded ×	·803	·827	·777	·739	·774	·736	·732
„ „ headed = hounded length ×	·238	·194	·154	·147	·154	·156	·183
Main topgallant mast hounded = breadth of vessel ×	·632	·958	·543	·456	·595	·511	·548
„ royal „ „ = „ „ „ ×	·426	·500	·362	·289	·369	·305	·286
„ „ „ pole = hounded length ×	·379	—	·191	·364	·096	·178	·208
„ skysail „ hounded = breadth of vessel ×	—	·361	—	—	—	—	—
„ „ „ pole = hounded length ×	—	·077	—	—	—	—	—
Fore topgallant „ hounded = main topgallant mast hounded ×	1·000	1·000	1·000	1·000	1·000	1·000	1·000
„ royal „ = „ royal mast hounded ×	1·000	1·000	1·000	1·000	1·000	1·000	1·000
„ „ „ pole = hounded length ×	·379	—	·191	·364	·096	·178	·208
„ skysail „ hounded = main skysail mast hounded ×	—	1·000	—	—	—	—	—
„ „ „ pole = hounded length ×	—	·077	—	—	—	—	—
Mizen topgallant „ hounded = main topgallant mast hounded ×	·500	·826	·746	·769	·780	·798	·849
„ royal „ = „ royal mast hounded ×	·323	·778	·762	·818	·774	·786	·750

TABLE OF FACTORS USED TO DETERMINE THE LENGTHS OF MASTS AND SPARS FOR FULL-RIGGED SHIPS (continued).

SPECIES OF MASTS AND SPARS		Clipper Ships		Screw Vessels				
				Ironclad Frigates		Wood-sheathed Corvette	Troop-ship	Merchant Steamer
		Ex. 1	Ex. 2	Ex. 1	Ex. 2			
Mizen royal mast pole	=hounded length	·454	—	·190	·300	·085	·136	·208
„ skysail mast hounded	=main skysail mast hounded	—	·846	—	—	—	—	—
„ „ „ pole	=hounded length	—	·090	—	—	—	—	—
Main yard. Whole length	=length on water-line	·353	·358	·278	·284	·291	·238	·268
Yard arms, each	=yard	·037	·036	·041	·044	·042	·050	·056
Fore yard. Whole length	=main yard	1·000	1·000	1·000	1·000	1·000	1·000	1·000
Yard arms, each	=yard	·037	·036	·041	·044	·042	·050	·056
Mizen yard. Whole length	=main yard	·789	·857	·676	·744	·701	·750	·755
Yard arms, each	=yard	·038	·038	·042	·094	·042	·100	·067
Main lower topsail yard	=main yard	·843	·877	—	—	—	—	—
Yard arms, each	=yard	·024	·052	—	—	—	—	—
Fore lower topsail yard	=main lower topsail yard	1·000	1·000	—	—	—	—	—
Yard arms, each	=yard	·024	·052	—	—	—	—	—
Mizen lower topsail yard	=main lower topsail yard	·770	·829	—	—	—	—	—
Yard arms, each	=yard	·026	·053	—	—	—	—	—
Main upper topsail yard	=main yard	·919*	·933*	·705	·744	·750	·800	·762
Yard arms, each	=yard	·052	·032	·081	·094	·085	·078	·082
Fore upper topsail yard	=main upper topsail yard	1·000	1·000	1·000	1·000	1·000	1·000	1·000
Yard arms, each	=yard	·052	·032	·081	·081	·085	·078	·082
Mizen upper topsail yard	=main upper topsail yard	·803	·794	·696	·672	·729	·687	·738
Yard arms, each	=yard	·038	·040	·082	·061	·083	·079	·100
Main topgallant yard	=main upper topsail yard	·816	·816	·622	·672	·678	·641	·672
Yard arms, each	=yard	·049	·039	·043	·061	·042	·061	·061

* Main lower topsail yard.

TABLE OF FACTORS USED TO DETERMINE THE LENGTHS OF MASTS AND SPARS FOR FULL-RIGGED SHIPS (concluded).

SPECIES OF MASTS AND SPARS		Clipper Ships		Screw Vessels				
				Ironclad Frigates		Wood-sheathed Corvette	Troop-ship	Merchant Steamer
		Ex. 1	Ex. 2	Ex. 1	Ex. 2			
Fore topgallant yard	=main topgallant yard	·000	1·000	1·000	1·000	1·000	1·000	1·000
Yard arms, each	=yard	·049	·039	·043	·061	·042	·061	061
Mizen topgallant yard	=main topgallant yard	·774	·762	·728	·711	·737	·732	·561
Yard arms, each	=yard	·035	·040	·042	·039	·044	·042	·045
Main royal yard	=main topgallant yard	·818	·742	·706	·667	·737	·732	·683
Yard arms, each	=yard	·047	·040	·042	·042	·044	·042	·045
Fore royal yard	=main royal yard	1·000	1·000	1·000	1·000	1·000	1·000	1·000
Yard arms, each	=yard	·047	·040	·042	·042	·044	·042	·045
Mizen royal yard	=main royal yard	·737	·76	·754	·717	·779	·733	·500
Yard arms, each	=yard	·045	·034	·042	·046	·040	·045	·071
Main skysail yard	=main royal yard	—	·773	—	—	—	—	—
Yard arms, each	=yard	—	·034	—	—	—	—	—
Fore skysail yard	=main skysail yard	—	1·000	—	—	—	—	—
Yard arms, each	=yard	—	·034	—	—	—	—	—
Mizen skysail yard	=main skysail yard	—	·690	—	—	—	—	—
Yard arms, each	=yard	—	·037	—	—	—	—	—
Spanker gaff. Whole length	=spanker boom	677	·785	·700	·700	·670	·660	·609
„ boom. „	=length of vessel	·216	·216	·184	·199	·197	·166	·188
Bowsprit, outside stem	= „ „ „	·103	·102	·129	·102	·075	·099	·112
Jibboom, housing excluded	= „ „ bowsprit	1·768	1·909	1·000	1·415	2·250	1·813	2·015
Housing	= „ „ jibboom	·527	·524	·337	·348	·466	·552	·496
Fore mast before after sternpost	= „ „ water-line	·771	·779	·575	·774	·826	·777	·809
Main „ „ „	= „ „ „	·452	·463	·425	·430	·441	·335	·455
Mizen „ „ „	= „ „ „	·190	·174	·161	·164	·161	·117	·175

TABLE OF FACTORS USED TO DETERMINE THE LENGTHS OF MASTS AND SPARS FOR BARQUES AND BRIGS.

SPECIES OF MASTS AND SPARS			Screw Steam Vessels					Sailing Merchant Vessel. Barque-rigged
			Ironclad Frigates. Barque-rigged		Merchant Vessels. Barque-rigged		Troop-ship. Barque-rigged	Merchant Vessel. Brig-rigged	
			Ex. 1	Ex. 2	Ex. 1	Ex. 2			
Main mast	hounded	= breadth of vessel ×	1·125	1·126	1·410	1·606	1·102	1·395	1·577
" "	headed	= hounded length ×	·254	·317	·264	·245	·278	·264	·276
Fore "	hounded	= main mast hounded ×	·913	·905	·927	·898	·908	·943	·928
" "	headed	= hounded length ×	·278	·351	·282	·272	·286	·280	·298
Mizen "	hounded	= main mast hounded ×	·873	·873	·837	·979	1·056	—	·928
" "	headed	= hounded length ×	·230	·228	·234	·167	·175	—	·211
Main topmast	hounded	= breadth of vessel ×	·687	·857	1·000	1·000	·820	1·052	1·267
" "	headed	= hounded length ×	—	—	·179	·167	·134	·175	·167
Fore "	hounded	= main topmast hounded ×	1·000	1·000	1·000	1·000	1·000	1·000	1·000
" "	headed	= hounded length ×	—	—	·179	·167	·134	·175	·167
Mizen "	hounded	= main topmast hounded ×	1·247	1·000	·821	1·567	1·093	—	1·289
" "	pole	= hounded length ×	·188	·188	·344	·086	·159	—	·207
Main topgallant mast	hounded	= breadth of vessel ×	·393	·250	·615	·623	·459	·631	·690
" " "	pole	= hounded length ×	·114	·071	·500	—	—	·667	—
Fore " "	hounded	= main topgallant mast hounded ×	1·000	1·000	1·000	1·000	1·000	1·000	1·000
" " "	pole	= hounded length ×	·114	·071	·500	—	—	·667	—
Main royal mast	hounded	= breadth of vessel ×	—	—	—	·475	·286	—	·408
" " "	pole	= hounded length ×	—	—	—	·310	·143	—	·138
Fore " "	hounded	= main royal mast pole ×	—	—	—	1·000	1·000	—	1·000
" " "	pole	= hounded length ×	—	—	—	·310	·143	—	·138
Main yard.	Whole length	= length of water-line ×	·205	·325	·224	·311	·217	·260	·382
	Yard arms, each	= yard ×	·067	·050	·066	·043	·044	·064	·047
Fore yard.	Whole length	= main yard ×	1·000	1·000	1·000	1·000	1·000	1·000	1·000
	Yard arms, each	= yard ×	·067	·050	·066	·043	·044	·064	·047

TABLE OF FACTORS USED TO DETERMINE THE LENGTHS OF MASTS AND SPARS FOR BARQUES AND BRIGS (concluded).

