THESIS

AN INVESTIGATION OF THE STRENGTH OF A WOODEN SCHOONER

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The ship chosen for this investigation was the five-masted schooner John B.Prescott,built at Camden,Maine,in 1898. The general dimensions of the Prescott are:

Length over all . . . . 320 feet
Length on water line (23 feet draft). . . 290 feet
Beam . . . . 42 feet
Displacement at 23 feet draft. . . . . . . 5792 tons

A body-plan (Plate I) was obtained by taking offsets from a model of the schooner,and fairing them by the method of differences. From this body-plan and a drawing of the midship section, showing the location and dimensions of the structural members, the hull weight per foot of length was determined for the various sections,as shown in the following table:

Section	Frame	Keel and Keelson	Planking	Decks	Straps, Rail, etc.	Total per frame space	Total per foot of length	Same (tons)
1	5800	900	5472	2258	1080	15510	5170	2.31
2	8700	3407	9728	4666	1080	27581	9193	4.10
4	10600	3407	11476	6246	1080	32809	10937	4.88
7-8-9	10640	3407	11652	8152	1080	34931	11644	5.20
13	9000	3407	10200	8152	1080	31839	10613	4.74
15	8000	3407	9272	7646	1080	29405	9802	4.38
16	7700	3407	8962	6835	1080	27984	9328	4.16
17	4000	2177	2280	2688	578	11723	3908	1.74

The specific weights of woods were taken as:

Yellow pine	38	lbs per cubic foot
Hackmatack	37	" " " "
Oak	50	" " " "

The concentrated weights were obtained from a sail-plan, showing the location and dimensions of masts,spars,deck-houses,etc.

The following table gives the concentrated weights:

Jigger mast,topmast,spars,sails and rigging	8 tons
Other masts, " " " " "	7 "
Bowsprit,jibboom and headsails	4.2 "
Rudder,rudder-post,etc.	2.5 "
Forward deckhouse,hoisting engine,etc.	32. "
After house	16. "
House amidships	7. "

Plate II shows the curve of hull weight and the curve of buoyancy,obtained by reducing to tons the areas of transverse sections of the ship in quiet water. The curve of total weights was obtained by adding 4273. tons of cargo to the hull weight, thus making the area under the curve of total weights equal to that under the curve of buoyancy.

The difference of the ordinates of the curves of buoyancy and weight at any point gives the ordinate of the curve of loads at that point. The loads are taken as positive at points where the weight exceeds the buoyancy,and at such points the curve of loads is laid off above the base line.

The sum of the loads up to any point represents the shearing force at that point. Hence by running the mechanical integraph over the curve of loads,the curve of shearing forces was obtained. Similarly,the integral of the curve of shearing forces up to any point represents the bending moment at that point. By running the integraph over the curve of shearing forces,the curve of bending moments was obtained.

Plate III shows the curves of buoyancy,weight,loads,shearing forces and bending moments for the same ship on the crest of a wave. The wave contour is the conventional trochoid used in such calculations,having a length equal to the length of the ship and a height equal to one twentieth of its length.

The maximum bending moments on both Plates II and III occur at sections approximately equal,in size and scantling,to the midship section. The computations for the moment of inertia of the midship section follow:

Taking an axis 15 feet above bottom of keel,the sums of the moments of the sections above and below this axis are,respectively, 484.54 and 836.92 . The total area of the sections is 152.93. Hence the neutral axis of the section is below this assumed axis a distance equal to $\frac{836.92 - 484.54}{152.93}$ or 2.3 feet.

Summary of Calculation for I.

Member.	I.
Keel and keelson	1157.
Outside planking and rail	3063.
Inside planking and lock strakes	3065.
Main deck	2515.
Upper deck	2680.
Total	12480.

For the ship in quiet water,Plate II gives the maximum bending moment at a point 5 feet aft of amidships,and equal to 14640. foot tons. I is 12480. and y is 16.5 feet. Hence from the common beam formula $f = \frac{My}{I}$,

we have $f = \frac{14640. \times 16.5}{12480.}$

=	19.36	tons	per	square	foot
=	43366.	lbs	"	"	"
=	301.2	"	"	"	inch

For the ship on the crest of a wave, Plate III gives the maximum bending moment at a point 5 feet forward of amidships, and equal to 15000. foot tons.

Here $f = \frac{15000. \times 16.5}{12480.}$

=	19.83	tons	per	square	foot
=	44419.	lbs	"	"	"
=	308.5	"	"	"	inch

The stress for the ship in quiet water is, of course, compression at the upper deck; for the ship on the crest of a wave it is tension at the upper deck.

