The Practical Lumberman

BY

Bernard Brereton

FOURTH EDITION

1921

Sincerely yours
Bernard Brereton.

The Practical Lumberman

FOURTH EDITION

PROPERTIES AND USES OF DOUGLAS FIR, CALIFORNIA REDWOOD AND THE LEADING COMMERCIAL WOODS OF THE PACIFIC COAST

Rapid Methods of Computing Specifications, Contents and Weight of Squared and Tapering Lumber, Octagon Spars and Logs

LOG TABLES AND GRADING RULES

THE METRIC SYSTEM

Includes Conversion Tables and Information Relative to Foreign Export Shipments

TABLE OF DISTANCES

From Pacific Coast Ports to Foreign Ports, also Inland Waters of Puget Sound, Columbia River and British Columbia

THIS BOOK IS FOR SALE ONLY BY THE AUTHOR AND PUBLISHER

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PREFACE

The object of the author in presenting this book to the public is to furnish reliable data pertaining to the properties and uses of Douglas Fir, California Redwood and Pacific Coast Forest Products.

The various subjects treated will save the Lumberman and Logger many hours of research, as the numerous problems covered cannot be solved without the practical and technical knowledge that can only be gained by a long and varied experience in both the Lumber and Shipping industries.

In the section of this book devoted to logs will be found the log tables in general use in British Columbia, Washington, Oregon and California, the methods for computing same, also the log grading rules and a special table computed by the author showing the actual or solid contents in board feet of logs ranging from six to forty-eight inches in diameter.

Shipowners, Captains and officers of the merchant marine, or any one connected with the operation of cargo carriers, will appreciate the information regarding the system for computing the general and lumber carrying capacity of oil and coal burning steamers also the Table of Distances which will enable the reader to ascertain the distance from the leading ports of the World, to any Douglas Fir or Redwood Cargo Mill on the Pacific Coast.

As Belgium, France, Italy and Countries using the "Metric System" require lumber and specifications to conform to their standard, the writer has specialized on this subject, so as to enable shipowners and lumbermen to successfully cater to this trade, which will increase to vast proportions as soon as exchange is stabilized and the demands of the Foreign buyer are satisfactorily complied with.

The increasing number of orders from the Atlantic Coast for Douglas Fir, which is usually shipped there in cargo lots via the Panama Canal, is sufficient evidence that the production of Eastern Pine is fast diminishing, and it is only a matter of a few years when the Southern States will cease to be a factor in the export lumber market.

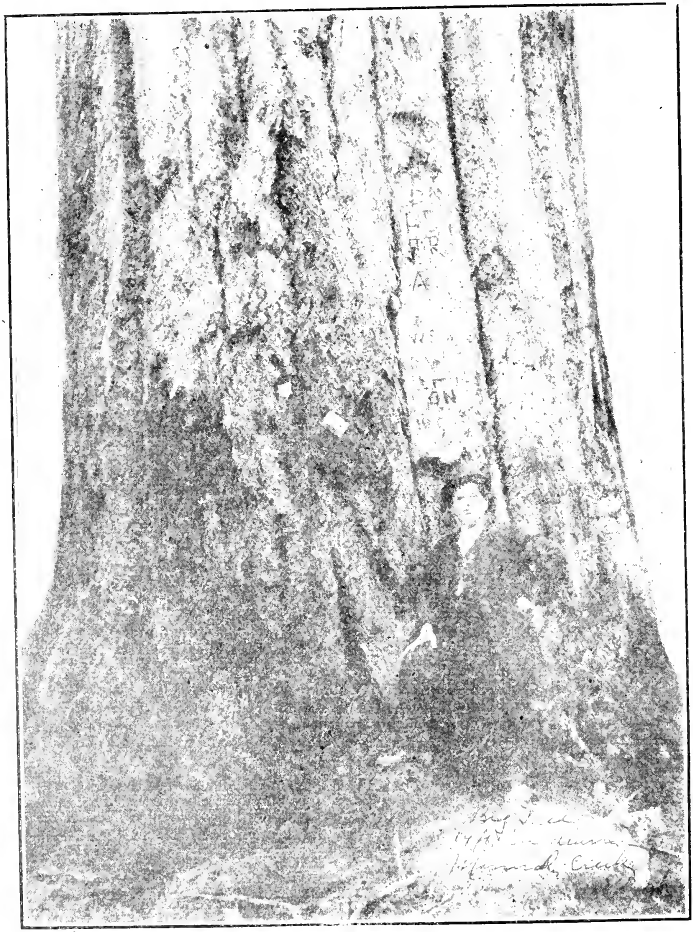
The United States and Foreign nations will then be mainly dependent on the forests of the West as a source of their supply of lumber for finish and heavy or light constructional purposes. It is therefore only a question of business policy that anyone engaged in the lumber or shipping industries, regardless of their position or location should avail themselves of the opportunity offered in this book to increase their knowledge of Western lumber so that they can successfully cater to this trade.

To those desirous of obtaining reliable data concerning Douglas Fir or California Redwood, the information in this book can be absolutely relied upon as I have personally supervised the manufacture, inspection or shipment of upwards of fifty million board feet of Pacific Coast Lumber annually for a period of over twenty-five years.

While the treatment of some of the subjects is necessarily brief it is to the point as the most casual perusal will disclose and if this work is the means of enlightening buyers and sellers of lumber throughout the world on the value and use of Pacific Coast Forest Products, one great purpose of the writer will be well accomplished.

In conclusion, I wish to express my appreciation to the officials of the United States and British Columbia Forest Service, the Bureau of Foreign and Domestic Commerce, the Lumber Trade Journals and my friends in the Lumber and Shipping Industries who have so courteously furnished me with much valuable material for this work.

BERNARD BRERETON,
Author and Publisher.



DOUGLAS FIR

DOUGLAS FIR

(Pseudotsuga Taxifolia)

Douglas Fir, widely known as Oregon Pine, reaches its best development for commercial purposes on the Pacific Coast, from the head of the Skeena River, in British Columbia, and southward through the States of Washington and Oregon to Central California.

The wood is comparatively light but very strong; it is the strongest wood in the world for its weight that is obtainable in commercial sizes and quantities.

With the exception of Spruce, Douglas Fir is in greater demand for Airplane construction than any other wood, and material of excellent qual ty for this purpose can be found in unlimited amounts.

THE CORRECT NAME

Douglas Fir is named after David Douglas, botanist, who explored British Columbia (then called New Caledonia) in 1825-30. It is the most important timber tree on the North American Continent, and is known by a great variety of names, such as Oregon Pine, Oregon Fir, Washington Fir, Yellow Fir, Red Fir, Douglas Spruce, Red Spruce, Puget Sound Pine, and British Columbia Pine.

The employment of so large a number of names for one class of tree is very confusing, detrimental and often misleading, and for these reasons the United States Forest Service some years ago took a lumber census which resulted in their adopting the name Douglas Fir, as it was used more than all others combined.

MERITS AND USES

The stand of timber in Oregon and Washington alone, it is estimated, comprises 25% of the remaining stand of timber in the United States, and in British Columbia is estimated to comprise one-third of the total timber supply of Canada. It is considered the strongest softwood in the world. (See United States Forest Service Bulletin No. 108). Douglas Fir is moderately hard but easy to work, straight grained, resilient, tough and durable.

Combining these qualities of great strength, light weight, ease of working and handling, Douglas Fir more than any other commercial timber, is the ideal wood for practically all building and structual purposes. Owing to the great size of the trees, Douglas Fir timber can be furnished in the largest dimensions required in modern heavy construction.

As complying with qualities essential in a wood acceptable for general building purposes, Douglas Fir is practically impervious to water, holds nails firmly, takes stain well in any shade or color, and combines beauty, utility and durability.

It is a superior wood for bridge and wharf building, and heavy timbers or joists where great strength is required, and is unsurpassed for masts, spars, derricks, ship and deck plank, (decking), framing material, car sills, car siding, car roofing, car lining, flooring, ceiling, silo stock, sash, doors and interior finish.

The lower grades are used in large quantities for underground mining purposes.

The United States Forest Service Bulletin No. 88, says: "Douglas Fir may, perhaps, be considered the most important of American woods. * * * It is manufactured into every form of lumber known to the saw mill operator. For house construction Douglas Fir is manufactured into all forms of dimension stock, and is used particularly for general building and construction purposes. Its strength and comparative lightness fit it for joists, floor beams, and other timbers which must carry loads.

"The comparative hardness of the wood fits it for flooring and it meets a large demand. Douglas Fir edge-grain flooring is considered superior to that made from any other softwood.

"Clear lumber, sawed flat grain, shows pleasing figures, and the contrast between the spring and summer wood has been considered as attractive as the grain of quarter-sawn oak. It takes stain well, and by staining, the beauty of the grain may be more strongly brought out and a number of rare woods can be successfully imitated."

The durability of the wood, and the fact that it resists saturation by water cause it to be used in large quantities for wooden piping, for continuous stave and jointed conduits used in power and irrigation works, for silos and tanks. It makes first-class railway ties, whether treated with preservatives or not. Street pavement of cresoted Douglas Fir blocks properly laid is noiseless, dustless, economical in upkeep, and is durable and long wearing even under heavy traffic such as that of freight and dock yards. The unusual valuable combination of qualities possessed by Douglas Fir adapt it to such a variety of uses that a complete list of them would cover nearly all the uses to which wood can be put.

WATERBORNE SHIPMENTS DURING 1920

From British Columbia, Washington and Oregon

According to the report of the Pacific Lumber Inspection Bureau, Seattle, Wash., a grand total of 1,840,791,139 Board Feet of lumber was moved by water from British Columbia, Washington and Oregon. This represents a gain of 475,786,777 Board Feet over the year 1919. Of this amount 1,199,704,338 Board Feet was shipped to Domestic Ports and 641,086,801 Board Feet was shipped Foreign.

California took a total of 1,066,123,859 Board Feet in the year 1920, compared with 851,681,985 Board Feet in the year 1919.

The bulk of these shipments were Douglas Fir lumber, laths and pickets, with a small percentage of Sitka Spruce, Western Cedar, Western White Pine and other Pacific Coast Forest Products.

CARGO AND PARCEL SHIPMENTS TO FOREIGN PORTS DURING 1920

Statement for waterborne shipments supplied by the Pacific Lumber Inspection Bureau, Seattle, Wash.

Foreign Shipments	Board Feet
Arabia	25,275
Australia	106,110,992
China	136,503,846
East Indies	251,189
Egypt	1,615,335
India and Strait Settlements	9,316,238
Japan	78,557,036
Manchuria	163,163
Mexico	4,154,486
New Zealand	7,413,972
South Africa	17,782,746
South America—East Coast	12,001,681
South America—West Coast	98,189,391
South Sea Islands	2,952,386
U. K. and Continent	146,368,638
West Indies	19,680,427
Total	**641,086,801**

CARGO AND PARCEL SHIPMENTS TO DOMESTIC PORTS DURING 1920

Domestic Shipments	Board Feet
Alaska	9,754,686
Atlantic Coast	49,706,591
Hawaiian Islands	59,690,547
Panama	7,007,667
Philippine Islands	7,420,988
Total	**133,580,479**

CARGO AND PARCEL SHIPMENTS TO CALIFORNIA DURING 1920

California	Board Feet
Total	**1,066,123,859**

SUMMARY OF WATERBORNE SHIPMENTS DURING 1920

	DOMESTIC Board Feet	FOREIGN Board Feet	TOTAL Board Feet
British Columbia	7,158,968	139,465,301	146,624,269
Puget Sound	291,762,775	245,467,064	537,229,839
Grays Harbor	293,273,214	33,023,616	326,296,830
Willapa Harbor	95,145,541	7,900,049	103,045,590
Columbia River	271,164,905	214,313,147	485,478,052
Coos Bay	241,198,935	917,624	242,116,559
Total	**1,199,704,338**	**641,086,801**	**1,840,791,139**

COMPARISON OF WATERBORNE SHIPMENTS DURING 1920 FROM BRITISH COLUMBIA, WASHINGTON AND OREGON

	Board Feet
British Columbia	146,624,269
Washington	1,016,812,739
Oregon	677,354,131
Total	**1,840,791,139**

BEST EXPORT MARKETS FOR DOUGLAS FIR

The bulk of shipments designated **"U. K. and Continent"** in the foregoing statement went to Great Britain, consequently it can be considered, that the best export markets for Douglas Fir are as follows: **Great Britain, China, Australia, West Coast of South America and Japan.**

AVERAGE STRENGTH VALUES FOR STRUCTURAL TIMBERS

Taken from U. S. Forest Service Bulletin 108

GREEN

SPECIES	Cross Section Under Test, Inches.	No. of Tests.	Rings per Inch.	Moisture Content, percent.	Weight, Oven Dry lbs., per cu. ft.	Fiber Stress at Elastic Limit, lbs., per sq. in.	Modulus of Rupture, lbs. per sq. in.	Modulus of Elasticity, 1000 lbs. per sq. in.	Relative Strength Based on Modulus of Rupture, Douglas Fir, 100%.	Relative Stiffness Based on Modulus of Elasticity, Douglas Fir, 100%
Douglas Fir	8x16	134	10.9	31.8	28.9	4282	6605	1611	100.0	100.0
Western Hemlock	8x16	27	17.6	41.9	28.1	3761	5821	1489	88.1	92.4
Long-leaf Pine	12x12 10x16 8x16 6x16 6x10	13	14.6	29.2	35.4	3855	6437	1466	97.4	91.0
Short-leaf Pine	8x16 8x14 8x12	33	12.3	48.4	31.4	3376	5948	1546	90.0	96.0
Loblolly Pine	5x12 8x16	78	6.2	58.0	31.2	3266	5568	1467	84.4	91.1
Western Larch	8x16 8x12	43	23.9	50.5	28.7	3677	5562	1364	84.2	84.6
Redwood	8x16 6x12 7x 9	30	19.5	90.2	23.3	4323	5327	1202	80.6	74.6

NOTE:—Care was taken in selecting Douglas Fir material to secure a large number of stringers of low grade. Douglas Fir contained more knots than its nearest competitor in strength Even with this handicap it shows greater strength values than other species.

AVERAGE STRENGTH VALUES FOR STRUCTURAL TIMBERS

Established by the U. S. Government

SPECIES	Green Stringers Breaking Strength Lbs. sq. in.	Green Stringers Breaking Strength Percent	Air-Seasoned Stringers Breaking Strength Lbs. sq. in.	Air-Seasoned Stringers Breaking Strength Percent
Douglas Fir	6605	100.0	7142	100.0
Longleaf Pine	6437	97.4	5957	83.6
Shortleaf Pine	5948	90.0	7033	98.5
Western Hemlock	5821	88.1	7109	99.6
Loblolly Pine	5568	84.4	6259	87.7
Western Larch	5562	84.2	6534	91.5
Redwood	5327	80.6	4573	64.1
Tamarack	4984	75.5	5865	82.3
Norway Pine	3767	57.0	5255	73 7

Note that Douglas Fir is unequalled in strength by any other species. It is 25 percent lighter in weight than its nearest competitor in strength.

DOUGLAS FIR RAILROAD TIES

STRENGTH OF DOUGLAS FIR COMPARED TO BALTIC TIMBER

The following table shows the results of tests made by the Great Eastern Railway Company of London, England, on an equal number of Douglas Fir and Baltic Ties (Sleepers).

The ties were partly seasoned and the table shows the actual weight at time of test.

Description of Timber	Weight per Cubic Ft.	Specific Gravity	Ultimate Strength Lbs. per Sq. In.	
			Depression	Tension
Douglas Fir	37.91	.607	5,695	11,450
Baltic Timber	31.06	.497	3,950	5,730

DOUGLAS FIR RAILROAD TIES DELIVERED TO EASTERN RAILROADS IN THE UNITED STATES DURING 1920

Statement supplied by R. L. Wyman, Supervising Inspector, Portland, Oregon.

From Oregon and Washington

Shipped to Atlantic Coast via Panama Canal	42,000,000 Board Feet
Shipped by Rail	28,000,000 Board Feet
Grand Total	**70,000,000 Board Feet**

DOUGLAS FIR RAILROAD TIES AND CROSSINGS EXPORTED DURING 1920

Statement Supplied by the Douglas Fir Exploitation and Export Company, San Francisco.

A—UNTREATED

UNITED KINGDOM

From Washington and Oregon	64,500,000 Board Feet
From British Columbia	38,600,000 Board Feet
Total	**103,100,000 Board Feet**

Sizes and Lengths

3% 4½x 9—8′ 6″ Ties.
85% 5 x10—8′ 6″ Ties.
3% 5 x12—8′ 6″ Ties.
9% 6 x12—6x14—6x16 Crossings, 9 to 30 feet.
7 x12—7x14—7x16, Crossings, 9 to 30 feet.

100%

WEST COAST SOUTH AMERICA

From Washington and Oregon .... 990,000 Board Feet

Sizes and Lengths

9% 1x6—4′ 6″ Ties.
18% 6x6—6′ Ties.
40% 6x8—8′ Ties.
33% 6x8 and 7x9 Crossings, 10 to 18 feet.

100%

CHINA

From Washington and Oregon .... 1,100,000 Board Feet

Sizes and Lengths

20% 4½x6—9′ Ties.
35% 5½x7—6′ Ties.
10% 7 x9—9′ Ties.
35% 6x8 Crossings, 6 to 12 feet.

100%

DOUGLAS FIR RAILROAD TIES—Continued

B—TREATED

CHINA—TAKU BAR

From Washington and Oregon........415,000 Board Feet

Sizes and Lengths

85% 6x9—8′ Ties.
15% 6x9 Crossings, 9 to 17 feet.

100%

INDIA

From Washington and Oregon	3,611,000 Board Feet
From British Columbia	3,800,000 Board Feet
Total	**7,411,000 Board Feet**

SAN DOMINGO

From Washington and Oregon........1,473,000 Board Feet

Sizes and Lengths

88% 6x8—8′ Ties.
12% 6x8 Crossings, 8½ to 15 feet.

100%

SUMMARY IN BOARD FEET

	A—UNTREATED	B—TREATED
United Kingdom	103,100,000	
West Coast South America	990,000	
China	1,100,000	415,000
India		7,411,000
San Domingo		1,473,000
Totals	**105,190,000**	**9,299,000**

TOTALS

A—UNTREATED TIES AND CROSSINGS	105,190,000 BOARD FEET
B—TREATED TIES AND CROSSINGS	9,299,000 BOARD FEET
GRAND TOTAL	**114,489,000 BOARD FEET**

Note: In British Countries, cross ties are called sleepers, and switch ties are termed crossings.

CROSS-TIES PER MILE

Center to Center	Number of Ties
18 inches	3,520
21 inches	3,017
24 inches	2,640
27 inches	2,348
30 inches	2,112

WEIGHT OF DOUGLAS FIR

MERCHANTABLE AND COMMON GRADES

1000 BOARD FEET EQUALS 3333 POUNDS

To quickly ascertain the weight of "green" Douglas Fir: Add one cipher to the board feet and divide by 3.

Example: Find the weight in pounds of 672 board feet of green Douglas Fir.

Process: 672x10 equals 6720, divided by 3 equals 2240 pounds.

WEIGHT FOR EXPORT CARGO SHIPMENTS

Lumber manufactured for export shipment during summer and early fall, say from July to October is invariably lighter in weight than that which is sawn during the winter and spring seasons, say from November to June. The length of time that lumber is cut prior to shipment has a governing effect on the weight, as all lumber and especially small dimension stock cut during fine weather for 30 days or longer becomes partially seasoned and thus loses weight through exposure to the air.

The heavy rain that occurs in the Douglas Fir region during the winter and spring months naturally increases the weight of lumber, for though it is piled solid before shipment, the water clings to the surface although it does not penetrate the lumber owing to its resistance to saturation. This is very noticeable as wet lumber is being loaded on board a vessel, for as the loads are elevated the water that clings between the boards or planks will drain off in great quantities.

Experienced lumber exporters base the weight for cargo shipments as follows:

SUMMER AND FALL LOADING

To determine the deadweight of lumber in tons of 2240 pounds for summer and early fall shipment, multiply the board feet by 1.44 and point off the three right hand figures.

Example: Find the deadweight in tons of four million (4,000,000) board feet of lumber at 1.44 tons per 1000 board feet.

Process: 4,000,000x1.44 equals 5,760,000, now point off the three right hand figures and you have 5,760, the weight in tons of 2240 pounds

WEIGHT OF DOUGLAS FIR—Continued

WINTER AND SPRING LOADING

To determine the deadweight of lumber in tons of 2240 pounds for winter and spring shipment multiply the board feet by 1.5 and point off the three right hand figures.

Example: Find the deadweight in tons of four million (4,000,000) board feet of lumber at 1.5 tons per 1000 board feet.

Process: 4,000,000x1.5 equals 6,000,000, now point off the three right hand figures and you have 6,000, the weight in tons of 2240 pounds.

Note: The deadweight displacement of a vessel is invariably computed in long tons of 2240 pounds.

WEIGHT OF CLEAR DOUGLAS FIR

Clear lumber is cut from the outside of the log in proximity to the sap wood consequently it contains more moisture and is closer grained than the merchantable and common grades that are manufactured from the heart lumber towards the center of the tree, which contains dryer wood and coarser grain. This explains the reason for clear lumber weighing more than the common grades.

DECKING AND FLITCHES

Rough clear ships' decking (deck plank) and cants for resawing purposes, which are usually known as flitches weigh 3500 pounds per thousand board feet.

Decking that has been surfaced four sides weighs 3000 pounds per 1000 board feet.

KILN DRIED LUMBER

Rough green clear boards lose about 10 percent of their weight during process of kiln drying and it is customary to compute the weight of rough dry stock at 3000 pounds per 1000 board feet

KILN DRIED DRESSED STOCK

WEIGHT PER 1000 BOARD FEET

	Pounds
1x3—1x4—1x6 Flooring, Vertical or Slash Grain	2000
1¼x3—1¼x4—1¼x6 Flooring, Vertical or Slash Grain	2200
⅜x4 Ceiling	900
½x4 Ceiling	1200
⅝x4 Ceiling	1400
1x4 and 1x6 Ceiling	2000
⅝x6 Drop Siding and Rustic	1600
1x4—1x6—1x8 Drop Siding and Rustic	2000
1x4 to 1x12 Surfaced 2 or 4 Sides	2500
1¼x4 to 1¼x12 Surfaced 2 or 4 Sides	2700
1½x4 to 1½x12 Surfaced 2 or 4 Sides	2700
2x4 to 2x12 Surfaced 2 or 4 Sides	2700
1¼—1½ or 2 inch, Stepping 8 to 12 inches wide	2700

METRIC WEIGHT

The weight of Douglas Fir in kilograms and metric tons is given in the "Metric Section."

WEIGHT OF DOUGLAS FIR LOGS OR PILING

Rafted logs or piling on account of being partly submerged in salt or fresh water, or freshly felled in the early summer months, will naturally weigh more than those felled in winter, or shipped direct on cars from forest to destination. To compute the approximate weight in pounds of rafted logs or piling, take average diameter including bark, then ascertain board measure contents by referring to the Brereton Solid Log Table and multiply the amount by 3.5.

For logs and piling shipped on cars multiply board measure contents by 3.4.

WEIGHT OF CREOSOTED DOUGLAS FIR PILES, POLES AND TIES

To compute weight in pounds of creosoted piles or poles, take average diameter, then ascertain board measure contents according to the Brereton Solid Log Table and multiply the amount by 3.5.

Butt treated or butt and top treated telephone, telegraph or electric light poles weigh about 3.4 pounds per board foot, exact contents.

Creosoted ties (sleepers) or lumber of small dimensions weigh about 3.6 pounds per board foot. Creosoted timbers weigh about 3.5 pounds per board foot.

POINTER FOR CHARTERER OR OWNERS OF VESSELS

Taint From Creosote

In making charters for vessels to carry creosoted piling or lumber, if possible arrange to carry this material on deck. If carried under deck it will taint perishable cargo in same compartment or perishable cargo carried on the return voyage.

EFFECT OF CREOSOTE ON CARRYING CAPACITY

The difference in weight between creosoted and untreated ties must also be taken into consideration as this affects the carrying capacity to a considerable extent; for instance, a steamer with a deadweight cargo carrying capacity of 5400 long tons that would ordinarily carry 3,620,000 board feet of untreated fir ties would only carry 3,360,000 board feet of creosoted ties, a difference of 260,000 board feet.

PULP WOOD

PAPER MAKING DESCRIBED

There are four general processes of reducing wood to a pulp condition, states the Forest Products Laboratory, Madison, Wis., in answer to frequent requests for general information on pulp and paper making. These are known as the ground wood, sulphite, sulphate and soda processes of pulping.

The ground wood process of pulping is used mainly for the reduction of non-resinous, long-fibered woods, such as spruce and balsam. The barked wood in two-foot lengths is ground on a grindstone, the surface of which has been sharpened to produce a cutting action. The yield of pulp is approximately 90 per cent of the weight of the raw wood. The pulp is inferior in quality and is used only to mix with longer and stronger fibered stock, such as unbleached sulphite pulp, in the manufacturing of paper in which permanency is not required, as in newsprint, cheap catalogue, magazine and certain other papers. It is also used to a large extent in the manufacture of wall board.

The sulphite process is used chiefly for the reduction of long-fibered, non-resinous, coniferous woods, such as spruce, balsam and hemlock, giving a yield of less than 45 per cent based on the weight of the original wood used. This pulp can be bleached to a high degree of white and is largely used both unbleached and bleached in the manufacture of books, newsprint, wrapping, bond and tissue papers.

The sulphate or kraft process of pulping is used for the reduction of any long-fibered wood and yields approximately 45 per cent. This is an alkaline process and can be used for the reduction of both resinous and non-resinous woods, such as the pines, spruces, hemlocks, firs, etc. Kraft pulp is normally not bleached; but on account of its strength it is used for the manufacture of kraft wrapping paper and high test container board.

The soda process is restricted in use to the short-fibered deciduous woods, such as aspen, cottonwood, willow, gum woods, etc., yielding less than 45 per cent. The resulting pulp is invariably bleached to a high degree of white, and after admixture with a longer and stronger-fibered stock, such as spruce sulphite, is used for the manufacture of book, lithograph, envelope papers, etc.

It is the opinion of the laboratory that under present conditions a balanced pulp and paper mill can not be erected at a cost of less than $15,000 or $50,000 per ton capacity or finished paper per day. It is not feasible, except under abnormal conditions, to erect a pulp plant of less than 25 tons capacity requiring approximately 60 cords of wood a day. Before proceeding with the erection of a pulp and paper mill a competent engineer who has specialized in this field should make a very careful survey of the economic conditions, such as labor, markets, living conditions, cost of fuel and power, as such factors are of decided importance in determining the financial success of the enterprise.

RESULTS OF PRACTICAL TESTS OF THE FOLLOWING WOODS FOR PULP PURPOSES

Western Hemlock under favorable conditions will yield 1050 pounds of sulphite pulp per cord of wood, is easily bleached and easily pulped, of good strength and fair color, very similar to White Spruce; or 2160 pounds of mechanical pulp of good strength and fiber, but a little off color.

Douglas Fir yields 850 pounds of sulphite pulp, difficult to bleach, hard to pulp, of fair strength and poor color, and with few uses; or 1,170 pounds of sulphate pulp, working up into a good grade of kraft or wrapping paper, but not so strong as White Spruce, but is not suitable for mechanical pulp.

Western White Pine is good for 1,080 pounds of sulphite pulp, hard to bleach, easily pulped, of good strength and color, and a good substitute for White Spruce; or 1,120 pounds of sulphate pulp; or 2,140 pounds of mechanical pulp, rather pitchy, but otherwise not much different from White Spruce.

Western Yellow Pine makes 1,140 pounds of sulphite pulp, difficult to bleach, of good strength and color, which might be substituted for White Spruce; or 1,420 pounds of sulphate pulp, of strong but coarse fibre, capable of being substituted for White Spruce pulp; or a very high yield of mechanical pulp, of very short fibre, very pitchy and only useful when mixed with better grades of wood having longer fibre.

Englemann Spruce makes 990 pounds of sulphite pulp, easily bleached, a little hard to pulp; of excellent strength and color, and practically the same as White Spruce; or 1,000 pounds of sulphate pulp of good quality; or 2,100 pounds of mechanical pulp of good strength and fibre, almost equal to White Spruce.

Balsam makes 970 pounds of sulphite pulp, easily bleached and pulped, of good strength and excellent color; can be substituted for White Spruce; or 1,010 pounds of high-grade kraft paper; or 1,910 pounds of mechanical pulp, of good strength and color, which can be substituted for White Spruce.

Larch makes 1,200 pounds of sulphite pulp per cord of wood, difficult to bleach and pulp, of poor strength and color, only useful for low grade wrapping paper; or 1,290 pounds of sulphate pulp, of good quality, for kraft fibre; or 2,100 pounds of mechanical pulp, of poor color, short fibre, fair strength, only useful when a medium quality of ground wood will serve the purpose, and is not economically profitable where other woods can be easily obtained.

Jack Pine works up into 1,080 pounds of sulphite pulp, very difficult to bleach, not easily pulped fairly strong, of poor quality, pulp shivery and full of pitch, mechanical difficulties preventing the use of this pulp in running over a paper machine; or 1,150 pounds of sulphate pulp, strong fibre, making good wrapping paper, building paper, or paper board; or 2,130 pounds of mechanical pulp, gray, soft in texture, of good strength, pitchy, poor finish; can be used for medium grade ground woods.

Cottonwood makes 1,035 pounds of sulphite pulp, easily bleached and pulped, very weak, of good color; or 1,030 pounds of soda sulphate pulp, soft texture, easily bleached, of the same uses as Aspen; or 1,080 pounds of mechanical pulp, short fibered, weak, good color; can be used as a filler with longer fibred stocks.

Aspen makes 1,030 pounds of sulphite pulp, easily bleached and pulped, weak fibre, excellent color, can be used with longer fibred stocks for better grades of paper; or 1,080 pounds of soda sulphate pulp, very soft, short fibre, easily bleached, when mixed with high-grade long fibre makes fine high-grade book, envelope and writing paper; or 2,170 pounds of mechanical pulp, very short fibre, poor strength, good color, used as a filler in good paper along with long fibred stock.

What is true of Cottonwood and Aspen is also true of Basswood; its pulps require to be mixed with long fibred stock to give good strength. It makes excellent pulps and is easily treated.

CONSUMPTION OF PULPWOOD IN CALIFORNIA, OREGON AND WASHINGTON DURING 1920

The 1920 consumption of pulpwood in California, Oregon and Washington exceeded by 23,000 cords, or 7.4 per cent, the greatest previous record, which was in 1919. Similarly the 1919 consumption of pulpwood exceeded by 18.6 per cent that of 1917, the previous record. The 1919 production of pulpwood fell short of the 1917 production by nearly 3 per cent, while the 1920 production exceeded the 1917 record by 14 per cent.

This statement is based upon the following complete figures published jointly by the bureau of the census for 1919 and the Forest Service, in co-operation with the American Paper & Pulp Association, for 1920:

Year	Number of Mills	Pulpwood Consumed (Cords)	Woodpulp Produced (Short Tons)
1920	11	334,193	243,819
1919	10	311,130	207,607
1918	9	239,771	168,654
1917	8	262,291	213,813
1916	8	259,544	188,782

The hemlock pulpwood consumed in 1920 exceeded by 72,000 cords, or 55 per cent, all other species combined. The detail of consumption by species and by processes follows:

Species	Cords Consumed
Hemlock	203,234
Spruce (domestic)	61,430
White Fir	41,862
Cottonwood	18,806
All Others †	8,861

Process	Cords Consumed	Pulp Produced (Short Tons)
Sulphite	174,753	97,660
Mechanical	134,601	135,657
Soda	24,839	10,532

† All other includes Douglas Fir imported spruce, slabs, etc.

Effect of Age on Pulp Wood Trees

In a recent test upon white fir trees 18 inches or less in diameter as compared with larger or older trees 40 inches in diameter, it was found that the older wood produced from 10 to 17 percent less mechanical pulp. The older wood also required more power in grinding but did not follow the usual rule that greater power requirements means stronger pulp. The young wood had the greater strength. The pulp from the young wood is also noticeably brighter.

Suitability of Certain Woods for Sulphite Pulp

In cooks made of noble fir, lodgepole pine, and western hemlock to determine their suitability for pulping by the sulphite process. Noble fir produced a pulp of reddish tinge and with a long, coarse fibre. Lodgepole pine pulp has a fibre that is very similar to the fibre in spruce pulp, light and fairly strong. Western hemlock produces a fibre with a reddish tinge, but somewhat longer than the fibre from eastern hemlock.

Wood Required to Make Paper

Hardy S. Ferguson, formerly chief engineer of the Great Northern Paper Co., for many years, but now a consulting engineer at 200 Fifth Avenue, New York, N. Y., gives the following figures as to the amount of wood required to make one ton of newspaper.

He assumes that one cord of wood will yield one ton air-dry ground wood pulp; that two cords of wood will yield one ton air-dry sulphite pulp; that in the paper mill 2 per cent of the sulphite is wasted, as is the case with 8 per cent of the ground wood.

Then he finds that with paper containing 25 per cent sulphite, one ton of paper requires 1.32 cords; that with paper containing 22½ per cent sulphite, one ton of paper requires 1.30 cords, and that with paper containing 20 per cent sulphite, one ton of paper requires 1.28 cords of wood.

Information

A very useful book describing the manufacture of pulp and other interesting information on this subject, entitled **By-Products of the Lumber Industry, "Special Agents Series" No. 110,** can be purchased by sending a money order for ten cents to the Superintendent of Documents, Washington, D. C.

Modern Pulp and Paper Making; a practical treatise by G. S. Witham, Sr., Price $6.00, published by H. W. Wilson Co., 958 University Avenue, New York City.

Information regarding suitable sites for pulp and paper mills in British Columbia can be obtained by communicating with the **Chief Forester, Victoria, British Columbia.**

The Forest Products Laboratory, Madison, Wisconsin, will gladly furnish information relative to the pulp and paper industries in the United States.

PULP WOOD—Continued

Alaska and British Columbia Pulp Wood

In Southern Alaska and British Columbia there is an immense supply of pulp wood and good opportunity for utilizing the numerous water possibilities at mills right at the ocean's edge.

The stands of suitable pulp wood timber are so dense that it is not unusual to find 100 to 150 cords to the acre, so great is the quantity that the 400 mile strip of Southeastern Alaska, extending along the British Columbia seaboard, contains sufficient timber to furnish half of the newsprint paper in the United States.

The stand of pulp wood is approximately two-thirds Western Hemlock and one-third Spruce.

Western Hemlock and Spruce are the standard mechanical and sulphite pulp woods for the United States mills in the Pacific Northwest, the hemlock being consumed in greater amounts than any other single species. Hemlock forms 60 per cent of the merchantable stand of timber on the Tongass National Forest, Alaska.

CORD MEASURE

Firewood, small pulp wood, and material cut into short sticks for excelsior, etc., is usually measured by the cord. A cord is 128 cubic feet of stacked wood. The wood is usually cut into 4 foot lengths, in which case a cord is a stack 4 feet high and wide, and 8 feet long. Sometimes, however, pulp wood is cut 5 feet long, and a stack of it 4 feet high, 5 feet wide and 8 feet long is considered 1 cord. In this case the cord contains 160 cubic feet of stacked wood. Where firewood is cut in 5 foot lengths a cord is a stack 4 feet high and 6½ feet long, and contains 130 cubic feet of stacked wood. Where it is desirable to use shorter lengths for special purposes, the sticks are often cut 1½, 2 or 3 feet long. A stack of such wood, 4 feet high and 8 feet long, is considered 1 cord, but the price is always made to conform to the shortness of the measure.

A cord foot is one-eighth of a cord and equivalent to a stack of 4 foot wood 4 feet high and 1 foot wide. Farmers frequently speak of a foot of cord wood, meaning a cord foot. By the expression "surface foot" is meant the number of square feet measured on the side of a stack.

In some localities, particularly in New England, cord wood is measured by means of calipers. Instead of stacking the wood and computing the cords in the ordinary way, the average diameter of each log is determined with calipers and the number of cords obtained by consulting a table which gives the amount of wood in logs of different diameters and lengths.

Relation Between Board Measure, Cubic Measure and Cord Measure

In order to determine the number of feet in a standard cord of stacked wood (4 feet x 4 feet x 8 feet), and also to ascertain the number of solid cubic feet of wood in a cord, the class in forest mensuration of the Montana Forest School has just completed a study on this phase of the subject. A number of 16-foot softwood logs (Douglas fir, western larch and western yellow pine), averaging about 12 inches in diameter at the small end, were first scaled with Scribner Decimal "C" Rule. The logs were next cut into 4-foot lengths and the number of cubic feet in each piece accurately determined. The 4-foot lengths were next split into the usually convenient cordwood stick and stacked into a pile 4 feet high and 8 feet long. The following were the results obtained:

A standard cord (128 cubic feet) of stacked wood (Douglas fir, western larch, western yellow pine) contains:

517 board feet (Scribner Dec. "C" Scale).

963 board feet (62.7 percent) of actual wood.

80.25 cubic feet of actual wood.

37.3 percent of a stacked cord is air space.

A similar study carried out by the forestry students of the University of Wisconsin (1914), in the university oak woodlot near Madison, Wis., gave 73 cubic feet (57 percent) of actual wood per cord. This was nearly all red and black oak, and the 73 cubic feet represented the average for 23 cords of wood, used by the university as fuel.—R. R. Fenska, acting dean, University of Montana, Missoula, Mont.

It is generally agreed that the conifers pile closer in cordwood than do the hardwoods and this explains the difference in the two sets of university figures referred to in the foregoing.

Metric Equivalent

1 Stere (Cubic Meter) equals 0.2759 of a cord.

1 Cord equals 3.624 Steres.

Note: 1 Stere or cubic meter equals 35.314 cubic feet.

Amount of Pulp Wood in a Cord

A cord of wood ordinarily yields about one ton of mechanical pulp or about one-half ton of chemical pulp.

Amount of Hemlock Bark for Tanning Purposes in a Cord

Although the cord is used as a standard of measure for bark, it is usually sold by weight in order to avoid variation due to loose piling.

Throughout the East 2,240 pounds are usually called a cord, although in some places 2,000 pounds are accepted.

A long cord of 2,240 pounds equals about 77 cubic feet, a short cord of 2,000 pounds equals about 66½ cubic feet.

It is highly important to keep Hemlock bark intended for tanning purposes well protected from the rain, for it leaches out easily and is soon ruined. For the same reason bark from logs which have been towed or driven is of little value.

Salt water ruins it entirely.

CORD MEASURE—Continued

SHINGLE BOLTS

Bolts are measured by stacking, a pile four feet high by eight feet long being considered a cord, or, more often, bolts are simply counted and reduced to cords by dividing by a factor representing the average number of bolts in a cord. This factor varies somewhat with different cutters and in different sized timber, and is usually obtained by stacking a few cords of each cutter's bolts. Bolts will run between 16 and 40 to the cord, and average from 20 to 22. In the Puget Sound region, bolts for 16-inch shingles are cut from 52 to 54 inches long. A cord of bolts averaging about 20 bolts is considered equivalent to 700 ft., B. M., or the same number of shingles that can be cut from 500 ft., B. M. of timber. In Eastern Washington and Northern Idaho, where the timber is smaller, a cord usually contains from 35 to 40 bolts and is considered equivalent to 850 ft., B. M. In this region, all bolts are cut in 52-inch lengths.

Relative Fuel Value of Cord Wood and Coal

In heating value, one pound of good coal may be taken as the equivalent of two pounds of seasoned wood, says the Bureau of Standards, Department of Commerce. Allowing 80 solid cubic feet of wood to an average cord and assuming the sticks to be well seasoned, a cord of hickory or other heavy wood is equivalent in heat value to one ton of coal. For lighter woods, as cedar, poplar, spruce and white pine, two cords are equivalent to one ton of coal.

Equal weights of dry non-resinous woods give off practically the same amount of heat in burning—that is, a ton of dry cottonwood will give off as much heat on burning as a ton of white oak Highly resinous woods, like some of the pines and firs, have an appreciably greater heating value per ton, because a pound of resin gives off twice as much heat during combustion as a pound of wood.

When buying wood by the cord, it must be remembered that different species vary greatly in weight per cubic foot, so that a cord of hickory has considerable more fuel value than a cord of soft maple. A cord of seasoned wood contains more wood than a cord of green wood, because of the shrinkage which takes place in seasoning.

The amount of moisture in firewood influences not only the vigor with which it burns, but the amount of heat actually given off. Therefore, to obtain a standard cord of wood of the greatest fuel value, thoroughly dry wood of the heaviest kind, straight in growth, cut into short lengths and with the largest diameters, should be selected. As a rule, the soft woods burn more readily than the hard woods and the lighter woods burn more readily than the heavier ones.

DOUGLAS FIR PICKETS ROUGH

The standard size, 1x3—4 feet and 4 feet 6 inches long, are tied in bundles of 10 pieces each; they are in great demand for the Australian market, and are used for fences, and occasionally are sawn into inch lath; they are also extensively utilized as staves for mutton-tallow barrels.

Grade According to Export "H" List

Pickets 1x3 in.—4 ft.—4 ft. 6 in.—5 ft. Will allow variations in size of 1/8 of an inch in thickness and 1/8 of an inch in width. Sap, pitch pockets, and two sound hard knots not over 1 inch in diameter allowed.