SPECIES OF MASTS AND SPARS		Screw Steam Vessels					Sailing Merchant Vessel. Barque-rigged
		Ironclad Frigates. Barque-rigged		Merchant Vessels. Barque-rigged		Troop-ship. Barque-rigged	Merchant Vessel. Brig-rigged	
		Ex. 1	Ex. 2	Ex. 1	Ex. 2			
Main topsail yard	= main yard ×	·709	·736	·760	·785	·812	·743	·762
Yard arms, each	= yard ×	·055	·074	·105	·073	·077	·086	·078
Fore topsail yard	= main topsail yard ×	1·000	1·000	1·000	1·000	1·000	1·000	1·000
Yard arms, each	= yard ×	·055	·074	·105	·073	·077	·086	·078
Mizen gaff topsail yard	= spanker gaff ×	·540	·543	— *	— *	·591	— *	— *
Yard arms, each	= yard ×	·100	·100	—	—	·095	—	—
Main topgallant yard	= main topsail yard ×	·628	·657	·631	·690	·700	·689	·656
Yard arms, each	= yard ×	·068	·068	·083	·066	·045	·050	·048
Fore topgallant yard	= main topgallant yard ×	1·000	1·000	1·000	1·000	1·000	1·000	1·000
Yard arms, each	= yard ×	·068	·068	·083	·066	·045	·050	·048
Main royal yard	= main topgallant yard ×	—	—	—	·684	·791	—	·714
Yard arms, each	= yard ×	—	—	—	·058	·041	—	·042
Fore royal yard	= main royal yard ×	—	—	—	1·000	1·000	—	1·000
Yard arms, each	= yard ×	—	—	—	·058	·041	—	·042
Spanker gaff. Whole length	= spanker boom ×	·661	·661	·625	·700	·670	·133†	·145†
" boom " "	= length of vessel ×	·191	·200	·155	·187	·147	—	—
Bowsprit, outside stem	= " " " bowsprit ×	·081	·089	·097	·120	·056	·143	·164
Jibboom, housing excluded	= " " " jibboom ×	1·306	1·181	1·061	·900	1·300	—	·944
Housing	= " " " jibboom ×	·782	·543	·943	·945	·461	—	·471
Fore mast before rudder post	= " " " water-line ×	·817	·818	·770	·787	·796	·706	·793
Main " "	= " " " " ×	·431	·426	·431	·436	·374	·287	·430
Mizen " "	= " " " " ×	·204	·209	159	·151	·141	—	·160

* Jib-headed topsail.

† Spanker gaff = length of vessel x.

TABLE OF FACTORS USED TO DETERMINE THE LENGTHS OF MASTS AND SPARS OF SCHOONERS AND BRIGS.

SPECIES OF MASTS AND SPARS				Screw Steam Vessels						Merchant Sailing Vessel. Brig-rigged
				Ironclads		Sloop of War, Schoon.-rigged	Merchant Vessels			
				3-masted Schooner	Schoon.-rigged		3-masted Schooner	Schoon.-rigged	Schoon.-rigged	Fore and Aft Schooner	
Fore mast hounded	. .	=breadth of vessel	. . ×	1·125	1·127	1·634	1·467	1·950	2·133	1·753	1·740
" " headed	. .	=hounded length	. . ×	·222	·237	·285	·230	·205	·202	—	·218
Main " hounded	. .	=fore mast hounded	. . ×	1·089	1·125	1·035	1·068	1·051	1·027	1·057	1·172
" " headed	. .	=hounded length	. . ×	·204	·211	·230	·213	·195	·200	—	·186
Mizen " hounded	. .	=fore mast hounded	. . ×	·911	—	—	·848	—	—	—	—
" " headed	. .	=hounded length	. . ×	·171	—	—	·173	—	—	—	—
Fore topmast hounded	. .	=breadth of vessel	. . ×	·675	·76	·807	·850	·800	1·500	1·333	1·368
" " headed	. .	=hounded length	. . ×	—	—	—	—	—	—	—	·140
" " pole	. .	= " "	. . ×	—	—	—	—	—	·115	·150	—
Main " hounded	. .	=fore topmast hounded	. . ×	1·426	1·370	1·738	1·608	1·75	1·04	1·000	1·368
" " headed	. .	=hounded length	. . ×	—	—	—	—	—	—	—	·140
" " pole	. .	= " "	. . ×	·170	·185	·100	·146	·143	·112	·200	—
Mizen " hounded	. .	=fore topmast hounded	. . ×	1·148	—	—	·100	—	—	—	—
" " pole	. .	=hounded length	. . ×	·161	—	—	·200	—	—	—	—
Fore topg. mast hounded	. .	=breadth of vessel	. . ×	·340	·394	·481	·533	·500	—	—	·600
" " " pole.	. .	=hounded length	. . ×	·185	·111	·236	·312	·400	—	—	—
Main " " hounded	. .	=fore topg. mast hounded	×	—	—	—	—	—	—	—	1·067
Fore royal " "	. .	=breadth of vessel	. . ×	—	—	—	—	—	—	—	·367
" " " pole.	. .	=hounded length	. . ×	—	—	—	—	—	—	—	·235
Main " " hounded	. .	=fore royal mast hounded	×	—	—	—	—	—	—	—	1·117
" " " pole.	. .	=hounded length	. . ×	—	—	—	—	—	—	—	·211
Fore yard. Whole length.		=length of vessel	. . ×	·300	·265	·400	·310	·354	·380	—	·450
Yard arms, each		=yard	. . ×	·050	·065	·060	·060	·043	·061	—	·048

SPECIES OF MASTS AND SPARS				Screw Steam Vessels						Merchant Sailing Vessel. Brig-rigged
				Ironclads		Sloop of War, Schoon.-rigged	Merchant Vessels			
				3-masted Schooner	Schoon.-rigged		3-masted Schooner	Schoon.-rigged	Schoon.-rigged	Fore and Aft Schooner	
Main yard. Whole length	. .	=fore yard	. . ×	—	—	—	—	—	—	—	1·072
Yard arms, each	. .	=yard	. . ×	—	—	—	—	—	—	—	·045
Fore topsail yard. Whole length	.	=fore yard	. ×	·683	·647	·741	·754	·739	·585	*	·705
Yard arms, each		=yard	. . ×	·073	·076	·090	·092	·074	·083	—	·055
Main topsail yard. Whole length	.	=fore tops. yard	×	—	—	—	—	—	—	—	1·055
Yard arms, each		=yard	. . ×	—	—	—	—	—	—	—	·055
Main gaff topsail yard. Whole length		=main gaff	. ×	·690	·617	·412	·542	·667	·709	·702	—
Mizen " " "		=mizen gaff	. ×	·583	—	—	·574	—	—	—	—
Fore topgallant yard. Whole length		=fore tops. yard	×	·683	·683	·655	·661	·653	—	—	·705
Yard arms, each		=yard	. . ×	·063	·074	·078	·072	·071	—	—	·035
Main topgallant yard. Whole length		=fore topg. yard	×	—	—	—	—	—	—	—	1·040
Yard arms, each		=yard	. . ×	—	—	—	—	—	—	—	·035
Fore royal yard. Whole length	.	=fore topg. yard	×	—	—	—	—	—	—	—	·756
Yard arms, each	.	=yard	. . ×	—	—	—	—	—	—	—	·050
Main royal yard. Whole length	.	=fore royal yard	×	—	—	—	—	—	—	—	1·128
Yard arms, each	.	=yard	. . ×	—	—	—	—	—	—	—	·050
Fore gaff. Whole length	. .	=lgth. of vessel	×	·145	·121	·206	·152	·146	·231	·223	·317
Main " "	. .	=fore gaff	. ×	1·000	1·214	1·100	1·127	1·142	1·060	1·088	1·000
Mizen " "	. .	= " "	. . ×	·837	—	—	·871	—	—	—	—
Spanker boom. Whole length	. .	=mizen gaff	. ×	1·416	1·53	1·560	1·425	1·700	1·056	1·513	†
Bowsprit, exclusive of housing	. .	=lgth. of vessel	×	·080	·105	·187	·105	·100	·200	·191	·213
Jibboom " "	. .	= " jibb.	. ×	2·562	—	—	1·000	1·230	—	—	1·728
Distance of fore mast bef. rudder post		= " vessel	×	·705	·721	·760	·767	·711	·754	·750	·756
" main " "		= " "	×	·330	·298	·303	·433	·315	·317	·316	·345
" mizen " "		= " "	×	·115	—	—	·141	—	—	—	—

* Fore gaff topsail yard = fore gaff × ·647

† Main boom = main gaff × 1·523.

Table of Factors used to Determine the Diameters of Ships' Masts and Spars.