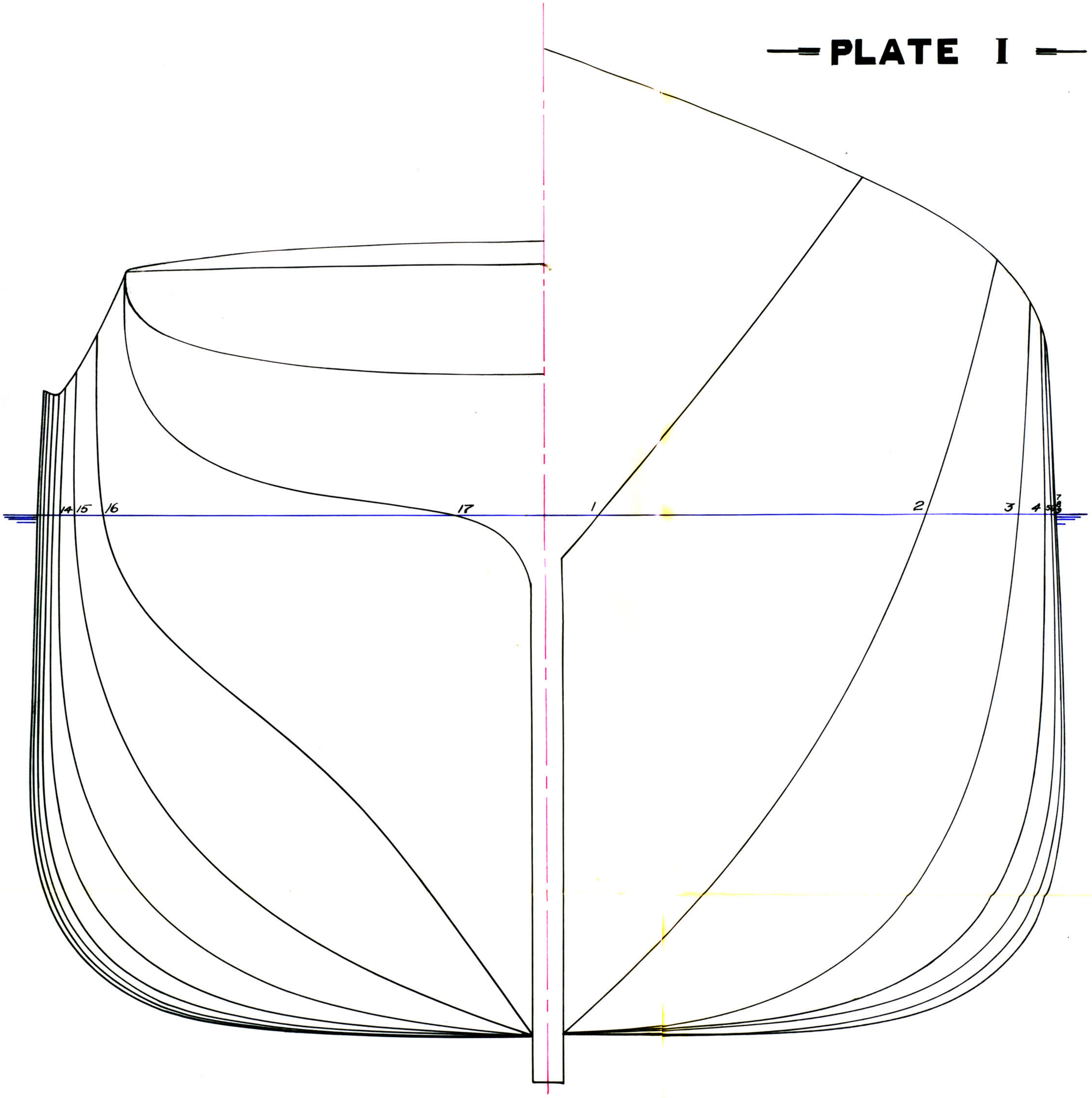
The breaking strength of yellow pine (dry) in compression is between 4000 and 7000 pounds per square inch. Taking the lower value and using a factor of safety of four, we shall have 1000. pounds per square inch as the allowable working fibre-stress in compression. For tension, the greatest allowable fibre-stress, with the same factor of safety, is about 1200. pounds per square inch.

The computed stresses in the hull of the Prescott are, then, less than one third the allowable working stresses for the timber.

This would seem to indicate that the ship is sufficiently strong to withstand the most severe strain that is likely to be brought upon her. Yet the experience of the Prescott,as well as that of several other of these large wooden schooners,has shown that such is not the case. This apparent contradiction may be explained by the consideration of two facts. First,the low efficiency of the joints in the longitudinal members greatly reduces the apparent moment of inertia of the section,and consequently increases the actual fibre-stress. Second,a ship fails when her timbers have been sprung or twisted sufficiently to allow serious leaking,and such springing of timbers will occur under a much smaller stress than that required to cause actual rupture of the wood.

It is impracticable,if not impossible,to determine to what extent these two circumstances affect the strength of the ship. It is not unlikely that they may reduce the true strength to one half,or even one third,of the value computed above. The loss of the Prescott by foundering would seem to show that such is the case.

PLATE I



— PLATE II —

Curve of Total Weights 1" = 4 tons
Curve of Buoyancy 1" = 4 tons
Curve of Loads 1" = 4 tons
Horizontal Scale 3/32" = 1'
Curve of Shearing Forces 1" = 170.7 tons
Curve of Bending Moments 1" = 7283 ft. tons
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1

PLATE III


Curve of Total Weights 1" = 4 tons
Curve of Buoyancy 1" = 4 tons
Curve of Bending Moments 1" = 7283. ft. tons
Horizontal Scale 3/32" = 1'
Curve of Shearing Forces 1" = 170.7 tons
Curve of Loads 1" = 4 tons
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1