Manufacture

Strict attention should be paid to their manufacture, and it is essential that they be uniform in thickness They can be made from air or kiln dried stock and many mills rip 2x3 to 15/16 of an inch to make them.

In most cases pickets are subject to rigid inspection, and it is useless to make them from anything but the best material.

Discoloration

Unless there are prospects of shipping pickets within a short time after they are manufactured, they should be piled on their edge in bundles, and crossed in alternate courses with an air space between each bundle of about 4 inches. This prevents discoloration, and is the method employed by a number of mills who aim to ship their stock in a satisfactory condition.

Measurement, Contents and Weight

1000 pcs. 1x3—4½ feet contain 1125 feet Board Measure, and average 4000 lbs. in weight.

The above weight is for green stock; when seasoned lumber is used, due allowance must be made for difference in material.

TO FIGURE CAPACITY OF FREIGHT CARS

DOUGLAS FIR LUMBER

To find the amount of Rough Green Lumber any car will carry, cut off a cipher from the marked capacity in pounds, add 10 per cent and multiply by 3; the result will be the limit of feet Board Measure the car is allowed to carry.

Example: What is the limit in feet Board Measure allowed a car of 80,000 pounds capacity?

8000 pounds
800 10 per cent

8800x3 equals 26,400 ft. Board Measure.—Answer.

CEDAR SHINGLES

To find approximate number of 16 inch Shingles that can be loaded in a box car.

Ascertain cubical capacity of the car, and to the number of cubic feet add two ciphers; the result will be the number of Shingles.

When loading Shingles or Lumber in furniture cars, precautions should be taken against exceeding the weight limit.

—Contents of 1-inch Boards of Different Lengths and Widths Given in Board Feet and Twelfths.

Length.	WIDTH OF BOARD (INCHES).																				
	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	CONTENTS (BOARD FEET).																					
Feet.																						
4	1	1^{4}	1^{8}	2	2^{4}	2^{8}	3	3^{4}	3^{8}	4	4^{4}	4^{8}	5	5^{4}	5^{8}	6	6^{4}	6^{8}	7	7^{4}	7^{8}	8
5	1^{3}	1^{8}	2^{1}	2^{6}	2^{11}	3^{4}	3^{9}	4^{2}	4^{7}	5	5^{5}	5^{10}	6^{3}	6^{8}	7^{1}	7^{6}	7^{11}	8^{4}	8^{9}	9^{2}	9^{7}	10
6	1^{6}	2	2^{6}	3	3^{6}	4	4^{6}	5	5^{6}	6	6^{6}	7	7^{6}	8	8^{6}	9	9^{6}	10	10^{6}	11	11^{6}	12
7	1^{9}	2^{4}	2^{11}	3^{6}	4^{1}	4^{8}	5^{3}	5^{10}	6^{5}	7	7^{7}	8^{2}	8^{9}	9^{4}	9^{11}	10^{6}	11^{1}	11^{8}	12^{3}	12^{10}	13^{5}	14
8	2	2^{8}	3^{4}	4	4^{8}	5^{4}	6	6^{8}	7^{4}	8	8^{8}	9^{4}	10	10^{8}	11^{4}	12	12^{8}	13^{4}	14	14^{8}	15^{4}	16
9	2^{3}	3	3^{9}	4^{6}	5^{3}	6	6^{9}	7^{6}	8^{3}	9	9^{9}	10^{6}	11^{3}	12	12^{9}	13^{6}	14^{3}	15	15^{9}	16^{6}	17^{3}	18
10	2^{6}	3^{4}	4^{2}	5	5^{10}	6^{8}	7^{6}	8^{4}	9^{2}	10	10^{10}	11^{8}	12^{6}	13^{4}	14^{2}	15	15^{10}	16^{8}	17^{6}	18^{4}	19^{2}	20
11	2^{9}	3^{8}	4^{7}	5^{6}	6^{5}	7^{4}	8^{3}	9^{2}	10^{1}	11	11^{11}	12^{10}	12^{9}	14^{8}	15^{7}	16^{6}	17^{5}	18^{4}	19^{3}	20^{2}	21^{1}	22
12	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
13	3^{3}	4^{4}	5^{5}	6^{6}	7^{7}	8^{8}	9^{9}	10^{10}	11^{11}	13	14^{1}	15^{2}	16^{3}	17^{4}	18^{5}	19^{6}	20^{7}	21^{8}	22^{9}	23^{10}	24^{11}	26
14	3^{6}	4^{8}	5^{10}	7	8^{2}	9^{4}	10^{6}	11^{8}	12^{10}	14	15^{2}	16^{4}	17^{6}	18^{8}	19^{10}	21	22^{2}	23^{4}	24^{6}	25^{8}	26^{10}	28
15	3^{9}	5	6^{3}	7^{6}	8^{9}	10	11^{3}	12^{6}	13^{9}	15	16^{3}	17^{6}	18^{9}	20	21^{3}	22^{6}	23^{9}	25	26^{3}	27^{6}	28^{9}	30
16	4	5^{4}	6^{8}	8	9^{4}	10^{8}	12	13^{4}	14^{8}	16	17^{4}	18^{8}	20	21^{4}	22^{8}	24	25^{4}	26^{8}	28	29^{4}	30^{8}	32
18	4^{6}	6	7^{6}	9	10^{6}	12	13^{6}	15	16^{6}	18	19^{6}	21	22^{6}	24	25^{6}	27	28^{6}	30	31^{6}	33	34^{6}	36
20	5	6^{8}	8^{4}	10	11^{8}	13^{4}	15	16^{8}	18^{4}	20	21^{8}	23^{4}	25	26^{8}	28^{4}	30	31^{8}	33^{4}	35	36^{8}	38^{4}	40
22	5^{6}	7^{4}	9^{2}	11	12^{10}	14^{8}	16^{6}	18^{4}	20^{2}	22	23^{10}	25^{8}	27^{6}	29^{4}	31^{2}	33	34^{10}	36^{8}	38^{6}	40^{4}	42^{2}	44
24	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48
26	6^{6}	8^{8}	10^{10}	13	15^{2}	17^{4}	19^{6}	21^{8}	23^{10}	26	28^{2}	30^{4}	32^{6}	34^{8}	36^{10}	39	41^{2}	43^{4}	45^{6}	47^{8}	49^{10}	52
28	7	9^{4}	11^{8}	14	16^{4}	18^{8}	21	23^{4}	25^{8}	28	30^{4}	32^{8}	35	37^{4}	39^{8}	42	44^{4}	46^{8}	49	51^{4}	53^{8}	56
30	7^{6}	10	12^{6}	15	17^{6}	20	22^{6}	25	27^{6}	30	32^{6}	35	37^{6}	40	42^{6}	45	47^{6}	50	52^{6}	55	57^{6}	60
32	8	10^{8}	13^{4}	16	18^{8}	21^{4}	24	26^{8}	29^{4}	32	34^{8}	37^{4}	40	42^{8}	45^{4}	48	50^{8}	53^{4}	56	58^{8}	61^{4}	64

TO COMPUTE SIZES NOT GIVEN IN THE BOARD MEASURE TABLE

A great variety of sizes can be computed or checked by the aid of the foregoing table.

If you wish to figure the contents of fractional lumber, plank, square or rectangular timbers the table can be used for that purpose.

For lumber $1\frac{1}{4}$ inches in thickness add $\frac{1}{4}$ to the amount given in the table for a board of corresponding width and length.

For lumber $1\frac{1}{2}$ inches in thickness you would add half the amount to the contents.

For lumber 2 inches in thickness double the amount of contents. In other words when the thickness exceeds one inch multiply the board feet amounts given in the table by the thickness.

EXAMPLES

Fractional Sizes: Find the contents of 1 piece $1\frac{1}{4}$x17—20 feet long.

By referring to the table you will find 1 piece 1x17—20 feet long, contains 28 feet and 4 inches, to this is added one-quarter (7 ft. 1 in.) which gives 35 feet 5 inches, the board feet contents of 1 piece $1\frac{1}{4}$x17—20 feet long.

If the board were $1\frac{1}{2}$ inches in thickness you would add to the contents of 1x17, half the amount.

Square Timbers: Find the contents of 1 piece 18x18—20 feet long.

According to the table, 1 piece 1x18—20 contains 30 board feet, the amount multiplied by one side of the square (18) gives 540, the board feet contents.

Rectangular Timbers: Find the contents of 1 piece 15x24—32 feet long.

In this case you can multiply the contents of 1x15—32 (40 feet contents) by 24, or 1x24—32 (64 feet contents) by 15, the result will be the same, namely 960 board feet contents.

Totals: In the table the fractions are given in twelfths (small figures) making adding easier. Thus the following 1 inch lumber would be added:

1 piece 1x 7—10 ft. equals	5 ft.	10 inches.
1 piece 1x10—12 ft. equals	10 ft.	0 inches.
1 piece 1x16—12 ft. equals	16 ft.	0 inches.
1 piece 1x13—14 ft. equals	15 ft.	2 inches.
1 piece 1x20—16 ft. equals	26 ft.	8 inches.

Total equals 72 and 20/12 ft., or $73\frac{2}{3}$ Board Feet.

To find the total contents of lumber thicker than 1 inch, proceed as if the lumber were 1 inch and multiply the total by the thickness.

In the foregoing example, if it were 3 inch lumber the total would be multiplied by 3, or a total of 221 board feet.

DOUGLAS FIR LATH

The standard for California and West Coast of South America is 1/3x1 1/2 in.—4 ft., tied in bundles of 100 pieces.

The Australian standard is as follows:

1/3x1 in.—1 1/2 ft., tied in bundles of 90 pieces.
1/3x1 1/4 in.—1 1/2 ft., tied in bundles of 90 pieces.
1/3x1 1/2 in.—1 1/2 ft., tied in bundles of 90 pieces

MEASUREMENTS, CONTENTS AND WEIGHTS

1/3x1 1/2 in.—4 ft.—
- 1000 Pcs. contain 166 2/3 ft. B. M.
- 6000 Pcs. equal 1000 ft. B. M.
- 1000 Pcs. Kiln Dried, weigh 500 lbs
- 1000 Pcs. Green, weigh 700 lbs.

1/3x1 in.—4 1/2 ft.—
- 1000 Pcs. contain 125 ft. B. M.
- 8000 Pcs. equal 1000 ft. B. M.
- 1000 Pcs. Kiln Dried, weigh 375 lbs.
- 1000 Pcs Green, weigh 530 lbs

1/3x1 1/4 in.—4 1/2 ft.—
- 1000 Pcs. contain 156 1/4 ft. B. M.
- 6400 Pcs. equal 1000 ft B M.
- 1000 Pcs. Kiln Dried, weigh 470 lbs.
- 1000 Pcs. Green, weigh 660 lbs.

1/3x1 1/2 in.—4 1/2 ft.—and
3/8x1 1/2 in.—4 ft.—
- 1000 Pcs contain 187 1/2 ft. B. M.
- 5333 Pcs. equal 1000 ft. B. M.
- 1000 Pcs. Kiln Dried, weigh 560 lbs.
- 1000 Pcs. Green, weigh 800 lbs.

When lath are made 3/8 of an inch in thickness, the contents and weight can be computed by adding to the measurements given in the preceding table 1/8 of the corresponding amount.

1000 Pcs. 1/3x1 1/2—4ft. lath will cover 70 yards of surface.

FREIGHT

When figuring lath of any of the foregoing sizes and lengths for cargo freight, the prevailing custom formerly was to reckon six pieces as being the equivalent of one foot board measure, but the correct way is to figure them at actual contents

TO FIND THE NUMBER OF LATH REQUIRED FOR A ROOM

Find the number of square yards in the walls and ceiling and by using the table given below, the result will be the number of lath necessary to cover the room.

For 1/3x1—4 ft., multiply the square yards by 22.
For 1/3x1 1/4—4 ft., multiply the square yards by 18.
For 1/3x1 1/2—4 ft., multiply the square yards by 16.

NUMBER OF LATH REQUIRED TO COVER 100 SQUARE YARDS

Lath 1/3x1—4 ft., requires 2200 pieces per 100 square yards.
Lath 1/3x1 1/4—4 ft., requires 1800 pieces per 100 square yards.
Lath 1/3x1 1/2—4 ft., requires 1600 pieces per 100 square yards.

At 16 lath to the square yard, 1000 lath will cover 63 yards of surface, and 11 pounds of lath nails will nail them on.

Note: For ordinary dwellings on the U. S. Pacific Coast and British Columbia the standard lath is 1/3x1 1/2—4 ft., tied in bundles of 50 or 100 pieces.

DOUGLAS FIR STAVES

ACCORDING TO EXPORT "H" LIST

No. 1 Staves 1x1 in. x 4 ft. Sawn full size clear. If seasoned will allow 1/8 of an inch scant in width.

No. 2 Staves 1x3 in. x 4 ft. Will allow variations in size of 1/8 of an inch in thickness and 1/8 of an inch in width. Sap and two sound hard knots not over 3/4 of an inch in diameter allowed.

DOUGLAS FIR SHINGLES

Douglas Fir Shingles are occasionally made and give excellent satisfaction when sawn from old growth logs of large diameter.

Manufacturers of this product claim they should be sawn vertical grain and not over 6 inches in width.

Like the Douglas Fir door they will come into general use, when they can be manufactured at a price which allows competition with Western Red Cedar.

BOARD MEASURE

The unit of board measure is the board foot, one foot square and one inch in thickness, and the number of board feet in any given material that is being measured according to this standard, is obtained by dividing this standard volume of a board foot into the net standard volume of the material to be measured. This rule applies whether the material be one inch in thickness or some greater or less thickness.

HOW TO FIGURE LUMBER

The ordinary way of finding the contents of squared lumber is to multiply together the length in feet, the width and thickness in inches and divide the product by 12.

Figuring lumber by the above rule is a slow process, and the following system is adopted by experts whose business makes rapid calculation essential to their success.

Multiply together the thickness and width in inches, divide the product by 12 and multiply result by the length; the answer is Board Measure contents.

EXAMPLES

A few examples will show the system for finding the contents of standard sizes in a few seconds, and many of them without a monent's hesitation.

Example: Find the Board Measure contents of the following sizes:

Pcs.	Size	Length	B. M.
1	2x 8 inches	30 feet	40
1	4x10 inches	18 feet	60
1	10x10 inches	36 feet	300
1	20x20 inches	60 feet	2000

Operation

2x8 equals 16 divided by 12 equals 16/12 or 1⅓. When this is multiplied by the length the answer is 40 feet; in other words, add one-third to the length and you have the Board Measure contents.

4x10 equals 40 divided by 12 equals 3⅓ or 10/3. In this instance a cipher is added to the length and when this is divided by three the result is 60 feet Board Measure contents.

10x10 equals 100; this divided by 12 equals 8⅓ or 100/12. It is easier to multiply by 100 and divide by 12 than to multiply by 8⅓, therefore add two ciphers to the length and divide by 12; the result is 300 feet Board Measure contents.

20x20 equals 400 divided by 12 equals 33⅓ or 100/3. All that is necessary is to add two ciphers to the length and divide by 3; the result is 2000 feet Board Measure contents.

After a short reflection on the above method, it will be apparent to everyone that when this system is used I have made good my statement that the contents of any ordinary stick of lumber can be figured inside of a few seconds.

The following standard sizes and multiples for same will serve as a basis for practice, and when memorized will benefit those who wish to become rapid in figuring lumber, and at the same time may prove a stepping stone to a better position and successful career.

STANDARD SIZES AND MULTIPLES

1 x 3	Divide lineal feet by 4.
1 x 4	Divide lineal feet by 3.
1 x 6	Divide lineal feet by 2.
1 x 8	Multiply lineal feet by 2 and divide by 3.
1 x10	Multiply lineal feet by 10 and divide by 12.
1 x12	Lineal feet and Board Measure the same.
2 x 3	Divide lineal feet by 2.
2 x 4	Multiply lineal feet by 2 and divide by 3.
2 x 8	Add to lineal feet ⅓ of amount.
2 x10	Multiply lineal feet by 10 and divide by 6.
2 x12	Multiply lineal feet by 2.
3 x 3	Multiply lineal feet by 3 and divide by 4.
3 x 4	Lineal feet and Board Measure the same.
3 x 6	Add to lineal feet ½ the amount.
3 x 8	Multiply lineal feet by 2.
3 x10	Multiply lineal feet by 10 and divide by 4.
3 x12	Multiply lineal feet by 3.
4 x 4	Add to lineal feet ⅓ of amount.
4 x 6	Multiply lineal feet by 2.
4 x 8	Multiply lineal feet by 3 and subtract ⅓ lineal feet from amount.
4 x10	Multiply lineal feet by 10 and divide by 3.
4 x12	Multiply lineal feet by 4.
8 x 8	Multiply lineal feet by 5⅓.
10x10	Multiply lineal feet by 100 and divide by 12.
12x12	Multiply lineal feet by 12.
14x14	Multiply lineal feet by 16⅓.
16x16	Multiply lineal feet by 21⅓.
18x18	Multiply lineal feet by 27.
20x20	Multiply lineal feet by 100 and divide by 3.
22x22	Multiply lineal feet by 40⅓.
24x24	Multiply lineal feet by 48.

HOW TO FIGURE LUMBER—Continued

Another Method

A handy method for computing Board Measure contents, preferred by a number of lumbermen, is as follows:

For all 12 ft. lengths, multiply width by thickness.
For all 14 ft. lengths, multiply width by thickness, and add 1/6.
For all 16 ft. lengths, multiply width by thickness, and add 1/3.
For all 18 ft. lengths, multiply width by thickness, and add 1/2.
For all 20 ft. lengths, multiply width by thickness, and add 2/3.
For all 22 ft. lengths, multiply width by thickness, and add 5/6.
For all 24 ft. lengths, multiply width by thickness, and double.

Some objection may be taken to the use of 2/3 and 5/6, but often by transposition you can substitute 1/6, 1/3, or 1/2, as in the following:

Examples: 10 pcs. 1x18—22 changed to 10 pcs. 1x22—18.
16 pcs. 1x22—20 changed to 20 pcs. 1x22—16.

In the first example, instead of multiplying 10x18 and adding 5/6 to the result, multiply 10x22 and add 1/2 to the result, which will give 330 ft. Board Measure. In the second item, instead of multiplying 16x22 and adding 2/3, multiply 20x22 and add 1/3, which gives 586 2/3 ft. Board Measure.

The above system is very handy, when figureing lumber from 12 to 24 feet in length, and also where odd widths and thicknesses frequently occur.

MULTIPLICATION

In computing contents of lumber it is often necessary to multiply by the figures from 13 to 19. A simple process is to multiply by the unit of the multiplier, set down the product under, and one place to the right of, and then add to the multiplicand.

Example: Multiply 238 by 15.

```
238
1190
----
3570 Answer.
```

To multiply any number by 101 to 109.
Example: Multiply 24356 by 103.

```
24356
   73068
-------
2508668 Answer.
```

Multiply by the unit of the multiplier, placing the product two figures to the right as in above example.

To multiply by 21-31-41-51-61-71-81-91.

Set the product by the tens under the multiplicand in proper position and add, thus:

Example: Multiply 76432 by 61.
Operation:

```
 76432x61
458592
-------
4662352
```

If ciphers occur between the two digits of the multiplier, the same method can be used by placing the figures in the correct position, thus:

Example: Multiply 76432 by 6001.
Operation:

```
   76432x6001
458592
---------
458668432
```

FRACTIONAL SIZES

To find the Board Measure contents of lumber 1 1/4 and 1 1/2 inches in thickness, proceed as if the lumber were of one inch and to the amount obtained add one-quarter or one-half, as the case may be.

To bring the lineal feet of fractional lumber to board measure when your time is limited, and you are not familiar with the correct multiple, multiply the lineal feet by the thickness, width and length and divide result by twelve.

ADDITION OF FRACTIONS

Find the sum of 3/8 and 5/13.

39 plus 40 equals 79
3/8 times 5/13 equals 104. Answer 79/104.

Explanation: Multiply the denominator (8) of the qrst fraction by the numerator (5) of the second fraction, which gives 40. Next multiply the numerator (3) of the first fraction by the denominator (13) of the second fraction, which gives 39. Now unite these products (40 plus 39 equals 79), which gives the numerator of the answer. The denominator of the answer is the product of the denominators (8 times 13 equals 104).

HOW TO FIGURE LUMBER—Continued

MULTIPLICATION OF FRACTIONS

When both the whole numbers are the same, and the sum of the fractions is a unit.

Examples:

Multiply $4\frac{1}{2}$ by $4\frac{1}{2}$. Answer $20\frac{1}{4}$.
Multiply $7\frac{3}{8}$ by $7\frac{5}{8}$. Answer 56 15/64.
Multiply $9\frac{1}{3}$ by $9\frac{2}{3}$. Answer 90 2/9.

Operation:

4 times 4 plus 4 equals 20 plus $\frac{1}{2}$ times $\frac{1}{2}$ equals $20\frac{1}{4}$.
7 times 7 plus 7 equals 56 plus $\frac{3}{8}$ times $\frac{5}{8}$ equals 56 15/64.
9 times 9 plus 9 equals 90 plus $\frac{1}{3}$ times $\frac{2}{3}$ equals 90 2/9.

When the whole numbers are alike and the fractions are one-half, such as $1\frac{1}{2}$x$1\frac{1}{2}$, $2\frac{1}{2}$x$2\frac{1}{2}$, $12\frac{1}{2}$ x$12\frac{1}{2}$, add one to one of the whole numbers, then multiply the whole numbers together and to the result add the multiplication of the halves, which always equals one-quarter.

The following examples are self-explanatory:

As Common Fractions:

$1\frac{1}{2}$ times	$1\frac{1}{2}$ equals	1 times	2 plus $\frac{1}{4}$ or	$2\frac{1}{4}$ Answer.
$2\frac{1}{2}$ times	$2\frac{1}{2}$ equals	2 times	3 plus $\frac{1}{4}$ or	$6\frac{1}{4}$ Answer.
$3\frac{1}{2}$ times	$3\frac{1}{2}$ equals	3 times	4 plus $\frac{1}{4}$ or	$12\frac{1}{4}$ Answer.
$12\frac{1}{2}$ times	$12\frac{1}{2}$ equals	12 times	13 plus $\frac{1}{4}$ or	$156\frac{1}{4}$ Answer.
$109\frac{1}{2}$ times	$109\frac{1}{2}$ equals	109 times	110 plus $\frac{1}{4}$ or	$11990\frac{1}{4}$ Answer.

AS DECIMAL FRACTIONS

1.5 times	1.5 equals	1 times	2 plus 25/100 or	2.25
2.5 times	2.5 equals	2 times	3 plus 25/100 or	6.25
3.5 times	3.5 equals	3 times	4 plus 25/100 or	12.25
12.5 times	12.5 equals	12 times	13 plus 25/100 or	156.25
109.5 times	109.5 equals	109 times	110 plus 25/100 or	11990.25

MULTIPLICATION OF MIXED NUMBERS

Multiply $46\frac{2}{3}$ by $21\frac{7}{8}$.

Operation:

```
322) 46 2/3
 42) 21 7/8
     ------
     966-14
      40-6
      14-0
     ------
    1020-20/24
```

Explanation: Find the product of the whole numbers (966) and to the right put down the product of the numerators of the fractions (2 times 7 equals 14). Now multiply the numerator (7) of the lower fraction by the upper whole number (46), which gives 322. Write this on the left of the upper number. Now divide the product thus obtained by the denominator (8) of the lower fraction, which gives 40 and a remainder of 2. Write the 40 in the whole number column and the remainder (2) we multiply by the upper denominator (3), which gives a product of 6 and is written under 14 in the fraction column.

Now multiply the lower whole number (21) by the numerator (2) of the upper fraction, which gives 42. Write it on the left. Now divide 42 by the denominator (3) of the upper fraction, which gives 14 and no remainder. Write a cipher in the fraction column. Now add the partial product and the product is complete. In cases where the partial products of the fractions amount to more than 1, carry the excess to the whole numbers.

DIVISION OF MIXED NUMBERS

Divide $46\frac{5}{8}$ by 7.

Operation:

```
7) 46 5/8
   ------
   6 37/56
```

Explanation: In cases where the divisor is a whole number, the foregoing example does away with the usual method of reducing dividend and divisor to the same denomination.

Proceed as follows: 7 is contained 6 times in 46, with a remainder of 4. Write down 6 to produce the fraction of the quotient we multiply the remainder (4) by the denominator (8), which gives 32; to this is added the numerator (5) and we have the 37, the numerator of the quotient.

The product of the divisor by the denominator is the denominator (56) of the answer.

SHORT RULES

3-inch Plank: One-half the width multiplied by half the length, gives the Board Measure contents.

12-foot Lengths: The Board Measure contents of any piece of lumber 12 feet long is equal to the thickness and width multiplied together.

Lumber 6 inches in Thickness: Half the width multiplied by the length gives the Board Measure contents.

To find Board Measure contents of 4x8 in. multiply lineal feet by 2 and add one-third to the product.

Example: How many feet board measure are there in a piece of 4x8-in. 30 feet long?

Operation:

30
Multiplied by 2
60
⅓ of 60 equals 20
80 ft. B. M. Answer.

To find Board Measure contents of 8x8 in. divide lineal feet by 2, add one cipher to the result and to this amount add one-third of the lineal feet. This system requires no mental effort in even lengths up to 26 feet long.

Example: Find Board Measure contents of 1 piece 8x8 in.—18 and 26 ft. long respectively.

Operation:

18 divided by 2 equals 9.
18 divided by 3 equals 6.

Place the 6 to the right of 9 and you have the answer, 96 ft. B. M.

26 divided by 2 equals 13.
26 divided by 3 equals 8⅔.

Place the 8⅔ to the right of 13 and you have the answer, 138⅔ ft. B. M.

To Covert Board Measure to Lineal Feet, simply reverse the multiple used to bring lineal feet to Board Measure; in other words, multiply Board feet by 12 and divide by thickness and width.

Example: How many lineal feet are there in 1000 feet Board Measure of 2x8?

Process:

1000
12
2) 12000
8) 6000
750 lineal feet. Answer.

Car orders frequently call for a specified amount of sizes containing special lengths. Before proceeding to load, it is necessary to find the number of pieces required.

Find the number of pieces in the following order:

1000 ft. B. M. 2x4—14.
1000 ft. B. M. 2x4—16.
1000 ft. B. M. 2x4—20.

Bring the Board Measure to lineal feet as shown in previous example, then divide the length into the lineal feet. The result will be the number of pieces.

Process:

1000
12
2) 12000
4) 6000
1500 lineal feet.

The lineal feet given is now divided by the respective lengths and the following answer is obtained:

107	Pcs. 2x4—14 containing	998 ft. 8 in. B. M.
94	Pcs. 2x4—16 containing	1002 ft. 8 in. B. M.
75	Pcs. 2x4—20 containing	1000 ft. B. M.
276		3001 ft. 4 in. B. M.

TO COMPUTE SQUARE AND RECTANGULAR TIMBERS

This method of computing the Board Measure contents of square or rectangular timbers that exceed 12 inches one or both ways, is known to but very few, if any, lumbermen. It is a rapid way of figuring the majority of sizes, and on account of its simplicity the system is easily committed to memory.

Rule: Multiply length by width, and to the result add one-twelfth of the thickness for each inch that exceeds twelve.

Example: Find the Board Measure contents of a timber 13 in. x 17 in.—48 feet long.

Operation:

48 multiplied by 17 equals 816
816 divided by 12 equals 68
884 Ans. in B. M. Contents.

Explanation: Multiply the length (48 ft.) by the width (17 in.), which equals 816. Now as the thickness (13) exceeds 12 inches by one inch, consider this as one-twelfth, which is divided into 816 and equals 68. This amount is added to the 816 and the result is 884 ft. Board Measure contents.

HOW TO FIGURE LUMBER—Continued

The following multiples will be of assistance to those who wish to practice this system of finding Board Measure contents of timbers by the preceding rule.

12x13 Multiply length by 13.
13x14 Multiply length by 14 and add 1/12 of result.
14x14 Multiply length by 14 and add 1/6 of result.
14x15 Multiply length by 15 and add 1/6 of result.
15x15 Multiply length by 15 and add 1/4 of result.
15x16 Multiply length by 16 and add 1/4 of result.
16x16 Multiply length by 16 and add 1/3 of result.
16x17 Multiply length by 17 and add 1/3 of result.
16x18 Multiply length by 18 and add 1/3 of result.
18x18 Multiply length by 18 and add 1/2 of result.
24x24 Multiply length by 24 and 2.
26x26 Multiply length by 26 and 2 1/6.
28x28 Multiply length by 28 and 2 1/3.
30x30 Multiply length by 30 and 2 1/2.
36x36 Multiply length by 36 and 3.

TAPERING LUMBER

How to Figure Trapezoids, or Boards With Only Two Parallel Sides

Find the Board Measure contents of a board one inch thick, whose parallel sides are 16 feet and 20 feet in length and 8 inches wide.

Add together the two parallel sides, and divide their sum by 2, multiply the result by the inches in width and divide by 12. The answer is 12 feet Board Measure contents.

Find the Board Measure contents of a board one inch thick, 24 feet long whose parallel ends are 10 inches and 18 inches respectively.

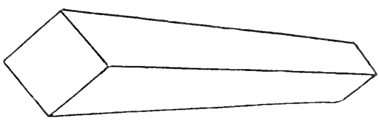
Operation:

Add both ends (10 and 18) and divide by 2, this gives 14, the average width, now multiply 14 by the length 24 and divide the result by 12 which gives 28 the contents in board feet.

HOW TO FIGURE THE FRUSTUM OF A PYRAMID, OR TAPERING TIMBER

As it frequently occurs there is a difference of opinion as to the correct way of ascertaining the Board Measure contents of tapering timber, the following method is both simple and correct, and will enable anyone to figure the exact contents without diving into square root.

Find the contents of a timber 40 feet high, 12x12 inches at the bottom and 6x6 inches at the top.



Square both ends separately, then multiply the top by the bottom side, add the sum together, and multiply this by the height and in all cases divide by 36.

Operation:

12x12 144 bottom
6x 6 36 top
6x12 72 top and bottom

252
40 ft. high

36) 10080 (280 ft. B. M.—Ans.
72

288
288

The common error that would be made in figuring a timber of this dimension would be to call it 9x9 the supposed size at the middle; the contents in that case would be 270 feet, or a difference of 10 feet. This is an important item that should be taken into consideration when figuring on contracts or freight.

I will now prove the method I used is correct by figuring a square timber on the same principal as a tapering stick.

Find the Board Measure contents of a timber 12 inches square and 40 feet long.

Operation:

```
12x12     144 bottom
12x12     144 top
12x12     144 top and bottom
          ----
           432
            40 ft. long
          -----
    36) 17280  (480 ft. B. M. Contents.
        144
        ---
         288
         288
         ---
```

CONTENTS BY PROGRESSIVE ADDITION

This rule is of great advantage when there is a range of odd and even lengths.

Example 1: Find the number of lineal feet in the following:

Ft. Long	Pieces	Lin. Ft.
10	0	480
11	8	48
12	6	40
13	4	34
14	7	30
15	23	23
	48	655

Explanation: First put down the pieces of the longest length (23 Pcs.) to this, add the pieces of the next longest length (7 Pcs.), which makes 30, put this down over the 23; now add to this the next number of pieces (4), which makes 34; add the next number (6), which makes 40; to this add the 8, which makes 48. The last item, in this case 48, if correct, will correspond with the total number of pieces.

This number (48) is multiplied by the shortest length, minus one, which in this case is ten. Now 48 times 10 equals 480; add this amount to the figures already obtained and the grand total is the number of lineal feet (655), not board feet.

When there are missing lengths repeat the number of pieces as shown by the following example:

Example 2:

Ft. Long	Pieces	Lin. Ft.
12	0	924
13	15	77
14	0	62
15	19	62
16	0	43
17	43	43
	77	1211

Explanation: In the foregoing example there are no pieces 14 or 16 feet long, so the amounts are repeated when there is a blank length. As in Example No. 1, the total pieces are multiplied by the shortest length, minus one. In this instance the 77 pieces are multiplied by 12, which gives 924, and the total addition shows 1211, the lineal feet.

FOR EVEN LENGTHS ONLY

Find the number of lineal feet in the following:

Ft. Long	Pieces	Lin. Ft.
12	46	287
14	54	241
16	62	187
18	58	125
20	67	67
	287	907
		907
		2870
		4684

Explanation: This system is the same as the preceding examples, with the exception that the addition (907) is repeated or doubled, and to this is added the number of pieces (287) multiplied by the next shortest even length (10). These items are now added together and the result shows the lineal feet (4684).

CARGO SPECIFICATIONS

As there does not seem to be any fixed rule for making up specifications in a uniform manner, reference to this subject will not be out of place. Some mills adopt the system of making all Domestic and Foreign Export Specifications out in feet Board Measure for each size and length, while others make out their specifications in lineal feet for each length and then add up their total and bring same to Board Measure.

The latter system of making out the extensions in lineal feet should be universally adopted, as everyone who is familiar with this class of work knows that a specification with the extensions in lineal feet, and showing the totals in Board Measure, can be finished in a quarter the time of a specification that shows the feet Board Measure for each length.

Steam schooners often arrive at San Francisco before the cargo manifest reaches consignee; this inconvenience and delay could often be avoided by the time gained in making up specifications with the extensions in lineal feet instead of Board Measure.

Foreign buyers, especially in the British trade, use the lineal measure more extensively than any other, and when they receive specifications in feet Board Measure they are put to the unnecessary inconvenience of converting them to lineal feet to correspond with their tables and price lists.

SHORT METHODS OF FIGURING SPECIFICATIONS

A very easy and short method of obtaining the Board Measure contents of each size and length, when required, is to halve the length and double the thickness. Simple as this rule seems, it is unknown to many experts.

Example: Find the Board Measure contents of each length in the following size:

Pieces	Size	Length	B. M. Feet
53	2 x 10	12	1060
42	2 x 10	14	980
36	2 x 10	16	960
48	2 x 10	18	1440
36	2 x 10	20	1200
30	2 x 10	22	1100
12	2 x 10	24	480
257			7220

In the above example, instead of saying twelve times fifty-three, halve the length and say six times fifty-three is three hundred and eighteen (318); now by doubling the thickness, we have the equal of 4x10 stead of 2x10; therefore, by adding a cipher to the 318 and dividing by 3, we have the Board Measure contents of the first length. The same rule applies to the remainder of lengths.

When it is only necessary to find the total feet Board Measure in a size containing a range of lengths, halve the lengths or pieces, and multiply the total result by the multiple of double the thickness of the size.

Example: Find the total feet Board Measure contained in the following:

Pieces	Size	Length	Contents
224	3 x 6	16	1792
112	3 x 6	18	1008
568	3 x 6	20	5680
45	3 x 6	22	495
120	3 x 6	24	1440
1069			10415
			3
		Feet B. M.	31245

HOW TO DECREASE OR INCREASE ORDERS

The method of decreasing or increasing orders will now be explained.

Reduce the following order by 41,000 feet Board Measure:

240,000 feet 12x12—40 to 60
280,000 feet 14x14—40 to 60
420,000 feet 16x16—40 to 60
160,000 feet 18x18—40 to 60

1,100,000

The first step necessary is to find the required percentage to reduce order in proportion. This is done by adding two ciphers to the amount that the order is to be reduced by and dividing the result by the amount of order. In this case it is 4 per cent. Each item must now be reduced separately by the percentage obtained, as follows:

Amt. of Decrease		Original Order		Reduced Order
9,600 ft.	or 4 % from	240,000 ft.	leaves	230,400
11,200 ft.	or 4 % from	280,000 ft.	leaves	268,800
16,800 ft.	or 4 % from	420,000 ft.	leaves	403,200
6,400 ft.	or 4 % from	160,000 ft.	leaves	153,600
44,000		1,100,000		1,056,000

If the above order of 1,100,000 feet had to be increased by 44,000 feet, 4 % would be added to each item, and the total would show the amount of order when increased.

CARGO SPECIFICATIONS—Continued

FIGURING PERCENTAGES

Cargo orders for California usually call for stipulated percentages of Nos. 1 and 2 in the common grades and clear and select in the uppers.

During progress of loading, it is essential to keep posted on the proportion of the percentage so as to avoid over-running or falling short on a grade.

Presume an order calls for 800,000 feet Nos. 1 and 2 Common, 25% No. 2 allowed, and in figuring up to see how your percentage is, you find your order stands thus:

306,600 ft. No. 1
113,400 ft. No. 2

420,000 ft. Total on board.

The following is the way to find your percentage:

Cut off the two right hand figures in your total (420,000) and divide the remaining amount (4200) into the Nos. 1 and 2 respectively. If your answer is correct your combined percentages will add to 100.

Operation:

No. 1 Common	No. 2 Common
4200)306600(73%	4200)113400(27%
29400	8400
12600	29400
12600	29400

Amount of Percentage

306,600 No. 1 or 73% of 420,000
113,400 No. 2 or 27% of 420,000

420,000 Total 100%

As your No. 2 in this instance exceeds the 25% allowed, notify the proper authorities of the fact, so that arrangements can be made to bring grade up to the required percentage.

THE PETROGRAD STANDARD

AN INCONVENIENT AND OUT-OF-DATE UNIT OF MEASUREMENT THAT SHOULD BE ABOLISHED

A Metric Standard for Timber

Metric measurement being in general use in Sweden, it is a surprise that shippers of wood goods from that country should perpetuate the use of the Petrograd standard hundred, a clumsy unit of computation which by the simple addition of less than 1 per cent could be converted into a metric standard. The advantages to the international timber trade of adopting a standard measurement of 2,000 board feet can scarcely be over-estimated, and not the least of these advantages is the simplification of clerical work. Amongst other advantages are that contracts with Continental buyers would be easier understood; and we are sure that the reform would be welcomed in all countries in which a decimal currency obtains. Spruce and pitch pine lumber shippers also, whom custom has caused to adopt the Petrograd standard for export to Europe, would find an advantage in the assimilation of invoices to their own methods of reckoning by the 1,000 ft. board measure. How and when the Petrograd standard hundred came into general use is involved in obscurity. In 1840 and up to about 1850 invoices for Norway and Gothenburg shipments were made out in the local standards in use at the various ports. These standards all differed from one another, each being based on the customary local standard deal. Somewhere about 1860 the Petrograd standard appears to have come into general use. This date coincides with the development of the sawn timber trade from the Gulf of Bothnia ports, where the Petrograd standard appears to have been generally adopted, and its use gradually spread to the other Scandinavian wood shipping ports; but why it supplanted the other standards is a matter of surprise, as it does not appear to offer any advantages. The Petrograd standard deal was 12 ft. by 1½ in. by 11 in.—a dimension which would not be called a deal at the present day is the basis of the Petrograd standard; 120 pieces—a long hundred—equalling 165 cubic feet. It is difficult to conceive of a more awkward or inconvenient unit of measurement. To reduce this standard, after multiplying feet by inches, length by thickness and breadth, it is necessary to divide successively by 3, 6, 11 and 120. Could anything more complicated be conceived? The great saving in clerical work in timber offices that the metrical standard would effect must appeal to every one engaged in the trade at home and abroad, but to start the reform it needs to be initiated by the leading Baltic exporting country, which appears to have unwisely adopted such an archaic and out-of-date unit of measurement—"The Timber Trades Journal," London, England.

THE PETROGRAD STANDARD

The "Petrograd Standard" is used in Great Britain, almost to the entire exclusion of all other standards.

The wholesale trade as a rule sells boards, battens, deals, planks, etc., by the Standard.

The Standard (Petrograd) deal contains 1 piece 3x11—6 feet and 120 pieces of this dimension make one Standard.

COMPOSITION OF STANDARDS

	Pcs.	Size Inches	Length Feet	B. M.	Cu. Ft. Conteuts
Petrograd	120	1½x11	12	1980	165
Irish or London	120	3 x 9	12	3240	270
Christiana	120	1¼x 9	11	1237½	103⅛
Drammen	120	2½x 6½	9	1462½	121⅞
Quebec	100	2½x11	12	2750	229⅙

The Drontheim Standard varies for different kinds of lumber. It contains:

2376 feet B. M. Sawn Deals.
2160 feet B. M. of Square Timber.
1728 feet B. M. of Round Timber.

The Wyburg Standard contains:

2160 feet B. M. of Sawn Deals.
1963⅔ feet B. M. of Square Timber.
1560 feet B. M. of Round Timber.
100 Petrograd Standard Deals equal 60 Quebec Deals.

The Riga "Last" contains 960 feet B. M. of Sawn Deals or Square Timber.

A Cubic Fathom of Lathwood is 6 ft. x 6 ft. and contains 216 cubic feet or 2592 feet B. M.

A Gross Hundred (120 pieces) makes a Standard Hundred.

FIGURING OF STANDARDS

Bring the following specification to Standard Measurement:

24 Pieces ¾x5½—24
20 Pieces 1 x6 —16
20 Pieces 1 x12 —20
40 Pieces 2 x10 —24
10 Pieces 2 x12 —22

Reduce each item as follows by multiplying the number of Pieces and all their dimensions together.

24x¾x5½x24	20x1x6—16	20x1x12—20
¾	1	1
18	20	20
5½	6	12
99	120	240
24	16	20
2376	1920	4800

When the products are obtained, then add together the total number of inches as shown in the specification below, which totals:

24 Pieces ¾x5½—24	2376 inches.
20 Pieces 1 x6 —16	1920 inches.
20 Pieces 1 x12 —20	4800 inches.
40 Pieces 2 x10 —24	19200 inches.
10 Pieces 2 x12 —22	5280 inches.
	33576 inches.