	Species of Masts and Spars	Given Diamr. = Whole Length ×	End Diameters = Given Diameter ×	
Lower masts	Ships', brigs', and barques'	·025 to ·028	heel	·833
			hounds	·800
			head	·735
	Cutters'	·020 „ ·021	heel	·833
			hounds	·750
			head	·500
	Schooners'	·020 „ ·022	heel	·833
			hounds	·800
			head	·670
	Luggers'	·020 „ ·021	heel	·933
			hounds	·750
			head	·583
Topmasts	Ships', brigs', and barques'	·023 „ ·025	hounds	·800
			head	·636
	Cutters' and schooners'	·020 „ ·022	hounds	·771
			head	·500
	Luggers'	·020 „ ·021	hounds	·771
			pole	·500
	Topgallant masts	·020 „ ·021	hounds	·771
			skysail pole	·500
Bowsprit	Ships', brigs', and barques'	·040 „ ·050	heel	·833
			head	·666
	Cutters' and schooners'	·040 „ ·050	heel	1·000
			head	·666
Yards	Lower yard	·020 „ ·025	yard arms*	·500
	Topsail yard	·017 „ ·020	„	·500
	Topgallant and royal yard	·017 „ ·018	„	·500
	Cross jack yard	·020 „ ·025	„	·500
	Cutters' and schooners' square sail	·014 „ ·017	„	·500
	Cutters' and schooners' topsail	·017 „ ·020	„	·500
	Luggers' yards	·018 „ ·023	„	·500
Booms	Driver boom	·017 „ ·020	outer end	·75
			inner „	·66
	Main and cutters' booms	·017 „ ·020	outer „	·75
			inner „	·71
	Jibboom	·020 „ ·025	outer „	·75
			inner „	1·00
	Flying jibboom	·017 „ ·020	outer „	·66
			inner „	·75
	Jib and flying jibboom in one	·022 „ ·026	outer „	·66
			inner „	·50
Gaffs	Ships' and brigs'	·018 „ ·022	outer end	·50
	Cutters' and schooners'	·018 „ ·022	„	·60
	Trysail gaffs	·030 „ ·040	„	·60

Note.—The factors in the above table will apply equally well whether the masts and spars are of wood or of iron.

Table of Position and Rake of Masts for Sailing Vessels.

Rig and Names of Masts		Distance from Middle of Water Line in Fractions of the Length of that Line		Rake in Twelve Feet
		Before	Abaft	Inches
Frigate	main mast	—	·062 to ·069	6 to 5
	fore „	·37 to ·39	—	2 to 1
	mizen „	—	·341 to ·404	10 to 9
Corvette	main „	—	·096 to ·06	6 to 10½
	fore „	·372 to ·399	—	2 to 1¾
	mizen „	—	·375 to ·356	10 to 10¾
Clipper ship	main „	—	·047	1
	fore „	·274	—	9
	mizen „	—	·309	15
Lugger	main „	—	·04	·12
	fore „	·396	—	·6
	mizen „	—	·396	·24
Barque	main „	—	·067	13
	fore „	·300	—	11
	mizen „	—	·349	17
3-masted schooner	main „	—	·033	27
	fore „	·295	—	24
	mizen „	—	·366	30
Common schooner	main „	—	·046	24
	fore „	·338	—	15
Bermuda schooner	main „	—	·108 to ·084	24 to 33
	fore „	·279 to ·31	—	16 to 36
Brig of war	main „	—	·147 to ·138	10 to 9
	fore „	·331 to ·323	—	3 to 2
Yacht as brig	main „	—	·144	10
	fore „	·323	—	2½
Ketch	main „	·11	—	12
	mizen „	—	·395	18
Revenue cutter	main „	·13 to ·104	—	14 to 13
Cutter yacht	main „	·112 to ·14	—	12 to 15

TABLE OF THE WEIGHT OF VESSELS, MASTS, SPARS, RIGGING, AND SAILS IN TONS.

Kind of Vessel	Sailing Ships				
Tonnage (B.M.)	2,600	2,200	1,700	1,400	1,000
Lower masts and bowsprit*	52·6	51·9	38·7	34·1	21·6
Topmasts and yards	37·1	36·0	27·5	26·5	18·6
Spare gear and booms	16·5	16·0	12·6	12·0	7·6
Standing rigging†	22·0	21·2	20·2	19·1	11·0
Running "	18·1	17·2	16·9	16·3	11·4
Blocks to "	12·2	11·1	10·6	10·0	5·4
Ship's sails	6·9	7·3	6·0	5·1	3·8
Spare "	4·2	4·4	3·7	3·4	2·3

Kind of Vessel	Sailing Ship	Brigs		Schooner	Cutter
Tonnage (B.M.)	500	380	230	180	160
Lower masts and bowsprit	9·1	7·5	4·3	6·4	5·5
Topmasts and yards	8·8	7·2	5·8	1·9	2·6
Spare gear and booms	4·1	3·0	2·2	1·2	—
Standing rigging†	9·4	3·8	2·4	1·9	1·7
Running "	6·5	4·5	2·8	1·4	1·3
Blocks to "	4·2	2·0	1·0	·3	·2
Ship's sails	2·1	1·5	1·2	1·3	1·8
Spare "	1·5	1·2	·85	·8	·25

* The masts and spars are all of wood. † Standing rigging of wire.

TABLE OF THE RELATIVE PROPORTIONS OF IRON AND HEMPEN CABLES, TOGETHER WITH THEIR WEIGHT.

Diamr. of Chain	Girth of Hemp	Weight of 100 Fathoms						Diamr. of Chain	Girth of Hemp	Weight of 100 Fathoms					
		Chain			Hemp					Chain			Hemp		
Ins.	Ins.	Cwt.	Qr.	Lb.	Cwt.	Qr.	Lb.	Ins.	Ins.	Cwt.	Qr.	Lb.	Cwt.	Qr.	Lb.
¾	7½	29	0	17	10	2	9	1½	15	110	0	14	43	0	1
	8				12	0	26		15½				45	3	27
	8½				13	3	16		16				48	3	24
⅞	9	39	1	21	15	2	25	1⅝	16½	136	2	10	51	3	2
	9½				17	0	22		17				55	1	0
1	10	50	0	14	19	0	21	1¾	17½	155	0	9	58	2	6
	10½				21	0	20		18				61	3	13
1⅛	11	65	3	5	23	1	0	1⅞	18½	180	3	14	65	2	1
	11½				25	0	15		19				69	0	17
	12				27	1	23		20				76	3	1
	12½				29	3	3	2	21	190	0	14	84	1	14
1¼	13	81	3	12	32	1	19		22				92	2	16
	13½				35	0	7	2⅛	23	216	0	0	101	2	8
1⅜	14	94	0	7	37	2	4		24				110	2	1
	14½				40	1	12		25				119	3	2

TABLE GIVING THE GIRTHS OF HEMP AND WIRE ROPE OF EQUIVALENT STRENGTHS.

Hemp (ins.)	Wire (ins.)	Hemp (ins.)	Wire (ins.)	Hemp (ins.)	Wire (ins.)	Hemp (ins.)	Wire (ins.)	Hemp (ins.)	Wire (ins.)	Hemp (ins.)	Wire (ins.)
12	4⅝	10¼	4⅛	8½	3⅜	6¾	2¾	5	2	3¼	1⅜
12½	—	10	4	8¼	3½	6½	2⅝	4¾	—	3	1¼
11¾	4½	9⅜	—	8	3⅜	6¼	2½	4½	1⅝	2⅞	1⅛
11½	—	9½	3⅞	7¾	3¼	6	2⅜	4¼	—	2½	1
11	4⅜	9¼	—	7½	3⅛	5¾	2¼	4	1⅜	2¼	⅞
10¾	—	9	3⅝	7¼	3	5½	2⅛	3¾	1⅜	2	¾
10½	4¼	8¾	—	7	2⅞	5¼	—	3½	1½	1¾	⅝

TABLE SHOWING FROM WHAT NUMBERS OF CANVAS THE DIFFERENT SAILS ARE MADE.

No. of Canvas	Species of Sails made of the given Number of Canvas
0	Courses, lower staysails, trysails.
1	Courses, lower staysails, trysails, awnings.
2	Courses, topsails, lower staysails, trysails, spankers, awnings.
3	Courses, topsails, spankers, jibs, lower and topmast staysails.
4	Topsails, topgallant sails, spankers, jibs, topmast staysails.
5	Topsails, lower and topmast studding sails, spankers, jibs, upper staysails, gaff topsails.
6	Topgallant sails, studding sails, jibs, flying jibs, upper staysails, gaff topsails, cutters' and schooners' crossjack sails and square topsails, sails of boats.
7	Topgallant sails, studding sails, flying jibs, royal staysails, cutters' and schooners' topsails, sails of boats.
8	Royals, skysails, topgallant and royal studding sails, cutters' and schooners' topgallant sails, sails of boats.

Note.—For the weight of the several numbers of canvas see p. 303.

WEIGHT OF SHIPS' RIGGING AND BLOCKS.

Weight of a ship's running rigging = weight of wire standing rigging ×
- sailing ships . 1·534
- barques . 1·632
- brigs . 1·719

Weight of a ship's blocks = weight of running rigging ×
- sailing ships . ·369
- barques . ·302
- brigs . ·254

Note.—The above constants must only be taken as rough approximations.

PROPORTIONS OF TRESTLE AND CROSS TREES IN SHIPS' TOPS.

Length of trestle-trees	= hounded length of topmast	× ·22
Breadth of ditto	= length	× ·11
Depth of ditto	= breadth	× ·67
Length of cross-trees	= hounded length of topmast	× ·31
Breadth of ditto	= breadth of trestle-trees	× 1·0
Depth of ditto	= breadth	× ·67
Length of lubber's hole	= length of trestle-trees	× ·41
Length of fid	= diameter of lower mast	× 1·50

TABLE SHOWING THE SIZES AND TOTAL WEIGHTS OF THE STANDING RIGGING OF SAILING VESSELS WHEN MADE OF MESSRS. R. S. NEWALL AND CO.'S PATENT IMPROVED WIRE ROPE, COMPARED WITH RIGGING MADE OF THE BEST HEMP ROPE.