Always divide the total (in this instance 33576) by the following figures, which are standing divisors and never vary; thus:

11)33576
18)3052
30)169 10/18
4)5.19 10/18

	Std.	Quarters	Deals	Parts
1.1.19 10/18 equals,	1	1	19	10/18

String and Caliper Measure

In Great Britain Timbers are sold on Caliper and String Measure. Round logs are sold by String Measure. Hewn and Square Timbers are sold by both String and Caliper Measure.

In String Measure, the string is passed around the log or waney timber; the circumference is thus obtained; the string is doubled twice, then placed on a rule which shows the quarter girth or the average side of the log measured.

In Caliper Measure no allowance is made for wane.

FREIGHT MEASUREMENT OF TIMBER AS USED IN ENGLAND

A Petrograd Standard Hundred contains 120 pieces of 12 feet by 1½ inches by 11 inches equals 165 cubic feet, or 1,980 superficial feet of 1 inch.

Deals, battens, scantings, rough boards, and sawn pitch pine timber, pay freight per Petrograd Standard Hundred.

Planed boards pay freight on actual measure when dressed, not by the specification of nominal sizes from which they are manufactured.

Squared timber pays freight per load of 50 cubic feet, Queen's caliper measure delivered.

Mahogany and cedar from Cuba pay freight per load of 50 cubic feet, Queens caliper measure the captain paying the measuring charge.

Most furniture woods pay freight per ton weight delivered.

1 shipping ton equals 42 cubic feet of Timbers.

100 Superficial feet of planking	equal 1 square.
120 Deals	equal 1 hundred.
50 Cubic feet of squared timbers	equal 1 load.
40 Cubic feet of unhewn timbers	equal 1 load.
600 Superficial feet of inch boards	equal 1 load.
216 Cubic feet of lathwood	equal 1 fathom.
108 Cubic feet of wood	equal 1 stack.
128 Cubic feet of wood	equal 1 cord.

Timber at 50 Cubic Feet to One Ton

Pitchpine, Spruce, Whitewood. Redwood, Elm, Walnut, Maple, Pine, Baltic, Dantzig, Riga and Memel Fir Timber are computed as weighing 50 cubic feet to the ton.

Timber at 40 Cubic Feet to One Ton

Birch, Oak, Ash, Elm, Mahogany, Teak, Beech, Green Heart, Hickory and Round Timber generally are computed as weighing 40 cubic feet to the ton.

Crowntrees

The term "Crowntrees" refers to small sleepers (ties). They are made from trees of about 7 inches in diameter, split in the middle, so that 2 sleepers can be obtained from each piece.

They are exported from Sweden to England and France, where they are used as ties in the coal mines. The dimensions are: Length 3 to 6 feet, thickness 2⅜ to 3½ inches, width about 7 inches.

Rickers

Rickers are small poles having a top diameter of 1½ to 3 inches, and a diameter at the middle of 3½ to 6½ inches, lengths 16 to 50 feet, they are shipped with the bark on from Sweden to Great Britain, where they are principally used for scaffolding in various industrial plants.

Definition of Sleepers and Crossings

In Great Britain railroad ties are termed "sleepers" and switch ties are called "crossings."

The standard size of Douglas Fir railroad ties (sleepers) exported to Great Britain is 5″x 10″—8′ 6″, and the standard size of switch ties (crossings) is 6″x12″, they advance by six inches in length from 9 to 24 ft.

Douglas Fir ties are shipped "green" and cresoted on arrival in Great Britain.

OCTAGON SPARS

As the custom is now becoming general to order Octagon Spars, both Sawn and Hewn, the information on this subject will be appreciated by those who make a specialty of this line.

An Octagon can be made out of a Square timber by the following rule:

From diagonal deduct one side of timber, and that will give one side of the Octagon.

To find the length of the side of the triangle to be taken off the corner of the timber at right angles to the diagonal, deduct half the diagonal from one side of the timber.

One side of a square timber divided by .707 gives the diagonal.

Example: Find the length of one side of an Octagon that can be made out of a timber 35 inches square.

Diagonal of 35x35 equals 49.50 inches.
One side of 35x35 equals 35.00 inches.

One side of Octagon equals 14.50 inches.

Example: What is the length of the side of a triangle to be taken off the corner of a timber 35 inches square to make an Octagon?

Process:

2)49.50 Diagonal

24.75 Half the Diagonal.

35.00 Inches one side of timber.
24.75 Inches, half the Diagonal.

10.25 Inches length of one side of triangle.

To find one side of an Octagon inscribed in a circle, multiply diameter by .38265.

To find area of an Octagon multiply square of side by 4.82843.

When one side of a square is given, to find one side of an Octagon, that can be made out of it—multiply one side of square by .41421.

When one side of an Octagon is given, to find the diameter of the circumscribed circle, multiply one side of the Octagon by 2.613.

TO COMPUTE BOARD FEET CONTENTS OF AN OCTAGON

To compute the board feet contents of an octagon multiply the square of one side of the Octagon by 4.82843; then multiply the result by the length and divide by 12.

Example: Find the board feet contents of an Octagon, one side of which is 4 inches and the length 60 feet.

Process:

	4.82843 decimal term
Multiplied by	16 the square of 4
	77.25488
Multiplied by	60 the length
Divided by	12)4635.29280
	386.2744 Board Feet Contents.

ANOTHER METHOD

To compute the board feet contents of an Octagon manufactured out of a square timber.

First find the contents of the square timber in the usual way, then square one side of the Octagon; multiply it by the length and divide by 12; subtract this amount from the contents of the square timber and the result will give the board feet contents of the Octagon.

Example: Find the board feet contents of an Octagon the side of which is 14½ inches, made of a timber 35 inches square and 60 feet long.

Process:

35″ x35″ —60 ft. equals 6125 Board Feet.
14½x14½—60 ft. equals 1051¼ Board Feet.

Contents of the Octagon 5073¾ Board Feet.

Note: The exact side of a square from which an Octagon of 14½ inches could be made, would be 35.0065 inches. In the foregoing example the figures past the decimal point, namely .0064 are discarded as being unnecessary for practical purposes.

TO COMPUTE THE AREA OF A REGULAR POLYGON

When length of a side only is given.

Rule: Multiply square of the side by multiplier opposite to term of polygon in the following table:

No. of Sides	Polygon	Multiplier
3	Trigon	.43301
4	Tetragon	1.
5	Pentagon	1.72048
6	Hexagon	2.59808
7	Heptagon	3.63391
8	Octagon	4.82843
9	Nonogon	6.18182
10	Decagon	7.69421
11	Undecagon	9.36564
12	Dodecagon	11.19615

TO COMPUTE THE BOARD FEET CONTENTS OF A REGULAR POLYGON

Rule: Multiply square of the side by multiplier opposite to the term of polygon in the foregoing table; then multiply the result by the length and divide by 12.

Example: Find the board measure contents of a Nonagon (9 equal sides) one side of which is 6 inches and the length is 30 feet.

Process:

	6.18182 decimal term
Multiplied by	36 the square of 6 inches
	37.09092
	185.4546
	222.54552
Multiplied by	30 the length
Divided by	12)6676.36560
	556.36380 Board Feet Contents.

TO COMPUTE CONTENTS OF A TAPERING OCTAGON OR FRUSTUM OF A PYRAMID

Rule: To the sums of the areas of the two ends of the tapering octagon or frustum add the square root of their product. Multiply the sum by the height and take one-third of the product.

Example: Find the cubic contents of a frustum of a pyramid whose height is 15 feet. The area of one end is 18 square feet and the other 98 square feet.

Operation: 18 plus 98 equals 116 (area of the two ends).

98 times 18 equals 1764 square root of 1764 equals 42.

116 plus 42 equals 158. 15 (height) times 158 equals 2370, which divided by 3 gives 790 cubic feet.

Remark: This rule also applies to frustums of cones.

USEFUL TABLE FOR MAKING OCTAGONS OUT OF SQUARE TIMBER

Square Timber First Column	Diagonal Second Column	One Side of Octagon Third Column	One Side of Corner Fourth Column	Square Timber First Column	Diagonal Second Column	One Side of Octagon Third Column	One Side of Corner Fourth Column
6x 6	8.48	2.48	1.76	22x22	31.12	9.12	6.44
7x 7	9.90	2.90	2.05	23x23	32.53	9.53	6.73
8x 8	11.31	3.31	2.35	24x24	33.95	9.95	7.02
9x 9	12.73	3.73	2.63	25x25	35.36	10.36	7.32
10x10	14.14	4.14	2.93	26x26	36.78	10.78	7.61
11x11	15.56	4.56	3.22	27x27	38.19	11.19	7.90
12x12	16.97	4.97	3.51	28x28	39.60	11.60	8.20
13x13	18.39	5.39	3.81	29x29	41.02	12.02	8.49
14x14	19.80	5.80	4.10	30x30	42.43	12.43	8.78
15x15	21.22	6.22	4.39	31x31	43.85	12.85	9.07
16x16	22.63	6.63	4.69	32x32	45.26	13.26	9.37
17x17	24.05	7.05	4.97	33x33	46.68	13.36	9.66
18x18	25.46	7.46	5.27	34x34	48.09	14.09	9.95
19x19	26.87	7.87	5.56	35x35	49.50	14.50	10.25
20x20	28.29	8.29	5.85	36x36	50.90	14.92	10.54
21x21	29.70	8.70	6.15				

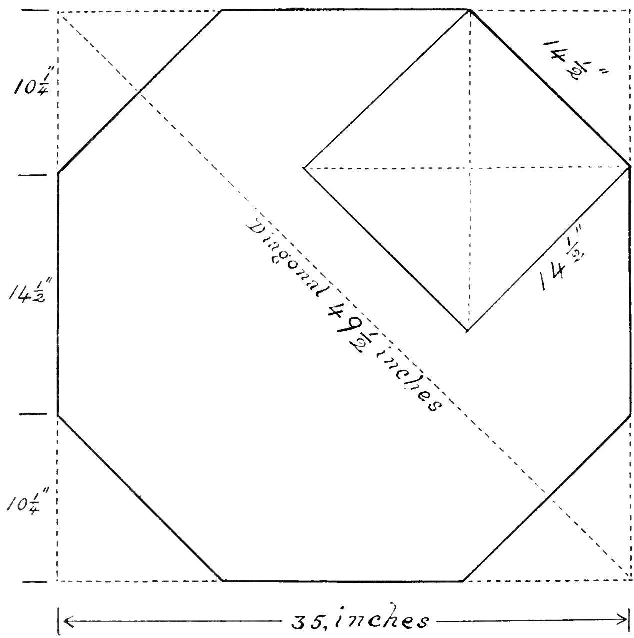
EXPLANATION OF OCTAGON TABLE

First Column shows the size of the timber to be made into an Octagon.

Second Column shows the diagonal or the length of a line joining the opposite angles of the timber.

Third Column shows the length of one side of the Octagon that can be made from the timber in First Column.

Fourth Column shows the length of one side of the triangle to be cut off each corner of the timber at right angles to the diagonal to make the Octagon.



The above diagram illustrates the system used in determining the contents of an Octagon. Note that one side of the square (35) deducted from the diagonal (49½) gives one side of the Octagon, and that the side of the small inner square equals one side of the Octagon. You will also observe that the area of the small square or combined areas of the four sections of the small square is the equivalent to the total area of the four corners taken off the large square to make the Octagon.

TO COMPUTE AVERAGES

WIDTHS—THICKNESS—LENGTHS

The following proforma specifications is used as an example in computing the above averages.

PROFORMA SPECIFICATION

Lengths	16	18	20	Pieces	Lineal Ft.	Board Ft.
Sizes						
2x12	2	2	2	6	108	216
2x14	2	2	2	6	108	252
2x16	2	2	2	6	108	288
	Total for sizes 2 inches thick			18	324	756
4x12	2	2	2	6	108	432
4x14	2	2	2	6	108	504
4x16	2	2	2	6	108	576
	Total for sizes 4 inches thick			18	324	1512
6x12	2	2	2	6	108	648
6x14	2	2	2	6	108	756
6x16	2	2	2	6	108	864
	Total for sizes 6 inches thick			18	324	2268
	Grand total of specification			54	972	4536
Total of each length	18	18	18			

THE AVERAGES FOR THE ABOVE SPECIFICATION ARE AS FOLLOWS

Average width..14 inches
Average thickness according to pieces..4 inches
Average thickness according to board feet.....................................4⅔ inches
Average length...18 feet

TO COMPUTE AVERAGE WIDTHS

Rule: Multiply the total pieces of each width separately, then add totals separately, and divide total of pieces into total of widths, the result will be the average width.

Example: Find the average width by using the proforma specification as an example.

Process:

6 pieces 2x12
6 pieces 4x12
6 pieces 6x12

18 pieces multiplied by 12, the width, equals 216

6 pieces 2x14
6 pieces 4x14
6 pieces 6x14

18 pieces multiplied by 14, the width, equals 252

6 pieces 2x16
6 pieces 4x16
6 pieces 6x16

18 pieces multiplied by 16, the width, equals 288

54 pieces divided into the total widths, 756
equals 14 inches, the average width.

TO COMPUTE AVERAGE THICKNESS
According to Board Feet Contents

Rule: Multiply the board feet contents of each thickness by the thickness, then add totals together, and divide the total board feet, into the total result of the board feet multiplied by the thickness.

Example: The proforma specification is used in this example.

Process:

Board Feet of each Thickness	Total
756 multiplied by 2 equals	1,512
1512 multiplied by 4 equals	6,048
2268 multiplied by 6 equals	13,608
4536 divided into total of	21,168

equals 4⅔ inches, the average thickness according to board feet contents.

TO COMPUTE AVERAGE THICKNESS

According to Pieces

Rule: Multiply the total lineal feet of each thickness by the thickness, then add totals together, and divide the total lineal feet into the total result of the lineal feet multiplied by the thickness.

Example: The proforma specification is used in this example.

Process:

Lineal Feet of Each Thickness		Thickness		Total
324	multiplied by	2	equals	648
324	multiplied by	4	equals	1,296
324	multiplied by	6	equals	1,944
972	**divided into total of**			**3,888**

equals 4, the average inches in thickness according to pieces.

TO COMPUTE AN AVERAGE RANGE OF LENGTHS

When an order of various widths and thicknesses calls for an average length, use the following system to compute it.

Rule: Add together the total pieces of each length, and multiply the pieces by their respective lengths; then add separately the pieces and lengths and divide the grand total of pieces into the grand total of lengths. The result will be the average length.

Example: The proforma specification is used in this example.

Process:

18 pieces multiplied by 16 ft. (the length) equals 288 lineal feet
18 pieces multiplied by 18 ft. (the length) equals 324 lineal feet
18 pieces multiplied by 20 ft. (the length) equals 360 lineal feet

54 pieces divided into the total lineal feet 972
gives 18 feet, the average length.

Note: When the total pieces and the total lineal feet is known, the total pieces divided into the total lineal feet gives the average length.

Note: When making contracts or specifications calling for a range of sizes and widths, it is advisable to insert the average length, width and thickness. When an average width is stipulated, buyers frequently omit the average thickness. This omission may seriously effect the proper execution of the order, as a mill company that is falling down on the average width could saw an excessive amount of wide widths on the minimum thickness, thus filling the specification according to contract and clearing themselves but often putting the buyer up against it.

TO COMPUTE AVERAGE ON BALANCE OF ORDER

Assume that you have sawn or delivered 756 board feet of sizes 2 inches in thickness, on an order totalling 4536 board feet, that the average thickness required on the order is 4 inches, and that you wish to know the average thickness necessary to correctly fill the balance of the order.

Rule: Multiply the amount of order (4536) by the required average (4) then multiply the amount sawn (756) by the thickness (2) now subtract the board feet and units of averages separately and divide the board feet result (3780) into the remaining result of the units of the average (16632) which gives 4.4 inches.

Example: The proforma specification is used in this example.

Process:

4536 multiplied by 4, the required average, equals 18,144 units
756 multiplied by 2, the present average, equals 1,512 units

3780 divided into balance of units 16,632 units

equals 4.4, the average thickness in inches required to fill the balance of order.

Proof

Amount sawn 756 ft. x 2 equals 1,512 units
Amount of shortage 3780 ft. x 4.4 equals 16,632 units

Amount of order 4536 ft. divided into 18,144 units
equals 4 inches, the thickness required on original order.

HARDWOOD AND SOFTWOOD TERMS

The terms hardwoods and softwoods or conifers are not exactly correct designations for the two large classes of woods; for so-called softwoods are harder than some so-called hardwoods, and some so-called conifers do not bear cones. Other designations, such as porous and nonporous woods, woods from deciduous and woods from evergreen trees, woods from broad-leaved trees and woods from trees with needle or scale-like leaves, are also inexact because exceptions are found in both classes. The botanical terms angiosperms (meaning seeds inclosed in an ovary) for hardwoods, including palmlike trees, and gymnosperms (meaning seeds not inclosed in an ovary) for softwoods or conifers are correct but are not in common usage.

DIFFERENTIAL TABLE

Table showing difference in board feet between actual contents of logs, 40 feet in length, 12 to 40 inches in diameter, and the Pacific Coast Log Scale's; also their respective allowances for slabs and saw kerf.

	12-in. Diam.	Allowance for Slabs and Saw Kerf.	14-in. Diam.	Allowance for Slabs and Saw Kerf.	16-in. Diam.	Allowance for Slabs and Saw Kerf.
Actual Contents	589	----	757	----	945	----
Scribner Scale	196	393	286	471	396	549
Spaulding Scale	192	397	286	471	402	543
British Columbia Scale	210	379	297	460	400	545

	18-in. Diam.	Allowance for Slabs and Saw Kerf.	20-in. Diam.	Allowance for Slabs and Saw Kerf.	22-in. Diam.	Allowance for Slabs and Saw Kerf.
Actual Contents	1155	----	1385	----	1636	----
Scribner Scale	534	621	700	685	836	800
Spaulding Scale	540	615	690	695	852	784
British Columbia Scale	518	637	652	733	800	836

	24-in. Diam.	Allowance for Slabs and Saw Kerf.	26-in. Diam.	Allowance for Slabs and Saw Kerf.	28-in. Diam.	Allowance for Slabs and Saw Kerf.
Actual Contents	1909	----	2202	----	2516	----
Scribner Scale	1010	899	1250	952	1456	1060
Spaulding Scale	1030	879	1220	982	1422	1094
British Columbia Scale	964	945	1145	1057	1337	1179

	30-in. Diam.	Allowance for Slabs and Saw Kerf.	32-in. Diam.	Allowance for Slabs and Saw Kerf.	34-in. Diam.	Allowance for Slabs and Saw Kerf.
Actual Contents	2851	----	3207	----	3584	----
Scribner Scale	1642	1209	1840	1367	2000	1584
Spaulding Scale	1640	1211	1870	1337	2112	1472
British Columbia Scale	1546	1305	1771	1436	2011	1573

	36-in. Diam.	Allowance for Slabs and Saw Kerf.	38-in. Diam.	Allowance for Slabs and Saw Kerf.	40-in. Diam.	Allowance for Slabs and Saw Kerf.
Actual Contents	3982	----	4401	----	4841	----
Scribner Scale	2304	1678	2670	1731	3010	1831
Spaulding Scale	2376	1606	2660	1741	2962	1879
British Columbia Scale	2266	1716	2536	1865	2822	2019

TAPER OF DOUGLAS FIR LOGS

The foregoing table is computed on the assumption that the 40-foot logs used as an example have an increase in taper of 6 inches, which is a fair average for this length of log.

To gauge the correct actual contents of a log, it is necessary to take the mean diameter, not the diameter at the small end, which is the usual method of scaling Douglas Fir logs; therefore to arrive at the actual contents given in the table, an increase of three inches over the diameter at the small end is allowed to give the correct mean diameter upon which the actual contents given in this table are based.

BOARD MEASUREMENT OF LOGS

Board Measure is designed primarily for the measurement of sawed lumber. The unit is the board foot, which is a board 1 inch thick and 1 foot square, so that with inch boards the content in board measure is the same as the number of square feet of surface; with lumber of other thicknesses the content is expressed in terms of inch boards.

For a number of years board measure has been used as a unit of volume for logs. When so applied the measure does not show the entire content of the log, but the quantity of lumber which, it is estimated, may be manufactured from it. The number of board feet in any given log is determined from a table that shows the estimated number which can be taken out from logs of different diameters and lengths. Such a table is called a log scale or log rule, and is compiled by reducing the dimensions of perfect logs of different sizes, to allow for waste in manufacture, and then calculating the number of inch boards which remain.

The amount of lumber which can be cut from logs of a given size is not uniform, because the factors which determine the amount of waste vary under different circumstances, such as the thickness of the saw, the thickness of the boards, the width of the smallest board which may be utilized, the skill of the sawyer, the efficiency of the machinery, the defects in the log, the amount of taper, and the shrinkage. This lack of uniformity has led to wide differences of opinion as to how log rules should be constructed. There have been many attempts to devise a log rule which can be used as a standard, but none of them will meet all conditions. The rules in existence have been so unsatisfactory that constant attempts have been made to improve upon them. As a result there are now actually in use in the United States 40 or 50 different log rules, whose results differ in some cases as much as 120 per cent for 20-inch to 30-inch logs, and 600 per cent for 6-inch logs. Some of these are constructed from mathematical formulae; some by preparing diagrams that represent the top of a log and then determining the amount of waste in sawdust and slabs; some are based on actual averages of logs cut at the mill; while still others are the result of making corrections in an existing rule to meet special local conditions.

The large number of log rules, the difference in their values, and the variation in the methods of their application have led to much confusion and inconvenience. Efforts to reach an agreement among lumbermen on a single standard log rule have failed so far. A number of States have given official sanction to specific rules, but this has only added to the confusion, because the States have not chosen the same rule, so there are six different state log rules, and, in addition, three different official log rules in Canada. It is probable that a standard method of measuring logs will not be worked out satisfactorily until a single unit of volume, like the cubic or board foot, is adopted for the measurement of logs.—U. S. Forest Service Bulletin 36.

The Brereton Solid Log Table shows the exact or solid contents in board feet of logs or round timbers, which will be found invaluable in a large number of instances as enumerated in the following pages, and also for comparison with the Pacific Coast and other numerous log scales now in use.

It is only a question of time when both buyer and seller will recognize the absolute fairness and benefit to be derived from making sales on the exact contents of a log, as the variation in quality can then be adjusted by the variation in price.

It is unreasonable to measure pulp wood logs in terms of manufactured lumber, as the entire log is used in making pulp. Theretore a solid measure is more appropriate than the usual log scale making allowance for slab and saw kerf.

ADVANTAGES AND USES OF THE BRERETON SOLID LOG TABLE SHOWING EXACT BOARD MEASURE CONTENTS OF LOGS

Situations arise where it is essential to arrive at a close estimate for freight purposes of the exact or solid contents of logs or piling which are often shipped by vessel to Foreign or Domestic ports or when it is necessary to compute their weight prior to shipping by rail, with a view of ordering cars that will stand the strain of heavy and long logs, spars or timbers.

It is also indispensable for ship's officers and stevedores to know the contents and weight of large logs and spars to enable them to judge as to the advisability of adjusting or doubling up their gear to avoid smashing derricks and winches or otherwise breaking down machinery.

POUNDS PER DEADWEIGHT TON

When computing deadweight of lumber, coal, or general cargo carried by British vessels, it is customary to use the long ton of 2240 pounds.

BRERETON SOLID LOG TABLE

ACTUAL CONTENTS OF LOGS OR ROUND TIMBERS IN BOARD FEET

Length in Feet	Average Diameter in Inches										
	6	7	8	9	10	11	12	13	14	15	16
16	38	51	67	85	105	127	151	177	205	236	268
18	42	58	75	95	118	143	170	199	231	265	302
20	47	64	84	106	131	158	188	221	257	295	335
22	52	71	92	117	144	174	207	243	282	324	369
24	57	77	101	127	157	190	226	265	308	353	402
26	61	83	109	138	170	206	245	288	334	383	436
28	66	90	117	148	183	222	264	310	359	412	469
30	71	96	126	159	196	238	283	332	385	442	503
32	75	103	134	170	209	253	302	354	411	471	536
34	80	109	142	180	223	269	320	376	436	501	570
36	85	115	151	191	236	285	339	398	462	530	603
38	90	122	159	201	249	301	358	420	487	560	637
40	94	128	168	212	262	317	377	442	513	589	670
42	99	135	176	223	275	333	396	465	539	619	704
44	104	141	184	233	288	348	415	487	564	648	737
46	108	148	193	244	301	364	434	509	590	677	771
48	113	154	201	254	314	380	452	531	616	707	804
50	118	160	209	265	327	396	471	553	641	736	838
52	123	167	218	276	340	412	490	575	667	766	871
54	127	173	226	286	353	428	509	597	693	795	905
56	132	180	235	297	367	443	528	619	718	825	938
58	137	186	242	307	380	459	547	642	744	854	972
60	141	192	251	318	393	475	565	664	770	884	1005

Length in Feet	Average Diameter in Inches										
	17	18	19	20	21	22	23	24	25	26	27
16	303	339	378	419	462	507	554	603	655	708	763
18	340	382	425	471	520	570	623	679	736	796	859
20	378	424	473	524	577	634	692	754	818	885	954
22	416	467	520	576	635	697	762	829	900	973	1050
24	454	509	567	628	693	760	831	905	982	1062	1145
26	492	551	614	681	750	824	900	980	1064	1150	1241
28	530	594	662	733	808	887	969	1056	1145	1239	1336
30	567	636	709	785	866	950	1039	1131	1227	1327	1431
32	605	679	756	838	924	1014	1108	1206	1309	1416	1527
34	643	721	803	890	981	1077	1177	1282	1391	1504	1622
36	681	763	851	942	1039	1140	1246	1357	1473	1593	1718
38	719	806	898	995	1097	1204	1316	1433	1554	1681	1813
40	757	848	945	1047	1155	1267	1385	1508	1636	1770	1909
42	794	891	992	1100	1212	1330	1454	1583	1718	1858	2004
44	832	933	1040	1152	1270	1394	1523	1659	1800	1947	2099
46	870	975	1087	1204	1328	1457	1593	1734	1882	2035	2195
48	908	1018	1134	1257	1385	1521	1662	1810	1964	2124	2290
50	964	1060	1181	1309	1443	1584	1731	1885	2045	2212	2386
52	984	1103	1229	1361	1501	1647	1800	1960	2127	2301	2481
54	1021	1145	1276	1414	1559	1711	1870	2036	2209	2389	2577
56	1059	1188	1323	1466	1616	1774	1939	2111	2291	2478	2672
58	1097	1230	1370	1518	1674	1837	2008	2187	2373	2566	2767
60	1135	1272	1418	1571	1732	1901	2077	2262	2454	2655	2863

BRERETON SOLID LOG TABLE—Continued

ACTUAL CONTENTS OF LOGS OR ROUND TIMBERS IN BOARD FEET

Length in Feet	Average Diameter in Inches										
	28	29	30	31	32	33	34	35	36	37	38
16	821	881	942	1006	1072	1140	1211	1283	1357	1434	1512
18	924	991	1060	1132	1206	1283	1362	1443	1527	1613	1701
20	1026	1101	1178	1258	1340	1426	1513	1604	1696	1792	1890
22	1129	1211	1296	1384	1474	1568	1665	1764	1866	1971	2079
24	1232	1321	1414	1510	1608	1711	1816	1924	2036	2150	2268
26	1334	1431	1532	1635	1743	1853	1967	2085	2205	2330	2457
28	1437	1541	1649	1761	1877	1996	2118	2245	2375	2509	2646
30	1539	1651	1767	1887	2011	2138	2270	2405	2545	2688	2835
32	1642	1761	1885	2013	2145	2281	2421	2566	2714	2867	3024
34	1745	1871	2003	2139	2279	2423	2572	2726	2884	3046	3213
36	1847	1982	2121	2264	2413	2566	2724	2886	3054	3226	3402
38	1950	2092	2238	2390	2547	2708	2875	3047	3223	3405	3591
40	2053	2202	2356	2516	2681	2851	3026	3207	3393	3584	3780
42	2155	2312	2474	2642	2815	2994	3178	3367	3563	3763	3969
44	2258	2422	2592	2767	2949	3136	3329	3528	3732	3942	4158
46	2360	2532	2710	2893	3083	3279	3480	3688	3902	4122	4347
48	2463	2642	2827	3019	3217	3421	3632	3848	4072	4301	4536
50	2566	2752	2945	3145	3351	3564	3783	4009	4241	4480	4725
52	2668	2862	3063	3271	3485	3706	3934	4169	4411	4659	4915
54	2771	2972	3181	3396	3619	3849	4086	4330	4580	4838	5104
56	2874	3082	3299	3522	3753	3991	4237	4490	4750	5018	5293
58	2976	3193	3416	3648	3887	4134	4388	4650	4920	5197	5482
60	3079	3303	3534	3774	4021	4277	4540	4811	5089	5376	5671

Length in Feet	Average Diameter in Inches									
	39	40	41	42	43	44	45	46	47	48
16	1593	1676	1760	1847	1936	2027	2121	2216	2313	2413
18	1792	1885	1980	2078	2178	2281	2386	2493	2602	2714
20	1991	2094	2200	2309	2420	2534	2651	2770	2892	3016
22	2190	2304	2420	2540	2662	2788	2916	3047	3181	3318
24	2389	2513	2641	2771	2904	3041	3181	3324	3470	3619
26	2588	2723	2861	3002	3146	3294	3446	3601	3759	3921
28	2787	2932	3081	3233	3388	3548	3711	3878	4048	4222
30	2986	3142	3301	3464	3631	3801	3976	4155	4337	4524
32	3186	3351	3521	3695	3873	4055	4241	4432	4627	4825
34	3385	3560	3741	3925	4115	4308	4506	4709	4916	5127
36	3584	3770	3961	4156	4357	4562	4771	4986	5204	5429
38	3783	3979	4181	4387	4599	4815	5036	5263	5494	5730
40	3982	4189	4401	4618	4841	5068	5301	5540	5783	6032
42	4181	4398	4621	4849	5083	5322	5567	5817	6072	6333
44	4380	4608	4841	5080	5325	5575	5832	6094	6361	6635
46	4579	4817	5061	5311	5567	5829	6097	6371	6651	6937
48	4778	5027	5281	5542	5809	6082	6362	6648	6940	7238
50	4977	5236	5501	5773	6051	6336	6627	6925	7229	7540
52	5177	5445	5721	6004	6293	6589	6892	7202	7518	7841
54	5376	5655	5941	6235	6535	6842	7157	7479	7807	8143
56	5575	5864	6161	6465	6777	7096	7422	7756	8096	8445
58	5774	6074	6381	6696	7019	7349	7687	8033	8386	8746
60	5973	6283	6601	6927	7261	7603	7952	8310	8675	9048

TABLE SHOWING BOARD FEET CONTENTS FOR ONE LINEAL FOOT OF ROUND TIMBER OR LOGS FROM ONE TO ONE HUNDRED INCHES IN DIAMETER

This Table can be used for computing the actual or solid Board Feet Contents of Props, Poles, Piling, Logs or Round Timbers, from One to One Hundred Inches in Diameter by multiplying the length in feet by the amount given opposite the diameter required.

Diameter in Inches	Board Feet Contents for 1 Lin. Ft.	Diameter in Inches	Board Feet Contents for 1 Lin. Ft.	Diameter in Inches	Board Feet Contents for 1 Lin. Ft.	Diameter in Inches	Board Feet Contents for 1 Lin. Ft.
1	.06545	26	44.24420	51	170.23545	76	378.03920
2	.26180	27	47.71305	52	176.97680	77	388.05305
3	.58905	28	51.31280	53	183.84905	78	398.19780
4	1.04720	29	55.04345	54	190.85220	79	408.47345
5	1.63625	30	58.90500	55	197.98625	80	418.88000
6	2.35520	31	62.89745	56	205.25120	81	429.41745
7	3.20705	32	67.02080	57	212.64705	82	440.08580
8	4.18880	33	71.27505	58	220.17380	83	450.88505
9	5.30145	34	75.66020	59	227.83145	84	461.81520
10	6.54500	35	80.17625	60	235.62000	85	472.87625
11	7.91945	36	84.82320	61	243.53945	86	484.06820
12	9.42480	37	89.60105	62	251.58980	87	495.39105
13	11.06105	38	94.50980	63	259.77105	88	506.84480
14	12.82820	39	99.54945	64	268.08320	89	518.42945
15	14.72625	40	104.72000	65	276.52625	90	530.14500
16	16.75520	41	110.02145	66	285.10020	91	541.99145
17	18.91505	42	115.45380	67	293.80505	92	553.96880
18	21.20580	43	121.01705	68	302.64080	93	566.07705
19	23.62745	44	126.71120	69	311.60745	94	578.31620
20	26.18000	45	132.53625	70	320.70500	95	590.68625
21	28.86345	46	138.49220	71	329.93345	96	603.18720
22	31.67780	47	144.57905	72	339.29280	97	615.81905
23	34.62305	48	150.79680	73	348.78305	98	628.58180
24	37.69920	49	157.14545	74	358.40420	99	641.47545
25	40.90625	50	163.62500	75	368.15625	100	654.50000

U. S. SHIPPING BOARD RULE

This rule is used for determining the contents of logs for freight purposes and is computed as follows:

Rule: Square the mean diameter of the log in inches, multiply this by the length in inches, and divide by 1728. The result is the cubic feet upon which freight is charged.

Example: Find the cubic feet for freight purposes of a log 40 inches average diameter and 50 feet in length.

Process: 40x40 equals 1600 multiplied by 600, the length (50 ft. x 12) in inches, equals 960,000 which is divided by 1728 and gives 555½ cubic feet or the equivalent of 6666 board feet.

Note: As the actual contents of a log 40 inches average diameter and 50 feet long is 5236 board feet, it means that the shipper would be paying extra freight on 1430 board feet or 27 per cent more than the actual contents of the log. The amount in excess of the actual contents is evidently added to make up for space apparently lost in stowage, but even this allowance is excessive and deviates from the correct system of measurement, as a number of logs will stow in less space than the square of their diameter.

CORRECT METHOD FOR DETERMINING FREIGHT ON LOGS

Freight on logs should be paid on actual contents. When logs have not been barked, the mean diameter should be taken outside of the bark. The mean diameter is determined by adding the end diameters together and dividing the result by two. **The "Brereton Solid Log Table"** gives the actual contents of logs from six to forty eight inches in diameter and from 16 to 60 feet in length.

The actual contents of logs that exceed the diameter given in the table can be ascertained by referring to the rule, for computing the contents of a log on page **40**.

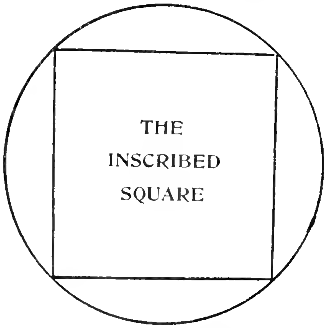
UNFAIR FREIGHT MEASUREMENTS

It is just as unfair to the shipper to be assessed freight on the contents of a log figured on the square of the mean diameter, according to the Shipping Board Rule, as it is that the shipowners or operators should only receive payment based on the log rules in general use, which allow from 30 to 60 per cent of the actual contents of a log for saw kerf and slabs.

The allowance made for saw kerf and slabs by the leading log scales of the Pacific Coast is shown in the differential table on page **33**.

TABLE SHOWING DIAMETER OF A LOG NECESSARY TO MAKE A SQUARE TIMBER

Diameter of log	Size of Timber	Diameter of log	Size of Timber
14½	10x10	34	24x24
16	11x11	35½	25x25
17	12x12	37	26x26
18½	13x13	38½	27x27
20	14x14	40	28x28
21½	15x15	41½	29x29
23	16x16	42½	30x30
24½	17x17	44	31x31
25½	18x18	45½	32x32
27	19x19	47	33x33
28½	20x20	48½	34x34
30	21x21	49½	35x35
31½	22x22	50½	36x36
33	23x23	54	38x38



To find the diameter of a log to make a square timber, divide one side of square by .707, or for practical purposes add a cipher to one side of square and divide by 7.

To find the largest size square timber that can be made out of a log, multiply diameter by 7 and divide by 10.

Example: What is the diameter of a log that will make a timber 21 inches square?

Process:

$$\begin{array}{r} 21 \\ 10 \\ \hline 7)210 \\ \hline 30 \end{array}$$

30 inches diameter. Answer.

What size timber can be made out of a log 40 inches in diameter?

$$\begin{array}{r} 40 \\ 7 \\ \hline 10)280 \\ \hline 28 \end{array}$$

28 inches square. Answer.

A NEW METHOD OF TAPER SAWING

From time to time the question of sawing parallel to the grain of a log is brought up. There are various methods for accomplishing this, and these methods were brought into considerable prominence during the war. A new method of sawing with the grain has been invented by C. W. Aue, sawyer, Snoqualmie Falls, Wash. Regarding this invention, which is patented, the Four L Bulletin said in part:

There is nothing new in the idea of cutting tapered logs parallel with the bark. As a rule, however, the bias lay of the log is achieved by means of placing blocks ahead of one or more of the set blocks. Mr. Aue cut the shafting between the setter's seat and the head block and installed a clutch coupling which the setter can operate with his foot and move the head block forward or backward one, two, three or four inches without affecting the others. The idea makes the operation of sawing a tapered log both more accurate and more speedy.

In addition, Mr. Aue suggests these advantages: The amount of taper is limited only to the length of the skid—one inch, two inches, three inches, four inches and up in multiples of these, as desired. The dogging of the log is simplified as it is always against the head block. If a change of taper is desired at any time there is no slack to contend with between the block and the log. It is inexpensive to install and very simple in operation.

HOW TO SAW TIMBERS

When it is necessary to make two sound timbers out of a large log, splitting through the heart should always be avoided, and if the following system is adopted better timbers will be produced, and the danger of exposing heart shakes will be greatly minimized.

Presume it is necessary to make two 12x12 timbers out of a log 32 inches in diameter. Square up a 12x28½ (the ½ inch allows for two cuts ¼ inch Kerf), then cut the first timber, and if free from heart shakes, turn cant over and saw off 4 inches and you will then have the second timber on the carriage. If after the first cut, shakey heart or other defects are exposed, without turning cant make another cut 4 inches, which leaves a 12x12 on the carriage, and a glance will show whether it is suitable or not for required order.

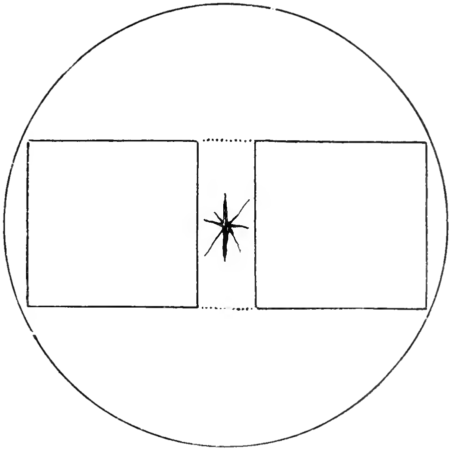


Diagram Illustrating Correct Method of Making Two Timbers Out of a Log

THE NINETEEN-INCH STANDARD LOG RULE

One of the standards in most common use is the so-called nineteen-inch standard or "**Market,**" of which the unit is a log 13 feet long and 19 inches in diameter at the small end inside the bark

Such a log is called a "**Market.**" Logs of other diameters are compared with this standard in proportion to their length, and in proportion also as to the squares of their diameters. In other words, the number of markets in a log of 20-inch diameter and 12 foot long would be 12x20x20, divided by 13x19x19.

This log rule is most commonly used in the Adirondack mountains of New York and is sometimes called the Glens Falls Standard rule.

Standard measure is commonly, though incorrectly, translated into board measure by multiplying the volume of a given log in standards by a constant. In the case of the Nineteen-Inch Standard rule it is assumed that one standard is equivalent to 200 board feet, and the number of standards in a lot of logs, multiplied by 200, gives the approximate board feet contents.

Rule for determining the contents of the 19 inch standard log.

Multiply the square of the diameter by the length and divide by 13x19x19.

THE ROPP RULE

For logs 12 inches and over in diameter.

Rule: From the square of the diameter (in inches) subtract 60, multiply the remainder by half of the length (in feet) and point off the right hand figure.

Example: Find the number of board feet in a log 30 inches in diameter and 40 feet long.

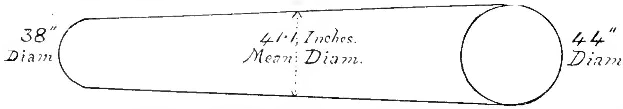
Process:

30x30 equals	900
Subtract	60
	840
Half of length	20
	1680.0 Answer 1680 Board Feet.

TO COMPUTE CONTENTS OF A LOG, ROUND TAPERING TIMBER OR FRUSTUM OF A CONE

To compute the board feet contents of a log, round tapering timber or frustum of a cone.

Rule: Add together squares of the diameters of the smaller and larger ends and product of the two diameters; multiply their sum respectively by .7854, and this product by length (height); then divide result by 12 and 3.



Example: Find the board feet contents of a log 38 inches diameter at the small end, and 44 inches diameter at the large end, 40 feet in length.