	Species of Standing Rigging	Ship, 1,300 T. Girth (ins.) Hemp	Ship, 1,300 T. Girth (ins.) Wire	Ship, 1,150 T. Girth (ins.) Hemp	Ship, 1,150 T. Girth (ins.) Wire	Ship, 900 T. Girth (ins.) Hemp	Ship, 900 T. Girth (ins.) Wire	Ship, 750 T. Girth (ins.) Hemp	Ship, 750 T. Girth (ins.) Wire	Ship, 600 T. Girth (ins.) Hemp	Ship, 600 T. Girth (ins.) Wire	Ship, 500 T. Girth (ins.) Hemp	Ship, 500 T. Girth (ins.) Wire	Ship, 400 T. Girth (ins.) Hemp	Ship, 400 T. Girth (ins.) Wire	Bark, 300 T. Girth (ins.) Hemp	Bark, 300 T. Girth (ins.) Wire	Bark, 200 T. Girth (ins.) Hemp	Bark, 200 T. Girth (ins.) Wire	Brig, 270 T. Girth (ins.) Hemp	Brig, 270 T. Girth (ins.) Wire
Lower masts	Fore & main shrouds	10	4	9½	3½	9	3½	8½	3⅜	8	3⅜	7½	3⅛	7	2⅞	6¼	2⅞	6	2⅜	6½	2⅜
	Mizen shrouds	8	3⅜	7½	3⅛	7½	3	7	2⅞	6½	2¼	6¼	2⅜	5⅝	2¼	5½	2⅜	4½	1⅝	—	—
	Fore stays (double)	10	4	9½	3½	9	3½	8¼	3⅜	—	—	7½	3⅛	7½	3⅛	—	—	6	2⅜	6½	2⅜
	" (single)	—	—	—	—	—	—	—	—	8¼	3⅛	—	—	—	—	8¼	3⅛	—	—	—	—
	Main stays (double)	10	4	9½	3⅜	—	—	8¼	3⅜	—	—	7½	3⅛	7½	3⅛	—	—	—	—	—	—
	" (single)	—	—	—	—	13½	5⅛	—	—	8¼	3⅛	—	—	—	—	8½	3⅜	8	3⅜	8¼	3⅛
	Mizen stay (single)	8	3⅜	7½	3⅛	7½	3⅜	7½	3	7	2⅞	6⅝	2⅜	6½	2⅜	6	2⅜	5¼	2⅛	—	—
Topmasts	Fore & main shrouds	6½	2⅜	6	2⅜	5½	2⅛	5½	2⅛	5	2	4⅝	1⅞	4	1⅝	3⅜	1⅜	3¼	1⅜	3⅜	1⅜
	Mizen shrouds	5½	2⅛	5¼	2⅛	5	2	4½	1⅞	4	1⅝	4	1⅝	3⅜	1⅜	3	1⅜	3	1⅜	—	—
	Fore stays (double)	9	3⅜	8½	3⅜	8¼	3⅛	8	3⅜	7½	3⅛	7	2⅞	6½	2⅜	5½	2⅛	4½	1⅝	5¼	2⅛
	" (single)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Main stays (double)	9	3⅜	8½	3⅜	—	—	8	3⅜	—	—	—	—	—	—	—	—	—	—	—	—
	" (single)	—	—	—	—	8¼	3⅜	—	—	8	3⅜	8	3⅜	7½	3⅛	7	2⅞	6	2⅜	6	2⅜
	Mizen stay "	6½	2⅜	6¼	2⅜	6	2⅜	5½	2⅛	5	2	4⅝	1⅞	4	1⅝	3⅜	1⅜	—	—	5¼	2⅛
Royal Topgallant masts	Fore & main backstays	9	3⅜	8½	3⅜	8¼	3⅛	8	3⅜	7½	3⅛	7¼	3⅛	6¼	2⅜	6	2⅜	4½	1⅝	—	—
	Mizen backstays	7½	3⅛	7	2⅞	6½	2⅝	6¼	2⅜	6	2⅜	5½	2⅛	5	2	4	1⅝	—	—	3	1¼
	Fore & main shrouds	5	2	5	2	4½	1⅞	4½	1⅝	4	1⅝	3½	1⅜	3	1⅛	—	—	—	—	—	—
	Mizen shrouds	4	1⅝	4	1⅝	3½	1⅜	3½	1⅜	3	1¼	3	1¼	2⅝	1	—	—	—	—	—	—
	Fore & main stays	6	2⅜	5⅝	2¼	5½	2⅛	5	2	5	2	4½	1⅝	4	1⅝	4	1⅝	3½	1⅜	3½	1⅜
	Mizen stay	4½	1⅝	4½	1⅝	4	1⅝	4	1⅝	3½	1⅜	3½	1⅜	3	1⅛	3	1⅛	3½	1	—	—
	Fore & main backstays	6½	2⅜	6¼	2⅜	6	2⅜	5½	2¼	5	2	4½	1⅝	4	1⅝	4	1⅝	3½	1⅜	4	1⅝
	Mizen backstays	5½	2¼	5⅛	2⅛	5	2	5	2	4½	1⅝	4½	1⅝	4	1⅝	—	—	—	—	—	—
Sky masts	Fore & main stays	4½	1⅝	4	1⅝	4	1⅝	3½	1⅜	3	1⅛	3	1⅛	2½	1	—	—	—	—	2½	1
	Mizen stay	3½	1⅜	3½	1⅜	3½	1⅜	3	1⅛	3	1⅛	2½	1	2½	1	—	—	—	—	—	—
	Fore & main backstays	5	2	5	2	4½	1⅝	4½	1⅝	4½	1⅝	3½	1⅜	3½	1⅜	—	—	—	—	3	1⅛
	Mizen backstays	4	1⅜	4	1⅜	3½	1⅜	3½	1⅜	3½	1⅜	3	1⅛	3	1⅛	—	—	—	—	—	—
	Fore & main stays	3½	1⅜	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Mizen stay	3	1⅛	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Fore & main backstays	4	1⅜	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Mizen backstays	3½	1⅛	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Jib gear	Outer jib stay	8	3⅜	8	3⅜	7½	3⅛	7	2⅞	7	2⅞	6½	2⅜	6½	2⅜	6½	2⅜	5	2	5½	2⅛
	Inner "	—	—	8	3⅜	7½	3⅛	7	2⅞	6½	2⅜	—	—	—	—	—	—	—	—	—	—
	Flying "	6½	2⅜	6	2⅜	5½	2⅛	5½	2⅛	5½	2⅛	—	—	5	2	4½	1⅞	—	—	4½	1⅝
	Standing guys	9	3⅜	8½	3⅜	8	3⅜	8	3⅜	7	2⅞	6½	2⅜	6½	2⅜	5½	2⅛	5	2	5½	2⅛
	Flying "	6½	2⅜	6	2⅜	5½	2⅛	5½	2⅛	5	2⅛	—	—	5	2	4½	1⅝	—	—	4½	1⅝
Total wt. of hemp rigging		Cwt. 20	Qr.Lb. 0 15	Cwt. 18	Qr.Lb. 0 8	Cwt. 15	Qr.Lb. 2 24	Cwt. 13	Qr.Lb. 1 14	Cwt. 11	Qr.Lb. 0 16	Cwt. 9	Qr.Lb. 2 24	Cwt. 8	Qr.Lb. 0 27	Cwt. 6	Qr.Lb. 2 16	Cwt. 5	Qr.Lb. 0 16	Cwt. 5	Qr.Lb. 2 24
" wire "		10	0 15	9	0 8	7	3 1	6	0 24	5	2 0	4	1 8	3	2 21	2	3 0	2	1 16	2	3 21

TABLE SHOWING THE SIZES AND TOTAL WEIGHTS OF THE STANDING RIGGING OF SAILING VESSELS WHEN MADE OF MESSRS. R. S. NEWALL AND CO.'S PATENT IMPROVED WIRE ROPE, COMPARED WITH RIGGING MADE OF THE BEST HEMP ROPE.

	Species of Standing Rigging	3,000 Tons Girth (ins.) Hemp	3,000 Tons Girth (ins.) Wire	2,500 Tons Girth (ins.) Hemp	2,500 Tons Girth (ins.) Wire	2,000 Tons Girth (ins.) Hemp	2,000 Tons Girth (ins.) Wire	1,500 Tons Girth (ins.) Hemp	1,500 Tons Girth (ins.) Wire	1,200 Tons Girth (ins.) Hemp	1,200 Tons Girth (ins.) Wire	1,000 Tons Girth (ins.) Hemp	1,000 Tons Girth (ins.) Wire	800 Tons Girth (ins.) Hemp	800 Tons Girth (ins.) Wire	600 Tons Girth (ins.) Hemp	600 Tons Girth (ins.) Wire	350 Tons Girth (ins.) Hemp	350 Tons Girth (ins.) Wire	200 Tons Girth (ins.) Hemp	200 Tons Girth (ins.) Wire
Lower masts	Fore & main shrouds	10½	4½	10¼	4⅜	10	4⅜	10	4½	10	4	9	4	9	3⅝	8½	3⅜	6½	2⅝	6	2½
	Mizen shrouds	7	3½	7	3⅜	6½	3⅜	6½	3	6½	2⅝	6	2⅜	6	2⅜	5½	2⅜	4½	2½	4	2
	Fore&main stays(dbl.)	12½	5	12¼	4⅞	12	4⅝	11½	4½	11½	4½	9½	4	9½	3⅞	9	3⅝	6½	2½	6	2⅜
	Mizen stay (single)	7½	3½	7½	3⅜	7½	3⅜	7	3⅜	6½	2½	6½	2½	6½	2⅜	6	2⅜	5	2½	4½	2⅜
	Fore & main shrouds	6	2½	5½	2⅜	5½	2⅜	5½	2½	5½	2½	5	2⅛	5	2	4½	2	3½	1⅝	3½	1⅝
	Mizen shrouds	4½	2⅛	4½	2⅛	4½	2⅛	4½	2⅛	4	1⅝	4	1⅝	4	1⅝	3½	1⅝	3	1⅜	3	1⅜
	Fore & main stays (dbl.)	9½	4	9½	3⅞	9	3⅞	8½	3⅞	8½	3⅞	8½	3⅜	8	3⅜	7	3⅛	5½	2⅛	5	2⅛
	Mizen stay (single)	6½	3	6½	3	6	2⅞	6½	2⅞	6	2⅜	5½	2⅛	5½	2⅛	5	2⅛	4	2	4	2⅛
	Fore & main backstays	9½	4	9½	3⅞	9	3⅞	8½	3⅞	8½	3⅜	8	3⅜	7	3⅛	7	3⅛	6	2⅞	6	2⅞
	Mizen backstays	6½	3	6½	2⅞	6½	2⅞	6½	2⅝	6	2⅜	5½	2⅛	5½	2⅛	5	2⅛	4	2	4	2
Topmasts	Fore & main shrouds	4½	2½	4½	2⅛	4½	2⅛	4½	2⅛	4	1⅝	3½	1⅜	3½	1⅜	3	1⅜	2½	1⅛	2½	1⅛
	Mizen shrouds	4	2	4	2	4	2	4	2	3½	1⅜	3	1⅛	3	1⅛	2⅝	1⅛	2	1	2	1
	Fore & main stays	6	2½	5½	2⅜	5½	2⅜	5½	2½	5½	2⅛	5	2	4½	2	4	1⅞	3½	1⅝	3	1⅜
	Mizen stay	4½	2	4½	2	4½	2	4½	2	4	1⅝	3½	1⅜	3½	1⅜	3	1⅜	2½	1⅛	2½	1
	Fore & main backstays	6½	2½	6	2⅜	6	2⅜	5½	2½	5½	2⅛	5	2	4½	2	4	1⅞	3½	1⅝	3½	1⅜
	Mizen backstays	5½	2⅛	5½	2⅛	5½	2⅛	5	2	4½	1⅝	4½	1⅝	4	1⅝	3½	1⅝	3	1⅜	3	1⅜
Royal Topgallant masts	Fore & main shrouds	4½	2½	4½	2⅛	4½	2⅛	4½	2⅛	4	1⅝	3½	1⅜	3½	1⅜	3	1⅜	2½	1⅛	2½	1⅛
	Mizen shrouds	4	2	4	2	4	2	4	2	3½	1⅜	3½	1⅜	3½	1⅜	3	1⅜	2½	1⅛	2½	1
	Fore & main stays	5½	2½	5½	2⅜	5½	2⅜	5½	2⅜	5½	2⅛	5	2	4½	2	4	1⅞	3½	1⅝	3½	1⅜
	Mizen stay	4½	2	4½	2	4½	2	4½	2	4	1⅝	3½	1⅜	3½	1⅜	3	1⅜	2½	1⅛	2½	1
	Fore & main backstays	6½	2½	6	2⅜	6	2⅜	5½	2½	5½	2⅛	5	2	4½	2	4	1⅞	3½	1⅝	3½	1⅜
	Mizen backstays	5½	2⅛	5½	2⅛	5½	2⅛	5	2	4½	1⅝	4½	1⅝	4	1⅝	3½	1⅝	3	1⅜	3	1⅜
Jib gear	Standing jib stay	7½	3½	7½	3⅜	7	3⅜	7	3⅜	6½	2½	6	2⅜	6	2⅜	5½	2⅜	5	2½	5	2⅛
	Flying "	5	2⅜	5	2⅜	4½	2⅜	4½	2⅛	4½	2	4	1⅞	4	1⅝	3½	1⅝	3½	1⅝	3½	1⅝
	Standing guys	7½	3½	7½	3⅜	6½	3⅜	7	3⅜	6½	3	6	2⅞	6	2⅞	5½	2⅞	5	2⅜	5	2⅜
	Flying "	5	2½	5	2⅜	4½	2⅜	4½	2½	4½	2	4	1⅞	4	1⅝	3½	1⅝	3½	1⅝	3½	1⅝
	Martingale stay	7½	3½	7½	3½	7	3½	6½	3½	6½	2⅞	6	2⅞	6	2⅞	5½	2⅞	5	2⅜	4½	2½
	Martingale back-ropes	5½	2½	5½	2½	5	2½	5	2½	4½	2⅛	4½	2½	4½	2½	4	1⅝	3½	1⅝	3½	1⅝
	Bob- {3 of wire (single)	10½	4½	10½	4½	10	4	9½	3⅞	9½	3⅝	9	3⅜	8½	3⅜	8	3¼	—	3⅜	8	3¼
	stays {3 of hemp (double)																				
	Bowsprit shrouds	9½	4	9½	4⅛	9	3⅞	9	3⅜	8	3⅜	8	3⅜	7½	3⅛	7	3¼	7	3¼	5½	2⅜
Total wt. of hemp rigging		Cwt. 227	Qr.Lb. 2 7	Cwt. 206	Qr.Lb. 1 10	Cwt. 186	Qr.Lb. 0 25	Cwt. 172	Qr.Lb. 1 8	Cwt. 146	Qr.Lb. 0 12	Cwt. 131	Qr.Lb. 1 9	Cwt. 108	Qr.Lb. 0 14	Cwt. 81	Qr.Lb. 0 11	Cwt. 53	Qr.Lb. 3 12	Cwt. 44	Qr.Lb. 0 15½
" wire "		147	0 20	128	0 14	112	3 1	106	3 26	96	2 4	90	1 1	72	3 6	63	1 7	35	1 5	27	2 2

Wire rigging is now almost universally used for the standing rigging of ships, as its advantages over that of hemp are considerable, its *bulk* being about only *one-sixth* that of hemp, while the *weight* is reduced to nearly *one-half*; it does not stretch permanently under great strains, as hemp rigging does, and neither is it liable to those sudden alterations of length to which hemp is subject by change in the state of moisture of the atmosphere, and which give rise to inconvenience and great labour in setting up the rigging.

TABLE FOR SAILING SHIPS, SHOWING THE PROPORTIONS WHICH THE DIAMETER OF CHAIN RIGGING AND THE GIRTHS OF HEMP OR WIRE RIGGING SHOULD BEAR TO THE DIAMETERS OF THE MASTS, YARDS, &c. FROM WHICH THE RIGGING LEADS.*

PARTS OF RIGGING		Ratios
Fore and main masts	Pendant	·375
	Shrouds †	·168
	Stays †	·227
	Ratlines	·057
Fore and main yards	Foot-ropes	·281
	Stirrups	·187
	Lifts	·250
	Braces	·250
	Tacks	·312
	Sheets	·312
	Clew garnets	·218
	Bowlines	·250
	Bridles	·250
	Buntlines	·187
	Leechlines	·156
	Slabline	·125
	Fore staysail stay †	·149
	Halliards	·187
	Sheets	·187
	Tack lashing	·125
	Downhaul	·156
	Lower studding sail :—	
	Halliards	·187
	Inner halliards	·187
	Sheets and tack	·187
Fore and main topmasts	Shrouds †	·153
	Ratlines	·065
	Backstays	·186
	Burton pendants	·290
	Stays †	·186
	Futtock shrouds	·153
	Ratlines	·065
	Staysail halliards	·193
	Downhaul	·161
	Pendants	·290
	Sheets	·226
Fore and main topsail yards	Topsail tyes ‡	·050
	Halliards	·250
	Foot-ropes	·291
	Stirrups	·167
	Flemish horses	·208
Fore & main topsail yards (concld.)	Braces	·250
	Lifts	·291
	Parrel rope	·333
	Clewlines	·291
	Buntlines	·250
	Bowlines	·250
	Reef tackles	·250
	Sheets ‡	·050
	Studding-sail halliards	·291
	Sheets	·272
	Tacks	·291
	Downhaul	·167
	Boom jiggers	·167
	Heel lashing	·250
	Boom-brace pendant	·291
	Whip	·167
Fore and main topgallant masts	Shrouds †	·194
	Backstays †	·208
	Stay †	·194
	Royal stay †	·111
	Backstay †	·111
Fore & main topgallant yards	Halliards and strapping	·438
	Foot-ropes	·313
	Braces and strapping	·250
	Lifts	·375
	Parrel ropes	·250
	Clewlines	·250
	Bowlines	·250
	Bridles	·250
	Sheets	·438
	Studding-sail halliards	·313
	Sheets	·250
	Tacks	·250
	Downhaul	·188
Fore and main royal yards	Halliards	·417
	Foot-ropes	·167
	Braces and strapping	·333
	Lifts	·167
	Parrel lashing	·167
	Clewlines & bowlines	·167
	Sheets	·375

* All the rigging is of hemp, except that marked otherwise.
† Wire-rope rigging. ‡ Chain rigging.