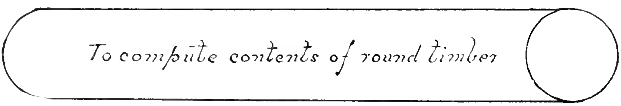
Process:

(Small diam)	38 x 38 equals	1444
(Large diam)	44 x 44 equals	1936
(Both diam's)	38 x 44 equals	1672
		5052
Sum of diameters by		.7854
		20208
		25260
		40416
		35364
		3967.8108
Multiplied by		40
Divided by		12)158713.6320
Divided by		3) 13226.1360
		4408.7120 Board Feet, Contents.

The exact mean diameter of the log in the foregoing example is 41.1 inches, not 41 inches as would be generally supposed. The difference is due to the converging slant height of a tapering body which gives a very slight increase in mean diameter over the approximate diameter which is computed by adding the top and bottom diameter together and dividing by 2.

When the diameter of a round timber is given or the mean diameter of a log is known the board feet contents can be obtained by reference to the Actual Contents Table, or using the following rule.

Rule: Multiply the square of the diameter by .7854, and the product by the length, then divide by 12.



Example: Find the board measure contents of a round timber 20 inches diameter and 50 feet in length.

Process:

Square of diam. 20 x 20 equals 400
400 multiplied by .7854 equals 314.16
314.16 multiplied by length 50 ft., equals 15708
15708 divided by 12 equals 1309—the Board Feet, Contents.

COMPUTING CONTENTS OF LOGS BY CIRCUMFERENCE

When the mean circumference of a log or round timber is known, the following rule gives the actual board measure contents.

Rule: Multiply the square of the circumference by twice the length and divide by 300.

Example: Find the actual board measure contents of a log 60 inches mean circumference and 50 feet in length.

Process:

60 x 60 equals 3600, the square of the circumference.
3600 x 100, (twice 50, the length) equals 360,000.
360,000 divided by 300 equals 1200, the board measure contents.

Note. The foregoing rule gives five feet more lumber in every thousand feet a log contains than if computed by the long and tedious rule of geometry and is sufficiently correct for all practical purposes.

The circumference of a log or circle multiplied by 0.31831 will give the diameter.

The diameter multiplied by 3 1/7 or for greater "accuracy" by 3.1416 will give the circumference of a log or circle.

KNOTS AND HOW THEY ARE CLASSIFIED

DOUGLAS FIR

A Pin Knot does not exceed half inch in diameter.

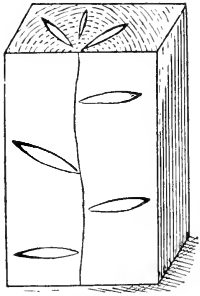
Round Knots are of a circular or oval formation, the average measurement across the face being considered the diameter.

Spike and Slash Knots are the same, and mean that the knot is sawn in a lengthwise direction.

Encased Knots usually are found in upper stock and are recognized by the ring of pitch which surrounds them; the knots on the outside of a plank may be encased, while on the heart side they are solid.

A thorough knowledge of knots is essentially of the utmost importance when grading lumber.

Knots spring from the heart in the same direction as the spokes do from the hub of a wheel.



The above illustration shows a 6 x 12 that has been sawn through the heart; the knots shown are classified as spike or slash.

The majority of knots are black at outside point, and encased about one-third the distance from outside point to the heart center.

The encased knots that penetrate lumber of one inch in thickness are liable to come out when seasoned and then surfaced; the damage is mostly caused by the force of the knife striking and loosening some of the knots as the board passes through the planer.

In lumber two inches and over in thickness, in the Merchantable and Common grades, it is only in very rare instances that the knots come out.

Special attention should be paid to the grain surrounding the knots, and the direction it takes, as this indicates more than anything else the strength of the piece.

THE DOYLE RULE

The Doyle Rule is variously known as the Connecticut River Rule, the St. Croix Rule, the Thurber Rule, the Moore and Beeman Rule, and the Scribner Rule—the last name due to the fact that it is now printed in Scribner's Lumber and Log Book. It is used throughout the entire country, and is more widely employed than any other rule. **It is constructed by deducting 4 inches from the small diameter of the log as an allowance for slab, squaring one-quarter of the remainder, and multiplying the result by the length of the log in feet.**

The important feature of the formula is that the width of slab is always uniform, regardless of the size of the log. This waste allowance is altogether too small for large logs and is excessive for small ones. The principal is mathematically incorrect, for the product of perfect logs of different sizes follows an entirely different mathematical law, and it is, therefore, astonishing that this incorrect rule, which gives wrong results for both large and small logs, should have so general a use.

Where the loss by defects in the timber and waste in milling have accidentally about balanced the inaccuracies of the rule, fairly accurate results have been obtained. Frequently, however, mill men recognize the shortcomings of the rule and make corrections to meet their special requirements. In general the mill cut overruns the Doyle log scale by about 25 per cent for short logs 12 to 20 inches in diameter; and for long logs with a small top diameter the overrun is very much higher.

DOYLE—SCRIBNER RULE

This is a combination of the Doyle and Scribner rule. It is used to a great extent for scaling hardwoods, and is the official scale of the Hardwood Manufacturers Association of the United States. It is also used to a considerable extent in the scaling of Southern Pine.

By this rule the contents of all logs 27 inches and under are measured by the Doyle Rule, and the Scribner Rule is used to measure logs 28 inches and over in diameter.

BRITISH COLUMBIA LOG TABLE

CONTENTS OF LOGS IN BOARD FEET

Length in Feet	Diameter in Inches									
	11	12	13	14	15	16	17	18	19	20
10	43	52	63	74	87	100	114	130	146	163
12	52	63	76	89	104	120	137	156	175	195
14	60	73	88	104	121	140	160	181	204	228
16	69	84	101	119	139	160	183	207	233	261
18	77	94	113	134	156	180	206	233	262	293
20	86	105	126	149	174	200	229	259	292	326
22	95	115	138	164	191	220	252	285	321	358
24	103	126	151	178	208	240	274	311	350	391
26	112	136	164	193	226	260	297	337	379	424
28	120	147	176	208	243	280	320	363	408	456
30	129	157	189	223	260	300	343	389	437	489
32	137	168	201	238	278	320	366	415	466	521
34	146	178	214	253	295	340	389	441	496	554
36	155	189	227	268	312	360	412	467	525	586
38	163	199	239	283	330	380	435	492	554	619
40	172	210	252	297	347	400	457	518	583	652

Length in Feet	Diameter in Inches									
	21	22	23	24	25	26	27	28	29	30
10	181	200	220	241	263	286	310	334	360	387
12	217	240	264	289	315	343	371	401	432	464
14	253	280	308	337	368	400	433	468	504	541
16	290	320	352	386	421	457	495	535	576	619
18	326	360	396	434	473	514	557	602	648	696
20	362	400	440	482	526	571	619	669	720	773
22	398	440	484	530	578	629	681	735	792	851
24	434	480	528	578	631	686	743	802	864	928
26	471	520	572	626	683	743	805	869	936	1005
28	507	560	616	675	736	800	867	936	1008	1083
30	543	600	660	723	789	857	929	1003	1080	1160
32	579	640	704	771	841	914	990	1070	1152	1237
34	615	680	748	819	894	971	1052	1137	1224	1315
36	652	720	792	868	946	1029	1114	1203	1296	1392
38	688	760	836	916	999	1086	1176	1270	1368	1469
40	724	800	880	964	1051	1143	1238	1337	1440	1547

BRITISH COLUMBIA LOG TABLE—Continued

CONTENTS OF LOGS IN BOARD FEET

Length in Feet	Diameter in Inches									
	31	32	33	34	35	36	37	38	39	40
10	414	443	472	503	534	567	600	634	669	706
12	497	531	567	603	641	680	720	761	803	847
14	580	620	661	704	748	793	840	888	937	988
16	663	708	756	804	855	906	960	1015	1071	1129
18	746	797	850	905	962	1020	1080	1141	1205	1270
20	828	886	945	1005	1068	1133	1200	1268	1340	1411
22	911	974	1039	1106	1175	1246	1320	1395	1473	1552
24	994	1063	1134	1207	1282	1360	1440	1522	1606	1693
26	1077	1151	1228	1307	1389	1473	1560	1649	1740	1834
28	1160	1240	1322	1408	1496	1586	1680	1776	1874	1976
30	1243	1328	1417	1508	1603	1700	1800	1902	2008	2117
32	1326	1417	1511	1609	1709	1813	1920	2030	2142	2258
34	1408	1506	1606	1709	1816	1926	2040	2156	2276	2399
36	1491	1594	1700	1810	1923	2040	2160	2283	2410	2540
38	1574	1683	1795	1911	2030	2153	2280	2410	2544	2681
40	1657	1771	1889	2011	2137	2266	2400	2537	2677	2822

Length in Feet	Diameter in Inches									
	41	42	43	44	45	46	47	48	49	50
10	743	781	820	860	901	943	985	1029	1074	1120
12	891	937	984	1031	1081	1131	1183	1235	1289	1344
14	1040	1094	1148	1203	1261	1320	1380	1441	1504	1568
16	1188	1249	1312	1375	1441	1508	1577	1647	1718	1791
18	1337	1405	1476	1547	1621	1697	1774	1853	1933	2015
20	1485	1562	1640	1719	1801	1885	1971	2058	2148	2239
22	1634	1718	1804	1891	1982	2074	2168	2264	2363	2463
24	1782	1874	1967	2063	2162	2262	2365	2470	2578	2687
26	1931	2030	2131	2235	2342	2451	2562	2676	2792	2911
28	2080	2186	2295	2407	2522	2639	2759	2882	3007	3135
30	2228	2342	2459	2579	2702	2828	2956	3088	3222	3359
32	2377	2498	2623	2751	2882	3016	3153	3294	3437	3583
34	2525	2655	2787	2923	3062	3205	3350	3499	3652	3807
36	2674	2811	2951	3094	3242	3393	3548	3705	3866	4031
38	2822	2967	3115	3266	3423	3582	3745	3911	4081	4255
40	2971	3123	3279	3438	3603	3770	3942	4117	4296	4479

CONTENTS OF LOGS IN BOARD FEET

Length in Feet	Diameter in Inches									
	51	52	53	54	55	56	57	58	59	60
10	1166	1214	1262	1312	1360	1414	1466	1520	1574	1629
12	1400	1457	1515	1574	1632	1697	1759	1823	1889	1955
14	1633	1699	1767	1837	1904	1979	2053	2127	2203	2281
16	1866	1942	2020	2099	2176	2262	2346	2431	2518	2606
18	2099	2185	2272	2362	2448	2545	2639	2735	2833	2932
20	2333	2428	2525	2624	2721	2828	2932	3039	3148	3258
22	2565	2671	2777	2886	2993	3110	3226	3343	3462	3584
24	2799	2913	3030	3149	3265	3393	3519	3647	3777	3910
26	3032	3156	3282	3411	3537	3676	3812	3951	4092	4235
28	3266	3399	3535	3674	3809	3959	4105	4255	4407	4561
30	3499	3642	3787	3936	4081	4242	4399	4559	4721	4887
32	3732	3885	4040	4198	4353	4524	4692	4862	5036	5213
34	3965	4127	4292	4461	4625	4807	4985	5166	5351	5536
36	4199	4370	4545	4723	4897	5090	5278	5470	5666	5864
38	4432	4613	4797	4986	5169	5373	5572	5774	5980	6190
40	4665	4856	5050	5248	5441	5655	5865	6078	6295	6516

Length in Feet	Diameter in Inches									
	61	62	63	64	65	66	67	68	69	70
10	1685	1745	1800	1859	1919	1980	2042	2105	2169	2233
12	2022	2094	2160	2231	2303	2376	2451	2526	2603	2679
14	2359	2443	2520	2603	2687	2772	2859	2947	3036	3126
16	2696	2791	2881	2975	3071	3168	3267	3368	3470	3672
18	3033	3140	3241	3347	3455	3565	3676	3789	3904	4019
20	3370	3489	3601	3719	3839	3961	4084	4210	4338	4465
22	3707	3838	3961	4091	4223	4357	4493	4631	4771	4912
24	4044	4187	4321	4463	4606	4753	4901	5052	5205	5358
26	4381	4536	4681	4834	4990	5149	5310	5473	5639	5805
28	4718	4885	5041	5206	5374	5545	5718	5894	6073	6251
30	5055	5234	5401	5578	5758	5941	6126	6315	6506	6698
32	5393	5583	5761	5950	6142	6337	6535	6736	6940	7144
34	5730	5932	6121	6322	6526	6733	6943	7157	7374	7591
36	6067	6281	6481	6694	6910	7129	7352	7578	7808	8037
38	6404	6630	6841	7066	7293	7525	7760	7999	8241	8484
40	6741	6979	7201	7437	7677	7921	8169	8420	8675	8930

DESCRIPTION OF BRITISH COLUMBIA LOG SCALE

AS AUTHORIZED BY THE BRITISH COLUMBIA GOVERNMENT

Deduct one and a half inches from the mean diameter in inches at the small end of the log.

Square the result and multiply by .7854 to find area.

Deduct three-elevenths.

Divide by 12 to bring to board measure and multiply by the length of the log in feet.

The above is intended to apply to all logs whose length is not greater than 40 feet.

It is further provided that in cases of logs over 40 feet in length an allowance on half the length of the log is made, in order to compensate for the increase in diameter; this allowance consists of an increase in the mean diameter at the small end of one inch for each additional 10 feet in length over 40 feet.

In other words, in cases of logs from 42 to 50 feet long the contents of half the length of the log are to be computed according to the mean diameter at the small end, the contents of the other half of the log according to a diameter one inch greater than the mean diameter at the small end; in cases of logs from 52 to 60 feet long, the contents of half the log according to the mean diameter at the small end, and those of the other half according to a diameter two inches greater than the mean at the small end, and so on; the contents of the second half to be computed according to a diameter one inch greater than that of the mean at the small end for each additional 10 feet in length after 40 feet.

It was not, however, considered necessary to extend the table for a length of log greater than 40 feet, as the contents of such a log of given diameter may be obtained with sufficient accuracy by adding the tabular contents of half the length of the log at the given diameter to the tabular contents of a similar log at a diameter increased one inch for each additional 10 feet in length beyond 40 feet.

AS PROVIDED UNDER SECTION 6 OF THE "ROYALTY ACT"

Cedar

No. 1—Logs 16 feet and over in length, 20 inches and over in diameter, that will cut out 50 per cent or over of their scaled contents in clear inch lumber: Provided that in cases of split timber the foregoing diameter shall not apply as the minimum diameter for this grade.

No. 2—Shingle grade. Logs not less than 16 inches in diameter and not less than 16 feet in length that are better than No. 3 grade, but not grade No. 1.

No. 3—Rough logs or tops suitable only for shiplap or dimension.

Culls—Logs lower in grade than No. 3 shall be classed as culls.

Douglas Fir

No. 1—Logs suitable for flooring, reasonably straight, not less than 20 feet long, not less than 30 inches in diameter, clear, free from such defects as would impair the value for clear lumber.

No. 2—Logs not less than 14 inches in diameter, not over 24 feet long or not less than 12 inches in diameter, and over 24 feet, sound, reasonably straight, free from rotten knots or bunch-knots, and the grain straight enough to ensure strength.

No. 3—Logs having visible defects, such as bad crooks, bad knots, or other defects that would impair the value and lower the grade of lumber below merchantable.

Culls—Logs lower in grade than No. 3 will be classed as culls.

Spruce, Pine and Cottonwood

No. 1—Logs 12 feet and over in length, 30 inches in diameter and over up to 32 feet long, 24 inches if over 32 feet long, reasonably straight, clear, free from such defects as would impair the value of clear lumber.

No. 2—Logs not less than 14 inches in diameter and not over 24 feet, or not less than 12 inches in diameter and over 24 feet long, sound, reasonably straight, free from rotten knots or bunch-knots, and the grain straight enough to ensure strength.

No. 3—Logs having visible defects, such as bad crooks, bad knots, or other defects that would lower the grade of lumber below merchantable.

Culls—Logs lower in grade than No. 3 will be classed as culls.

Diameter measurements, wherever referred to in this Schedule, shall be taken at the small end of the log.

SCALING AND GRADING RULES OF THE COLUMBIA RIVER LOG SCALING AND GRADING BUREAU

No. 1 Logs shall be 30 inches and over in diameter inside the bark at the small end and not less than 16 or more than 40 feet in length, and shall, in the judgment of the scaler, be practically suitable for the manufacture of upper grades of lumber.

No. 2 Logs shall be 16 inches and over in diameter inside the bark at the small end and not less than 16 or more than 40 feet in length, and shall, in the judgment of the scaler, be practically suitable for the manufacture of merchantable lumber.

No. 3 Logs shall be 12 inches and over in diameter inside the bark at the small end and not less than 16 or more than 40 feet in length, and shall, in the judgment of the scaler, be practically suitable for the manufacture of inferior grades of lumber.

Cull Logs shall be any logs which in the judgment of the scaler are not practically suitable for manufacture.

All logs to be scaled by the Spaulding Rule.

THE SPAULDING RULE

The Spaulding is the statute rule of California, adopted by an act of the legislature in 1878. It is used also in Oregon, Washington, Utah and Nevada. It was computed from carefully drawn diagrams of logs from 10 to 96 inches in diameter at the small end. Mill men seem to be well satisfied with its results. It is very similar to the Scribner Rule.

SPAULDING LOG TABLE

CONTENTS OF LOGS IN BOARD FEET

Length in Feet	Diameter in Inches								
	12	13	14	15	16	17	18	19	20
16	77	94	114	137	161	188	216	245	276
18	87	106	129	154	181	211	243	276	310
20	96	118	143	171	201	235	270	306	345
22	106	130	157	188	221	258	297	337	379
24	116	142	172	206	242	282	324	368	414
26	125	153	186	223	262	304	360	398	448
28	134	164	200	240	282	328	378	428	482
30	144	176	214	257	302	352	404	460	516
32	154	188	228	274	322	376	432	490	552
34	164	200	243	291	342	398	458	520	586
36	174	212	258	308	362	422	486	552	620
38	183	224	272	325	382	446	512	582	654
40	192	236	286	342	402	470	540	612	690
42	202	248	300	359	422	492	566	644	724
44	212	260	314	376	442	516	596	674	758
46	222	272	329	394	463	540	620	704	792
48	232	284	344	412	484	564	648	734	828
50	241	295	358	429	503	587	674	766	861
52	250	306	372	446	524	608	720	796	896
54	259	317	386	463	544	632	728	826	930
56	268	328	400	480	564	656	764	858	964
58	278	340	414	497	584	680	782	888	998
60	288	352	428	514	604	706	808	920	1032

Length in Feet	Diameter in Inches									
	21	22	23	24	25	26	27	28	29	30
16	308	341	376	412	449	488	528	569	612	656
18	346	384	423	463	505	549	594	640	688	738
20	385	426	470	515	561	610	660	711	765	820
22	423	469	517	566	617	671	726	782	841	902
24	462	512	564	618	674	732	792	854	918	984
26	500	554	611	668	730	792	858	924	994	1066
28	538	596	658	720	786	854	924	996	1070	1148
30	576	640	704	774	842	915	990	1066	1146	1230
32	616	682	752	824	898	976	1056	1138	1224	1312
34	654	724	798	874	954	1036	1122	1208	1300	1394
36	692	768	846	926	1010	1098	1188	1280	1376	1476
38	730	810	892	978	1066	1158	1254	1352	1452	1558
40	770	852	940	1030	1122	1220	1320	1422	1530	1640
42	808	896	986	1080	1178	1281	1386	1493	1606	1722
44	846	938	1034	1134	1234	1342	1452	1565	1682	1804
46	884	980	1080	1184	1290	1402	1518	1636	1758	1886
48	924	1024	1128	1236	1348	1464	1584	1708	1836	1968
50	961	1066	1174	1289	1404	1524	1650	1778	1911	2050
52	1000	1108	1220	1338	1460	1584	1716	1848	1988	2132
54	1038	1151	1268	1390	1516	1646	1782	1920	2064	2214
56	1076	1192	1316	1440	1572	1706	1838	1992	2140	2296
58	1114	1236	1362	1494	1628	1768	1914	2062	2226	2378
60	1152	1280	1408	1548	1684	1830	1980	2132	2292	2460

SPAULDING LOG TABLE—Continued

CONTENTS OF LOGS IN BOARD FEET

Length in Feet	Diameter in Inches									
	31	32	33	34	35	36	37	38	39	40
16	701	748	796	845	897	950	1006	1064	1124	1185
18	789	841	895	951	1009	1069	1132	1197	1264	1333
20	876	935	995	1056	1121	1188	1258	1330	1405	1481
22	964	1028	1094	1162	1233	1307	1384	1463	1545	1629
24	1052	1122	1194	1268	1346	1426	1510	1596	1686	1778
26	1139	1214	1292	1372	1458	1544	1634	1728	1826	1926
28	1226	1308	1392	1478	1570	1662	1760	1862	1966	2074
30	1314	1402	1492	1584	1682	1782	1886	1994	2106	2222
32	1402	1496	1592	1690	1794	1900	2012	2128	2248	2370
34	1490	1588	1690	1796	1906	2020	2138	2261	2388	2518
36	1578	1682	1790	1902	2018	2138	2264	2394	2528	2666
38	1664	1776	1890	2006	2130	2256	2390	2526	2668	2814
40	1752	1870	1990	2112	2242	2376	2516	2660	2810	2962
42	1840	1963	2089	2218	2354	2495	2642	2793	2950	3110
44	1928	2056	2188	2324	2466	2614	2768	2926	3090	3258
46	2016	2150	2288	2430	2579	2732	2894	3059	3230	3407
48	2104	2244	2388	2536	2692	2852	3020	3192	3372	3556
50	2190	2337	2486	2640	2804	2970	3144	3324	3512	3704

Length in Feet	Diameter in Inches									
	41	42	43	44	45	46	47	48	49	50
16	1248	1312	1377	1448	1512	1581	1652	1724	1797	1872
18	1404	1476	1549	1629	1701	1779	1858	1939	2022	2106
20	1560	1640	1721	1810	1890	1976	2065	2155	2246	2340
22	1716	1804	1893	1991	2079	2174	2271	2370	2470	2574
24	1872	1968	2066	2172	2268	2372	2478	2586	2696	2808
26	2028	2132	2238	2352	2456	2568	2684	2800	2920	3044
28	2184	2296	2410	2534	2646	2766	2890	3016	3144	3276
30	2340	2460	2582	2714	2834	2964	3096	3232	3370	3510
32	2496	2624	2754	2896	3024	3162	3304	3448	3594	3744
34	2652	2788	2926	3076	3212	3360	3510	3663	3819	3978
36	2808	2952	3098	3258	3402	3558	3716	3879	4043	4212
38	2964	3116	3270	3439	3590	3755	3923	4094	4268	4446
40	3120	3280	3442	3620	3780	3952	4130	4310	4492	4680

Length in Feet	Diameter in Inches									
	51	52	53	54	55	56	57	58	59	60
16	1948	2025	2104	2184	2266	2350	2486	2524	2613	2704
18	2191	2278	2367	2457	2550	2644	2740	2839	2940	3042
20	2435	2531	2630	2730	2833	2938	3045	3155	3266	3380
22	2678	2784	2893	3003	3116	3232	3349	3470	3592	3718
24	2922	3038	3156	3276	3400	3526	3654	3786	3920	4056
26	3164	3290	3418	3548	3682	3818	3958	4100	4246	4394
28	3408	3544	3682	3822	3966	4112	4262	4416	4572	4732
30	3652	3796	3944	4094	4250	4406	4566	4732	4900	5070
32	3896	4050	4203	4368	4532	4700	4872	5048	5226	5408

SCRIBNER LOG TABLE

CONTENTS OF LOGS IN BOARD FEET

Length in Feet	Diameter in Inches								
	12	13	14	15	16	17	18	19	20
10	49	61	72	89	99	116	133	150	175
12	59	73	86	107	119	139	160	180	210
14	69	85	100	125	139	162	187	210	245
16	79	97	114	142	159	185	213	240	280
18	88	109	129	160	178	208	240	270	315
20	98	122	143	178	198	232	267	300	350
22	108	134	157	196	218	255	294	330	385
24	118	146	172	214	238	278	320	360	420
26	127	159	186	231	257	302	347	390	455
28	137	171	200	249	277	325	374	420	490
30	147	183	214	267	297	348	400	450	525
32	157	195	229	285	317	371	427	480	560
34	167	207	243	303	337	394	454	510	595
36	176	220	257	320	356	418	481	540	630
38	186	232	272	338	376	441	507	570	665
40	196	244	286	356	396	464	534	600	700
42	206	256	300	374	416	487	561	630	735
44	216	268	315	392	436	510	587	660	770
46	225	281	329	409	455	534	614	690	805
48	235	293	343	427	475	557	641	720	840
50	245	305	357	445	495	580	667	750	875
52	255	317	372	463	515	603	694	780	910
54	265	329	386	481	535	626	721	810	945
56	274	342	400	498	554	650	748	840	980
58	284	354	405	516	574	673	774	870	1015
60	294	366	429	534	594	696	801	900	1050
62	304	378	443	552	614	719	828	930	1085
64	314	390	458	570	634	742	854	960	1120
66	323	403	472	587	653	766	881	990	1155
68	333	415	486	605	673	789	908	1020	1190
70	343	427	500	623	693	812	934	1050	1225

TO COMPUTE THE SPAULDING RULE

The following formula gives a result closely identical with the Spaulding Log Rule.

Rule: To compute the number of board feet in a log without allowing for taper, take the mean or average diameter of the small end inside the bark, square the diameter from which deduct the product of three times the diameter, multiply the remainder by one-half the length of the log and divide the result by 10 or point off right hand figure. The result is the board feet contents with saw kerf and slabs allowed for.

Example: Find the board feet contents of a log 30 inches diameter at small end and 40 feet long.

Process:

30x30 equals 900
Deduct 90 three times product of diameter.

810
Half the length 20

16200 divided by 10 equals 1620, the board feet contents.

WHY LUMBER SHOULD BE SEASONED BEFORE TREATMENT WITH PRESERVATIVES

The reason for seasoning beiore treatment is that ties or other lumber if creosoted when "green" will check severely atter treatment, due to the moisture in the interior of the lumber, and interior rot will ensue. Although a uniform penetration of about one-half inch is secured in the treatment of green ties, the checks will extend through this region and allow decay to reach the interior.

If lumber is well seasoned before treatment, on the other hand, all the checking will take place previous to the treatment, and the creosote will fill all of the checks, thus preventing decay.

SCRIBNER LOG TABLE—Continued

CONTENTS OF LOGS IN BOARD FEET

Length in Feet	Diameter in Inches									
	21	22	23	24	25	26	27	28	29	30
10	190	209	235	252	287	313	342	363	381	411
12	228	251	283	303	344	375	411	436	457	493
14	266	292	330	353	401	439	479	509	533	575
16	304	334	377	404	459	500	548	582	609	657
18	342	376	424	454	516	562	616	654	685	739
20	380	418	470	505	573	625	684	728	761	821
22	418	460	517	555	630	687	752	801	837	903
24	456	502	564	606	688	750	821	874	913	985
26	494	543	611	656	745	812	889	946	989	1067
28	532	587	658	707	802	875	958	1019	1065	1149
30	570	627	705	757	859	937	1026	1092	1141	1231
32	608	669	752	808	917	1000	1094	1165	1218	1314
34	646	711	799	858	974	1062	1162	1238	1294	1396
36	684	752	846	909	1031	1125	1231	1310	1370	1478
38	722	794	893	959	1089	1187	1300	1383	1446	1560
40	760	836	940	1010	1146	1250	1368	1456	1522	1642
42	798	878	987	1060	1203	1312	1436	1529	1598	1724
44	836	920	1034	1111	1261	1375	1505	1602	1674	1806
46	874	961	1081	1161	1318	1437	1572	1674	1750	1888
48	912	1003	1128	1212	1375	1500	1642	1747	1826	1970
50	950	1045	1175	1262	1432	1562	1710	1820	1902	2052
52	988	1087	1222	1313	1490	1625	1778	1893	1979	2135
54	1026	1129	1269	1363	1547	1687	1847	1966	2055	2217
56	1064	1170	1316	1414	1604	1750	1915	2038	2131	2299
58	1102	1212	1363	1464	1662	1812	1984	2111	2207	2381
60	1140	1254	1410	1515	1719	1875	2052	2184	2283	2463
62	1178	1296	1457	1565	1776	1937	2120	2257	2359	2545
64	1216	1338	1504	1616	1834	2000	2189	2330	2435	2627
66	1254	1379	1551	1666	1891	2062	2257	2402	2511	2709
68	1292	1421	1598	1717	1948	2125	2326	2475	2587	2791
70	1330	1463	1645	1767	2005	2187	2394	2548	2663	2873

THE SCRIBNER RULE

This is the oldest log scale now in general use. It was originally published in Scribner's Lumber and Log Book, in later editions of which it was replaced by the Doyle Rule. It is now usually called the "Old Scribner Rule," and is used to some extent in nearly every state. The rule was based on computations derived from diagrams drawn to show the number of inch boards that can be sawed from logs of different sizes after allowing for waste. The contents of these boards was then calculated and the table built up in this way.

Sometimes the Scribner Rule is converted into what is known as the Scribner Decimal Rule by dropping the units and rounding the values to the nearest tens. Thus 107 board feet would be written 11 in the Decimal Rule; 104 would be written 10. The Hyslop Rule is practically the same as the Scribner Decimal Rule. The Scribner Rule is known in Minnesota as the Minnesota Standard Rule. In the original table no values were given below a diameter of 12 inches.

In the judgment of most sawyers, the Scribner Rule gives very fair results for small logs cut by circular saws (about 8 gauge), but that for larger logs, about 28 inches, for example, the results are too small. It often happens that defects are greater in large logs than in small ones, because the larger are from older trees, which are more likely to be overmature. Even with these, however, the Scribner Rule is fairly satisfactory if the scaler does not make a further deduction for defects. As a matter of fact, a log rule should make no allowance for defect, because that is unfair to high-grade sound logs; only the scaler should make such allowance. In sound logs the saw cut has been known to overrun the Scribner scale from 10 to 20 per cent.

The Forest Service of the United States Department of Agriculture has adopted the Scribner Decimal Rule for timber sales on the National Forests. It has been in use for about four years and, in the main, has proved satisfactory, since competitive bids enable the buyer to bid higher if the character of the logs indicates a mill overrun.

SCRIBNER LOG TABLE—Continued

CONTENTS OF LOGS IN BOARD FEET

Length in Feet	Diameter in Inches									
	31	32	33	34	35	36	37	38	39	40
10	444	460	490	500	547	577	644	669	700	752
12	532	552	588	600	657	692	772	801	840	903
14	622	644	686	700	766	807	901	934	980	1053
16	710	736	784	800	876	923	1029	1068	1120	1204
18	799	828	882	900	985	1038	1158	1201	1260	1354
20	888	920	980	1000	1095	1152	1287	1335	1400	1505
22	977	1012	1078	1100	1204	1267	1416	1468	1540	1655
24	1066	1104	1176	1200	1314	1382	1544	1602	1680	1806
26	1154	1196	1274	1300	1423	1498	1673	1735	1820	1956
28	1243	1288	1372	1400	1533	1613	1802	1869	1960	2107
30	1332	1380	1470	1500	1642	1728	1930	2002	2100	2257
32	1421	1472	1568	1600	1752	1843	2059	2136	2240	2408
34	1510	1564	1666	1700	1861	1958	2188	2269	2380	2558
36	1598	1656	1764	1800	1971	2074	2317	2403	2520	2709
38	1687	1748	1862	1900	2080	2189	2445	2536	2660	2859
40	1776	1840	1960	2000	2190	2304	2574	2670	2800	3010
42	1865	1932	2058	2100	2299	2419	2703	2803	2940	3160
44	1954	2024	2156	2200	2409	2534	2831	2937	3080	3311
46	2042	2116	2254	2300	2518	2650	2960	3070	3220	3461
48	2131	2208	2352	2400	2628	2765	3089	3204	3360	3612
50	2220	2300	2450	2500	2737	2880	3217	3337	3500	3762
52	2309	2392	2548	2600	2847	2995	3346	3471	3640	3913
54	2398	2484	2646	2700	2956	3110	3475	3604	3780	4063
56	2486	2576	2744	2800	3066	3226	3604	3738	3920	4214
58	2575	2668	2842	2900	3175	3341	3732	3871	4060	4364
60	2664	2760	2940	3000	3285	3456	3861	4005	4200	4515
62	2753	2852	3038	3100	3394	3571	3990	4138	4340	4665
64	2842	2944	3136	3200	3504	3686	4118	4272	4480	4816
66	2930	3036	3234	3300	3613	3802	4247	4405	4620	4966
68	3019	3128	3332	3400	3723	3917	4376	4538	4760	5117
70	3108	3220	3430	3500	3832	4032	4504	4672	4900	5267

GROWTH OF TREES

Since there is a marked tendency among timberland owners to cut their timber with an eye to the future, some knowledge of the growth of forest trees becomes important.

Trees grow by adding each year a layer of wood underneath the bark. Since each year contains only one growing season and the spring and summer part of this layer are not alike, each year's growth, layer, or "annual ring" usually is distinguishable. The central fact of tree growth is that each ring means a year. The exceptions to this are not important enough to merit notice here.

Trees growing in the heart of the forest are generally straight and tall as it is necessary for their leaves to receive sunlight and air sufficient for vitalizing the sap; the lower branches of these trees only last a few years when they die and fall off. On the edges of the forest the lower branches of the trees remain alive and active so that timber cut from such places is knotty and occasionally cross-grained, while that cut from the inside trees is straight grained and contains a larger percentage of clear lumber.

OLD GROWTH LOGS

In reference to lumber manufactured from "old growth" logs, it means that the trees from which they were logged are mature, of large diameter and grown in a virgin forest, and not from trees in a process of decay through age.

Old growth Douglas Fir furnishes excellent lumber for high grade wide clears, in either edge or slash grain.

SCRIBNER LOG TABLE—Continued

CONTENTS OF LOGS IN BOARD FEET

Length in Feet	Diameter in Inches									
	41	42	43	44	45	46	47	48	49	50
20	1590	1679	1745	1850	1898	1983	2070	2160	2246	2340
22	1749	1847	1919	2035	2088	2181	2277	2376	2471	2574
24	1908	2015	2094	2220	2278	2380	2484	2592	2695	2808
26	2067	2183	2268	2405	2467	2578	2691	2808	2920	3042
28	2226	2351	2443	2590	2657	2776	2898	3024	3124	3276
30	2385	2518	2617	2775	2847	2974	3105	3240	3369	3510
32	2544	2686	2792	2960	3037	3173	3312	3456	3594	3744
34	2703	2854	2966	3145	3227	3371	3519	3672	3818	3978
36	2862	3022	3141	3330	3416	3569	3726	3888	4043	4212
38	3021	3190	3315	3515	3606	3768	3933	4104	4267	4446
40	3180	3358	3490	3700	3796	3966	4140	4320	4492	4680
42	3339	3526	3664	3885	3986	4164	4347	4536	4717	4914
44	3498	3694	3839	4070	4176	4363	4554	4752	4941	5148
46	3657	3862	4013	4255	4365	4561	4761	4968	5166	5382
48	3816	4030	4188	4440	4555	4759	4968	5184	5390	5616
50	3975	4197	4362	4625	4745	4957	5175	5400	5615	5850

Length in Feet	Diameter in Inches									
	51	52	53	54	55	56	57	58	59	60
20	2434	2530	2630	2730	2832	2938	3044	3154	3266	3380
22	2677	2783	2893	3003	3115	3232	3348	3469	3593	3718
24	2921	3036	3156	3276	3398	3526	3653	3785	3919	4056
26	3164	3289	3419	3549	3682	3819	3957	4100	4246	4394
28	3408	3542	3682	3822	3965	4113	4262	4416	4572	4732
30	3651	3795	3945	4095	4248	4407	4566	4731	4899	5070
32	3894	4048	4208	4368	4531	4701	4870	5046	5226	5408
34	4138	4301	4471	4641	4814	4995	5175	5262	5552	5746
36	4381	4554	4734	4914	5098	5288	5479	5677	5879	6084
38	4625	4807	4997	5187	5381	5582	5784	5993	6205	6422
40	4868	5060	5260	5460	5664	5876	6088	6308	6532	6760
42	5111	5313	5523	5733	5947	6170	6392	6623	6859	7098
44	5355	5566	5786	6006	6230	6464	6697	6939	7185	7436
46	5598	5819	6049	6279	6514	6757	7001	7254	7512	7774
48	5842	6072	6312	6552	6797	7051	7306	7570	7838	8112
50	6085	6325	6575	6825	7080	7345	7610	7885	8165	8450

SCRIBNER LOG TABLE—Continued

CONTENTS OF LOGS IN BOARD FEET

Length in Feet	Diameter in Inches									
	61	62	63	64	65	66	67	68	69	70
20	3496	3614	3734	3858	3982	4110	4240	4374	4510	4648
22	3846	3975	4107	4244	4380	4521	4664	4811	4961	5113
24	4195	4337	4481	4630	4778	4932	5088	5249	5412	5578
26	4545	4698	4854	5015	5177	5343	5512	5686	5863	6042
28	4894	5060	5228	5401	5575	5754	5936	6124	6314	6507
30	5244	5421	5601	5787	5973	6165	6360	6561	6765	6972
32	5594	5782	5974	6173	6371	6576	6784	6998	7216	7437
34	5943	6144	6348	6559	6769	6987	7208	7436	7667	7902
36	6293	6505	6721	6944	7168	7398	7632	7873	8118	8366
38	6642	6867	7095	7330	7566	7809	8056	8311	8569	8831
40	6992	7228	7468	7716	7964	8220	8480	8748	9020	9296
42	7342	7589	7841	8102	8362	8631	8904	9185	9471	9761
44	7691	7951	8215	8488	8760	9042	9328	9622	9922	10226
46	8041	8312	8588	8874	9158	9453	9752	10060	10373	10791
48	8390	8674	8962	9260	9556	9864	10176	10498	10824	11156
50	8740	9035	9335	9645	9955	10275	10600	10935	11275	11620

DIAMETER GROWTH

Some trees grow so slowly that a hand lens is necessary to clearly distinguish the rings, others may have rings a half inch in width. In any case, a little practice improves the ability to note all the rings.

To find the age of a felled tree at any section, then, requires only the accurate counting of the rings. The total age of the tree is shown by the total number of rings at the ground; or the total number of rings on the stump plus the number of years required to grow as high as the stump. An examination of a number of small trees would give an idea of the time required to grow up to stump height. This varies from one year in trees coming up as stump sprouts to as high as twenty years or more in some Rocky Mountain conifers, for heights of 1 to 3 feet.

Since trees often grow faster on one side than another, the average growth is gotten only by finding the average radius and counting and measuring the rings along it. Thus the radius of the tree may be found at ten, twenty, thirty years, etc., and by doubling these the diameters are found at these ages.

EXPLANATION OF THE TERM "SAP"

The term "sap" sometimes is used wrongly to mean the moisture in wood, and at other times to mean the sapwood. Sap is formed, mainly in the early spring, in the leaves from water rising from the roots through the sapwood. In the leaves this water is converted into true sap, which contains sugar and soluble gums. The sap descends through the bark and feeds the tissues in process of formation between the bark and the sapwood. The heartwood contains no sap.

SAPWOOD AND HEARTWOOD

The end surface of a log usually shows an outer lighter colored region, the sapwood, and an inner darker core, the heartwood. All young wood is light-colored; but as the tree becomes older the inner part becomes infiltrated with gums, resins, and other materials the exact nature of which has not been determined, which color the wood to a greater or less degree.

In some woods the heartwood is very dark, and in others there is little difference in color between the sapwood and heartwood. The spruces, true firs (not Douglas Fir), Hemlock, Port Orford cedar, and Buckeye belong to the latter class. In lodgepole pine, pinon, cottonwood, beech (white heart), cotton gum, sycamore, hackberry, and basswood, the heartwood is only slightly darker than the sapwood. The sapwood is often not white but is slightly tinged with the same color that is found in the heartwood. In black locust, honey locust, coffeetree, mulberry, and osage orange the sapwood is pale yellowish. The bark sometimes discolors the sapwood by leaching after the tree is cut. Sap stain imparts a bluish color to the sapwood, especially in the pines, hackberry, sugarberry and red gum.

Douglas Fir and Western Larch occasionally contain zones of light colored wood inside the heartwood. These zones are known as internal sapwood. They have been found to take preservative treatment as well as the outer sapwood.

The width of the sapwood varies with the age and vigor of the tree, the distance from the stump, and the species. Young and vigorous trees have wider sapwood than mature trees, although more annual rings are usually present in the sapwood of old trees because of their slower growth in diameter. The sapwood decreases in width from the stump to the top and often varies in different directions from the center, so that an annual ring may be sapwood in one part of a tree and heartwood in another.

DECAY AND DRY ROT IN DOUGLAS FIR

Its Cause and Appearance

Dry rot universally, classed as stained lumber by mill men, is frequently caused by bacteria attacking trees, that are located in districts where the soil is of such a nature that it is unable to properly nourish and keep them in a healthy condition as they approach maturity.

The infection appears to start from the ground, as is plainly shown by the prevalence of dry rot in Butt Logs. In most cases this form of decay takes the same direction as the annual rings, and is easily recognized by its brown or violet shade.