TABLE FOR SAILING SHIPS, SHOWING THE PROPORTIONS OF CHAIN AND HEMP AND WIRE-ROPE RIGGING IN RELATION TO THE MASTS AND SPARS (concluded).*

PARTS OF RIGGING		Ratios
Mizen topmast	Shrouds †	·146
	Burton pendants	·250
	Ratlines	·069
	Stay †	·174
	Seizings †	·027
Jack yard	Foot-ropes	·231
	Stirrups	·200
	Lifts	·200
	Braces & strapping	·200
Mizen topmast	Shrouds †	·167
	Stay †	·167
	Ratlines	·056
	Backstays †	·156
	Futtock shrouds †	·156
	Topsail tyes ‡	·050
	Halliards for do.	·274
	Foot-ropes	·211
	Stirrups	·274
	Flemish horses	·211
	Parrel rope	·316
	Lifts	·316
	Braces	·274
	Sheets ‡	·050
	Clewlines	·211
	Buntlines	·211
	Span	·211
	Bowlines	·211
	Bridles	·211
	Reef tackles	·237
Topgallant mast	Shrouds †	·179
	Backstays †	·179
	Stay †	·179
	Royal stay †	·144
	Backstays †	·144
	Foot-ropes	·231
	Parrel lashing	·231
	Lifts	·308
	Halliards	·346
	Sheets	·308
	Clewlines	·231
	Bowlines	·231
	Bridles	·231
	Strapping, ¼-blocks	·308
Mizen royal yard	Foot-ropes	·200
	Braces and strapping	·200
	Parrel lashing	·100
	Lifts	·300
	Halliards	·400
	Sheets	·200
	Clewlines	·200
Spanker boom	Topping lifts	·450
	Falls and strapping	·300
	Boom sheet	·350
	Outhauler	·350
	Guy pendants	·350
	Falls	·250
	Strapping to do.	·250
Gaff	Throat halliards	·400
	Peak halliards	·400
	Vang pendants	·350
	Falls and strapping	·200
	Peak brails	·200
	Throat brails	·250
	Middle brails	·200
	Hook brails	·200
Bowsprit	Gammoning ‡	·028
	Shrouds ‡	·028
	Bobstays ‡	·033
	Man-ropes	·150
Jibboom	Jibstay †	·152
	Guys, single †	·143
	Foot-ropes	·214
	Martingale stay †	·205
	Martingale backropes †	·134
	Halliards	·232
	Downhaul	·214
	Sheets	·178
	Pendants	·321
Flying jibboom	Flying jib stay †	·150
	Guys †	·125
	Foot-ropes	·250
	Martingale stay †	·175
	Halliards and strapping	·250
	Downhaal and strapping	·200
	Sheets	·250
	Heel lashing	·150

* All the rigging is of hemp, except that marked otherwise.
† Wire-rope rigging. ‡ Chain rigging.

Note.—Girth of any lanyard = girth of rope set up by it × 5.

TABLE OF THE DIMENSIONS OF SHIPS' BLOCKS (in Inches).

Common Single-thick Blocks.

Length of Block	Breadth of Block	Thickness of Block	Length of Mortice	Diameter of Sheave	Thickness of Sheave	Size of Pin-hole
3	2¼	1½	2¼	1½	⅜	7/16
4	3¼	2	3¼	2⅓	½	⅝
5	4	2⅔	3⅔	3¼	⅝	⅝
6	4¾	2⅞	4⅓	3¾	¾	9/16
7	5⅝	3¼	5¼	4½	⅞	9/16
8	6¼	3⅝	6¼	5	1	11/16
9	7	4⅛	7¼	5¾	1⅛	¾
10	7¾	4½	7⅞	6½	1¼	¾
11	8½	5	8½	7	1⅜	⅞
12	9¼	5¼	9¼	7¾	1½	1
13	10¼	5¾	10	8¼	1⅝	1
14	10¾	6	10⅞	9	1¾	1⅛
15	11¼	6½	11⅜	9½	1⅞	1⅛
16	12¼	7	12⅜	10	2	1¼

Common Single-thin Blocks.

8	6¾	3¾	6¾	5⅜	⅞	9/16
9	7½	3¾	7⅜	6	1	¾
10	8¼	4⅛	8	6¾	1⅛	¾
11	9	4¼	8¾	7⅛	1⅛	¾
12	9¾	4¾	9⅜	8¼	1¼	⅞
13	10¾	5	10⅜	9	1¼	⅞
14	11¼	5¼	11¼	9¾	1⅜	1
15	12	5½	12	10⅜	1⅜	1⅛
16	12¾	5¾	12⅜	11¼	1⅜	1⅛
17	13⅓	6	13¾	12	1⅜	1⅛
18	14¼	6	14⅓	12¾	1⅜	1⅛

Clump Blocks.

5	3½	2⅞	3⅜	2⅜	⅞	9/16
6	4¼	3½	4⅛	3⅜	1	¾
7	4⅞	4	5¼	4	1⅛	¾
8	5½	5	6	4½	1⅛	⅞
9	6½	5⅛	6⅛	4⅞	1⅜	⅞
10	7	5¾	7⅜	5¼	2	1
11	7¼	6	7⅞	5¾	2¼	1
12	8	6¾	8¼	6½	2½	1¼

Clewline Blocks.

5	4¾	4⅛	—	2½	¾	½	8	7¾	7	—	4	1¼	¾
	6	5½	—	3⅜	1		10	9½	8	—	4¾	1½	1
7	6¾	6⅜	—	3⅞	1⅛	¾	11	10½	9	—	5¼	1⅝	1

TABLE OF THE DIMENSIONS OF SHIPS' BLOCKS (in Inches)—continued.

Double-thick Blocks.

Length of Block	Breadth of Block	Thickness of Block	Length of Mortice	Thickness of Partition	Diameter of Sheave	Thickness of Sheave	Size of Pin-hole
3	2½	2⅜	2½	⅜	1¾	⅜	7/16
4	3¼	3	3⅜	½	2½	½	⅝
5	4	3⅝	4⅛	⅝	3¼	⅝	⅝
6	4⅞	4¼	4¾	¾	3¾	¾	9/16
7	5½	5	5⅝	⅞	4½	⅞	9/16
8	6¼	5⅞	6¼	1	5	1	11/16
9	7	6⅝	7	1⅛	5⅝	1⅛	¾
10	7¾	7	7¾	1⅛	6½	1¼	¾
11	8½	7¾	8½	1¼	7	1⅜	⅞
12	9¼	8¼	9¼	1⅜	7¾	1½	1
13	10	9	10	1½	8¼	1⅝	1
14	10¾	9½	10¾	1½	9	1¾	1⅛
15	11½	10⅛	11½	1⅝	9½	1⅞	1⅛
16	12½	11	12¼	1¾	10	2	1¼
17	13	11¾	13	1⅞	10½	2⅛	1⅜
18	13¾	12¾	13¾	1⅞	11¼	2¼	1⅜
19	14¼	13¼	14¼	2	12	2⅜	1½
20	15¼	13⅞	15¼	2⅛	12½	2½	1½
21	16	14¼	16	2¼	13	2⅝	1⅝
22	16¾	15	16¾	2¼	14	2⅞	1⅝
23	17½	15⅞	17½	2⅜	14½	2⅞	1⅝
24	18¼	16	18¼	2½	15	3	1¾
25	19	16¾	19	2½	15¾	3⅛	1⅞
26	19¾	17	19¾	2⅝	16¼	3¼	2
27	20½	17½	20½	2⅝	17	3⅜	2
28	21¼	18	21¼	2⅞	17¾	3½	2⅛
29	22	18½	22	2⅞	18¼	3⅝	2⅛
30	22¾	19	22¾	2⅞	19	3¾	2⅛

Double-thin Blocks.

9	6¾	5¼	6⅜	⅞	5⅜	⅜	9/16
10	7½	6	7⅛	1	6	1	¾
11	8¼	6⅝	8	1⅛	6¾	1⅛	¾
12	9	6¾	8⅝	1⅛	7½	1⅜	⅞
13	9¾	7	9⅜	1⅜	8¼	1⅜	⅞
14	10¾	7¼	9⅞	1⅜	9	1½	1
15	11¼	8	11¼	1⅜	10½	1⅝	1
16	12	8¼	12	1½	10½	1⅝	1⅛
17	12¾	8¾	12¾	1⅝	11¼	1⅝	1⅛
18	13¼	9¼	13¼	1⅝	12	1⅝	1⅛
19	15	6¼	15	1⅞	13½	1¾	1¼
20	15¾	6¾	15¾	1⅞	13¾	1⅞	1¼
21	16½	7¼	16½	2	14½	1⅞	1¼
22	17¼	7¾	17	2	15	1⅞	1¼
23	18	8¼	17½	2⅛	15¾	1⅞	1¼
24	18¾	8¾	18¼	2⅛	16¼	1⅞	1¼
25	19½	9¼	19	2⅛	17	1⅞	1¼
26	20¼	7	20½	1⅝	18	1⅞	1¼
27	21	7¼	21½	1⅝	19¼	1⅞	1¼
28	21¾	7	22¼	1⅝	20¼	1⅞	1¼

Treble-thick Blocks.