In freshly sawn lumber dry rot can be detected by its mouldy odor, and its appearance in the first stage is indicated by a reddish tinge, and when knots are large they are usually black. In the second stage darker red and gray streaks predominate. The last stage is dark gray or chocolate color with soft spots and knots that are black or rotten. Occasionally dry rot is of a violet shade, but this color soon fades after sawing and in the course of a few days changes to dull gray.

White Specks: This form of decay is caused by fungi attacking the wood that is located in a damp atmosphere. When this species of fungi germinates it sends out a thin, filmlike white thread which by repeated branching penetrates the entire structure of the wood, eating away the fiber and causing the wood to become brittle and rotten.

The process of decay is hastened by alternate exposure to moisture and dryness.

When logs affected by the first stages of dry rot are sawn the lumber, though stained if exposed to the sun or dry air for a few days, will assume a natural color, and will often defy detection unless closely inspected.

It is against the rules to pile for foreign cargo shipment, lumber containing dry rot in any stage, as this class of lumber is excluded from the export merchantable and better grades.

WOOD DESTROYING FUNGI

The fungi that causes what is generally termed "dry rot" in wood, is a low form of plant life, which can only progress under continued conditions of moisture, they also require a small amount of air, as they absorb oxygen like all other plants. They are not susceptible to cold and will live through extremely cold spells, but thrive best at from 75 to 85 degrees fahrenheit.

Out of about 50 species of wood destroying fungi tested at the Forest Products Laboratory, Madison, Wisconsin, it was found that none grew after being subjected to a temperature of 118 degrees fahrenheit.

If lumber infected with the preliminary stages of dry rot is thoroughly air or kiln dried the decay will cease, and if it is maintained in a dry condition for any considerable length of time, the fungi undoubtedly will be entirely killed.

VALUE OF FIRE KILLED AND DEAD TIMBER

Lumber that is manufatured from insect or fire killed trees is just as good for any structural purpose as that cut from live trees of similar quality provided the wood has not been subsequently injured by decay or further insect attack.

The fact is frequently overlooked that the heartwood of all trees is dead. It no longer functions in an important way in the life of the tree. It serves in a mechanical way to sustain the weight of the trunk by furnishing the strength that is necessary to stand against strong winds. The heartwood provides a storing place for water while the tree is yet alive and in a less degree for food necessary for the tree's growth; but such service is not absolutely necessary, for it is well known that many trees survive and continue to grow many years after the heartwood has wholly decayed. The sycamore furnishes a good example of this. Large trunks of that species are usually hollow, there being only a thin shell of sapwood with all the heartwood gone.

There in no such thing as living heartwood. All wood is originally sapwood and as the inner layers die they become heart. Therefore, all lumber sawed from heart is dead; but it is not discriminated against on that account. Only sap lumber is cut from living wood.

In some respects dead timber may have a slight advantage over living, because the wood has been partly seasoned, is a little lighter to handle, takes creosote better and does not require so much kiln or air drying after it has been converted into lumber.

Result of Recent Test of Fire Killed Poles

The following is the result of a test made by United States District Forester, Allen S. Peck, of 561 poles belonging to the Rifle Light, Heat and Power Company, Colorado.

The poles were installed between the company's plant and the town of Rifle eleven years ago. They were from fire-killed pine trees and were treated with creosote at the forest department's plant at Norrie, Colo. The test showed that 90 per cent of the poles are still sound after eleven years in the ground. There has long been a prejudice against fire-killed pine for commercial purposes, the district forester declares, particularly by railroad companies, which refuse to use them for ties. The creosote test removes all reasons for this prejudice, according to the forestry official, and opens up the way for the disposal of large quantities of fire-killed timber in Colorado.

DESTRUCTION OF WOOD BY ANIMAL LIFE

The destruction of wood by certain forms of animal life is not as great as that due to decay but constitutes the principal menace to the life of timber used in salt waters exceeding a certain minimum salinity where the temperature is high enough to sustain the life of certain forms of mollusks and crustaceans which find their food or make their homes in wood. This form of destruction is encountered in piling and construction timbers subject to the attack of teredos, xylotrya, pholas and other members of the mollusk family, and of limnoria, sphaeroma, chelura and other members of the crustacean family. In certain countries, also, timber is attacked on dry land by termites or white ants, as in China, India, Mexico, and parts of the Southwestern region of the United States.

DENSITY OF WOOD

Dense as applied to wood, means compact, heavy (when dry), containing much wood substance in small space. For example, hickory is a very dense wood.

The oven dry specific gravity is a measure of the density of wood.

The term "dense wood" is used to define the quality of wood which is desirable in timbers subjected to stresses such as occur in frame structures. The term applies to the wood itself, irrespective of defects. Since dry weight, which is the most accurate index to the mechanical properties of wood, cannot be determined from a casual inspection of the timber, dense—or, in other words, comparatively heavy—wood will be defined as:

(1) Wood that shows more than eight rings per inch, or the rings of which contain more than 30 per cent summerwood.

(2) Wood which is resilient—that is, which, when struck with a hammer or similar blunt instrument, gives a sharp, clear sound, while the hammer shows a marked tendency to rebound and the wood to recover from the effects of the blow.

CAUSES OF VARIATIONS IN STRENGTH

Variations in strength of timber can be accounted for more accurately than is usually supposed. In some species there is a difference in strength in wood from different positions in the tree, different localities of growth, etc. But such variations have been overestimated, and a knowledge of them is not essential in order to estimate with a fair degree of accuracy the properties of a piece of timber. Differences in strength are usually due to differences in defects, moisture content, or density, or to combinations of these.

Differences of moisture content cause considerable variation in the strength values of air-dry or partially air-dry material, but have no effect as long as all material is thoroughly green.

One of the principal factors causing differences in strength is variable density. As might be expected, the greater the density of a given stick or the more wood it has per unit volume, the stronger is the stick.

Accurate determinations made at the Forest Products Laboratory on seven species of wood, including both hardwood and coniferous species, showed a range of only about 4½ per cent in the density of the wood substance, or material of which the cell walls are composed. Since the density of wood substance is so nearly constant, it may be said that the density or specific gravity of a given piece of wood is a measure of the amount of wood substance contained in it.

ANNUAL RINGS

Annual rings denote the spring and summer growth of the tree; the spring ring is distinguished by its light color; it is invariably wider than the summer ring on account of its more rapid growth which produces a softer fiber. The summer ring is darker in color, is harder and has a much more solid appearance than the spring ring. The line of separation in annual rings is caused by the suspension of the growth of the stem during winter.

The annual rings are not always uniform as they are generally thicker on that side of the tree which has the longest exposure to the sun. For this reason the distance from pith to bark will often vary several inches; for instance, the measurement of a log from heart to bark would be, say 15 inches on one side and 20 inches on the other.

The widest rings are found around the heart center from whence they gradually diminish in thickness as they radiate towards the sap, where their growth is so compact that it is almost impossible to count them without the aid of a microscope.

In determining the strength of lumber which is the principal point when inspecting the merchantable grades generally used for high class constructional purposes, the width, uniformity and compactness of the growth of the annual rings should be carefully noted. When the summer ring is narrow and the spring ring wide or porous, weakness is the result. When the spring and summer rings are nearly equal in width and uniformly close, it denotes natural strength so requisite in the quality of lumber used for ship and bridge work, masts, spars, dredge spuds, derricks or similar purposes for which Douglas Fir is unequalled.

In small trees the annual rings are proportionately closer and more uniform from heart center to bark than the larger species, though there are occasional exceptions.

The annual rings are larger at the top than at the base of tree.

Small and medium sized logs which range from 17 to 36 inches in diameter, as a rule produce excellent timbers and a good grade of merchantable lumber.

ANNUAL RINGS DENSITY AND DECAY

Specific gravity or density of lumber materially influences resistance to decay of the heartwood; the more dense the wood the more durable it is. Specific gravity is a property which can not be determined from inspection, but it can be estimated by recourse to the proportion of summerwood to springwood in the annual growth rings which proves to be a safe criterion of the durability of heartwood; i. e., an increase in summerwood results in an increase in specific gravity. The specific gravity of Douglas Fir when freshly sawn is 640.

The width of the growth rings furnishes a further index of durability; the summerwood, which is of greater density and contains more pitch, shows more resistance to fungus attack than the spring rings of porous growth.

The resisting qualities of pitch to decay is principally through its water-proofing effect on wood, and thus its influence on the absorption of moisture by wood containing it; that is, the power of wood to absorb moisture is very important in its decay. It is well known that below a certain maximum of moisture in wood, fungi will not grow. Any property of the wood which will influence this balance of moisture is of importance in decay resistance. Thus, if the wood contains enough pitch to have a material waterproofing effect, it must play a role in durability.

SPECIFIC GRAVITY

The weight of wood is sometimes expressed by a comparison of the weight of a given volume of wood with that of an equal volume of water, or by what is known as "specific gravity." If the specific gravity of a certain kind of wood is stated as .300, it means that a given volume of this wood weighs .300 times as much as an equal volume of water. Since a cubic foot of water weighs 62.5 pounds, or 1000 ounces, a cubic foot of wood of specific gravity of .300 weighs .300 times 62.5 equals 18.75 pounds.

A cnbic foot of green Douglas Fir whose specific gravity is .640, weighs .640 times 62.5 equals 40 pounds per cubic foot. Hence the weight per cubic foot of any kind of wood can be quickly ascertained when the specific gravity is known.

The specific gravity of a body or substance divided by 16 will give the weight of a cubic foot of it in ponnds.

Example: The specific gravity of a cubic foot of green Douglas Fir is 640; what is the weight of it?

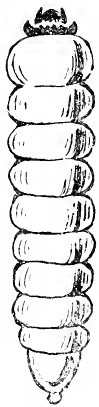
Process: 640 divided by 16 equals 40, the weight of a cubic foot in pounds.

When the weight of a cubic foot of lumber is known, the specific gravity can be ascertained by multiplying the number of pounds by 16.

Example: Find the specific gravity of dry Redwood weighing 26 pounds per cubic foot.

Process: 26 times 16 equals 416, the specific gravity.

Douglas Fir is a remarkably strong wood for its weight; its strength in terms of specific gravity, being materially greater than the average of American woods. This makes it a material of much greater strength than woods of its own weight, and equal in strength to much heavier woods.



THE TREE BORER

The tree borer or wood grub worm is about three to four inches long; its body is about half an inch in diameter and of a light cream color. The head, which is smaller thau the body, is black and has two projectious, which appear like the npper parts of a beak. They are placed on a level and slightly apart, being used as cutters by the worm to bore into the tree.

This borer attacks windfalls, dead timber, or trees that have been killed by fire, aud though they do not bore into Douglas Fir as rapidly as Eastern Pine, holders of timber limits should, if possible, log off infected sections without delay, as this borer can bore through one inch of Douglas Fir inside of an hour and its destructive work is liable to render trees useless in less than a year's time.

DURABILITY OF WOOD

Timber cut in spring or in summer is not so durable as that cut in winter, when the life processes of trees are less active. Scientific investigations sustain this statement. The durability depends not only upon the greater or less density but also upon the presence of certain chemical constituents in the wood. Thus a large proportion of resinous matter increases the durability, while the presence of easily soluble carbohydrates diminishes it considerably.

During the growing season the wood of trees contains sulphuric acid and potassium, both of which are solvents of carbohydrates, starch, resins and gums; they are known to soften also the ligneous tissue to a considerable degree. During the summer months the wood of living trees contaius eight times as much sulphuric acid and five times as much potassium as it does during the winter months. The presence of these two chemical substances during the growing season constitutes the chief factor in dissolving the natural preservatives within the wood and in preparing the wood for the different kinds of wood-destroying fungi, such as polyporus and agaricus. The fungi can thus penetrate more quickly and easily into the interior of the wood when these wood gums are already partly dissolved and available for their own immediate use.

From this staudpoint it seems that the best time to cut down the tree is in the winter, when sulphuric acid and potassium are present to a much smaller degree, and the fungi will not be assisted in dissolving the natural preservatives in the wood. The amount of wood gum is always less and more easily soluble in sapwood than in heartwood.—Scientific Americam.

SEASONING OF WOOD

IMPORTANCE OF PROPER SEASONING METHODS

Practically all wood before being put to use is either seasoned in the air or dried in a kiln. The main objects of seasoning are to increase the durability of the wood in service, to prevent it from shrinking and checking, to increase its strength and stiffness, to prevent it from staining and to decrease its weight. The sooner wood is seasoned after being cut the less is the chance that it will be injured by the insects, which attack unseasoned wood, or decay before the time comes to use it. Wood that is to be treated with preservatives needs in nearly all cases to be seasoned as much as wood that is to be used in the natural state.

Wood has a complicated structure. The walls of the cells of which it is made up shrink and harden when moisture is removed from them, and unless timber that is to be air-seasoned is piled in the right way, or conditions in the dry kiln are maintained in accordance with certain well-defined physical laws, the material is likely to warp or check, or in some way to be damaged seriously. Until recently proper methods of seasoning received comparatively little attention from manufacturers, and large losses, especially among woods that are difficult to dry, were the rule. Sometimes as much as 20 or 25 per cent of the seasoned lumber was rendered unfit for the use intended by defects which had their origin in the drying process. Since the quality of the finished product can be impaired seriously by wrong methods, the importance of right methods becomes apparent.

FIBER SATURATION POINT AND SHRINKAGE

Water exists in wood in two conditions: (a) as free water contained in the cell cavities, and (b) as water absorbed in the cell walls. When wood contains just enough water to saturate the cell walls, it is said to be at the "fiber saturation point." Any water in excess of this which the wood may contain is in the form of free water in the cell cavities. Removal of the free water has no apparent effect upon the properties of the wood except to reduce its weight, but as soon as any of the absorbed water is removed the wood begins to shrink. Since the free water is the first to

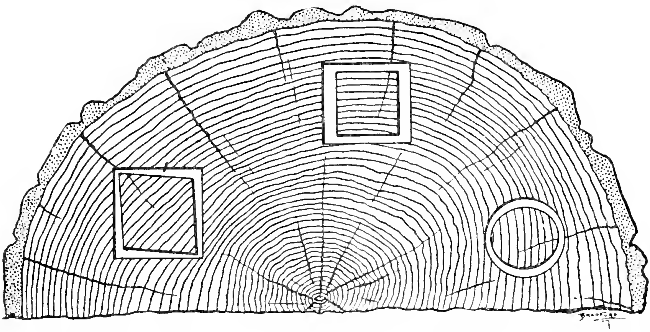


Fig. 1.—Shrinkage as affected by direction of annual rings; approximately twice as great tangentially as radially.

be removed, shrinkage does not begin, as a general rule, until the fiber saturation point is reached. In the case of eucalyptus and some of the oaks, however, shrinkage begins above this point. For most woods the fiber saturation point corresponds with a moisture content of from 25 to 30 per cent of the dry weight of the wood. Figure 1 shows graphically the difference between tangential and radial shrinkage.

Shrinkage is due to the contraction of the cell walls, and sets up stresses which tend to cause the wood to check. As observed in a cross section of a piece of lumber, shrinkage in the tangential direction is about twice as great as in the radial direction; lengthwise of the lumber it is very slight.

HOW WOOD MAY BE INJURED IN SEASONING

Checking

Checking is caused by unequal shrinkage. If the outside of a piece of wood dries considerably faster than the inside, the surface in time will contract until it can no longer extend around the comparatively wet interior, and so will be torn apart in checks. Checks often are classified as end checks and face checks. End checking or splitting during seasoning causes nearly as much loss as face checking.

CASE HARDENING AND CHECKING

Case hardening and honeycombing may be explained thus: Suppose a block of wood is very wet, and is placed in a kiln at too high a temperature and too low a humidity. The surface begins to dry and tends to shrink, but is prevented from doing so by the wet interior. Being plastic, it yields to this resistance and becomes stretched. If not plastic, it will check open. As drying proceeds, the surface hardens and sets in an expanded condition, and acts as a strong shell. The interior now dries very slowly, does not become set, but shrinks; and as the exterior is already hard, it opens up or "honeycombs." When the exterior once becomes set or "case hardened," the interior is almost certain to become honeycombed, whether the drying takes places in the kiln or a long time afterward. The only remedy is to moisten the exterior by steaming or soaking before it is too late. Air dried material may also case harden and honeycomb.

Warping

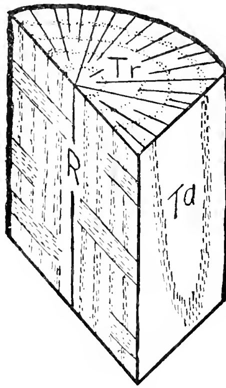
Warping or twisting in lumber is due to unequal shrinkage. Some woods are much more subject to warping than others. The trouble can be prevented to some extent by careful piling, both during drying and afterward.

Collapse

In some woods, notably western red cedar and redwood, when the very wet wood is dried at a high temperature, depressions appear on the surface of the boards, presumably due to the collapse of the plastic cell walls in certain places. If, however, the woods in question are heated above the boiling point while wet, the steam generated in the nonporous cells causes the wood to bulge on the surface.

ILLUSTRATION AND EXPLANATION OF LUMBER SURFACES

Wood can be cut in three distinct planes with respect to the annual rings. The end surface of a piece of wood shows a cross section of the annual layers of growth. This is also known as the transverse surface. (See illustration). It shows the size and arrangement of the cells better than any other surface. When wood is cut lengthwise through the center or pith of the tree, the surfaces exposed are known as the radial, or "quartered," surfaces. A longitudinal surface which does not pass through the center is known as the tangential, or "bastard," surface. Plain sawed lumber is tangentially cut. Technically, a tangential surface is at right angles to the radius.



A block of wood showing, **Tr**, tranverse, or end surface; R, radial, or "quartered' surface; Ta, tangential, or "bastard" surface.

Radial

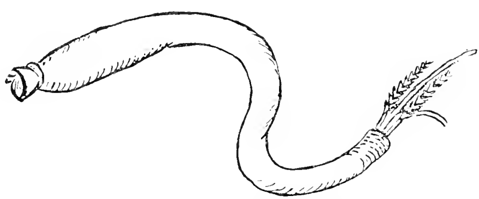
Radial means extending outward from a center or an axis. Thus a radial surface in a tree is one extending trom the pith of the tree outward, such as the wide face of vertical or edge grain flooring or a quarter sawed board.

Tangential

Tangential means tangent to or parallel to the curves of the annual rings in a cross section. Thus a tangential surface is a surface perpendicular to the radius of a tree; in other words it is the wide face of a slash or flat grain board.

THE TEREDO

The Teredo, which is often called a ship worm, in reality is a bivalve mollusk. The body is shaped like a worm and in color and appearance it is white, and slimy. The head is of shell with two sharp pointed protuberances, with which it cuts away the wood to make its burrow. The average length of the body is about five inches, with a diameter of a quarter of an inch, though in rare instances it has been known to attain a length of four to six feet, with a diameter of about one inch.



At the posterior end of the body are two perfect feather shaped projections, which appear to be made of shell or bone, and there are also two short muscular tubes of same substance as the body, with the longer tube it takes in food and water, and the shorter one is used to eject the fine wood borings that are made by cutting valves, and swallowed by the Teredo, which bores into the wood below the water's surface to obtain a place of shelter.

THE TEREDO—Continued

The entrance hole made by these marine borers is about the size of a pin's head, and from that the diameter inside gradually increases to about a quarter of an inch.

The Teredo thrives best in very salty, warm and clear water and, as it penetrates into the wood it secretes a substance that forms a white lining around its burrow; and on arriving at maturity, which usually takes about four weeks after first entering the timber, the eggs of the female are ejected into the water, where they immediately hatch, and in the course of a month appear as very minute clams.

At this stage they seek an entrance into wood that is not protected against their attack, and in six months to three years, according to locality, they will honeycomb piling or timbers to such an extent that they will be rendered worthless.

The feather shaped end of the mature Teredo usually projects about a quarter of an inch outside the entrance hole, and if this is broken it will cause their death, as they are very sensitive.

Teredoes can only exist in salt water, and when they gain an entrance into wooden vessels they can be destroyed by running the infected ship into fresh water.

The bark on piling is considered an absolute protection against the Teredo, but to be effective it must remain intact as these marine borers only require a minute surface to effect an entrance.

The Teredo is found along the greater part of the Atlantic and entire length of the Pacific Coasts, and is particularly destructive around Puget Sound and the Straights of San Juan de Fuca.

There are many remedies that can be applied to piling that will temporarily resist the attacks of these marine borers, each and every one of which has its particular value, but cost of material and distance of transportation to different localities must be taken into consideration when comparing the relative virtues of various remedies, however, it may be stated that for protection against the attack of marine borers the full-cell processes, either Bethell, boiling, Boulton or steaming method are invariably used because of the necessity of injecting the maximum amount of preservative.

KILN DRYING LUMBER

SOME BASIC PRINCIPLES

* The particular method to be used in the proper drying of lumber for different purposes varies directly with the class of material to be dried. No one great "process" has ever been devised that will meet all conditions.

Green and unseasoned lumber contains moisture that exists in the wood in two forms: as free water in the cell cavities, and as absorbed moisture in the cell walls. The proportion of free water in the cavities of the cells of the sap-wood is such that in a freshly cut log these cells are usually almost completely full. In the heart-wood, however, the cell cavities are relatively empty, containing, in the case of such conifers as Douglas fir and pine, less than ten per cent of water. So long as free water is found in the cell cavities, the cell walls are necessarily saturated. In the case of Douglas fir the amount of water required to saturate the cell walls amounts to, roughly twenty-five per cent of the dry weight of the wood.

In kiln drying wood, the water should be evaporated from the cavities of the cells before any water is removed from the cell walls. The removal of this water does not cause the wood to shrink; no shrinkage can take place until further drying causes the evaporation of moisture from the cell walls.

If the first or primary evaporation is carefully controlled, the heat applied to the wood causes the cell walls to acquire a certain degree of plasticity, so that when the drying has progressed to such a point that water is removed from the cell walls their plastic condition permits the wood to shrink without checking.

It follows, therefore, that in kiln drying lumber it should first be heated through and through in an atmosphere as completely saturated with moisture or steam as possible; in fact, partially seasoned lumber should first be steamed by opening the spray pipes in the kilns before steam is admitted to the heating system, so that the preliminary drying will not cause the over-drying or case-hardening of the cell walls at the surface of the lumber. This preliminary seasoning does not open the "pores" of the wood. Wood is not made up of an accumulation of clam shells, but is of rather simple cellular structure. There are no pores that can be opened and closed through any mysterious property of saturated steam.

Heat, and heat only, is available as a medium in removing moisture from wood. In a dry kiln the heat is applied to the lumber through the medium of air or superheated steam. Other gases, such as carbon dioxide, could as well be used, were it not for the cheapness and availability of air or steam. In drying lumber for creosoting, heat is carried to the lumber from a heating system such as is used in a dry kiln, but instead of surrounding the lumber with air, it is kept immersed in hot creosote oil until it is dry.

The first requisite in drying lumber is a kiln-building that is tight—one that is built in such a manner that the moist air that surrounds the lumber cannot escape to the atmosphere through holes or leaks in the ceiling of the kiln. Unless the kiln building is properly constructed, drying conditions within the kiln are beyond the control of the operator.

The free water is most readily removed by heating the wood in an atmosphere highly saturated with moisture. The application of heat to the wood causes the vapor pressure within the cells to rise to high point, an internal pressure of as much as 10 to 15 pounds per square inch being developed. All of the moisture in the lumber can be evaporated in this manner, but after the free water has been removed this method of drying becomes inefficient, and the moisture content of the air in the kiln should be reduced, at first gradually, and then in proportionately greater increments. In this way lumber can be dried rapidly and yet with a minimum amount of checking. If the lumber is dried in a "Super-Speed" kiln, the same result is obtained when the temperature within the kiln is increased to a point above the boiling point of water, 212 degrees fahrenheit.

Efficiency in drying demands the proper circulation of air or steam in the kiln. The air or steam should be circulated through the heating coils to the lumber at a rate that is proportional to the capacity of the lumber to absorb the heat. Too rapid circulation will result in the over-drying of the surface of the lumber, unless the temperature within the kiln is reduced to such a point that the heat is used in a very inefficient manner.

* From literature courteously supplied by the North Coast Dry Kiln Company, Seattle, Wash.

KILN DRYING "COMMON" LUMBER

One of the greatest problems confronting the western manufacturer of lumber is the disposal of common grades of lumber. Freight rates to eastern markets are very high and will always remain high. The kiln drying of common grades is the only possible manner in which the Coast manufacturer can reduce the weights on lumber in an economical manner.

Due to the climatic conditions that exist west of the Cascade mountains in British Columbia, Washington and Oregon, and west of the Sierra Nevadas in California, very little can be gained by air seasoning. Air seasoning normally reduces the moisture content of lumber to a minimum of only 18 to 20 per cent, and during the greater portion of the year lumber stacked in the yard seasons only very slowly. Air seasoning is also expensive, and for this reason common lumber is usually shipped in a green and unseasoned condition.

The following items account for the high cost of air seasoning in this region:

1. Interest on the capital perpetually invested in the lumber piled in the yard.
2. Cost of piling and unpiling the lumber stacked in the yard.
3. Interest on the capital perpetually invested in item No. 2.
4. Cost of maintenance of foundations for lumber piles, runways, docks, fire-fighting equipment, tractors, lumber dollies and other necessary equipment.
5. Interest on money invested in item No. 4.
6. Interest on money invested in yard space.
7. Cost of insurance on lumber piled in yard and upon yard equipment.
8. Interest upon perpetual investment in item No. 7.
9. Taxes.
10. Loss through degrading of material stacked for seasoning.

The above items render the cost of air-seasoning lumber so high, that the gain in lower shipping weights on air seasoned lumber, if a careful accounting system is kept, will be overshadowed by the cost of seasoning the lumber in the yard. One-inch Douglas fir lumber stacked for seasoning in the middle of August will usually reabsorb so much moisture during the winter months that minimum shipping weights cannot be obtained until twelve months have elapsed. Lumber stacked in May can, on the other hand, be shipped in September. As a general average it can be said that fairly reasonable shipping weights can only be obtained after lumber has been stacked eight months or more.

The side-cut of mills in the Douglas fir region, or the common lumber, is therefore very commonly shipped in a green condition, and even in the case of mills that make an attempt to air season this material, a considerable amount is shipped unseasoned.

Timbers, which are always cut to special orders, must necessarily be shipped without seasoning. The shipping of other grades in this condition amounts to nothing less than a sheer wanton waste of money.

According to data prepared by the West Coast Lumbermen's Association, under existing freight rates the delivered prices of 2x4's at middle western and eastern points represent:

Freight paid to railroads	61%
Money received by the saw mill	39%

Our friends in the Southern Pine region are more fortunate. Railroad hauls are short and freight rates are low. Lumber stacked in the mill-yard of the sunny south seasons very rapidly. Negro labor, very cheap and fairly efficient, and a ten-hour day, reduce the cost of piling and unpiling in the yard, so that air seasoning brings a reasonable good return. The delivered prices of similar material from the South therefore represent the following items:

Freight paid to railroads	37%
Money received by the saw mill	63%

The most superficial sort of an analysis of the above percentages demonstrates beyond any possibility of error that there is but one single manner in which this terrific handicap upon the western shipper can be overcome. Low prices of lumber at the mill simply increase the handicap or "freight-percentage." The cutting of scant sizes will decrease the freight-percentage but will prove an insurmountable obstacle to the extension of West Coast markets.

The drying of common dimension to a definite moisture content is the one existing possibility. Approximately a fifth of the money paid to the railroad companies by the western manufacturers of lumber is paid for the privilege of shipping water with the lumber. The consumer of lumber does not care for this high priced water; in fact, he is willing to pay a little more for dry lumber that is clean and bright.

During the past ten—yes, fifteen—years, this "talk" of drying common dimension lumber has been heard by the Western lumberman. Common lumber has been dried at more than one mill, quite successfully, and yet—

There is an explanation for this condition of affairs, and a good explanation, too. When lumber prices were high, mills made money. When prices slumped, this money was promptly lost. When lumber prices were high, the drying of common seemed unnecessary. When prices slumped, no money was available for "experimenting."

Today, however, conditions are different. The drying of common dimension is no longer an experiment. A real, genuine solution to the problem of reducing the freight-percentage has been found.

"Super-Speed" Drying as a Solution

The fact that common grades of western woods can be successfully and quickly dried, with a negligible loss through degrading, has been completely established. As common grades can be brought to a lower shipping weight than is possible through air seasoning in twenty-four hours—an even day—the investment in dry kilns is relatively very small. A tremendous decrease in handling costs, made possible through the use of North Coast automatic edge stackers and unstackers, combined with mechanical handling devices leading to a dry storage shed, also scores heavily in emphasizing the advantages of the "Super-Speed" method of handling and preparing common grades of lumber for shipment.

One item must not be overlooked. As the lumber can be piled "solid" in the dry-shed, comparatively little space is required. Again, the lumber can be brought to a definite shipping weight, and when it is unloaded in the yard of the eastern retailer it will be bright and clean, no mold and mildew covering the lumber and carrying the insinuation that our western woods do not possess the virtue of superior durability.

In shipping five ordinary carloads of green lumber to eastern points, the western manufacturer pays the freight on a tank-car of water. The useless waste of money in such freight shipments will very quickly absorb the cost of equipping a typical mill with "Super-Speed" kilns.

TO DETERMINE MOISTURE CONTENT OF LUMBER

Definition: The moisture content of a piece of lumber is the amount or weight of moisture as compared with the bone dry weight of the piece. This would be the weight of the water divided by the bone dry weight.

Example:

Weight of sample of green sap hemlock	85.23 grams
Weight of sample bone dry	37.61 grams
Weight of water in green sample	47.62 grams.

Moisture content of green sample equals 47.62 divided by 37.61 equals 1.26 equals 126%.

Method: Cut off about one foot of the end of a board and discard it. Then cut a sample about one inch long across the board and weigh it to hundreds of a gram on your scale. Place the sample in a small electric oven and hold at 212 to 215 degrees. Weigh the sample at intervals until it stops losing weight at which point it has become bone dry. The difference between the original weight and the bone dry weight is, of course, the weight of the water that was in the sample. This weight of water divided by the bone dry weight as stated above is the moisture content.

Actual Practice: Suppose we have a car of lumber we think is about ready to come out of the kiln. Or if it is a single charge kiln we believe the lumber is about dry: Remove three or four boards from the kiln, cut a foot off one end of each and obtain a one-inch sample and weigh it. Dry this, as previously explained, bone dry. Comparing with the previous example:

Weight of sample of kiln dried lumber	40.62
Weight of sample bone dry	37.61
Weight of water	3.01

Moisture content of kiln dried sample equals 3.01 divided by 37.61 equals .08 equals 8%.

The proper moisture content of kiln dried lumber for ordinary commercial purposes is 8% to 10%. By checking up the moisture content at regular intervals you will establish a schedule of temperature, humidity and time of drying for your kiln, whereby you can depend on the moisture content of your lumber.

THE PRESERVATIVE TREATMENT OF WOOD WITH SPECIAL REFERENCE TO DOUGLAS FIR

* The importance of properly preparing wood for preservative treatment is not always realized. The moisture content or sap in green wood is resistant to the penetration of preservatives, principally because it fills the cellular structure of the wood fiber thus occupying the volumetric spaces into which the preservative must be injected. This moisture content must be reduced in volume or consistency before it can be replaced by the preservative. There are four common methods by which this can be accomplished and the method adopted depends somewhat on the kind and condition of the wood to be treated:

1. Air seasoning, or exposing the wood, properly stacked, to the action of the open air by which the moisture in the wood is gradually evaporated.

2. Placing the wood in a kiln and drying out the moisture by application of hot air, regulating the temperature and humidity so that the wood fiber is not injured.

3. Placing the wood in the usual treating cylinder or retort and applying steam followed by vacuum to dry out the moisture, carefully regulating the pressure and time to prevent injury to the wood fiber.

4. Placing the wood in the retort, filling the retort with a hot oil preservative and boiling under vacuum to keep the temperature at a point which will not injure the wood fiber.

A fifth method of preparing wood for treatment was made available for general use when the perforating patent held by Mr. O. P. M. Goss of Seattle was dedicated to the public on October 6, 1919. This method consists in puncturing all exposed surfaces of the wood with sawtooth holes scientifically spaced both across and along the grain and so arranged that the punctures form diagonal lines. Experiments in this method have been carried on since 1913 and the results have proved to the satisfaction of most of the leading experts in wood preservation that perforating or incising before treatment will accomplish the following results:

1. Control, reduction, or complete elimination of checking in green ties and timber if perforating is done promptly after cutting.

2. Reduction of the temperature required to secure satisfactory impregnation.

3. Reduction of the time required to treat ties and timber in the retorts.

4. A complete and uniform penetration of the preservative to the depth of the perforations or incisions.

5. Reduction of not over eight to ten per cent in the strength of the tie or timber in compression perpendicular to the grain. This means a reduction of the present loss in the strength and mechanical life of the treated unperforated ties or timber, which varies from 30% to 40%, to a point which will balance the cost of treatment to the satisfaction of the demands of engineers.

The application of perforating to timbers subjected to loading in tension or shear must wait for the results ot scientific experiments on the effect of the punctures upon the tensile and shearing strength of the timber.

The mechanical application of the perforating process has so far been confined to cross ties and dimension timbers but there is reason to believe that eventually some mechanical device will be designed which will be able to perforate round, tapering sticks such as piling and poles.

* By Edmund M. Blake, Production Engineer for Chas. R. McCormick & Co., St. Helens Creosoting Co., St. Helens, Wash.

It may be stated as probably representing the concensus of expert opinion in the wood preserving industry that the ideal preparation of wood for treatment is perforation as promptly as possible after cutting, followed by a reasonable period of air seasoning because by this method the cellular structure of the wood will be best prepared to receive and retain the preservative material. Such a preparation involves not only additional expense but necessitates the purchase and proper storage of green material several months ahead of the time at which the wood is to be treated and used, the interest on which investment must be added to the cost.

The following fundamental considerations should be noted in the preparation of wood for treatment:

1. The wood which is to be kept in storage yards before treatment should be stacked on well drained ground free from vegetation. This will prevent the growth of fungi. In arid localities, the piles should be less open than in humid regions in order to avoid severe checking.

2. If any length of air seasoning is to be given, the wood should preferably be cut during the winter, as spring and summer are the better seasoning periods.

3. The greater the surface area of a piece of wood in comparison to its volume, the more quickly will it dry.

4. Timber which has to be cut, adzed, bored, notched, tapped or morticed during its erection should always be so framed before treatment. Otherwise surfaces will be exposed which are not protected by any of the preservative and the treatment of the particular stick will be nullified.

5. All wood placed in any one retort for treatment should be in as nearly the same condition of seasoning as possible in order to insure uniform treatment for every part of each charge. Care should be taken not to place green timber and well seasoned timber in the same charge.

6. Wood that is apt to split or check severely while seasoning should be protected by driving S irons or irons of other shapes into the ends of the sticks.

7. The bark must always be removed before treatment.

WOOD PRESERVATIVES

The two preservatives in most common use are creosote oil and zinc chloride. With 117 treating plants operating in the United States in 1916, the consumption of creosote was about 90,500,000 gallons and the consumption of zinc chloride about 26,750,000 pounds. With only 107 treating plants operating in 1918, the consumption of creosote dropped to about 52,750,000 gallons while the consumption of zinc chloride increased to 31,000,000 pounds. The figures for 1919 are not available but the amount of creosote used is known to have been much less than in 1918, and it will probably be even less during 1920 than it was in 1919. This is partly accounted for by the very extended use of coal tar in the United States for fuel during the war, the elimination of the German supply, and the great reduction in the British supply, coupled with the high prices for both domestic and foreign creosote. The situation is such this year that most of the railroads of the United States will continue a very large use of zinc chloride in the treatment of cross ties, holding their depleted creosote supplies for piling and bridge timbers.

In addition to creosote and zinc chloride there are some forty or more other preservatives, the use of which in 1918 amounted to over 4,000,000 gallons. Among the most important of these are carbolineum, carbosota, corrosive sublimate and sodium fluoride, the latter of which has received particular attention during the past two years.

Zinc chloride solution is made from fused or solid zinc chloride which must be acid free, containing at least 94% soluble zinc chloride and not more than 0.1% iron. The concentrated solutions, from which the treating solutions are made, should contain at least 50% soluble zinc chloride.

As zinc chloride is soluble in water its tendency is to leach out more or less from the timber treated with it if the surroundings are moist or damp. Its most effective use is in dry, arid climates. Common practice in the past with some railroads has been to use one-quarter of a pound zinc chloride per cubic foot of material treated, but, on account of its tendency to leach and thereby lose its effectiveness, the best modern practice calls for one-half pound per cubic foot.

The most common use for zinc chloride solution and the one by which its greatest efficiency is probably secured, is in the treatment of railroad cross ties, particularly in areas of low rainfall and long dry periods. It is also used when low first cost is essential.

The creosote oil used in the preservation of wood is derived from the destructive distillation of coal gas or coke oven tar and consists of the fractions coming off between 200 degrees and 400 degrees C. Aside from this fundamental requirement, the American Railway Engineering Association and the American Wood-Preservers' Association recognize three grades of creosote oil which differ from each other principally in fractions distilling up to 235 degrees C. The highest grade of distillate creosote oil, grade No. 1 or standard grade, contains the smallest percentage of the low boiling fractions and if grades No. 2 or No. 3 are used, careful consideration should be given to the advisability of injecting a greater quantity per cubic foot than in the case of grade No. 1. In all three grades the oil must contain not more than 3% of water, not more than 0.5% of matter insoluble in benzol and not more than 2% of coke residue; the specific gravity must not be less than 1.03 at 38 degrees C. compared with water at 15.5 degrees C., the specific gravity of the fraction between 235 and 315 degrees C. must not be less than 1.03 and between 315 and 355 degrees C. not less than 1.10 and the residue above 355 degrees C. must be soft.

In the best modern practice the highest grade of distillate creosote oil is specified for the protection of piling and timbers to be used in salt waters subject to the attack of marine borers and the quantity injected per cubic foot must be sufficient to give a minimum penetration of at least three-quarters of an inch of creosote. Grades No. 2 and No. 3 are used principally in land work as compared with marine work.

There is also a standard specification for creosote-coal-tar solution for cross ties and structural timbers of which at least 80% must be distillate oil and the remainder refined or filtered coal gas tar or coke oven tar. This solution has a higher specific gravity and a greater coke residue and is applicable to inland work and railroad cross ties.

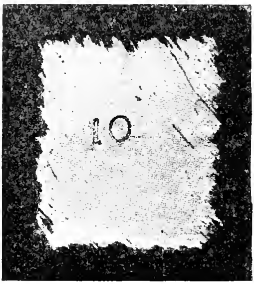
There is also a standard specification for coal-tar-oil for paving blocks of which at least 65% must be a distillate and the remainder refined coal gas or coke oven tar with still higher specific gravity and still higher coke residue.

It is also believed by several of the leading experts connected with railroad treating plants that a mixture of 50% distillate creosote oil with 50% of crude oil will make a solution entirely satisfactory to the treatment of railroad cross ties.

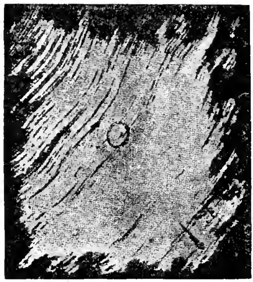
PENETRATION

The penetration of preservative is a subject which does not always appear to be clearly understood by users of treated wood. Penetration is governed not only by the pressure and temperature maintained in the retorts and by the length of treatment but is also and fundamentally dependent upon the cellular structure of the wood itself. The viscosity of creosote oil is an important factor of the amount of penetration which can be obtained and recent tests made at the Forest Products Laboratory, Madison, Wisconsin, have established the fact that a very definite relationship exists between viscosity and penetration. Penetration will increase with a decrease in the viscosity of the oil. High temperatures in the retorts will reduce the viscosity of oil and therefore tend to increase the penetration. If the pressures and temperatures are kept too high the fiber of the wood is injured with a resulting loss in the mechanical strength of the wood. If the period of treatment in the retorts under pressures and temperatures otherwise satisfactory is too long, the same injury results to the fiber of the wood. If the cellular structure of the wood is such that the preservative can be injected through the walls of the cells under reasonable pressure, temperature and length of treatment, satisfactory penetration can be secured without injury to the mechanical strength of the wood. On the other hand, there are woods, notably Douglas fir, whose cellular structure in the heartwood is so greatly and variably resistant to the injection of preservative that the penetration specified often cannot be secured without maintaining high pressures and temperatures and long periods of treatment in the retorts with the consequent danger of injury to the mechanical strength of the wood itself.

Furthermore, the quantity of preservative per cubic foot of treated wood required to secure a definite penetration is governed by the relation between the surface area and the volume of the wood to be treated. For example, if an injection of twelve pounds of creosote oil per cubic foot will result in a penetration of three-quarters of an inch on the four sides of a 12x12 timber, the same quantity per cubic foot injected into one-inch boards will give less than one-quarter of an inch penetration. This inverse relation which penetration bears to the surface-volume percentage of wood treated under a specified injection of preservative per cubic foot is too seldom recognized in the drawing up of treatment specifications. For example, when a specification for the treatment of one-inch boards calls for twelve pounds of creosote oil per cubic foot with complete penetration of the boards, something is being called for which cannot be accomplished in actual practice.



Perforated



Not Perforated

PENETRATION OF CREOSOTE IN TWO PIECES OF SAME DOUGLAS FIR CROSS TIE

Both treated in same charge during experiments in 1916.