3	2½	3⅛	2½	⅜	1⅞	⅜	7/16
4	3¼	4	3⅜	½	2½	½	⅝
5	4	5	3⅝	⅝	3¼	⅝	⅝
6	4⅝	6	4¼	¾	3¾	¾	9/16
7	5½	7	5⅛	⅞	4½	⅞	9/16
8	6¼	7⅞	6¼	1	5	1	11/16
9	7	8¾	7	1⅛	5⅝	1⅛	¾
10	7¾	9¾	7¾	1⅛	6½	1¼	¾
11	8½	10¾	8¼	1¼	7	1⅜	⅞
12	9¼	11¾	9¼	1⅜	7¾	1½	1
13	10	12	10	1½	8¼	1⅝	1
14	10¾	13	10¾	1½	9	1¾	1⅛
15	11½	13¾	11¼	1⅝	9½	1⅞	1⅛
16	12½	14¾	12⅜	1¾	10	2	1¼
17	13	15¼	13	1⅞	10½	2⅛	1⅜
18	13¾	16¼	13¾	1⅞	11¼	2¼	1⅜
19	14¼	17¼	14¼	2	12	2⅜	1½
20	15¼	18¾	15¼	2⅛	12½	2½	1½
21	16	19¾	16	2¼	13	2⅝	1⅝
22	16¾	20¼	16¾	2¼	14	2¾	1⅝
23	17½	21	17½	2⅜	14½	2⅞	1⅝
24	18¼	21¾	18	2½	15	3	1¾
25	19	22¼	19	2½	15¾	3⅛	1⅞
26	19¾	23	19¾	2⅝	16¼	3¼	2
27	20½	23¾	20½	2⅝	17	3⅜	2
28	21¼	24	21¼	2⅞	17¾	3½	2⅛
29	22	24¾	22	2⅞	18¼	3⅝	2⅛
30	22¾	25	22¾	2⅞	19	3¾	2⅛

TABLE OF THE DIMENSIONS OF SHIPS' BLOCKS (in Inches)—continued.

Long-tackle Blocks.

Length of Block	Breadth of Upper Block	Breadth of Lower Block	Thickness of Block	Diameter of Upper Sheave	Diameter of Lower Sheave	Thickness of Sheaves	Length of Upper Mortice	Length of Lower Mortice	Thickness of Mortice	Size of Pin-hole
10	4 1/2	3 1/2	3	3 7/8	2 3/4	1/2	4 3/4	3	1	1/2
11	5 1/4	3 3/4	3 1/4	4 1/2	3	1/2	5 1/4	3 1/2	1	1/2
12	5 1/2	3 3/4	3 1/4	4 7/8	3	1/2	5 1/2	4	1	1/2
13	6 1/4	5	3 1/2	5	3 1/2	1/2	6 1/2	4 1/2	1	1/2
14	6	5 1/4	3 1/2	5 1/8	4	1/2	6 1/2	5	1	1/2
15	7	5 1/2	3 3/4	5 3/8	4 1/8	1/2	7 1/2	5 1/4	1 1/4	1/2
16	7 1/4	6	4	6 1/4	4 1/4	1/2	7 1/2	5 1/2	1 1/4	1/2
17	8 1/4	6 1/4	4	6 1/2	4 1/2	1/2	7 3/4	5 3/4	1 1/4	1/2
18	8 1/4	6 1/2	4	7 1/8	4 5/8	1/2	8 1/2	5 3/4	1 1/4	1/2
19	—	—	—	7 3/8	5	1/2	—	—	—	1/2
20	—	—	—	8	5 1/4	1/2	—	—	—	1/2
21	—	—	—	8 3/4	5 3/4	1/2	—	—	—	1/2
22	—	—	—	9	6 1/4	1/2	—	—	—	1/2
23	—	—	—	9 1/2	6 1/2	1/2	—	—	—	1/2
24	—	—	—	10 1/4	6 3/4	1/2	—	—	—	1/2
25	—	—	—	10 3/4	7	1/2	—	—	—	1/2
26	—	—	—	11	7 1/4	1/2	—	—	—	1/2
27	13 1/4	9 1/2	5 1/4	11 1/2	7 1/2	1/2	12 3/4	9 1/4	1 1/2	1/2
28	13 1/2	9 3/4	5 1/4	11 3/4	8 1/4	1/2	13 1/4	9 3/4	1 1/2	1/2
29	—	—	—	12 1/4	8 1/4	1/2	—	—	—	1/2
30	—	—	—	12 1/2	8 1/2	1/2	—	—	—	1/2

Topsail-sheet Blocks.

Length of Block	Breadth of Block	Thickness of Block	Length of Mortice	Diameter of Sheave	Thickness of Sheave	Size of Pin-hole	Length of Block	Breadth of Block	Thickness of Block	Length of Mortice	Diameter of Sheave	Thickness of Sheave	Size of Pin-hole
6	4 1/2	2 1/2	4	3 3/4	1/2	1/4	13	10	6 1/2	10 1/4	8 1/4	1 1/2	1/4
7	5 1/4	3	5	4 1/4	1/2	1/4	14	10 1/2	6 1/2	10 1/4	8 1/2	2	1/4
8	6 1/4	3 1/4	6	5	1	1/4	15	11	7 1/4	11	9	2 1/2	1/4
9	7	4	7	5 1/4	1 1/2	1/4	16	12 1/4	7 1/2	11	9 1/4	2 1/2	1/4
10	7 3/4	4 1/4	7 3/4	6 1/4	1 1/2	1/4	17	13	7 1/2	12	10	2 1/2	1/4
11	8 1/4	5	8	6 1/2	1 1/2	1/4	18	13 3/4	8	12	10	2 1/2	1/4
12	9 1/4	5 1/4	9	7 1/4	1 1/2	1/4	—	—	8 1/2	13	10 1/4	2 1/2	1/4

Nine-pin Blocks.

Length of Block	Breadth of Block	Thickness of Block	Length of Mortice	Diameter of Sheave	Thickness of Sheave	Length of Pin	Length of Block	Breadth of Block	Thickness of Block	Length of Mortice	Diameter of Sheave	Thickness of Sheave	Length of Pin
8	5 1/2	4	6 1/4	4 1/4	1 1/2	5 1/4	11	6 7/8	5	8 1/4	6	1 1/2	6
9	5 1/4	4 1/2	6 3/4	4 1/4	1 1/2	5 1/4	12	7 3/4	5 1/4	9 1/2	6 1/4	1 1/2	7
10	6 1/4	4 1/2	7 3/4	5 1/4	1 1/2	5 3/4							

TABLE OF THE DIMENSIONS OF SHIPS' BLOCKS (in Inches)—continued.

Snatch Blocks.

Length of Block	Breadth of Block	Thickness of Block	Length of Mortice	Thickness of Mortice	Diameter of Sheave	Thickness of Sheave	Size of Pin-hole	Length of Block	Breadth of Block	Thickness of Block	Length of Mortice	Thickness of Mortice	Diameter of Sheave	Thickness of Sheave	Size of Pin-hole
7	3	3 1/4	5	1	3 1/2	1	7/8	17	9 1/4	7 1/2	11	2 5/8	7 1/2	2 5/8	1 1/2
8	4 1/2	3	5 1/2	1 1/2	3 1/2	1 1/4	1	18	10	7 1/2	11 1/2	2 3/4	7 1/2	2 3/4	1 1/2
9	4 1/2	4 1/2	5 1/2	1 1/4	3 1/2	1 1/4	1	19	10 1/2	8	12 1/2	2 3/4	8 1/2	2 3/4	1 1/2
10	5 1/4	4 1/2	6 1/4	1 1/2	4	1 1/4	1	20	11	8 1/2	13	2 3/4	8 1/2	2 3/4	1 1/2
11	5 1/2	5	6 1/2	1 1/2	4 1/2	1 1/2	1	21	11 1/2	9	14	2 3/4	9 1/2	2 3/4	1 1/2
12	6 3/4	5 1/4	7 1/4	1 1/2	5 1/4	1 1/2	1	22	12	9 1/4	14 1/2	3	10	2 3/4	1 1/2
13	7 1/4	5 3/4	8 1/4	1 3/4	5 1/2	1 1/2	1	23	12 1/2	9 3/4	15 1/2	3 1/4	10 1/2	2 7/8	1 1/2
14	7	6 1/4	9	2	6 1/4	1 3/4	1 1/4	24	13	10	16	3 1/4	11	3	1 1/2
15	8	6 1/4	9 3/4	2 1/4	6 1/2	1 3/4	1 1/4	25	13 1/2	10 3/4	16 3/4	3 1/2	11 3/4	3 1/8	2
16	8 1/2	7	10 1/2	2 1/4	7	2	1 1/4	26	14	11 1/4	17 1/2	3 1/2	12 1/4	3 1/4	2

Single-sister Blocks.

Length of Block	Diameter of Block	Diameter of Sheave	Thickness of Sheave	Size of Pin-hole	Length of Block	Diameter of Block	Diameter of Sheave	Thickness of Sheave	Size of Pin-hole	Length of Block	Diameter of Block	Diameter of Sheave	Thickness of Sheave	Size of Pin-hole
5	3 1/2	2	1/2	1/4	7	4	3	1	1/2	9	4 3/4	4	1 1/2	3/4
6	3 1/2	2 1/2	1/2	1/4	8	4 1/2	3 1/2	1 1/2	1/2					

Double-sister Blocks.

Length of Block	Diameter of Block	Diameter of Sheave	Thickness of Sheave	Size of Pin-hole	Length of Block	Diameter of Block	Diameter of Sheave	Thickness of Sheave	Size of Pin-hole	Length of Block	Diameter of Block	Diameter of Sheave	Thickness of Sheave	Size of Pin-hole
10	3 1/2	2 3/4		1/4	17	4 7/8	4 1/4	1 1/4	1/2	22	6	5 1/8	1 1/2	1
11	3 3/4	2 3/4		1/4	18	5 1/8	4 1/4	1 1/4	1/2					
12	3 3/4	3		1/4	19	5 1/4	4 1/4	1 1/4	1/2					
13	3 3/4	3 1/4	1	1/4	20	5 3/8	4 1/2	1 1/4	1/2					
14	3 3/4	3 3/4	1	1/4	21	5 1/2	5	1 1/2	1/2					
15	4	3 3/4	1 1/4	1/4	22	6	5 1/8	1 1/2	1/2					
16	4 3/8	3 3/4	1 1/4	1/4										

Trucks.