This subject of penetration brings up the consideration of Douglas fir and it is really Douglas fir in the treatment of which engineers west of the Rocky Mountains are most vitally interested. Douglas fir is practically the only kind of treated timber used for piling on the Pacific Coast and, aside from a small quantity of western yellow pine, is the only kind of timber treated in the form of cross ties and lumber on the Pacific Coast. Very large quantities of Douglas fir are used annually in the mines of California, Nevada and Arizona. It is the most refractory wood commonly used today in the resistance of its cellular structure to the penetration of preservative in the heartwood. Not only is the heartwood of Douglas fir refractory but its resistance to penetration varies on different surface areas in the same stick. In some cases, even under standard treatment, the penetration may exceed three-quarters of an inch over parts of the surfaces while over adjoining areas there may be nothing more than a "painting" of the surface. It is not surprising, therefore, that the development of perforating before treatment should have been carried on with Douglas fir on the Pacific Coast. In fact, it was the desire of the Santa Fe as far back as 1912 to use treated Douglas fir cross ties that first led to the study of the possibilities of securing an even penetration by perforating before treatment. That a predetermined depth of penetration may be definitely secured by preliminary perforation is assured and the first perforating machine for ties and timbers to be designed at the shops of Greenlee Bros. & Company, Rockford, Illinois, is now completed and in operation at the plant of the St. Helens Creosoting Company, St. Helens, Oregon. A series of very careful scientific experiments are now being conducted partly in connection with commercial orders, and it is expected that very important data will be collected during the next few years. Special tests will also be made on structural timbers which will be subjected to tension and shear to determine the effect of perforating upon their tensile and shearing strength.

Where sapwood is present in Douglas fir piling, cross ties or lumber, it is generally possible to secure full penetration to the depth of the sapwood under temperature, pressure and time of treatment conditions which will not injure the mechanical strength of the wood. All sapwood should be fully treated wherever it occurs in any event as it is that portion of the wood which is first affected by decay. In drawing up specifications for the treatment of Douglas fir heartwood in any form, including piling where the depth of sapwood is not specified, the following factors should be clearly kept in mind by the engineer:

1. Penetration secured by high temperatures and pressures or by long periods of treatment may result in serious injury to the mechanical life of the wood.

2. A predetermined depth of penetration cannot be guaranteed in the heartwood of Douglas fir or other woods without preliminary perforating.

3. The depth of penetration for a given injection of oil per cubic foot depends upon the relations between the exposed surface and the volume of the wood; i. e., it will take more oil per cubic foot to secure full penetration in one-inch boards than it will to secure three-quarters of an inch penetration on the four sides of a 12x12 stick. It is also true that it will take more oil per cubic foot to secure a specified penetration in a stick 8 inches in diameter than in a stick of larger diameter. The dual requirements, often counter-posed in the same specifications, calling for both a definite injection and a definite penetration of the preservative, are too frequently irreconcilable. Therefore, unless the depth of sapwood is specified or perforating is called for in the treatment of Douglas fir, it is more consistent to specify the minimum amount of injection and both the minimum and average penetration desired.

4. Furthermore, it has been the almost universal practice to call for prices per lineal foot of treated piling while specifying an injection in pounds per cubic foot and at the same time stating the minimum diameters of butt and top and the minimum penetration. This is a practice which it appears could be easily changed to the mutual benefit of both the purchaser and the treating contractor by employing the same unit for specified injection and price in addition to providing for the correct relation between specified penetration and specified injection.

For example, take a specification calling for a twelve pound treatment, ¾ inch penetration, 14 inch minimum butt, 8 inch minimum top and piling 60 feet long. If the piling has those exact butt and top diameters with a uniform taper, the cubical contents will average 0.68 cubic feet per lineal foot and one pile will contain 40.8 cubic feet which will call for 489.6 pounds of creosote. If the treating contractor could get piling all of which had the minimum butt and top specified, with an even taper, the difficulty caused by the present form of this part of the specification would be largely removed but this is practically impossible. The treating contractor must therefore guess at what the piling received will over-run in cubical contents. For the piling in the above example he might figure 0.75 cubic feet to the lineal foot and base his quotation on the oil required for that case. When the piling is delivered at his plant for treatment, it may be found that the cubical contents run as high as 1.00 cubic foot or more to the lineal foot which means a loss to him while the purchaser gets a larger pile than he pays for under the contract. The basic difficulty lies in the fact that the piling contractor will not agree to furnish exact butts and tops unless he is paid a higher price for that selection out of the piling cut.

Now consider the second phase of the problem. Assume for the moment that the specified penetration can be obtained. As penetration bears an inverse relation to the surface-volume percentage of wood treated under a specified injection of preservative per cubic foot, the penetration in piling under a specified injection of creosote per cubic foot is governed by the diameter of the piling because the smaller the diameter the greater will be the percentage which the surface area per lineal foot of piling bears to its volume per lineal foot and hence the less the depth of penetration. An injection of 12 pounds per cubic foot will give a greater penetration at the 14 inch butt than it will at the 8 inch top but if the average diameter is used in determining the amount of oil required, proper penetration will be provided for all parts of the stick.

Therefore, it would be more consistent with the facts, eliminate the confusion resulting from the use of different units in present specifications and be fairer both to purchaser and treating contractor to specify the minimum injection in pounds of creosote per lineal foot of piling for each variation of 1 inch in the average diameter of the piling actually treated. The purchaser first of all must have a specified minimum penetration and secondly cannot wish to obtain it at a loss to the treating contractor. A condensed tabular form would simplify such a specification and not complicate quotations and the injection specified for a desired penetration should be consistent with the results possible to obtain in the treatment of Douglas fir.

MODERN METHODS OF TREATMENT

The modern commercial methods or processes commonly used in the preservation of wood are divided into two general classes, the first being non-pressure processes and the second pressure processes. The results obtained from the use of non-pressure processes are not comparable with those obtained from the use of pressure processes and it should be understood that the former are makeshifts and not to be considered in the same class with the latter.

NON-PRESSURE PROCESSES

Non-pressure treatments coat the wood with a superficial absorption only and the best results are obtained only when thoroughly seasoned wood is used.

The oldest and simplest form of this method consists in applying the preservative with a brush, using as many coats as may be considered desirable and requiring a container to hold and in which to heat the preservative.

When the wood to be preserved is in place and brushing is inconvenient, spraying is sometimes used as an alternative but the waste of preservative has prevented general use of this method of application.

The penetration resulting from the two above methods is very slight.

Another method consists in dipping the wood in hot or cold preservatives in open tanks in which the wood is left to soak up all that it will absorb. This results in a greater penetration than can be obtained by brushing or spraying.

The best method of non-pressure treatment is that of placing the wood in hot preservative for a proper length of time, then removing it and plunging it into cold preservative. A hot bath of from one to two hours followed by a cold bath of the same period is usually enough. This results, when properly manipulated, in fairly good penetration and is used extensively for the butt treatment of poles and posts. Where only small lots of material are to be treated and the chance of abrading or splitting the treated wood is reduced to a minimum, this process is economical for certain classes of material. It may be noted that the open tank non-pressure process has been used very extensively in the study of the penetration of creosote oil into the cellular structure of Douglas fir from which undoubtedly the early conclusions were reached that some form of perforation would have to be employed in preparing Douglas fir for satisfactory treatment.

PRESSURE PROCESSES

The general pressure method of impregnating wood with preservative is in cylinders which range in size from 72 inches in diameter and 42 feet in length to 108 inches in diameter and 172 feet in length. The pressure process is now the almost universal method of treating wood and is always used where large quantities of material are to be treated and a deep penetration of the preservative is to be obtained. After the wood to be treated has been placed in the cylinders or retorts and the retorts have been hermetically sealed, the preservative is forcibly injected into the wood by means of pressure produced by pumps and accompanied by more or less high temperatures produced by steam coils laid in the retorts.

The pressure processes are divided into two classes, the first being full-cell treatments which force into and leave in the wood practically all the preservative it will hold where penetrated, thereby giving a maximum protection against decay or attack by animal life for the depth of penetration secured; the second being empty-cell treatments which reduce materially the final retention of the preservative in the cells while not reducing the depth of penetration. In both of these treatments it is clearly seen how important it becomes to remove the moisture or sap from the cells in order that they may be filled with the preservative. The full-cell treatment, as its name implies, leaves the cells filled with the preservative while in the empty-cell treatment the walls of the cells are left coated with preservative.

Either green or seasoned timber may be treated by pressure processes but when green timber is put into the cylinder it is generally seasoned by steaming at a pressure of from 90 to 100 pounds per square inch or boiled in the preservative which is heated by means of steam coils. In both cases a vacuum is used to draw the moisture content from the wood. In the case of Douglas fir the boiling is carried on under vacuum in order to reduce the injury to the wood fiber. This boiling under vacuum process is not used anywhere except on the Pacific Coast but has been found to be the most satisfactory form of treatment for Douglas fir.

The modern pressure processes used in the United States are as follows:

BETHELL OR FULL-CELL PROCESS

Briefly—a preliminary vacuum of at least 22 inches maintained until the wood is as dry and as free of air as practicable. Creosote oil introduced without breaking the vacuum and the pressure gradually raised and maintained at a minimum of 125 pounds per square inch until a satisfactory quantity of preservative is injected into the wood. The temperature of the preservative during the pressure period shall be not less than 170 degrees F. nor more than 200 degrees F. and shall average at least 180 degrees F. After pressure is completed and the cylinder emptied of preservative, a final vacuum shall be maintained until the wood can be removed from the cylinder free of dripping preservative. Green timber is sometimes subjected to live steam bath at about 20 pounds pressure before preliminary vacuum.

LOWRY OR EMPTY-CELL PROCESS WITH FINAL VACUUM

Briefly—the preservative is introduced into the cylinder at not over 200 degrees F. The pressure is then raised and maintained until there is obtained the largest practicable injection that can be reduced to the required final retention by a quick vacuum. After pressure is completed the cylinder is speedily emptied of preservative and a vacuum of at least 22 inches promptly created and maintained until the quantity of preservative injected is reduced to an average of 6 to 8 pounds of creosote per cubic foot. The air imprisoned in the cellular structure by injecting oil without preliminary vacuum is expanded during the final vacuum forcing out a certain amount of oil with it.

RUEPING OR EMPTY-CELL PROCESS WITH INTERNAL AIR PRESSURE AND FINAL VACUUM

Briefly—after the material is placed in the cylinder it is subjected to air pressure of sufficient intensity and duration to provide under final vacuum the evacuation of preservative necessary to secure the required retention. The preservative is then introduced, air pressure being maintained constant until cylinder is filled. The pressure is then gradually raised to at least 150 pounds per square inch and held until all sapwood and as much heartwood as practicable are saturated. Temperature of preservative during pressure period must be not less than 170 degrees F. nor more than 200 degrees F. and shall average at least 180 degrees F. After pressure is completed the cylinder is speedily emptied of preservative and a vacuum of at least 22 inches is promptly created until the material finally retains an average of at least 5 pounds of creosote oil per cubic foot.

BURNETT OR ZINC CHLORIDE PROCESS

Briefly—the material is steamed in a cylinder for one or two hours at a pressure of about 20 pounds. A preliminary vacuum of at least 22 inches is maintained until the wood is as dry and as free from air as practicable. Condensate is drained from cylinder and preservative introduced without breaking vacuum. Pressure is raised and maintained at a minimum of 125 pounds per square inch until the timber has absorbed ½ pound of dry zinc chloride per cubic foot. Temperature during pressure period shall be not less than 130 degrees F. nor more than 190 degrees F. and shall average at least 150 degrees F. Strength of zinc chloride solution shall not exceed 5 %.

STEAMING OR COLMAN PROCESS

Briefly—the timber is first steamed at a pressure of 90 to 100 pounds for 3 to 10 hours. The steam is then released and a vacuum drawn until the timber is considered seasoned, the temperature within retort during vacuum usually being maintained above 200 degrees F. Creosote oil is injected at a maximum pressure of 100 to 150 pounds until the desired absorption is obtained.

Referring briefly to the uses to which these various processes are put, it may be stated that for protection against the attack of marine borers the full-cell processes, either Bethell, boiling, Boulton or steaming method, are always used because of the necessity of injecting the maximum amount of preservative. For protection against decay and white ants where marine borers are not present, empty-cell processes, Rueping or Lowry method, are commonly used because it is not necessary to have a maximum retention of preservative for protection against decay although a maximum penetration is essential. Water soluble salts are also effective against white ants.

The Burnett and Card processes are commonly used where a saving in first cost is desirable or necessary. There was a time when the low cost of untreated ties and the labor of placing them in the track, combined with the low cost of these two processes, resulted under certain conditions in a lower annual charge for track maintenance than would have resulted had the ties been treated by the more expensive oil processes. However, the rising cost of timber and labor, combined with the increased cost of preservatives, has extended largely the conditions under which the use of oil treatments may be economically adopted.

CARD OR ZINC CHLORIDE AND CREOSOTE OIL PROCESS

Briefly—the method used is the same as that in the Bethell or full-cell process and it is customary to inject about ½ pound of zinc chloride and 2 to 3 pounds of creosote oil per cubic foot. The mixture of zinc chloride and creosote oil is kept agitated during treatment by means of a rotary pump which draws the mixture from top of retort and returns it at bottom through a perforated pipe.

BOILING PROCESS

Briefly—creosote oil is introduced into cylinder at about 160 degrees F. and heated to 225 to 250 degrees F. at atmospheric pressure, the vapors being passed through a condenser. Heating is continued until the rate of condensation falls to 1/6 to 1/10 of a pound of water per cubic foot of wood per hour. The cylinder is then filled with cool oil allowing the temperature to fall. Pressure is then applied from 120 to 150 pounds until the desired injection of preservative is obtained.

BOULTON OR BOILING UNDER VACUUM PROCESS

Briefly—creosote oil is introduced into cylinder, heated to 190 to 210 degrees F., subjected to a vacuum and the escaping vapors passed through a condenser. Heating and vacuum are continued until the rate of condensation falls to 1/6 to 1/10 of a pound of water per cubic foot of wood per hour. The vacuum is then discontinued and the necessary pressure applied and maintained until the desired injection of preservative is obtained. The object of the vacuum during boiling is to evaporate the water from the wood at a lower temperature than in steaming or straight boiling processes which results in less injury to the fiber of the wood.

SERVICE DATA

Based on high grade timber carefully selected and on scientific treatment carefully carried out with the proper quality of preservative.

Douglas Fir

Piling—in waters infested with marine borers.

Untreated—life from 4 to 9 months up to 15 to 18 months, depending upon severity of the attack.

Treated with Creosote—life from 25 years up.

In Oakland Long Wharf—20 to 29 years, approximately 71 % still sound when removed.

In the L. & N. R. R. bridge across the Ohio River at Henderson, Ky.—34 years. Pile tops cut before treating and caps entirely covered pile tops; approximately 75 % still sound when removed.

In dock at Port Bolivar on Galveston Bay—40 years.

Lumber

Untreated—life from 4 to 12 months, in waters infested with marine borers.

Treated with Creosote—as long as the mechanical life of the wood. The use of untreated fenders or cross-brading, when attached to treated material below high water is bad practice because the teredo, growing to an adult form in the green material, is not then stopped by the creosote protection of the treated material.

Cross Ties

Untreated—life from 4 to 8 years, depending upon the climatic conditions under which they are used. The life is longest in dry, arid regions. White oak, which gives the best results of any untreated tie, has a life of about 9 years; yellow pine, 7 to 8 years; inferior woods, 2 to 5 years.

Treated with Zinc Chloride—average life about 14 years.

Treated with Creosote under the Rueping Process—protected against decay for the full mechanical life of the wood which may exceed 20 years.

The Rueping process allows the use of the minimum amount of creosote necessary to protect the tie throughout its mechanical life.

Creosoted Baltic pine ties in France have been in service for over 26 years.

SUMMARY

For comparative purposes and with a degree of accuracy which may be depended upon in deciding upon investment in treated material the following statements are called to the attention of users of wood:

1. Properly creosoted Douglas fir piling cost four to five times as much as green piling and will give a life protected against marine borers from 25 to 40 times longer.
2. Properly creosoted Douglas fir lumber will cost from 3 to 4 times as much as green lumber and will give a life protected against marine borers and decay from 10 to 15 times longer depending upon its mechanical life.
3. Properly zinc chloride Douglas fir cross ties will cost about 40 % more than the green ties and give about twice the service; while Rueping creosoted Douglas fir cross ties will cost about 80 % more than the green ties and give about three times the service, depending only upon the mechanical life of the wood.

In all cases, to get maximum service, every reasonable precaution must be taken in erecting treated material and in maintaining the same not to injure in any way the seal of preservative.

In conclusion, the cost of preserving wood against injury and destruction by decay, marine borers and white ants, even at the high level of prices existing today, which will probably never recede to the prewar level, is fully justified by the increased service from the treated material thereby assured and if treating specifications, so varied and tending to confusion today, can be standardized along scientific lines, the interests of both purchaser and treating contractor will be harmonized to the mutual benefit of each. Investment in properly treated material is a wise and far-sighted policy when forest products are to be used in railroad cross ties, switch ties and bridge timbers, in piling and all kinds of lumber required in water-front construction, in poles, fence posts, paving block for outside and inside use, wood pipe staves, building sills and all lumber in contact with the ground, culverts, drain boxes, highway bridges, mining timber for above ground or under-ground construction and in all those forms of inland construction where air, moisture and heat expose the wood to fungus attack.

If there is a difference between the average life of untreated wood used under specific conditions of destructive fungus or marine borer action and its possible life of mechanical usefulness under conditions in which those destructive forces are inactive, then preservative treatment is advisable. The extent of increased life which can be obtained by treatment that is necessary to balance the mechanical life of the wood used then becomes the determining factor in deciding whether the investment shall be for a temporary or permanent form of preservative treatment.

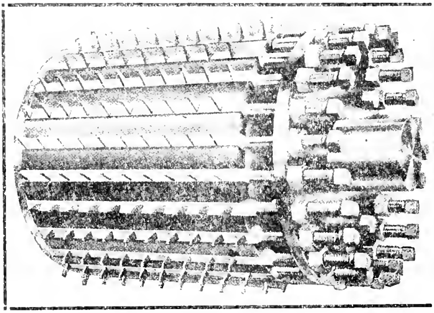
PERFORATING TIES BEFORE TREATMENT

In view of the increasing demand for treated ties, it is believed that the importance of a proper preparation of ties for preservarive treatment is sufficient to justify the publication at this time of a brief statement on the mechanical application and results of the so-called "perforating process." This method of preparation preliminary to treatment consists in puncturing all the exposed surfaces of the wood, except the ends, with saw-tooth holes scientifically spaced both across and along the grain and so arranged that the punctures along the longitudinal axis of the tie form diagonal lines. More accurately speaking, this method should be called the "incising process," inasmuch as the punctures penetrate to a depth of about seven-eights of an inch into the surface of the wood and do not actually "perforate," or pierce through the wood.

The spacing of the holes is such that a complete and uniform penetration of the preservative to the depth of the incisions may be expected to be secured within reasonable ranges of temperature and time of treatment in the retorts. The proper spacing of the puncturing teeth on the machine may likely be found to vary for different kinds of wood. It is believed that a minimum depth of about three-fourths of an inch for the incisions will meet the most rigid demands for protection of the tie against decay.

Perforating, or incising, preliminary to treatment has been developed because heartwoods were encountered which were so refractory in their resistance to the injection of preservative, due to the nature of their cellular structure, that it was practically impossible to secure satisfactory penetration of the preservative, at least not without serious injury to the mechanical strength of the timber caused by the higher temperatures and excessive length of treatment required in the retorts in order to get any reasonable penetration. The method is also of great value in the preparation of sapwood ties for treatment.

While the experiments on this method have been largely conducted in the Pacific Northwest on Douglas fir, the process will apply equally as well to the heartwood of any kind of timber. It is also applicable to lumber for practically every use, such as sheathing, bulkheading, pontoons, marine railways, bracing, mining timbers, cross arms, sewer outfalls, culverts, etc. It is possible



VIEW OF ONE OF THE FOUR TOOTHED ROLLS OF THE GREENLEE PERFORATING OR INCISING MACHINE

Showing set screw arrangement for adjusting rows of teeth

also that machinery may later be devised which will make it practicable to perforate, or incise, round tapering sticks, such as poles and piling. Its application to structural timbers for use in bridges and buildings in which the beams are subjected to loading in tension or shear, can only be settled after a thorough investigation of the effect of the punctures upon the tensile and shearing strength of the timber.

Experiments on cross ties since 1913 have shown that preservative treatment after perforating, or incising, results in an ultimate reduction of not over 8 per cent to 10 per cent in the strength of the timber in compression perpendicular to the grain. Without preliminary perforating, or incising, the temperatures and length of treatment necessary to secure a satisfactory penetration in heartwoods was such that the reduction in strength ran from 30 per cent to 40 per cent.

Machinery for applying the perforating, or incising process to cross ties and dimension timber has recently been designed and built by Greenlee Bros. & Company of Rockford, Illinois, makers of the adzing-boring-branding machines, and the first machine so constructed has been in service at the plant of the St. Helens Creosoting Co., St. Helens, Oregon, since September 21, 1920. Briefly describing this machine, it has a massive main frame on which are mounted four rolls or drums, two horizontal and two vertical. The diameter of all these drums is 14½ inches. The top horizontal drum and one of the vertical drums is flexible and adjustable mounted to provide for variations in tie and timber sizes and to permit of a rocking or tilting position to allow for ties of more or less irregular form. These two drums are fitted with heavy coil springs with tension adjustment.

The maximum size capacity of the machine for ties and timber is 8 inches in thickness and 14 inches in width, the minimum thickness to which it will work being 3 inches and the minimum width 6 inches. It will therefore perforate, or incise, material varying from 3″x6″ to 8″x14″. The machine is driven by a 15 H. P. motor and has a speed of about 70 lineal feet per minute which will permit the perforating, or incising, of about eight ties 8 feet in length per minute or, at this rate, of about 3,800 ties in eight hours. The ties and timber go through the machine much as in the case of a planer.

To summarize briefly, it is expected that perforating, or incising, before treatment will accomplish the following results, applicable to both heartwood and sapwood:

1. Control, reduction or complete elimination of checking in green ties and timber if perforating is done promptly after cutting. This will be a very important accomplishment expecially in the case of ties to be transported long distances or stored for air seasoning before treatment.
2. Reduction of the temperatures required to secure satisfactory impregnation. This will reduce the injury to the fiber.
3. Reduction of the time required to treat ties and timber in the retorts. This will reduce the loss in mechanical strength.
4. A complete and uniform penetration of the preservative to the depth of the perforations.
5. Reduction of not over 8 to 10 per cent in the strength of the timber in compression perpendicular to the grain. The present loss in the strength and mechanical life of treated unperforated ties or timber varies from 30 to 40 per cent.

The economy in the use of perforated treated ties, is therefore, obvious and this is all the more important in view of the recent report of a committee of the Roadmasters' & Maintenance of Way Association made at St. Louis in September, 1920, which recommended the use of treated ties for the following reasons, as quoted from Railway Maintenance Engineer of October, 1920:

1. The conservation of timber.
2. Reduction in the number of tie renewals. We all fully realize the cost of such work under present labor conditions.
3. More time for general maintenance.
4. Lessened disturbance of the roadbed, which insures better surface and alinement at a reduced cost.

We also find, on account of the scarcity of tie timber many kinds of inferior wood are being used with satisfactory results when treated.

GRAND FIR—WHITE FIR

Grand Fir (Abies Grandis) is a closely allied variety of White Fir (Abies Concolas) therefore for all practical purposes, a description of one serves for both.

WHITE FIR

(Abies Concolor)

White Fir is a massive tree and generally averages from 140 to 200 feet in height, with a diameter of 40 to 60 inches.

WEIGHT

When green the lumber is very heavy, and butt logs often sink in water. The wood naturally contains a large percentage of moisture, but after a thorough seasoning boards one inch in thickness will weigh about 2,000 pounds to 1,000 board feet.

THE WOOD

The wood is soft, straight grained and works easily. It is only used or suitable for a light class of construction work or temporary mining purposes. In color it is whitish-gray to light indistinct brown. The sawn product closely resembles Hemlock in appearance, but it is inferior to it for finish or construction. White Fir should on no account be classed or confused with Douglas Fir (Pseudotsuga Taxifolia) which botanically is not a Fir, and the wood of which is entirely different and vastly superior to that of the White Fir.

More than half of the total output of White Fir is supplied by California, and approximately 10 per cent each by Washington, Idaho and Oregon. Small quantities are produced in Montana, Colorado and other Rocky Mountain States.

ITS USE FOR PULPWOOD

Experiments conducted at the Forest Service laboratory at Washington show that this wood is admirably adapted for the production of paper pulp by the sulphite process. The wood is found to yield very readily to the action of the sulphite liquor used, which is of the usual commercial strength, viz., about 4.0 percent total sulphur dioxide, 1.0 per cent combined and 3.0 per cent available. The length of treatment has varied in the different tests from eight to ten hours, and the steam pressure from 60 to 75 pounds. These pressures correspond to maximum temperatures of 153 to 160 degrees C.

The pulp produced in these experiments is from nearly white to light brown in color, according to the variations in the method of cooking, and by selecting the proper conditions of treatment, it would be readily possible to produce a grade of fiber which could be used in many kinds of paper without the least bleaching. If, however, it is desired to employ the fiber for white book or writing papers, it could be readily bleached to a good white color.

Results of laboratory tests show that the bleach required to bring the fiber up to the usual color for bleached sulphite spruce fiber is from 15 to 23 per cent to the weight of unbleached fiber; that is, assuming the bleaching power to contain 35 per cent available chloride. Sulphite spruce fiber now on the market requires from 175 to 500 pounds of 35 per cent bleach per ton of product or from 9 to 24 per cent of the unbleached fiber. It is seen, therefore, that so far as bleaching is concerned, the pulp made from white fir is just as good as that made from spruce.

The yields obtained in these experiments ranged from 43 to 49 per cent on the bone-dry basis. This is exclusive of screenings, which in no case exceed 1¼ per cent of the dry wood used. From careful observation of the methods employed in determining the yields, it seems probable that those figures will be increased slightly when larger quantities of wood are used, and it is believed that in the matter of yield the Fir wood is fully equal to spruce.

The fiber from these cooks is in most cases light colored and somewhat lustrous, and the sheets formed from it without any beating are remarkably tough and strong. Microscopic examination and measurements show that the fibers are of very remarkable length, being from one-half to two-thirds as long again as the commercial sulphite spruce fiber.

It is believed from the results that, so far as the product is concerned, the manufacture of fiber from white fir would be a commercial success, and that the fiber produced would find its greatest usefulness in the production of manilas where great strength is required, and in tissues which need very long fibers. It seems probable, also, that it would make very good neswpaper, for which purpose its naturally light color would particularly adapt it.

CALIFORNIA REDWOOD

(Sequoia Sempervirens)

DESCRIPTION

Redwood is lumber from the "big trees" of California—the Eighth Wonder of the World. Scientists call them **Sequoia sempervirens,** which, when translated into our every-day tongue, means "Sequoia ever-living." Sequoia is an Indian name; the name of a chief of great power and influence among his people. It was natural, therefore, for the Indians to name the giant trees after their most powerful chief.

They are wonderful trees. Their living power is without peer among perishable and animal life. The secret of their great age is resistance to rot and fire, and practical immunity to the attack of insect life and fungus growth so destructive to most other kinds of wood. In the forests, the Redwoods have fought decay and fire down the sweep of many centuries—they lived on sturdy and strong while other forest trees matured and died in successive crops.

RANGE

By a freak of nature the Redwoods grow nowhere else in the world but in California. Their range is confined to a strip along the Pacific Coast north of San Francisco Bay to the Oregon State line, and extending inland not more than 10 to 20 miles. The principal stand of commercial lumber today is in the three north coast counties of Mendocino, Humboldt and Del Norte. Their growth ranges from the sea level to an altitude of 2500 feet.

YIELD

The Redwoods grow in what is known as the "fog belt," and thrive only in excessive moisture. There are millions of trees, and estimated by the Government to contain between 50,000,000,000 and 60,000,000,000 board measure feet of lumber—more than enough to keep all the sawmills now cutting Redwood busy day and night for 100 years. The Redwoods grow big and dense, yielding on an average from 75,000 to 100,000 board feet of commercial lumber per acre. There are quite a number of instances where the Redwoods grow so dense and so big that a single acre has yielded more than 1,000,000, board feet of lumber.

HEIGHT

The Redwood forest is one of the sublimities of nature. The massive trees, with their straight trunks covered with cinnamon-colored bark and fluted from the base to the apex of the tree like a Corinthian column, are as impressive as the cold, silent walls of an ancient cathedral. They grow from 5 to 25 feet in diameter, and from 75 to 300 feet in height. The great size and height of these trees can best be appreciated when it is known that, if hollowed out, one of the large Redwoods would make an elevator shaft for the famous Flatiron Building in New York; in height it would tower 50 feet above the torch of the Statute of Liberty in New York Harbor! They are so large that a single tree has produced enough lumber to build a church at Santa Rosa, California, that will seat 500 people.

The enormous logs make it necessary to use the most powerful and expensive logging machinery. Many of the large logs must be split with gun-powder before they can be handled on the saw carriage at the mill. It is not uncommon for a butt log (the first cut above the ground) to weigh from 30 to 50 tons, according to the diameter of the tree. The butt cut is usually 16 feet in length.

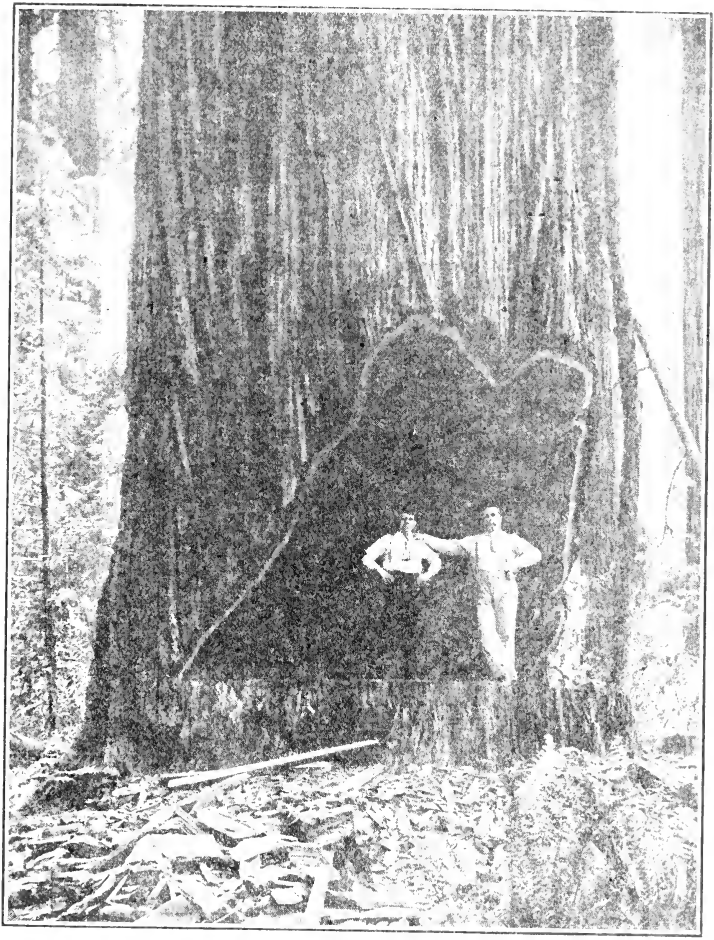
ROOT FORMATION

One of the strange things about the Redwoods is the root formation, which is slight in comparison with the size of the tree. Redwood actually has an insecure footing. There is no tap root to push straight down into the earth to give the tree stability. The roots radiate a few feet below the surface of the soil. It is supposed they protect themselves by dense growth. The floor of the forest is covered with a luxuriant growth of magnificent ferns and beautiful rhododendrons.

THE BIG TREES OF CALIFORNIA

DESCRIPTION

The **Sequoia gigantea,** or **Sequoia washingtonia,** as the United States Forest Service refer to them, are the "big trees" of the tourist. They are first cousins of the Redwoods. Geologists assert that they are the lone living survivors of all plant and animal life that existed before the glacial age. The few remaining trees are confined to an area of about 50 square miles on the western slope of the Sierra Nevada Mountains, in central California, and of which the Yosemite Valley is a part. Many of these trees are 4000 years of age—and sone bold scientists have estimated one to be from 8000 to 10,000 years old! They are located in an altitude of from 4000 to 7000 feet above sea-level, and bear evidence of having passed maturity and are in their decline. If the decline lasts proportionately as long as it took the trees to reach maturity, they are still good for untold centuries. These "big trees" are found only in protected valleys and spots in the mountains, indicating the cause of their survival of the glacial upheaval.



CALIFORNIA REDWOOD
(Sequoia Sempervirens)

THE GRIZZLY GIANT

The "Grizzly Giant" in Mariposa Grove, Yosemite Park, is 91 feet in circumference at the ground, and its first branch, which is 125 feet from the ground, is 20 feet in circumference. The "General Sherman" is 280 feet high, 103 feet circumference at the ground, which means a diameter of 36½ feet, and at a point 100 feet from the ground it is 17.7 feet in diameter. These are two of the most noted of the "big trees."

The "big trees" of California afford an inexhaustible reservoir of information for the scientist who reads this story of the past by the study of the annular growth. By means of this he is able to determine the season and locate with a degree of definiteness climatic conditions and changes on the Pacific Coast as far back as 4000 years ago!

SAP

Sap is always white. Some manufacturers make a specialty of turning out a "sappy clear" grade. Lumber of this description shows a streak of white along one edge and presents a most beautiful contrast between the red and white in the wood. This "sappy clear" is highly prized for interior finish.

COLOR AND GRAIN

In color Redwood shades from light cherry to dark mahogany; its grain is straight, fine and even. The color and grain present in combination a handsome appearance. It runs strong to upper grades, and phenominal widths, sometimes as wide as 36 inches, entirely free from check or other defects.

PAINTING AND POLISHING

Redwood is easily worked, and when properly seasoned it neither swells, shrinks, nor warps—it "stays put," and being free from pitch takes paint well and absorbs it readily. The dark color of the wood makes three coat work necessary, since the priming coat must be mixed extremely thin to fully satisfy the surface. It also takes a beautiful polish, especially if given two coats of shellac and then a wax finish on top.

INTERIOR AND EXTERIOR FINISH

For doors, windows, pattern or panel work, wainscoting, ceiling, casing, shelving, moulding and every description of interior or exterior finish the finest results can be obtained. For interior finish Redwood should not be painted any more than you would cover oak or mahogany. Redwood's beauty for interior finish lies in its individuality, its soft, warm tone and color possibilities.

QUALITY

Redwood is the most durable of the coniferous woods of California and possesses lasting qualities scarcely equalled by any other timber. Although very light and porous, it has antiseptic properties, which prevent the growth of decay producing fungi. So far as is known, none of the ordinary wood rotting fungi grow in Redwood timber. This is an exceedingly valuable property which should extend the use of this wood for all kinds of construction purposes.

DURABILITY

For tanks, stave water pipe, poles, posts, paving blocks or foundations, it will last almost indefinitely under the trying conditions of being placed in contact with the ground and subject to alternate wet and dry conditions.

For exterior boarding, finish and shingling, whether painted or not, its durability in thousands of instances has been demonstrated to be very great.

PATTERN WORK

Leading engineering and shipbuilding works in California have been using Redwood for pattern work during the past twenty-five years, as it works easily and time has proved that it retains its shape as well as any other wood used for this purpose.

CAR MATERIAL

Redwood is in great demand for all kinds of finish for car material. Its special recommendations for this class of work are its durability and well known fire resisting qualities. Examinations of car siding in use for twenty years have failed to show traces of dry rot or any other form of decay.

The hardest service to which wood can be subjected is the railway tie.

It is not only in constant contact with the ground, but it must stand the strain and stresses of swiftly-moving heavy trains. In his report on "Timber, An Elementary Discussion of the Characteristics and Properties of Wood," to the Division of Forestry, U. S. Department of Agriculture, Filbert Roth, special agent in charge of timber physics, gives the following table on

THE RANGE OF DURABILITY IN RAILROAD TIES

Redwood	12	Elm	6 to 7
Black Locust	10	Long Leaf Pine	6
Oak (white and chestnut)	8	Hemlock	4 to 6
Chestnut	8	Spruce	5
Tamarack	7 to 8	Red and Black Oaks	4 to 5
Cherry, Black Walnut Locust	7	Ash, Beech, Maple	4

To get best service out of the Redwood tie under heavy equipment, tie plates should be used.

Redwood ties are in big demand in South America, England and the continent, Australia and the Orient, because of its resistance to decay and resistance to attack of destructive insects so common in the tropical countries.

HOLDING OF SPIKES

Respecting the "holding of spikes" Redwood ties compare favorably with all other ties ordinarily classed as soft wood.

CALIFORNIA REDWOOD GRADES

Adopted April 5, 1917, by California Redwood Association
San Francisco, California

SPECIAL NOTES

1. All worked lumber shall be measured and invoiced for contents before working.

2. All rough lumber unseasoned shall allow an occasional variation equivalent to 1/16 of an inch in thickness per inch and 1/32 of an inch in width per inch.

3. All rough lumber seasoned shall allow a variation equivalent to 3/32 of an inch in thickness per inch.

4. All rough lumber seasoned shall allow a variation in width as follows:
   - 6-inch and less, ¼ of an inch in width.
   - 8, 10 and 12 inch, ½ of an inch in width.
   - 14-inch and wider, ¾ of an inch in width.

5. Surfaced lumber will be ⅛ of an inch less for one side and 3/16 of an inch less for two sides. Rustic, T. & G., T. G. & B. will be 3/16 of an inch less for one side and ¼ of an inch less for two sides. (Above less than rough thickness.)

6. Grain of all grades shall be as the lumber runs.

7. Worked lumber to be in accordance with patterns adopted by California Redwood Association, April 5, 1917.

KNOTS

In these Grading Rules, knots are classified as sound, loose and soft.

A Sound Knot, irrespective of color, is solid across its face, as hard or harder than the wood it is in, and so fixed by growth or position that it will retain its place in the piece.

A Loose Knot is one not held firmly in place by growth or position.

A Soft Knot is one not so hard as the wood itself.

GRADES

Uppers

(Under the heading of Uppers shall be included all Redwood of a grade higher than Extra Merchantable, including Clear, Sap, Select, Standard, Pickets, Battens, etc.)

Clear: Shall be good and sound, free from knots, shakes or splits. Will allow a reasonable amount of birdseye, and sap not exceeding four per cent of the area of all the surfaces. A fair proportion in each shipment may contain pin knots showing on one face only.

Sap Clear: Shall conform generally to the grade of clear, except that it may contain any amount of sap. Discolored sap, when sound, shall not be considered a defect.

Select: Shall be good and sound, free from shakes or splits. Shall be graded from the face side and will allow birdseye and one small, sound knot one inch in diameter or its equivalent in each six superficial feet. In the absence of other defects, will allow one soft knot one-half inch in diameter in each six superficial feet. Sap allowed not exceeding four per cent of the area of all the surfaces.

Standard: Shall be graded from the face side and will allow birdseye, any amount of sap, and in each six superficial feet, two sound knots not exceeding an inch and a quarter in diameter, or their equivalent. In the absence of sound knots, will allow one soft knot one inch in diameter or its equivalent in each six superficial feet.

Clear, Sap Clear and Select Worked: Shall be well manufactured and worked smoothly to uniform thickness. Will admit of slight roughness or variation in milling, and defects mentioned under grades of Clear, Sap Clear and Select.

Standard Worked: Will admit in addition to stock of regular Standard Grade, Clear, Sap Clear, and Select, which, owing to poor machinery, is unsuitable for these grades.

SUNDRY COMMONS

(Under the heading of Sundry Commons shall be included Extra Merchantable, Merchantable, Construction, Shop, etc.)

Extra Merchantable: In one inch shall be free from shakes and splits. Will admit any number of sound knots but not more than one knot two and a half inches in diameter in each five superficial feet, and small, soft knots that do not materially affect the strength or usefulness of the board. Will allow sap not exceeding ten per cent of the area of all the surfaces.

In dimension Extra Merchantable shall consist of sound lumber free from shakes, large loose knots, or such other defects as would materially impair its usefulness. Will allow sap not exceeding ten per cent of the area of all the surfaces.

Extra Merchantable Rustic and Shiplap: This grade shall conform to the grade of Extra Merchantable, except that Sap in any amount shall be allowed.

Construction: Shall be suitable for ordinary construction. Will allow sap, loose and soft knots, shakes and other defects, and splits not extending over one-sixth the length of the piece.

Merchantable: This grade is recommended for general building purposes. It consists of sixty per cent Extra Merchantable and not to exceed forty per cent Construction.

Shop: There shall be but one grade in Shop.

Inch Shop: Each piece shall contain not less than fifty per cent of cuttings five inches and wider and three feet and longer, having no defects except sap.

Inch and a Quarter to Two-Inch Shop: Each piece shall contain not less than fifty per cent of two face clear cuttings, exclusive of sap, five inches and wider, and of this fifty per cent of clear cuttings forty per cent shall be suitable for door stiles six feet seven inches and longer.

Two and a Half Inch and Thicker Shop: Shall contain sixty per cent of clear cuttings five inches and wider and two feet and longer.

REDWOOD AND THE TEREDO

The Teredo will attack and destroy Redwood piles or timber as quickly as any other wood.

REDWOOD SHINGLES

Redwood shingles as a roof or side wall covering give long life and fire protection.

No other shingle, or substitute roof covering gives the ideal combination of rot resistance and fire retardance, with the additional merit of being rust proof and free from tar, gum or any other substance to melt in the sun and fill gutters, water pipes or drains.

Always lay Redwood shingles with zinc-coated cut iron nails. This will prolong the life of your roof many years. The ordinary steel shingle nail will rust out while the shingle itself is still in first-class condition. A Redwood shingled roof, laid with the right kind of nails, will give satisfactory service from 30 to 50 years.

You can buy Redwood shingles in two grades, No. 1 Clear and Star A Star. The former is a carefully selected vertical grain shingle, free from all defects, and is used invariably on coverings where service demands first consideration. The latter is a 10-inch clear butt shingle, "slash" grain being no defect, and it is recommended for side walls rather than for roofing.

In 1893 Redwood shingles were taken from the roof of General U. S. Grant's headquarters at Fort Humboldt, California, where they had been for 40 years. The wood was absolutely sound and without a trace of rot, although the shingles were worn thin by wind-driven sand.

REDWOOD AND THE WHITE ANT IN INDIA

In reports to the Canadian Trade and Commerce Department, Ottawa, Ontario, from the Director of the Commercial Intelligence Service, India, it is stated that where California Redwood has been used for railway sleepers (ties) in an untreated condition that the white ant has made short work of them.

FIRE RESISTING QUALITIES

Redwood, owing to its freedom from pitch, will not ignite easily nor make a hot fire when burning and is very easily extinguished.

It is an actual fact that fires have been extinguished in Redwood buildings with comparatively slight damage, when the same fire would have made practically a total loss had the buildings been constructed of pine or cedar. The reason is plain. Redwood is not slow in combustion, but absorbs moisture readily and when moistened, resists fire wonderfully.

REDWOOD LATH

Redwood lath have given most satisfactory service for many years, the fire-retarding property of Redwood giving lath of this material a decided advantage over the ordinary kinds. For best results the rough coat of plaster should be allowed to dry thoroughly before applying the finish coat.

GROWS STRONGER WITH AGE

Redwood actually grows stronger with age! This has been demonstrated by tests made at the University of California. Timbers taken from a house built 37 years ago, on the Campus of the University, at Berkley, were tested and found to be actually stronger than the day when the building was erected. There wasn't the slightest trace of decay in these timbers, and when sawn the wood was virile and healthy in color and texture. Air seasoning had taken place under the most favorable conditions.

The 37-year Redwood had a longitudinal crushing strength one-quarter greater than Redwood which had been air seasoned two years.

WEIGHT OF REDWOOD LOGS

Butt logs absorb so much moisture that the first and second cuts usually sink in water. Left in the sun they require three to four years to dry.

A STRONG WOOD FOR ITS WEIGHT

Seasoned Redwood is one of the strongest woods for its weight. Dry Redwood weighs 26.2 pounds per cubic foot—slightly less than Cypress, which weighs 27.6. It is equal in strength to Cypress, and its breaking strength, according to U. S. Government figures, is 62 per cent of that of White Oak, which is one of the strongest and toughest of American woods.

The standard of lumber weight and measure is based on a "board-measure" foot. A board-measure foot means a piece one inch thick and 12 inches square. One-inch boards, in the rough, dry, weigh 2400 pounds per 1000 board-measure feet. The same boards dressed smooth on two sides would weigh 2000 pounds, and if dressed four sides will weigh 1800 pounds.

WEIGHT OF REDWOOD FOR EXPORT CARGO SHIPMENTS

"Green" Redwood for cargo shipment weighs about 5 pounds per board foot. A simple method for computing the shipping weight is to multiply the board feet by 2.2 per thousand, this gives the weight in tons of 2240 pounds.

The weight in tons of 2240 pounds of seasoned redwood boards is computed by multiplying the board feet by 1.1 per thousand.

Redwood is frequently shipped to Foreign Ports in conjunction with Douglas Fir cargoes. In steamer shipments it is customary to stow "green" Redwood first in lower hold and dry Redwood in the Bridge space, Shelter deck or 'Tween decks. Douglas Fir is loaded last in the balance of space under deck and on deck. The object of combining Redwood and Douglas Fir cargoes is to balance the weight so as to carry the maximum amount of cargo with a minimum of water ballast.

Under ordinary circumstances a combined cargo with weight of lumber correctly balanced and stowed should only require one-third the amount of water ballast that would be necessary with a straight cargo of Douglas Fir.

Redwood immersed in salt water or otherwise exposed to its action will gradually blacken on the surface and for this reason it should not be shipped on deck unless precautions are taken to protect it from the elements.

The exact proportion of green and seasoned Redwood and Douglas Fir to obtain the best results cannot be given as so much depends on the specifications type of vessel and intelligent stowage.

The following proportions will give good results under usual circumstances for an ordinary tramp steamer.

20% of cargo Green Redwood
15% " Dry Redwood
65% " Douglas Fir.

If pickets or lath are not available for stowage, about 5% of cargo in Redwood doorstock would be a good substitute.

WESTERN RED CEDAR

(Thuja Plicata)

This cedar is by far the largest of the four true cedars in the world. Since ancient times cedar has been famous for its resistance to decay and its remarkable durability. Western Red Cedar combines these qualities in the highest degree. The wood is exceptionally light, soft, and of close straight grain, making it easy to handle and work. It is free from pitch. Its qualities render it free from warping, shrinking or swelling.

Western Red Cedar is unsurpassed by any other wood where durability, lightness of weight or ease of working are essential. It also is an excellent wood for exterior siding, finish, corrugated decking and porch flooring, battens, porch columns, newels, lath, common boards, flume constructions, drains, canoes, rowboats, trellis-work, hothouse frames and sash, and for all other purposes in which the material used is exposed to the weather or comes in contact with damp soil. Cabinet makers use it for many purposes, including the backs and sides of drawers, shelves, boxes, and partitions.

From Western Red Cedar is made sixty-six per cent of all wooden shingles used in the United States. The red cedar shingle satisfies architecture's basic requirement of combining, utility, durability and beauty.

Western Red Cedar shingles are not a fire-hazard.

The life of a Western Red Cedar shingle roof is determined by the life of the shingle nail used. Such a roof put on with an old-fashioned iron nail coated with pure zinc should last from thirty to forty years. A soft bright wire nail, on the other hand, is sometimes eaten out by the decay-resisting chemicles in the wood so that the life of the roof is greatly shortened. The same applies to the use of the so-called galvanized shingle nail, which, however, may resist the chemical action of the wood for from eight to ten years.

A Western Red Cedar roof will not rot, rust or corrode. Its light weight saves expense in the whole structure of the house. Such a roof is not torn off by wind or storm. It will not require constant up keep and painting. It is noiseless during heavy rain and hail storms. It is a non-conductor of heat and cold. It is easily put on.

RED CEDAR SHINGLES

The standard length of shingles is 16 inches. The expression 6 to 2 and 5 to 2 means that the butt ends of 6 and 5 shingles, respectively, equals 2 inches in measurement. One bunch contains 25 double courses. One double course contains 10 pieces estimated at 4 inches wide. Four bundles are reckoned to the thousand.

Though it is customary to compute shingles as averaging 4 inches in width, the ordinary 16 inch Western Red Cedar Shingle contains random widths and the average piece runs close to 8 inches wide.

One thousand feet log scale will make ten thousand shingles. When shingles are shipped by vessel, freight is usually paid at the rate of 10,000 shingles being equal to 1,000 feet Board Measure.

One thousand shingles can be stowed in a space equal to 10 cubic feet.

To estimate the number of shingles required for a roof when laid 4 inches to the weather, multiply the number of square feet of roof surface by 9.

It is easy to see why the foregoing rule is correct. Each shingle is 4 in. wide and 4 in. only of its length are left exposed, hence it covers 16 sq. inches, or 1/9 of a square foot—9 shingles will cover a square foot.

Estimators usually allow 1,000 shingles to each 100 square feet of roof surface.

To find the number of shingles equal to 1 square foot:

When laid 4 inches to weather, multiply by 9.
When laid 4½ inches to weather, multiply by 8.
When laid 5 inches to weather, multiply by 7 1/5.
When laid 6 inches to weather, multiply by 6.

APPROXIMATE WEIGHT

1000 shingles, kiln dried, weigh 160 pounds.
1000 shingles, green, weigh 200 to 240 pounds.

To find approximate amount of shingles that can be loaded in a box car, ascertain the capacity of car in cubic feet, add two ciphers to this amount and the result will be the number of shingles required.

THE SQUARE PACK

Adopted by the Shingle Branch of the West Coast Lumbermen's Association, Seattle, Wash.

In the interest of uniformity and standardization of the shingle product, the West Coast Lumbermen's Association has adopted the "square" pack and on February 1st, 1921, issued revised rules governing the grading and packing of Red Cedar Shingles.

The standard of packing all 16 inch shingles is set forth as a bunch having twenty double courses, which, based on a 5 inch weather exposure, insures a covering capacity of twenty-five square feet per bunch. Four such unit bunches will cover one hundred square feet of surface. Five such unit bunches will contain exactly the same number of lineal inches of shingles as were contained in the former "thousand" unit.

This adjustment means a strictly uniform unit bunch.

And it means that no matter whether a dealer desires to sell by the thousand or by the square, the unit bunch composing each will be strictly identical on all 16 inch shingles.

The covering capacity (twenty-five square feet) based on a 5 inch weather exposure will be stamped on each bunch. This insures the same ease of estimating that has always been claimed for the "square" unit. And it also insures a uniform basis of estimating for such dealers as quote and estimate on the "thousand" basis.

With the gradual, yet positive, improvement that has been made in the grade of shingles under five years of Rite-Grade inspection, a 16 inch shingle can now safely be laid five inches to the weather, insuring an even better roof covering than was possible with the former uncertain grade of shingles produced without any inspection laid with a lesser weather exposure.

The shingle branch has gone strongly on record against the manufacture and use of a 6 to 2 shingle for permanent roofing purposes. It knows that it is this type of shingle that has permitted inroads on shingle business by substitute forms of roofing material.

The shingle branch will conduct a vigorous educational campaign in behalf of the 5 to 2 and thicker shingle for roofing purposes, to the end that the 6 to 2 grade may be dropped from the Rite-Grade grading specifications at as early a date as possible.

But the shingle branch also realizes that approximately 40 per cent of the trade at present uses a 6 to 2 shingle almost exclusively, and that to discontinue this grade prior to the education of the trade to the merits of the thicker shingle would be fair neither to such retail trade nor to the manufacturers of the 6 to 2 shingle.

Accordingly action has been taken by the shingle branch board of trustees holding in abeyance both the discontinuance of this grade and the use of the Rite-Grade trade-mark thereon until such time as in its opinion such discontinuance will not work a material hardship either on the dealer who has handled this grade of shingles principally, or on the manufacturer who has his trade established on this grade exclusively.

But perhaps the most important results of this recent adjustment will be that a great many more mills and a greatly increased percentage of the shingle production will be placed under the supervision of strict Rite-Grade inspection. This can have no other result than greatly raising the standard of shingle grades, which in turn is the basis of price stabilization.

It will mean a great extension of advertising for red cedar shingles, both to the consumer and to the dealer, thus better acquainting the public with the real merit of shingles as a roofing and siding material, and making their sale by the dealer a much easier thing.

It will mean an association of the shingle manufacturers of such strength that they will be better able to cope with the problems that may confront the industry and to remedy many of the evils that now exist.

COVERING CAPACITY

On all 24 inch shingles, the covering capacity showing 33⅓ square feet based upon a 7½ inch weather exposure and ⅛ inch spacing, must be shown on each bunch.

On all 18 inch shingles, the covering capacity showing 25 square feet based upon a 5½ inch weather exposure and ⅛ inch spacing, must be shown on each bunch.

On all 16 inch shingles, the covering capacity showing 25 square feet based upon a 5 inch weather exposure and ⅛ inch spacing, must be shown on each bunch.

SHIPPING WEIGHT FOR RED CEDAR SHINGLES

Are to be Used for the Purpose of Computing Delivered Prices

	Lb. per Bunch	Lb. per Square	Lb. per M
24″ Royals, 8/16″ and all 8/16″x24″ shingles	61⅓	184	-----
Perfections, and all 18″, 5/2¼″ shingles	42½	170	-----
Eurekas, and all 18″, 5/2″ shingles	38¼	153	-----
Extra Clears, and all 16″, 5/2″ shingles	37½	150	187½
6/2″ Extra Star-A-Stars, and all 16″, 6/2″ shingles	32	128	160

These weights are based on the actual number of board feet in each bunch of shingles.

Computation of the "Square" Unit on 16 Inch Shingles

The "square" unit on 16 inch shingles specifies 20 double courses per bunch, four bunches per "square" width of bunch 20 inches, with 1½ inch tolerance permitted per course for "fits" in packing.

20x2x4 equals 160 courses per square lineage per course 18½ inches, weather exposure 5 inches.

160x18½x5 equals 14,800 square inches of covering capacity per "square."

14,800 divided by 144 equals 102.8 square feet guaranteed covering capacity per "square," laid on a regular surface.

There are on the average 460 actual shingle pieces in one "square" of 16 inch shingles.

Correct shingle laying practice specifies at least ⅛ inch spacing between shingles. This amounts to a total lineage of 58 inches per "square." Fifty-eight inches, laid 5 inches to the weather amounts to 2 square feet.

Green shingles should be laid with butts close together.

There are, on the average, 375 actual shingle pieces in one "square" of 18 inch shingles.

Factors for Converting Square and Thousands

Quantity

To change	Number	M. 16 in. shingles	into	Number	Sq.	multiply by	1.1364
"	"	Sq.	"	"	M.	multiply by	.88
"	"	M. 18 in.	"	"	Sq.	multiply by	1.3889
"	"	Sq.	"	"	M.	multiply by	.72

Price

To change	M.	price to	equivalent	Square	price,	16 in.	shingles,	multiply	by	.88
"	Sq.	"	"	M.	"	16 in.	"	"	"	1.1364
"	M.	"	"	Square	"	18 in.	"	"	"	.72
"	Sq.	"	"	M.	"	18 in.	"	"	"	1.3889

CEDAR RUST

Thousands of cedar trees are being cut down by order of the West Virginia department of agriculture because it has been learned, through experiments conducted in the State, that these trees in proximity to apple orchards cause what is known as "cedar rust," which destroys apple trees.

CAUSE OF BUTT ROT AND BROWN STREAKS IN CEDAR

Brown streaks and butt rot in cedar are caused by a wood destroying fungi, the Polyporous Juniperinus.

The hollow butts found in mature trees are the result of hundreds of years toil on the part of this fungi, which will continue their slow but destructive work even after the tree is felled.

This fungi remains dormant in dry wood and no further decay takes place, if the wood is heated up to a temperature of about 140 degrees fahrenheit, it gives up entirely and dies.

Shingles. From experiments made by the U. S. Forest Service, it was found that in sections taken from the brown streaks of air seasoned shingles and incubated under ideal conditions, the fungi developed, though quite slowly. The fungi could not be persuaded to grow in sections taken from kiln dried shingles, indicating that kiln dried shingles, provided that they are not over-dried, can be expected to give superior service as compared with air seasoned shingles.

PORT ORFORD CEDAR; LAWSON CYPRESS

(Chamaecyparis Lawsoniana)

On account of its great beauty as an ornamental evergreen, Lawson Cypress, the Port Orford Cedar of lumbermen, is widely known in this country and abroad. It is little known, however, as a forest tree. It is the largest of its genus and also the largest representative of its tribe (Cupressineoe) in North America.

THE WOOD

Port Orford Cedar, also known as White Cedar, is very fine grained, and in color is creamy white, with the slightest tinge of red. The wood has a pleasant rose aromatic odor, which is strong when freshly sawn, but not so pronounced after seasoning. It is a rather hard and firm wood, works as easily as the choicest pine, and is very durable without protection under all sorts of exposure. Experiments have proven that it can be stained to imitate mahogany more closely than any other wood.

It is susceptible to a high polish, and possesses all the features necessary to class it as an excellent material for the better class of interior finish. It is also considered very desirable for airplane material, boat building, shelving, chests and wardrobes where expensive furs and valuable clothes are kept, as its odor is an absolute preventative from the attack of moths. Its straight grain and the facility with which it is worked gives this wood a high place among those used for match and pattern making.

Nearly all the knots are rotten, in fact in many cases nothing remains but the hole where the knot formerly existed. In spite of this defect, however, the surrounding wood does not decay but is practically everlasting.

FACTORY LUMBER

A large percentage of No. 3 Common would cut up into the best grade of factory lumber, as the knots usually of standard size are wide apart, say at intervals of 4 to 10 feet, and outside of this defect the lumber is clear without blemish.

RAILROAD TIES

Port Orford Cedar Ties are used on Western Railroads in great quantities, and give excellent satisfaction; the demand usually exceeds the supply, as they are preferred to most of the Coast woods on account of their strength, close grain and resistance to decay without preservative treatment. It is certain that the future production of ties will steadily decrease as Port Orford Cedar is now used in lengths as short as one foot and the prices paid for it, both in lumber and the log have placed the timber value too high for use as ties except where they can be produced in small tracts of timber which are more or less inaccessible for the extension of logging roads.

SHIPPING PORTS

The shipping ports are Coos Bay, and Coquille River, Oregon, consignments destined for the United Kingdom or other Foreign Ports, would probably be reshipped at San Francisco.

As this wood splits easily, great care should be exercised in the handling to avoid breakages.

NOBLE FIR

(Abies Nobilis)

Of all true firs, Noble Fir is considered the most valuable. In the deep forests which it inhabits, it is, when at its best, one of the most magnificently tall and symmetrically formed trees of its kind. The remarkably straight, even and only slightly tapering trunks are often clear of branches for 100 feet or more. Large trees are from 140 to 200 feet in height, or exceptionally somewhat taller, and from 30 to 60 inches in diameter; trees 6 to 7 feet in diameter occur, but they are rare.

RANGE

Noble Fir grows chiefly on the western slope of the Cascade Mountains, at elevations of from 2,000 to 5,000 feet, from Mount Baker in Northern Washington to the Siskiyou Mountains in Southern Oregon. It also occurs in the Olympic Mountains and in the coast ranges of Western Washington.

Though uncommon on the eastern slope of the Cascade Range, it is very abundant on the Western slope in the vicinity of the Columbia River in Oregon.

In Multnomah County, Oregon, near Bridal Veil, there are about six to eight thousand acres which are estimated to contain over 150 million board feet of Noble Fir, which is standing in a body of 15,000 acres, the balance of the stand being principally old growth Douglas Fir.

Noble Fir is abundant on Mount Rainier at elevations of 4,000 to 5,000 feet, and noted near Ashford at 3,500 feet.

COLOR AND GRAIN

The wood is of a creamy white color, irregularly marked with reddish brown areas, which adds much to its beauty. It is moderately hard, strong, firm, medium close grain, and compact. It is free from pitch, is of soft texture, but hard fiber and when dressed shows a peculiar satin sheen. In quality it is entirely different from and superior to any of the light, very soft fir woods. When seasoned this wood so closely resembles Western Hemlock that it is almost impossible to distinguish between the two when thoroughly dry.

FINISH

It is one of the best woods known for interior or exterior finish, siding, mouldings, sash and doors, and factory work for it retains its shape and "holds its place" well.

FLOORING

On account of the hard fiber, when sawn vertical (edge) grain, it makes a very satisfactory flooring, for it is close grained and presents a hard wearing surface.

GENERAL QUALITY

As the amount of surface clear cut from Noble Fir logs, generally runs from 60 to 80 per cent, the merchantable or common grades are consequently proportionately small.

The smaller trees are fine grained and sound knotted, the knots being firm and red, and interwoven with the fiber of the surrounding wood. For this reason an excellent "board" is the result, for stock boards, for barns, and other purposes where good sound common boards are wanted. This lumber holds a nail well, and produces good merchantable piece stuff such as studs, joists, planks, timbers, and ties.

In the butt cut of larger trees, the knots are often black and loose and lumber cut from this class of log produces a fine grade of "cut up" material.

The wood is odorless, tasteless and non-resinous, making boxes fit for butter, and other articles which would taint from contact with some other kind of woods.

WEIGHT

While the wet, green lumber is heavy—much heavier than Douglas Fir, it dries out so that it ships considerably lighter.

WESTERN WHITE PINE

(Pinus Ponderosa)

Western White or Soft Pine is botanically a yellow pine; the range extends from Southern British Columbia to lower California and Northern Mexico, including its Rocky Mountain form (P. Ponderosa Scopularum) occurring in every state west of the Great Plains and one hundredth meridian. The total stand of Western White Pine timber is greater than that of any other pine in North America.

TRADE TERMS

Western White Pine is sold under various trade names. In California it was formerly known as Western Yellow Pine, but for commercial reasons the name was changed to California White Pine.

In British Columbia it is known as Western Soft Pine and is termed such by the British Columbia Forest Service Department. In Idaho and Washington it is also known as Western Soft Pine and in Arizona as Arizona White Pine.

Height and Diameter

Trees range in height from 80 to 140 feet, with a practically clear trunk of from 40 to 60 feet, the diameter runs from 2 to 4 feet.

Unusually large trees are from 150 to 180 feet high, while trees are said to have been found over 200 feet in height. The largest diameter recorded is about 8 feet.

The Wood

Western White or Soft Pine is the coming wood of the soft pine group; it is soft, light, strong in proportion to its weight, works very easily and smoothly without splintering or splitting, and readily takes and holds paints, stains and varnishes.

It seasons unusually well, being very free from warping and checking, and once seasoned holds its shape without shrinking or swelling. It varies in color and texture according as to whether it comes from the outer or inner part of the tree.

The outer wood of the tree is yellowish white in color, with a very fine grain and soft satiny texture; it is from the outer part of the log that all the clear grades are cut.

The wood near the center of the tree is very similar to Norway Pine, being orange brown or reddish brown in color. It is less soft than the light colored outer portion, and having as a rule grown faster, it is somewhat coarser in grain. The lower grades of lumber are sawn from the central part of the log, and also from the top log.

Owing to the large size to which Western Pine grows, and because the wood does not check in seasoning, it can be obtained in wide clear stock. The knots are usually larger than in Eastern White Pine but few in number.

Short clear lengths such as are used for sash and door stock can be cut from between the knots easily, and with little waste, a valuable quality appreciated by factories which purchase Pine for cutting out clear lumber between the defects. The soft, even fiber, fine grain, and good working qualities of the wood make it highly valued for all kinds of finish work.

Interior Finish

Western White Pine is a splendid wood for interior finish. Any form of varnish, hard oil, stain, paint or enamel may be used on it. Oils or stains penetrate readily below the surface and give a permanent color, which gradually softens, darkens and becomes more beautiful with age. On account of its softness, even texture, and ease of working, the wood comes from the planing machines without showing any knife marks or fuzz, and with a smooth surface which can be given a high, satin-like finish with less expensive hand labor than most woods. The wood, if properly dried, does not check while seasoning, and when thoroughly dry it stays in place and does not swell or shrink.

Dimension and Framing Timber

A large quantity of the Pine is cut into the ordinary dimension material used in buildings, such as joists, rafters, sheathing, studding, shiplap, etc. Some of the qualities which give it value for these uses are: It does not warp or shrink after being seasoned, is easy to work, nails without splitting and holds nails well. It is used in buildings of every kind—houses, barns, granaries, garages, sheds, and all farm buildings.

WESTERN WHITE PINE CONTINUED

Siding

Western White Pine is manufactured into all varieties of siding—drop, bevel, novelty, barn, and also the old-fashioned bevel siding commonly called "weather boarding." Its ability to take and hold paint, and the fact that even the thin bevel siding will nail without splitting, makes it especially suitable for this purpose.

Siding is manufactured in two widths, four inch and six inch. In the cities four inch siding is in strong demand, owing to the better style and architectual effects obtainable by its use. In the rural districts the six inch siding has been used most, but the narrower width is now becoming popular.

Outside Finish

All wood exposed to the weather should be kept well painted, since paint keeps out moisture and fungi and prevents decay. Some woods do not have the quality of holding paint well. If they are used for outside finish the continual repainting which they need is a big item in the upkeep expenses of a building. Western White Pine is especially adapted for outside finish, because it takes and holds paint so well.

Sash and Doors

A large proportion of the shop and factory grades are shipped to Minnesota, Wisconsin and Michigan, the home of Eastern White Pine, and there manufactured into sash and doors for which the Eastern White Pine formerly was exclusively used.

Patterns

Owing to the ability of seasoned Western White Pine to hold its shape without warping, shrinking, or swelling, it is also used, like Eastern White Pine, for pattern lumber.

Boxes

Western White Pine as a box material is extensively used from the Pacific Coast east to the Mississippi River, especially for fruit boxes. It makes a box that is strong, serviceable, and also attractive in appearance. The wood is light in weight, takes a good, smooth finish from the planer, and is easy to print on. Very thin lumber can be used, because it is strong and does not split when being nailed.

Cooperage and Tanks

Western White Pine is used in slack cooperage for buckets, kegs, and barrels tor shipping fruit. It is also used a great deal for tank stock.

Furniture

Western White Pine is well suited for making all kinds of cheap furniture, such as kitchen tables, chairs, and cupboards.

Agricultural Implements

Western White Pine is much used in the manufacture of agricultural implements, carriage frames, wagon boxes, and similar products.

WEIGHT

The following weights, which have been obtained by manufacturers in making shipments, and are shown in shipping records, may be considered approximately correct:

	Per 1,000 Feet B. M.		
	Dry	Half Dry	Green
Boards, Dressed one side	2,000 lbs.	2,450 lbs.	2,900 lbs.
" Rough	2,400 "	2,800 "	3,200 "
Shiplap, Finish	1,800 "	2,200 "	2,600 "
Dimension, Dressed one side and one edge	2,150 "	2,575 "	3,000 "
Timbers, Rough	2,500 "	2,900 "	3,300 "
Drop Siding and Flooring	1,750 "	-------	-------
Bevel Siding and Ceiling, ⅝	750 "	-------	-------
Ceiling	1,700 "	-------	-------
Lath, per 1,000 pieces	450 "	-------	-------

ANNUAL PRODUCTION IN CALIFORNIA AND BRITISH COLUMBIA

During recent years the annual production of White Pine in California has averaged about three hundred and fifty million board feet and in British Columbia, seventy-five million board feet.

WESTERN AND EASTERN WHITE PINE COMPARED

The superiority of one of the pines over the other depends upon the particular quality considered. Southern yellow pines are stronger than the Western white pine; hence if strength is of first consideration it might be asserted that the southern pines are of higher class. Woodworkers often classify a lumber according to the ease with which it may be cut, fitted, and finished; and from that viewpoint some would prefer Western white pine, because it is much softer than any of the principal southern yellow pines.

Some users judge a pine by the grain of the wood, or rather by the figure produced by the growth rings. Generally, the southern pines show stronger figure than the Western white pine. But sometimes the very plainness of the wood is a desirable quality, and when such is the case, the Western pine may have the advantage.

Sometimes weight of a wood is an advantage or a disadvantage and the wood is rated accordingly. Western white pine is much lighter than the southern yellow pines.

Southern yellow pine is not a single species, but consists of more than a half dozen, differing among themselves in quality. The three leading yellow pines of the South are longleaf, shortleaf, and loblolly. Botanically the Western white pine is also a yellow pine; but because of its light, white wood, and freedom from resin, it is generally called white pine. The Norway pine of the northern and eastern States also is a yellow pine, but it is often compared with the northern white pine.

The following figures make some comparisons between the physical properties of these six commercial pines. The dry wood per cubic foot weighs in pounds as follows:

Longleaf pine	42	Norway pine	34
Shortleaf pine	38	Western white pine	28
Loblolly pine	38	Northern white pine	27

Below is shown the comparison of these woods in hardness. The figures tell the pressure in pounds required to sink a steel ball of certain size a certain distance in the side of a dry stick. The value of this data lies in the fact that a means is provided for comparing one wood's hardness with another's:

Longleaf pine	1020	Norway pine	600
Shortleaf pine	880	Northern white pine	470
Loblolly pine	840	Western white pine	460

It is thus shown that longleaf is more than twice as hard as Western white pine. Tests of strength of dry wood show the comparative rating of these pines as follows; the figures indicating modulus of rupture:

Longleaf pine	16700	Norway pine	12300
Loblolly pine	15600	Western white pine	9800
Shortleaf pine	13900	Northern white pine	9000

The conclusion to be drawn from comparing data concerning these pines is that one may be better for one purpose, another for another; and a person is seldom warranted in a statement that one wood is better or poorer than another, unless the statement is understood to apply to particular uses.

IDAHO WHITE PINE
(Pinos Monticola)

The Idaho white pine, which is produced in Northern Idaho, Eastern Washington and Western Montana, is a very closely related species of the white pine of the East, and its wood is used for every purpose that the eastern white pine is. It differs, however, in some respects, particularly in the common lumber, as it is characteristically a very small-knotted type and makes a very high quality of common. It is also free from shake and remarkably straight grained. It was pronounced by the government as one of the best woods in the country for airplane purposes. It is used in pattern work, exterior trim, siding, porch work, mill work, and in fact is the same all around wood that the white pine of the East has always been.

SUGAR PINE
(Pinus Lambertiana)

Sugar Pine belongs to the white pine group, and botanically closely resembles its eastern relative, the white pine (Pinus Strobus).

The wood of Sugar Pine is soft, straight grained, and easily worked. It is very resinous, and the resin ducts are large and conspicuous. The heartwood is light brown in color, while the sapwood is yellowish white. When finished the wood has a satiny luster that renders it excellent for interior finish.

The specific gravity of the dry timber is 0.3684, and rough dry timber averages about 2.5 pounds to the board foot.

In contact with the soil Sugar Pine shows moderately durable qualities, although this might prove less apparent in a climate not so dry as that of California. In brief, Sugar Pine closely approaches the Eastern White Pine in its physical characteristics.

Sugar Pine timber has an almost endless variety of uses. It is used extensively for doors, blinds, sashes, and interior finish. In pattern work Sugar Pine is largely replacing White Pine, as it is cheaper, and its softness and straight grain render it an excellent substitute. Its freedom from odor or taste causes the wood to be much used in the manufacture of druggists' drawers.

Other common uses are for oars, mouldings, ship work, chain boards, bakery work, cooperage, and woodenware—in short, for almost any purpose for which White Pine is used. The poorest grades are used extensively for boxes, especially fruit boxes, and for drying-tray slats.

Logs too knotty to cut uppers, but otherwise sound and straight grained, are sometimes turned into bolts for matchwood.

Sugar Pine is one of the leading woods of California, and in the year 1918 the annual production of this lumber in the state amounted to one hundred and eight million board feet.

WESTERN LARCH
(Larix Occidentalis)

Western Larch is the largest and most massive of North American Larches. Its straight trunks grow ordinarily to a height of from 100 to 180 feet, and to a diameter of 3 or 4 feet. Not infrequently trees reach a height of over 200 feet and a diameter of from 5 to 8 feet. The tapering trunks are clear of branches for from 60 to 100 feet or more.

Description of the Wood

The heart-wood is a bright reddish-brown color, while the sap-wood, which is usually from ½ to 1½ inches thick, is yellowish-white. Western Larch lumber is practically all heart-wood, because the sap-wood is so thin that it is generally cut off with the slab in sawing the logs. The annual rings are clearly marked, each showing two distinct bands, one of light colored wood grown in the spring, and the other of darker, harder, and stronger wood grown in the summer. The grain of the wood is straight and very close. The fiber is hard and tough; the wood does not split easily, and it holds nails firmly. The knots are sound, tight, and small, being seldom over 1½ inches in diameter. In appearance Western Larch lumber somewhat resembles Longleaf Pine, and is also very similar to European Larch, which is the most highly prized of European conifers. It is more uniform in quality and more durable than the average Southern Yellow Pine lumber (the latter is a trade name for several species, which differ widely in quality and strength).

Uses and Durability

Few woods can compare with Western Larch in its remarkable combination of strength, durability, and beauty, and it is used for a great variety of purposes, outside and inside, ranging from the heaviest wharf or bridge construction to the finest interior finish.

Dimension Timber

Western Larch grows to an exceptional size—much larger than any of the Southern Yellow Pines. For this reason, and because of its strength and durability, it makes fine dimension timbers, very suitable for all kinds of construction work, and particularly for work exposed to the weather or in contact with the soil. It is used in railway trestles, bridges, wharves, docks, tramways, culverts, warehouses, factories, snow sheds, boat and ship building, car construction, and similar work in which both strength and durability are required.

Piling, Poles and Posts

As a piling timber Western Larch is unsurpassed. It can be obtained in any dimension required, is exceedingly tough and strong, drives easily and without shattering, and has great durability in contact with the soil. These qualities make it very suitable also for posts and poles.

Railway Ties

Western Larch ties are preferred by British Columbia railways to those of any other species. The experience of many years has demonstrated their durability, strength, and especially their ability to withstand rail cutting.

Framing

Though a large proportion of Western Larch is sawn into framing lumber and used for all general building purposes, it has usually been mixed with Douglas Fir and other woods and has seldom been sold under its own name. For this reason its splendid qualities as a framing lumber —durability, strength, toughness, and the manner in which it holds nails—have not received full recognition by the trade. Additional value is given to Western Larch by the fact that its knots are small and sound, and do not weaken or impair its strength. Western Larch is especially suitable for framing that is in contact with the soil or exposed to weather or moisture, as, for example, in hothouses and factories where there is a large amount of moisture in the air.

Outside Finish

As an outside wood Western Larch takes a high rank owing not only to its natural durability even when unpainted, but also to its ability to take and hold paint, stains, and varnishes.

Here, also, its hardness and wearing qualities are valuable, and the life of any building is increased by using it.

WESTERN LARCH—Continued

Interior Finish

Those who have used Western Larch consider it an excellent wood for interior work on account of its distinct and striking grain, fine texture, and its finishing qualities. It finishes smoothly and easily, takes a high satin-like polish, does not dent or mar easily, is durable, and readily takes and holds stains, varnishes, oil finish, and paints. Owing to its beautiful grain and appearance when oiled or stained, it is particularly well suited for ceiling, wainscot, door and window casings, and base boards, etc.

To some extent this wood resembles Southern Long-leaf Pine in appearance, though its grain is softer and its freedom from pitch makes it finish better. When finished in natural color, Western Larch gradually darkens with age and takes on a rich red mahogany color.

Flooring

One of the severest tests to which wood is put is when used as flooring. Here it gets hard and continual wear, and is often wetted and dried. It must be dense and hard enough to resist abrasion, must not splinter, and must take and hold stains, varnish, polish or paint.

Western Larch meets all these requirements; in fact, for flooring it is as good as many of the hardwoods and is, of course, much cheaper.

Boats

Western Larch is especially suitable for boat building, for besides having the requisite strength and hardness it is very resistant to water soakage and to decay. It is used for:

Frames	Keels	Stem-pieces	Stems
Flooring	Knees	Stem-posts	Stringers.

Grain Elevators

For building the large grain elevators and the granaries now becoming so common , Western Larch is a favored wood not only on account of its strength, durability, and cheapness, but also because it is more than usually fire-resistant.

Silos, Tanks, Water Troughs and Refrigerators

One of the largest demands for Western Larch is from the Eastern States for tank and silo stock. Its ability to withstand exposure and moisture makes it unsurpassed for these uses.

Wood-Block Paving

As a material for wood-block paving—the best form of paving known—Western Larch is in the first rank, because of its hardness and resistance to wear, its natural durability, and because it can be easily and cheaply creosoted. A properly laid Western Larch pavement is very long wearing, economical in upkeep, and easy to repair when necessary. The surface is level, and smooth but not slippery, and gives good footing to horses. It is a sanitary pavement, for wood blocks are clean, do not produce dust, and the creosote in them is a disinfectant. It is a non-conductor of heat and is free from glare and radiation. The fact that a wood pavement is noiseless is an advantage appreciated by every city inhabitant.

Telephone Cross-Arms

Western Larch, on account of its great strength and great durability, is one of the best cross-arm materials available.

Gates and Fences

A wood suitable for gates and fences must be very durable, even when unpainted and in contact with the ground. It must must also be strong and must hold nails extremely well. Western Larch meets all these requirements and is shipped as far east as the State of Iowa for manufacture into gates and fence material.

Other Uses

In addition to those mentioned above, Western Larch is used for a great many other purposes, such as flumes, wooden piping, conduits, culverts, implement and vehicle stock, and furniture.

Weight

Western Larch usually weighs about 43.8 pounds per cubic foot when green, about 35.4 pounds when air seasoned, and about 29.7 pounds when oven dry. Comparing oven dry weights, it is thus 2 pounds heavier per cubic foot than Douglas Fir and 9 pounds lighter than the Long-leaf Pine of the Southern States.

Shrinkage

On account of its weight when green, practically all larch is air-seasoned before being placed on the market. The average shrinkage during seasoning is as follows:

Radially	4.4 per cent
Tangentially	8.7 "
Longitudinally	0.2 "

Various Names for Western Larch

Western Larch is known by the following local names: Tamarack, Red American Larch, Larch, Western Tamarack, and Hackmatack. It is widely known as "Montana Larch" and the growing demand for it is evidence of its increasing popularity with Eastern buyers.

WHY WESTERN LARCH IS NOT EXPORTED

As Western Larch is principally manufactured by Inland Mills, it cannot be profitably shipped in cargo lots to Foreign Countries on account of the extra cost of transportation by car to a shipping port, and the competition of other Coast woods.

WESTERN OR SITKA SPRUCE

(Picca Sitchensis)

In comparison with other soft woods in the United States that are used for lumber, Western Spruce also known as Sitka and Pacific Spruce, is particulary clean and white, of a soft texture with tough fiber and has a beautiful sheen or glow peculiar to itself.

WESTERN AND EASTERN SPRUCE COMPARED

Comparing Western Spruce with the Spruce of the Eastern States, it bears the same relation that the large tree does to the sapling. The Western Spruce grows very large, the average size of the logs being nearly four feet in diameter, while the average diameter of the Eastern Spruce is less than one foot.

The small tree is fine grained and contains many small red knots, while the larger tree is coarser in grain with a much larger percentage of clear, and what knots occur in the body of the tree are usually black and loose.

USE FOR FINISH

The uses for which Spruce is best adapted are finish, siding, doors, sash, factory work, musical instruments and boxes, especially those for containing pure food products.

Because Spruce is the best substitute for White Pine, now becoming scarce, it is used by sash and door factories in the manufacture of doors, windows, mouldings, frames, etc., and is found to be a very satisfactory wood for these purposes.

PIANO SOUNDING BOARDS

Spruce is one of the most resonant woods, because the fibers are long and regularly arranged. It is one of the best woods for the bodies of violins and the sounding boards of pianos.

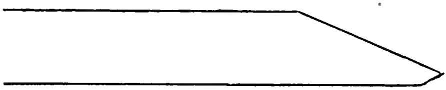
BOXES FOR FOOD PRODUCTS

Many of the manufacturers of Spruce on the Pacific Coast have box factories and the lower grades are manufactured into box shooks for all purposes. The spruce lumber, however, should be reserved for use in those boxes which are to contain food products, such as crackers, corn starch, butter, dried fruits, etc., because it is so clean, sweet and odorless that it does not taint these substances. It is also largely used for egg cases to be placed in cold storage, because eggs will taste if packed in boxes made from pine or wood containing pitch. Spruce is used for lining refrigerators for the same reason.

SECRET OF SURFACING

There has been a great deal of complaint on the part of those who have bought and tried to work spruce because it works so hard. The factory man who was used to white pine with its short and brittle grain, has been disappointed because his methods did not bring the same results with spruce. There is but one secret about spruce and the man who knows this can get first class results without special effort. The secret is to have the wood thoroughly dry and use sharp knives. The fiber of spruce, being long and tough when wet, cuts very hard, but when dry there is no difficulty if the knives are sharp.

HOW TO GRIND KNIVES FOR DRESSING SPRUCE



The cut shows the back bevel on the planer knife successfully used by planing mill experts for surfacing "Green" or "Dry" Spruce. When the knife is ground with the bevel as illustrated, it makes a square cut and leaves a smooth surface, as it breaks off the chip instead of tearing it away from the board.