Diameter of Truck .	5	6	7	8	9	10	11	12	13
Thickness of Truck .	1 3/4	1 3/4	1 3/4	2	2 1/4	2 1/2	2 1/2	2 3/4	3 1/4
No. of Sheaves . .	3	3	3	3	3	3	3	Double 3	Double 3

TABLE OF THE DIMENSIONS OF SHIPS' BLOCKS (in Inches)—concluded.

Dead-eyes.

Length	Breadth	Thickness	Length	Breadth	Thickness	Length	Breadth	Thickness	Length	Breadth	Thickness
5	5	3	9	9	5½	13	13	8	17	17	10
6	6	4	10	10	6½	14	14	8½	18	18	10½
7	7	4½	11	11	7	15	15	9	19	19	11
8	8	5	12	12	7½	16	16	9½	—	—	—

Closed Hearts.

Length	Breadth	Thickness	Gouging	Length	Breadth	Thickness	Gouging	Length	Breadth	Thickness	Gouging	Length	Breadth	Thickness	Gouging
5	4⅛	3⅛	1⅜	9	7⅞	5	2	13	10⅛	7	2⅞	17	13⅛	9¼	3¼
6	4⅜	3½	1½	10	8	5⅜	2	14	11⅛	7½	2¾	18	14½	9¾	3½
7	5¾	4	1⅝	11	8⅛	6¼	2⅛	15	11¾	8	3	—	—	—	—
8	7	4½	1⅞	12	9⅛	6½	2¼	16	12½	8¼	3⅛	—	—	—	—

Open Hearts.

Length	Breadth	Thickness	Gouging	Length	Breadth	Thickness	Gouging	Length	Breadth	Thickness	Gouging	Length	Breadth	Thickness	Gouging
5	4⅜	3¾	¾	9	8⅛	6¼	1⅛	13	12	8	1½	17	15⅜	9¼	2
6	5⅛	4¼	1	10	9⅛	6½	1⅛	14	13¼	8⅛	1⅛	18	16⅜	10½	2⅛
7	6¾	5⅛	1	11	9¾	7	1⅜	15	14¼	8¾	1⅜	—	—	—	—
8	7¼	5¾	1¼	12	11	7½	1⅜	16	14⅜	9	1⅜	—	—	—	—

TABLE OF THE VALUE OF THE BELGIAN GAUGE IN DECIMALS OF AN INCH.

Mark	Size	Mark	Size	Mark	Size	Mark	Size	Mark	Size
1	·004	7	·015	13	·034	19	·067	25	·111
2	·006	8	·017	14	·037	20	·074	26	·120
3	·008	9	·019	15	·041	21	·082	—	—
4	·009	10	·022	16	·045	22	·089	—	—
5	·011	11	·026	17	·052	23	·097	—	—
6	·013	12	·030	18	·059	24	·104	—	—

VOCABULARY OF TECHNICAL TERMS USED IN SHIPBUILDING.

ENGLISH—FRENCH.

Abaft, en arrière
Aboard, à bord
Admiral, amiral
Admiralty, amirauté
Afire, herminette
Afloat, à flot
Aft, arrière, de l'arrière
Air pump, pompe à air
Alee, sous le vent
Amidships, au milieu du navire
Anchor, ancre
Angle iron, cornière, fer d'angle
Apron, radier, contre-étrave, platine
Ash, frêne
Astern, à l'arrière, de l'arrière
Athwart, par le travers
Awning, tente
Azimuth compass, compas de variation
Back of stern-post, contre-étambot
Backstay, galhauban
Barge, grand canot, allège
Bar iron, fer en barres
Barque, barque, bateau
Barrel of the capstan, mèche du cabestan
Barrel of the steering wheel, tambour de la roue du gouvernail
Batten, liteau
Beam, bau
Beech, hêtre
Bending press, machine à cintrer les tôles
Between-decks, entrepont
Bevel, angle oblique, angle d'équerrage
Bilge, petit fond d'un navire
Bilge pump, pompe de cale
Bilge ways, coittes
Binnacle, habitacle
Bitts, bittes
Blade of a screw, aile d'hélice
Blister steel, acier poule
Block, poulie, mouffle
Block and fall, palan
Boarding pike, pique d'abordage
Boat, bateau, canot
Boatswain, maître d'équipage
Bobstay, sous-barbe
Body plan, plan vertical
Boiler maker, chaudronnier
Boiler plate, tôle
Bollard, corps mort
Bolt, cheville, boulon
Bolt rope, ralingue
Boom, bout dehors, arc-boutant
Bow, l'avant d'un vaisseau
Bower-anchor, ancre du bossoir
Bowsprit, beaupré
Brace, bras
Bracket, courbaton
Brail, cargue
Bread room, soute au pain
Breadth extreme, plus grande largeur
Breaker, brisant, baril de galère
Breast-plate, conscience
Brig, brig
Brigantine, brigantin
Bucket, baille
Builder, constructeur
Bulk head, cloison
Bunker, soute
Bunt-line, cargue-fond
Buoy, bouée, balise
Buoyant, léger, émergé
Burton, petit palan
Butt, about, tête d'un couple
Butt cover, plaque de jonction d'écart de tôle
Cabin, cabine, chambre, lit
Cable, câble
Cable tier, fosse aux câbles

TABLE OF THE STRENGTH OF LONG COLUMNS WHOSE LENGTH EXCEEDS THIRTY TIMES THEIR DIAMETER.

W = breaking weight in tons. L = length in feet. D = external diameter in inches. d = internal diameter in inches.

Kind of Column	Both Ends Rounded	Both Ends Flat
Hollow cast-iron cylindrical pillars	$W = 13\frac{D^{3\cdot76} - d^{3\cdot76}}{L^{1\cdot7}}$	$W = 44\cdot34\frac{D^{3\cdot76} - d^{3\cdot76}}{L^{1\cdot7}}$
Solid cast-iron cylindrical pillars	$W = 14\cdot9\frac{D^{3\cdot76}}{L^{1\cdot7}}$	$W = 44\cdot16\frac{D^{3\cdot76}}{L^{1\cdot7}}$
Solid wrought-iron cylindrical pillars	$W = 42\cdot8\frac{D^{3\cdot76}}{L^2}$	$W = 123\cdot75\frac{D^{3\cdot76}}{L^2}$
Solid square pillars of dry deal		$W = 7\cdot81\frac{D^4}{L^2}$
Solid square pillars of dry Dantzic oak	—	$W = 10\cdot95\frac{D^4}{L^2}$

STRENGTH OF SHORT COLUMNS.

W = breaking weight of long column of same diameter.

w = breaking weight of short column.

C = crushing force of materials in tons × sectional area of column.

$$w = \frac{WC}{W + \frac{3}{4}C}$$

RIVETED JOINTS.

t = thickness of plate in inches.

d = diameter of rivet in inches.

p = pitch or distance from centre to centre of rivet.

n = number of rows of rivets.

$$p = d + \frac{\cdot7854d^2}{t}$$

$$n = \frac{(p - d)t}{\cdot7854d^2}$$

Note.—Each plate is weakened by the rivet holes in the ratio

$$\frac{p - d}{p} = \frac{\cdot7854nd}{t + \cdot7854nd}$$

TABLE OF DIMENSIONS OF RIVETS GENERALLY USED.

Thickness of Plates in Inches	Diameter of Rivets in Inches: Lloyds	Liverpool Registry	Admiralty	London: Diameter of Rivets in Inches	London: Length Countersunk in Inches	London: Length Snap Points in Inches
5/16	5/8	1/2	1/2	5/8	1 1/8	1 1/2
3/8	5/8	5/8	5/8	5/8	1 1/4	1 5/8
7/16	5/8	5/8	3/4	5/8	1 3/8	1 3/4
1/2	3/4	12/16	3/4	3/4	1 1/2	2
9/16	3/4	12/16	7/8	3/4	1 11/16	2 3/16
5/8	3/4	12/16	7/8	7/8	1 15/16	2 3/8
11/16	7/8	7/8	7/8	7/8	2 3/16	2 5/8
3/4	7/8	7/8	1	7/8	2 3/8	2 3/4
13/16	7/8	15/16	1	7/8	2 1/2	2 7/8
7/8	1	1	1 1/8	1	2 5/8	3
15/16	1	1 1/16	1 1/8	1	2 3/4	3 1/8
1	1	1 1/8	1 1/8	1	2 7/8	3 1/4

Note.—Lloyds require a spacing of 4½ diameters.
Liverpool Registry require a spacing of 4 diameters.
Admiralty require a spacing of 4½ to 5 diameters in edges and butts of bottom plating and bulkhead plating, and 5 to 6 diameters in water-tight work elsewhere.
Veritas require a spacing of 4 diameters for single-riveting and 4½ diameters for double-riveting.

NOTES ON RIVETED JOINTS.

1. A closer pitch of rivets should be adopted in single- than in double-riveted butts and in double- than in treble-riveted butts.
2. With a 4-diameter pitch the efficiency of a single-riveted butt is very small.
3. With a 4-diameter pitch the strength of a double-riveted butt is about at the maximum when the plates are not more than ½ in. thick.
4. When plates are more than ¾ in. thick larger rivets should be put in than those generally in use.

BUTT STRAPS.

FIG. 153.

In joints of the character shown in the diagram the strength of the plates joined is only weakened to the extent caused by cutting away a width equal to the diameter of one rivet.