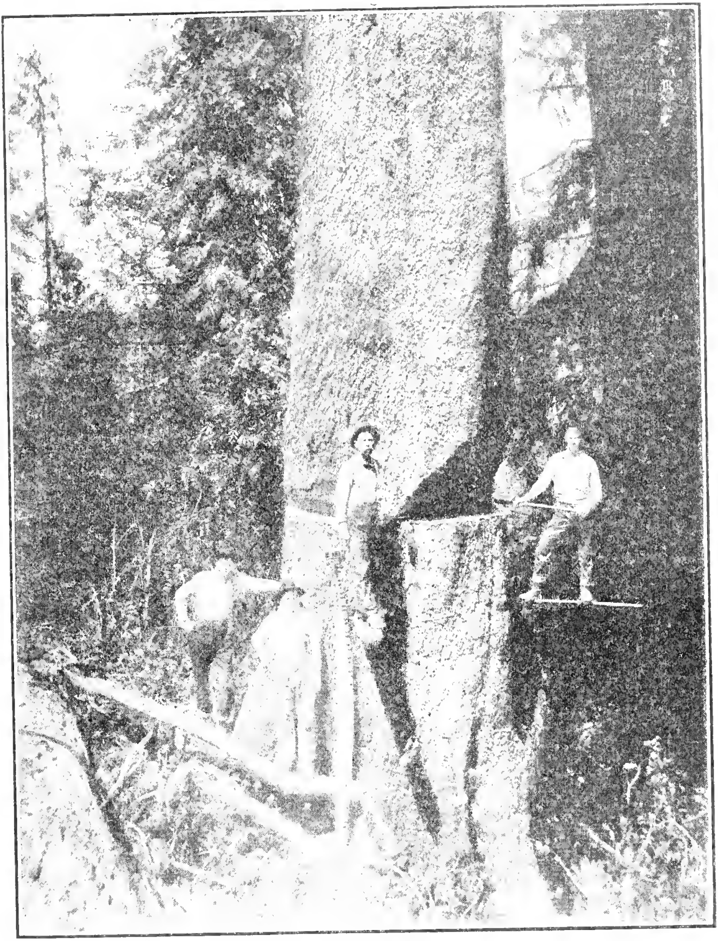
QUALITY

Spruce grades are always good because of the character of the wood. The principal defect is knots and as these are largely black and loose, the wood must be cut up into practically clear lumber. After this is done, the grade is likely to be satisfactory to any buyer.

Spruce has just the right texture to receive and hold paint nicely and is the best known wood for making sign boards, first, because any size and length can be secured, and second, because two coats of paint on spruce will give as good a finish as three coats on almost any other soft wood.

The spruce trees of the Pacific Coast are so large that the percentage of sap is small, indeed. For this reason spruce does not stain or discolor easily, even if the lumber is placed where it will become mouldy, the blue mould will dress off with a very light cut.

The above statement regarding the spruce of the Pacific Coast will enable the buyer to judge whether it is adapted to his purpose.



WESTERN OR SITKA SPRUCE
(Pica Sitchensis)

SPRUCE FOR AIRPLANES

Western Spruce is the ideal wood for airplane construction. It is the toughest softwood for its weight, possesses tremendous shock absorbing qualities, and does not splinter when hit by a missile, it is used in the frames of airplane wings, ailerons, fins, rudders, elevators, and for the stabilizers, the struts, landing gear, fuselage, flooring, engine bed, after deck, and even the seats are made of it. About 350 pieces of spruce are required in a single airplane, but not all of them are individually different; the wing beams are practically of similar dimensions, and the struts vary only in size according to the strains put upon them.

Roughly, the specifications for spruce parts are: Straight grain, clear from knots and defects so as to give maximum strength. The size of the rough pieces must be such as to insure a finished dimension after deducting losses for finishing, checking and shrinkage. Desirable pieces run 1¼ inch to 3 inches thick, 3 inches and upward in width, and from 5 feet to 17 feet in length. Practically all the available spruce is in the United States and along the western coast of British Columbia. In this country, it grows close to the Pacific coast on the western slopes of the Cascade range in the States of Washington and Oregon. The stand of Sitka spruce, which is the best airplane stock, in these two States is estimated at 11,000,000,000 feet. But less than half of it is near enough to transportation facilities, or in dense enough stands to be commercialized.

WESTERN HEMLOCK
(Tsuga Heterophylla)

The wood of Western Hemlock is light, fairly soft, strong and straight-grained. It is free from pitch or resin. Its strength and ease of working distinguish it from the Eastern Hemlock (**tsuga canadensis and tsuga caroliniana**). For ordinary building purposes Western Hemlock is equally as useful as Douglas Fir. It is manufactured into the common forms of lumber, and sold and used for the same purposes as Douglas Fir. It is suitable for inside joists, scantling, lath, siding, flooring and ceiling; in fact, it is especially adapted to uses requiring ease of working, a handsome finish or lightness combined with a large degree of strength. For the manufacture of sash and door stock, fixtures, furniture, turned stock, wainscot and panel it is recognized as a wood of exceptional merit. It is also largely used in the manufacture of boxes and shelving.

The true value of Western Hemlock timber has not been appreciated on account of its name, since it has been confused with the Eastern Hemlock, which produces wood of inferior quality.—"Forest Trees of the Pacific Coast," by George B. Sudworth.

INTERIOR FINISH

Unlike its Eastern relative, Western Hemlock contains a good proportion of uppers. The clear grades are specially suitable for inside finish, are not easily scratched and when dressed have a smooth surface with a satin sheen, susceptible of a high polish. It will also take enamel finish to perfection, and is well adapted to use as core stock for veneered products. If sawn slash the figure of the grain presents a beautiful effect. The wood is non-resinous and odorless (when dry).

FLOORING

Vertical Grain Hemlock makes an exceptionally satisfactory flooring. It hardens with age and as a proof of its lasting and wearing qualities the Hemlock floor laid in the Court House of Clatsop County, Oregon, was according to Judge Trenchard in good condition when the building was torn down, after 50 years continual service.

In the Judge's old home, built in 1860, the Hemlock flooring is in excellent condition and so hard that it is now difficult to even drive a tack into it.

BEVEL SIDING

Millions of feet of Clear Western Hemlock are annually manufactured into Bevel Siding. It is a great competitor of Spruce, which it closely resembles, and is often bought or sold as such, either through ignorance or misrepresentation.

USE FOR LIGHT CONSTRUCTION

For sheathing, shiplap, roof or barn boards Western Hemlock is an ideal wood; it is noted for holding nails well, is free from pitch or gum, and the knots in merchantable grades are firm and small. For sanitary reasons it should have a decided preference in the construction of dwelling houses, as it is practically proof against insects, vermin or white ants, and is shunned by rats and mice.

WESTERN HEMLOCK—Continued

MINING TIMBERS

Entire or part cargoes of Western Hemlock timbers, ties and planks are regularly shipped from the States of Washington and Oregon into California or Mexico, where the lumber is generally used for mining purposes.

PULP WOOD

Many millions of feet of Hemlock are yearly converted into pulp for the making of paper. Practically all of the Hemlock on the Columbia River is used for this purpose by the mills of Oregon City and La Camas.

BOXES AND PACKING CASES

Boxes or Packing Cases manufactured out of Hemlock compare very favorably with other woods for this purpose. A great number of Hemlock oil cases are shipped to the Orient. One firm in Washington is exporting 50,000 cases per month to Hong Kong and Singapore.

WEIGHT

Though Hemlock is very heavy when green, after seasoning it will weigh from 300 to 500 pounds per 1,000 board feet less than Douglas Fir. When paying from 40 to 50 cents per hundred pounds for freight by rail, it means an additional profit that the business man should not lose sight of in cases where the competitive price of other woods is close.

GRADING

The same grading rules that apply to Douglas Fir are generally used for Hemlock.

KILN DRYING

The regular and even structure of the wood and total absence of pitch renders it capable of rapid kiln drying at high temperature without injury.

STRENGTH

The strength of Western Hemlock will be found in the table "Average Strength Values for Structual Timbers," Page 8.

WESTERN HEMLOCK FOR FOREIGN CARGO SHIPMENT

Buyers and sellers of Western Hemlock will find it to their advantage to act on the following suggestions:

Freshly sawn Hemlock is very heavy and often weighs from four to six pounds per board foot and if shipped in this condition, it displaces more deadweight than Douglas Fir.

The ordinary tramp steamer will carry about ten per cent more in board feet measurement of Douglas Fir than Hemlock, therefore it would not be good policy to ship a straight cargo of freshly sawn Hemlock.

If Hemlock is shipped in amounts of ten to fifteen per cent of cargo, it should be a paying proposition if stowed first in lower hold, as the heavy weight in the bottom of the vessel will increase the stability and should cause a reduction of water ballast. This equalizes matters as the extra weight of the Hemlock displaces water ballast upon which no freight is paid.

SIZES BEST ADAPTED FOR CARGO SHIPMENT

The following sizes and lengths can be manufactured to advantage, make good stowage, and can be used with satisfactory results for house construction or similar work.

CLEAR GRADES

1x3 to 1x12—8 to 24 feet long.
2x3 to 2x12—8 to 24 feet long.

MERCHANTABLE GRADES

1x3 to 1x 8—8 to 24 feet long.
2x3 to 2x12—8 to 32 feet long.
3x3 to 3x12—8 to 32 feet long.
4x4 to 4x12—8 to 32 feet long.

SIZES FOR RE-SAWING PURPOSES

It is not advisable to ship Hemlock timbers or sizes of 6 inches in thickness or over, that contain boxed heart, if they are to be used for re-sawing purposes, as Hemlock usually opens up shakey at the heart, and this would cause a loss to the buyer, and result in general dissatisfaction.

BLACK COTTONWOOD

(Populus Trichocarpa)

This species, the largest of our poplars, is sometimes known as Balsam Cottonwood, but usually simply as Cottonwood. Black Cottonwood is a western species, not unlike the common Cottonwood which occurs from the Atlantic seaboard to the eastern side of the Continental divide.

Trees 80 to 125 feet high and from 3 to 4 feet in diameter are not uncommon; trees somewhat taller and from 5 to 6 feet through are reported in immense stands in the Naas Bay and Skeena River districts of British Columbia; large stands are also found between Prince George and Quesnel which can be reached by the Pacific Great Eastern Railway.

Large logs obtainable from the best grown trees, give a large percentage of wide clear stock.

The wood is grayish white, soft, odorless, tasteless, straight and even grained, very light, long fibered and readily nailed, glued and veneered. In addition it resists shrinking, swelling, warping and splitting. Because of its softness, light color and long, straight fiber, it is particularly adapted to pulp and excelsior manufacture. Its color, lack of odor, lightness, cheapness and facility in nailing, fit it especially for box material.

It is in demand for carriage and automobile bodies, and to some extent for furniture. Its great strength in comparison with its light weight, renders it especially valuable for the manufacture of laminated wood products, drawer bottoms, shelving and like uses.

In the near future black cottonwood will be in great demand in the U. S. Pacific States and British Columbia, owing to its many excellent properties and the scarcity of other broad leaf timber trees suitable for the special purposes to which this wood can be put.

Green cottonwood is likely to stain badly when piled, accordingly a number of lumbermen either end dry the material or pole dry it for a week or two and then place it in a stack pile.

Weight per Cubic Foot

Green 46 pounds	Air dried 24 pounds	Kiln dried 23 pounds.

THE INTERNATIONAL METRIC SYSTEM

SYNOPSIS OF THE SYSTEM

The fundamental unit of the metric system is the Meter—the unit of length. From this the units of capacity (Liter) and of weight (Gram) were derived. All other units are the decimal sub-divisions or multiples of these. These three units are simply related; e. g., for all practical purposes one Cubic Decimeter equals one Liter and one Liter of water weighs one Kilogram. The metric tables are formed by combining the words "Meter," "Gram," and "Liter" with the six numerical prefixes, as in the following tables:

PREFIXES	MEANING			UNITS
milli-	equals one thousandth	1/1000	.001	
centi-	equals one hundredth	1/100	.01	**"meter"** for length
deci-	equals one tenth	1/10	.1	
	Unit equals one		1	**"gram"** for weight or mass
deka-	equals ten	10/1	10	
hecto-	equals one hundred	100/1	100	**"liter"** for capacity
kilo-	equals one thousand	1000/1	1000	

UNITS OF LENGTH

milli-meter equals	**.001**	**meter**
centi-meter equals	**.01**	**meter**
deci-meter equals	**.1**	**meter**
METER equals	**1**	**meter**
deka-meter equals	**10**	**meter**
hecto-meter equals	**100**	**meter**
kilo-meter equals	**1000**	**meter**

Where miles are used in England and the United States for measuring distances, the kilo meter (1,000 meters) is used in metric countries. The kilometer is about 5 furlongs. There are about 1,600 meters in a statute mile, 20 meters in a chain, and 5 meters in a rod.

The meter is used for dry goods, mer chandise, engineering construction, building, and other purposes where the yard and foot are used. The meter is about a tenth longer than the yard.

The centimeter and millimeter are used instead of the inch and its fractions in machi ne construction and similar work. The centimeter, as its name shows, is the hundredth of a meter. It is used in cabinet work, in expressing sizes of paper, books, and many cases where the inch is used. The centimeter is about two-fifths of an inch and the millimeter about one twenty-fifth of an inch. The millimeter is divided for finer work into tenths, hundredths and thoudandths.

If a number of distances in millimeters, meters and kilometers are to be added, reduction is unnecessary. They are added as dollars, dimes, and cents are now added. For example, "1,050.25 meters" is not read "1 kilometer, 5 dekameters, 2 decimeters and 5 centimeters," but "one thousand and fifty meters, twenty-five centimeters," just as "$1,050.25" is read "one thousand and fifty dollars and twenty-five cents."

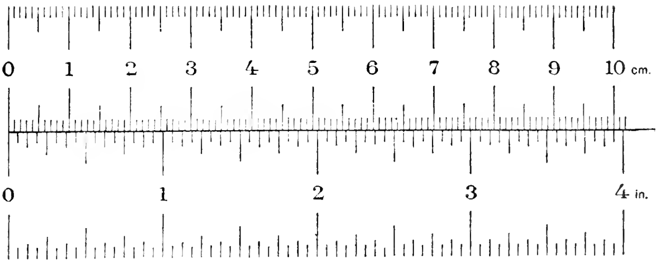


FIG. 1. COMPARISON SCALE: 10 CENTIMETERS AND 4 INCHES. (ACTUAL SIZE.)

AREA

The table of areas is formed by squaring the length measures, as in our common system. For land measure 10 meters square is called an "Are" (meaning "area"). The side of one are is about 33 feet. The Hectare is 100 meters square, and, as its name indicates, is 100 areas, or about 2½ acres. An acre is about 0.4 hectare. A standard United States quarter section contains almost exactly 64 hectares. A square kilometer contains 100 hectares.

For smaller measures of surface the square meter is used. The square meter is about 20 per cent larger than the square yard. For still smaller surfaces the square centimeter is used. A square inch contains about 6½ square centimeters.

VOLUME

The cubic measures are the cubes of the linear units. The cubic meter (sometimes called the stere, meaning "solid") is the unit of volume. A cubic meter of water weighs a metric ton and is equal to 1 kiloliter. The cubic meter is used in place of the cubic yard and is about 30 per cent larger. This is used for "cuts and fills" in grading land, measuring timber, expressing contents of tanks and reservoirs, flow of rivers, dimensions of stone, tonnage of ships, and other places where the cubic yard and foot are used. The thousandth part of the cubic meter (1 cubic decimeter) is called the Liter.

For very small volumes the cubic centimeter (cc or cm3) is used. This volume of water weighs a gram, which is the unit of weight or mass. There are about 16 cubic centimeters in a cubic inch. The cubic centimeter is the unit of volume used by chemists as well as in pharmacy, medicine, surgery and other technical work. One thousand cubic centimeters make 1 liter.

UNITS OF CAPACITY

milli-liter equals	.001	liter
centi-liter equals	.01	liter
deci-liter equals	.1	liter
LITER equals	1	liter
deka-liter equals	10	liter
hecto-liter equals	100	liter
kilo-liter equals	1000	liter

The hectoliter (100 liters) serves the same purposes as the United States bushel (2,150.42 cubic inches), and is equal to about 3 bushels, or a barrel. A peck is about 9 liters. The liter is used for measurements commonly given in the gallon, the liquid and dry quarts, a liter being 5 per cent larger than our liquid quart and 10 per cent smaller than the dry quart. A liter of water weighs exactly a kilogram, i. e., 1,000 grams. A thousand liters of water weighs 1 metric ton.

UNITS OF WEIGHT (OR MASS)

milli-gram equals	.001	gram
centi-gram equals	.01	gram
deci-gram equals	.1	gram
GRAM equals	1	gram
deka-gram equals	10	gram
hecto-gram equals	100	gram
kilo-gram equals	1000	gram

Measurements commonly expressed in gross tons or short tons are stated in metric tons (1,000 kilograms). The metric ton comes between our long and short tons and serves the purpose of both. The kilogram and "half kilo" serve for every day trade, the latter being 10 per cent larger than the pound. The kilogram is approximately 2.2 pounds. The gram and its multiples and divisions are used for the same purposes as ounces, pennyweights, drams, scruples and grains. For foreign postage, 30 grams is the legal equivalent of the avoir dupois ounce.

EQUIVALENTS OF METRIC WEIGHTS AND MEASURES

In the metric system multiples of the units are expressed by the use of the Greek prefix deca, hecto and kilo, which indicates, respectively, tens, hundreds, and thousands; decimal parts of the unit are expressed by use of the Latin prefix deci, centi, and milli, which indicates, respectively, tenth, hundredth and thousandth. For all practical purposes 1 cubic decimeter equals 1 liter, and 1 liter of water weighs 1 kilogram or 1 kilo, as it is generally abbreviated. In the tables following are comparisons of the customary and metric units.

LENGTHS

1 millimeter (mm) equals 0.03937 inch.	1 inch equals 25.4001 millimeters.
1 centimeter (cm) equals 0.3937 inch.	1 inch equals 2.54001 centimeters.
1 meter (m) equals 3.28083 feet.	1 foot equals 0.304801 meter.
1 meter equals 1.093611 yards.	1 yard equals 0.914402 meters.
1 kilometer (km) equals 0.62137 mile.	1 mile equals 1.60935 kilometers.

AREAS

1 square millimeter equals 0.00155 square inch.	1 square inch equals 645.16 square millimeters.
1 square centimeter equals 0.155 square inch.	1 square inch equals 6.452 square centimeters.
1 square meter equals 10.764 square feet.	1 square foot equals 0.0929 square meter.
1 square meter equals 1.196 square yards.	1 square yard equals 0.8361 square meter.
1 square kilometer equals 0.3861 square mile.	1 square mile equals 2.59 square kilometers.
1 hectare equals 2.471 acres.	1 acre equals 0.4047 hectare.

VOLUMES

1 cubic centimeter equals 0.061 cubic inch.	1 cubic inch equals 16.3872 cubic centimeters.
1 cubic meter equals 35.314 cubic feet.	1 cubic foot equals 0.02832 cubic meter.
1 cubic meter equals 1.3079 cubic yards.	1 cubic yard equals 0.7645 cubic meter.

CAPACITIES

1 milliliter equals 0.03381 liquid ounce.	1 liquid ounce equals 29.574 milliliters.
1 milliliter equals 0.2705 dram	1 dram equals 3.6967 milliliters.
1 milliliter equals 0.8115 scruple.	1 scruple equals 1.2322 milliliters.
1 liter equals 1.05668 liquid quarts.	1 liquid quart equals 0.94636 liter.
1 liter equals 0.26417 gallon.	1 gallon equals 3.78543 liters.
1 liter equals 0.9081 dry quart.	1 dry quart equals 1.1012 liters.
1 liter equals 0.11351 peck.	1 peck equals 8.80982 liters.
1 dekaliter equals 1.1381 pecks.	1 peck equals 0.881 dekaliter.
1 hectoliter (hl.) equals 2.83774 bushels.	1 bushel equals 0.35239 hectoliter.

MASSES

1 gram equals 15.4324 grains.	1 grain equals 0.0648 gram.
1 gram equals 0.03527 avoir. ounce.	1 avoir. ounce equals 28.3495 grams.
1 gram equals 0.03215 troy ounce.	1 troy ounce equals 31.10348 grams.
1 kilogram (kg.) equals 2.20462 avoir. pounds.	1 avoir. pound equals 0.45359 kilogram.
1 kilogram equals 2.67923 troy pounds.	1 troy pound equals 0.37324 kilogram.

Note: The unit of lumber measure is called the "Stere" and is equal to the cubic meter.

COMPARISON OF THE VARIOUS POUNDS AND TONS IN USE IN THE UNITED STATES

1 Troy Pound Equals

0.822857	Avoirdupois Pounds.
0.37324	Kilograms.
0.00041143	Short Tons.
0.00036735	Long Tons.
0.00037324	Metric Tons.

1 Avoirdupois Pound Equals

1.21528	Troy Pounds.
0.45359	Kilograms.
0.0005	Short Tons.
0.00044643	Long Tons.
0.00045359	Metric Tons.

1 Kilogram Equals

2.67923	Troy Pounds.
2.20462	Avoirdupois Pounds.
0.00110231	Short Tons.
0.00098421	Long Tons.
0.001	Metric Tons.

1 Short Ton Equals

2430.56	Troy Pounds.
2000	Avoirdupois Pounds.
907.18	Kilograms.
0.89287	Long Tons.
0.90718	Metric Tons.

1 Long Ton Equals

2722.22	Troy Pounds.
2240	Avoirdupois Pounds.
1016.05	Kilograms.
1.12	Short Tons.
1.01605	Metric Tons.

1 Metric Ton Equals

2679.23	Troy Pounds.
2204.62	Avoirdupois Pounds.
1000	Kilograms.
1.10231	Short Tons.
0.98421	Long Tons.

Note: A cubic meter of water weighs a metric ton and is equal to one kiloliter. The cubic meter is used in the place of the cubic yard and is about 30 per cent larger.

THE METRIC UNIT OF LUMBER MEASURE

The unit of lumber measure is called the **Stere,** and is equal to the cubic meter.

1 Stere (cubic meter) equals 35.314 Cubic Feet.
1 Cubic foot equals 0.028317 Cubic Steres.
1 Stere equals 0.2759 Cords.
1 Cord (128 cubic feet) equals 3.624 Steres.

The term Stere is from the Greek stereos, meaning solid.

WEIGHT

One Stere or cubic meter of Green Douglas Fir contains 423.7731 Board Feet and weighs approximately 1413 pounds or 636 kilograms.

1 Metric Ton equals 0.984206 Long Tons.
1 Metric Ton equals 1.102311 Short Tons.
1 Metric Ton equals 1000. Kilograms.
1 Metric Ton equals 2204.62234 Pounds.
1000 Board Feet Green Douglas Fir weighs 3333 Pounds.
1000 Board Feet Green Douglas Fir weighs 1512 Kilograms.

METHOD USED FOR COMPUTING APPROXIMATE WEIGHT OF FOREIGN EXPORT CARGO SHIPMENTS OF DOUGLAS FIR

1000 Board Feet weighs 1½ Long Tons.
1000 Board Feet weighs 1½ Metric Tons.
1 Board Foot weighs 1½ Kilograms.

One Petrograd Standard of 165 cubic feet (1980 board feet) weighs 6593 pounds or 2970 kilograms.

HOW TO CUT METRIC LENGTHS

Orders from France and Belgium usually call for lengths of lumber to be cut to the metric foot, which represents the third part of a meter.

The required length is equivalent to 13⅛ inches. The thickness and width usually correspond to English measure.

French orders contain large amounts of 3x9 of number 2 Clear and better grade.

HOW TO FIGURE METRIC ORDERS

To convert Metric to English lengths, multiply by 35 and divide by 32, or to the Metric Feet add one-twelfth and one-eighth of one-twelfth.

How many feet, Board Measure, are contained in the following items of 3x9 cut to Metric Feet?

Process:

Pcs.	Size	Met. Ft.	Extensions	
60	3x9	12	720	
114	3x9	14	1,596	
112	3x9	16	1,792	
40	3x9	18	720	
60	3x9	20	1,200	
386			6,028	Metric Lineal Feet.
			502.33	
			62.79	
			6,593.12	English Lineal Feet.
			2¼	
			13,186.24	
			1,648.28	
			14,834.52	Feet Board Measure.

The addition of the extensions shows the number of Metric Lineal Feet, the line below shows that amount divided by 12, and this in turn is divided by 8.

The total thus obtained shows the English Lineal Feet. This is brought to Board Measure in the usual way by multiplying by 2¼.

FOUR METERS OR THIRTEEN FEET

The favorite length used in France and Continental Europe.

In all parts of France and the Continent of Europe, four meters, which is the equivalent to thirteen feet, is a length that is liked very much, is in great demand and preferred to all others.

When executing orders for Continental Europe, special efforts should be made to produce a large percentage of thirteen feet lengths, as it will be appreciated by the buyer who is often willing to pay an extra price for this accommodation.

THREE BY NINE

The favorite size used in France and Continental Europe.

In France and Continental Europe the equivalent of 3x9 inches in the clear and merchantable grades is the favorite standard.

The size required according to the metric measurement is 75 millimeters in thickness, and 225 millimeters in width, consequently lumber cut 3x9 inches is a shade full both ways, this allows for natural shrinkage, a point appreciated by the export buyer, who invariably prefers lumber cut full in width and thickness.

In Great Britain, Australia, New Zealand, South Africa and other British countries there is a very great demand for 3x9 especially in the merchantable grades.

To facilitate the work of comparing inches to millimeters and millimeters to inches refer to the conversion table on the following page.

TO COMPUTE METRIC DRAFT

French and a number of foreign ships use the metric system, and the draft is painted on the forward and after end of vessel in meters and twentieth parts of a meter, as follows:

The height of figures and distance between figures is uniform, i. e.: each figure is one-tenth of a meter (3.937 inches) in height, and the blank distance between figures is also one-tenth of a meter.

Each advancing meter is indicated by the letter "M" to the right of the numeral.

For example: Presume the draft water line is at the bottom of 60, and the first figure representing the meters above the water line is 4M, the draft would be 3.60 meters or 11.811 feet (11 ft. 9¾ in.). If the water line was level with the top of the figure 60, the draft would then be 3. 70 meters or 12.139 feet (12 ft. 1¾ in.).

4M
80
60
40
20
3M
80
60
40
20
2M

TO CONVERT METRIC TO ENGLISH DRAFT

Rule: To convert the metric draft to English feet, multiply the meters by 3.281.

Example: Find the number of English feet when the draft is 7.20 meters?

Operation: 7.20 times 3.281 equals 23.6232 feet (23 ft. 7½ in.) Multiplying the meters by 105 and dividing by 32 gives the same result.

TO CONVERT ENGLISH TO METRIC DRAFT

Rule: To convert English to Metric draft, multiply the feet by 3.048.

Example: Find the number of Meters, when the English draft in feet is 23 ft. 7½ inches (23.6232 feet).

Operation: 23.6232 times 3.048 equals 7.20035136 Meters.

The same result is obtained by multiplying the English feet by 32 and dividing by 105.

Example: Find the numbers of meters, where the English draft is 21 feet.

Operation: 21 multiplied by 32 equals 672; 672 divided by 105 equals 6.40 meters.

USEFUL TABLES FOR CONVERTING DRAFT EQUIVALENTS OF DECIMAL AND BINARY FRACTIONS OF AN INCH IN MILLIMETERS

Fractions of an Inch		Millimeters	Decimals of an Inch
1/64	equals	0.397	0.015625
1/32	equals	.794	.03125
1/16	equals	1.588	.0625
1/8	equals	3.175	.1250
1/4	equals	6.350	.2500
1/2	equals	12.700	.5
1/100	equals	0.254	

Inches to Millimeters	Millimeters to Inches
1 equals 25.4001	1 equals 0.03937
2 equals 50.8001	2 equals 0.07874
3 equals 76.2002	3 equals 0.11811
4 equals 101.6002	4 equals 0.15748
5 equals 127.0003	5 equals 0.19685
6 equals 152.4003	6 equals 0.23622
7 equals 177.8004	7 equals 0.27559
8 equals 203.2004	8 equals 0.31496
9 equals 228.6005	9 equals 0.35433
10 equals 254.0006	10 equals 0.39370
11 equals 279.4006	11 equals 0.43307
12 equals 304.8006	12 equals 0.47214

U. S. Miles to Kilometers		Kilometers to U. S. Miles		Nautical Miles to Kilometers		Kilometers to Nautical Miles	
1	1.6093	1	0.62137	1	1.8532	1	0.53959
2	3.2187	2	1.24274	2	3.7065	2	1.07919
3	4.8280	3	1.86411	3	5.5597	3	1.61878
4	6.4374	4	2.48548	4	7.4130	4	2.15837
5	8.0467	5	3.10685	5	9.2662	5	2.69796
6	9.6561	6	3.72822	6	11.1195	6	3.23756
7	11.2654	7	4.34959	7	12.9727	7	3.77715
8	12.8748	8	4.97096	8	14.8260	8	4.31674
9	14.4841	9	5.59233	9	16.6792	9	4.85634
10	16.0935	10	6.21370	10	18.5325	10	5.39593

METRIC SYSTEM—Continued

CONVERSION TABLES

CONVERSION OF FEET TO METERS

Feet	Meters	Feet	Meters
1	0.30480	51	15.54483
2	.60960	52	15.84963
3	.91440	53	16.15443
4	1.21920	54	16.45923
5	1.52400	55	16.76403
6	1.82880	56	17.06883
7	2.13360	57	17.37363
8	2.43840	58	17.67844
9	2.74321	59	17.98324
10	3.04801	60	18.28804
11	3.35281	61	18.59284
12	3.65761	62	18.89764
13	3.96241	63	19.20244
14	4.26721	64	19.50724
15	4.57201	65	19.81204
16	4.87681	66	20.11684
17	5.18161	67	20.42164
18	5.48641	68	20.72644
19	5.79121	69	21.03124
20	6.09601	70	21.33604
21	6.40081	71	21.64084
22	6.70561	72	21.94564
23	7.01041	73	22.25044
24	7.31521	74	22.55525
25	7.62002	75	22.86005
26	7.92482	76	23.16485
27	8.22962	77	23.46965
28	8.53442	78	23.77445
29	8.83922	79	24.07925
30	9.14402	80	24.38405
31	9.44882	81	24.68885
32	9.75362	82	24.99365
33	10.05842	83	25.29845
34	10.36322	84	25.60325
35	10.66802	85	25.90805
36	10.97282	86	26.21285
37	11.27762	87	26.51765
38	11.58242	88	26.82245
39	11.88722	89	27.12725
40	12.19202	90	27.43205
41	12.49682	91	27.73686
42	12.80163	92	28.04166
43	13.10643	93	28.34646
44	13.41123	94	28.65126
45	13.71603	95	28.95606
46	14.02083	96	29.26086
47	14.32563	97	29.56566
48	14.63043	98	29.87046
49	14.93523	99	30.17526
50	15.24003	100	30.48006

CONVERSION OF METERS TO FEET

Meters	Feet	Meters	Feet
1	3.28083	51	167.32250
2	6.56167	52	170.60333
3	9.84250	53	173.88417
4	13.12333	54	177.16500
5	16.40417	55	180.44583
6	19.68500	56	183.72667
7	22.96583	57	187.00750
8	26.24667	58	190.28833
9	29.52750	59	193.56917
10	32.80833	60	196.85000
11	36.08917	61	200.13083
12	39.37000	62	203.41167
13	42.65083	63	206.69250
14	45.93167	64	209.97333
15	49.21250	65	213.25417
16	52.49333	66	216.53500
17	55.77417	67	219.81583
18	59.05500	68	223.09667
19	62.33583	69	226.37750
20	65.61667	70	229.65833
21	68.89750	71	232.93917
22	72.17833	72	236.22000
23	75.45917	73	239.50083
24	78.74000	74	242.78167
25	82.02083	75	246.06250
26	85.30167	76	249.34333
27	88.58250	77	252.62417
28	91.86333	78	255.90500
29	95.14417	79	259.18583
30	98.42500	80	262.46667
31	101.70583	81	265.74750
32	104.98667	82	269.02833
33	108.26750	83	272.30917
34	111.54833	84	275.59000
35	114.82917	85	278.87083
36	118.11000	86	282.15167
37	121.39083	87	285.43250
38	124.67167	88	288.71333
39	127.95250	89	291.99417
40	131.23333	90	295.27500
41	134.51417	91	298.55583
42	137.79500	92	301.83667
43	141.07583	93	305.11750
44	144.35667	94	308.39833
45	147.63750	95	311.67917
46	150.91833	96	314.96000
47	154.19917	97	318.24083
48	157.48000	98	321.52167
49	160.76083	99	324.80250
50	164.04167	100	328.08333

NAUTICAL WEIGHTS AND MEASURES

MEASURES OF LENGTH

12 inches equals 1 foot	6 feet equals 1 fathom
3 feet equals 1 yard	3 nautical miles equals 1 league.

Sea or Nautical Mile—one-sixtieth of a degree of latitude, and varies from 6,046 ft. on the Equator to 6,092 ft. in Lat. 60°.

Nautical Mile for Speed Trials, generally called the Admiralty Measured Mile—6,080 feet; 1.151 statute miles; 1.853 kilometers.

Cable's Length—the tenth of a nautical mile, or approximately 100 fathoms or 200 yards.

A Knot—a nautical mile an hour, is a measure of speed, but is not infrequently, though erroneously, used as synonymous with a nautical mile.

Length of European Measures of Distances compared with the Nautical Mile of 6,080 feet:

	Length in Nautical Miles		Length in Nautical Miles
Nautical Mile	1.000	German Ruthen	4.064
British Statute Land Mile	0.868	Italian Mile	1.000
Austrian Mile	4.094	Norwegian Mile	6.097
Danish Mile	4.064	Russian Verst	0.576
French Kilometer	0.539	Swedish Mile	5.769
German Geographical Mile	4.000		

BRITISH SHIPPING WEIGHT

16 ounces	equals 1 pound (lb.)
28 pounds	equals 1 quarter (qr.)
4 quarters or 112 pounds	equals 1 hundredweight (cwt.)
20 hundredweight or 2240 pounds	equals 1 ton (T.)

U. S. AND BRITISH SHIPPING MEASURES

1 Register ton .... equals 100 cubic feet.

1 United States Shipping ton equals 40 cubic feet or 32.14 U. S. bushels or 31.16 Imperial bu.

1 British Shipping ton ...... equals 42 cubic feet or 32.72 Imperial bushels or 33.75 U.S. bu.

IMMERSION IN SALT AND FRESH WATER

To find the difference of immersion or draft in salt and fresh water: If from salt to fresh, multiply the draft of salt water by 36, and divide the product by 35. If from fresh to salt, multiply the draft of fresh water by 35 and divide the product by 36.

Example: Required the draft of a vessel in fresh water when drawing 20 ft. in salt water: 20 ft. times 36 equals 720 divided by 35 equals 20 ft. 7 in.

BARRELS

To find the number of gallons in a cask or barrel.

Rule: Take all the dimensions in inches. Add the head and bung diameters and divide by 2 for the approximate mean diameter. Square the mean diameter and multiply by the depth. Multiply the result by .0034 for gallons.

Example: How many gallons are contained in a cask the bung diameter of which is 24 inches, the head diameter, 22 inches, and the depth 30 inches?

Operation: 22 plus 24 equals 46 divided by 2 equals 23 (mean diameter). Square of 23 equals 529 times 30 (depth) equals 15870. 15870 times .0034 equals 53.9 gallons.

MEASURING TANKS

To find the number of gallons contained in a tank.

Rule: Multiply the cubic capacity in feet by 7.48.

Example: How many gallons in a tank 6x6x4 feet?

Explanation: 6 times 3 time 4 equals 72 cubic feet. 7.48 times 72 equals 538.56 gallons. 538.56 divided by 31½ equals 17.10—. bbl.

CISTERNS

To find the capacity of a cistern.

Rule: Multiply the square of the diameter by the depth; this will give the cylindrical feet; multiply the cylindrical feet by 5⅞ for gallons; .1865 for barrels, or .09325 for hogsheads.

Example: How many gallons in a cistern 42 feet in diameter, 12 feet deep?

Operation: 42 times 42 equals 1764; 1764 times 12 equals 21168; 5⅞ times 21168 equals 124362 gallons—Answer.

How many barrels?—Answer, 394.8.

FRESH WATER EQUIVALENTS

In the following table, one cwt. (hundredweight) equals 112 pounds, and one ton equals 2240 pounds.

One Imperial gallon	equals	277.27	Cubic inches.
One Imperial gallon	equals	0.16	Cubic feet.
One Imperial gallon	equals	10.00	Pounds.
One Imperial gallon	equals	4.54	Liters.
One Imperial gallon	equals	1.20	U. S. gallons.
One U. S. gallon	equals	231.00	Cubic inches.
One U. S. gallon	equals	0.134	Cubic feet.
One U. S. gallon	equals	8.33	Pounds.
One U. S. gallon	equals	0.83	Imperial gallons.
One U. S. gallon	equals	3.80	Liters.
One pound of water	equals	27.74	Cubic inches.
One pound of water	equals	0.083	U. S. gallons.
One pound of water	equals	0.10	Imperial gallons.
One cwt. of water	equals	11.2	Imperial gallons.
One cwt. of water	equals	13.44	U. S. gallons.
One cwt. of water	equals	1.79	Cubic feet.
One ton of water	equals	35.88	Cubic feet.
One ton of water	equals	223.60	Imperial gallons.
One ton of water	equals	268.80	U. S. gallons.
One ton of water	equals	1000.00	Liters (approx.)
One ton of water	equals	1.00	Cubic meter (approx.)
One cubic inch of water	equals	0.036	Pounds.
One cubic inch of water	equals	0.0036	Imperial gallons.
One cubic inch of water	equals	0.0043	U. S. gallons.
One cubic foot of water	equals	0.027	Ton.
One cubic foot of water	equals	0.55	Cwt.
One cubic foot of water	equals	64.42	Pounds.
One cubic foot of water	equals	6.23	Imperial gallons.
One cubic foot of water	equals	7.48	U. S. gallons.
One cubic foot of water	equals	28.31	Liters.
One cubic foot of water	equals	0.028	Cubic meters.
One liter of water	equals	0.22	Imperial gallons.
One liter of water	equals	0.264	U. S. gallons.
One liter of water	equals	61.00	Cubic inches.
One liter of water	equals	0.0354	Cubic feet.
One cubic meter of water	equals	220.00	Imperial gallons.
One cubic meter of water	equals	264.00	U. S. gallons.
One cubic meter of water	equals	1.308	Cubic yards.
One cubic meter of water	equals	35.31	Cubic feet.
One cubic meter of water	equals	61024.00	Cubic inches.
One cubic meter of water	equals	1000.00	Kilos.
One cubic meter of water	equals	1.00	Ton (approx.)
One cubic meter of water	equals	1000.00	Liters.
One Pood	equals	3.60	Imperial gallons.
One Eimer	equals	2.70	Imperial gallons
One Vedros	equals	2.70	Imperial gallons.
One Miners inch of water	equals	10.00	Imperial gallons (approx.)
One column of water 1 foot high	equals	0.434	Lb. pressure per sq. in.
One column of water 1 meter high	equals	1.43	Lb. pressure per sq. in.
A pressure of 1 lb. per square inch	equals	2.31	Feet of water in height.

NOTE—The center of pressure of water against the side of the containing vessel or reservoir is at two-thirds the depth from the surface.

SALT WATER EQUIVALENTS

At 62° Fahrenheit

One Imperial gallon	equals	10.27	Pounds.
One U. S. gallon	equals	8.558	Pounds.
One cubic foot	equals	64.11	Pounds.
One ton (2240 pounds)	equals	35.00	Cubic feet.
One ton (2240 pounds)	equals	218.11	Imperial gallons.
One ton (2240 pounds)	equals	240.00	U. S. gallons.
One ton (2000 pounds)	equals	31.20	Cubic feet.
One ton (2000 pounds)	equals	194.74	Imperial gallons.
One ton (2000 pounds)	equals	233.70	U. S. gallons.

TONNAGE EXPLAINED

There are five kinds of tonnage in use in the shipping business. They are deadweight tonnage, cargo tonnage, gross, net, and displacement tonnages.

1. **Deadweight Tonnage** expresses the number of tons of 2,240 pounds that a vessel can transport of cargo, stores, and bunker fuel. It is the difference between the number of tons of water a vessel displaces "light" and the number of tons it displaces when submerged to the "load water line." Deadweight tonnage is used interchangeably with deadweight carrying capacity. A vessel's capacity for weight cargo is less than its total deadweight tonnage.

2. **Cargo Tonnage** is either "weight" or "measurement." The weight ton in the United States and in British countries is the English long or gross ton of 2,240 pounds. In France and other countries having the metric system a weight ton is 2,204.6 pounds. A "measurement" ton is usually 40 cubic feet, but in some instances a larger number of cubic feet is taken for a ton. Most ocean package freight is taken at weight or measurement (W/M), ship's option.

3. **Gross Tonnage** applies to vessels, not to cargo. It is determined by dividing by 100 the contents, in cubic feet, of the vessel's closed-in spaces. A vessel ton is 100 cubic feet. The register of a vessel states both gross and net tonnage.

4. **Net Tonnage** is a vessel's gross tonnage minus deductions of space occupied by accommodations for crew, by machinery for navigation, by the engine room and fuel. A vessel's net tonnage expresses the space available for the accommodation of passengers and the stowage of cargo. A ton of cargo, in most instances, occupies less than 100 cubic feet; hence the vessel's cargo tonnage may exceed its net tonnage, and, indeed, the tonnage of cargo carried is usually greater than the gross tonnage.

5. **Displacement** of a vessel is the weight, in tons of 2,240 pounds, of the vessel and its contents. Displacement "light" is the weight of the vessel without stores, bunker fuel, or cargo. Displacement "loaded" is the weight of the vessel, plus cargo, fuel, and stores.

For a modern freight steamer the following relative tonnage figures would ordinarily be approximately correct:

Net tonnage	**4,000**
Gross tonnage	**6,000**
Deadweight carrying capacity	**10,000**
Displacement loaded, about	**13,350**

A vessel's registered tonnage, whether gross or net, is practically the same under the American rules and the British rules. When measured according to the Panama or Suez tonnage rules most vessels have larger gross and net tonnages than when measured by British or American national rules.

STOWING TO SECURE MAXIMUM WEIGHT AND VOLUME

GENERAL CARGO

A ship properly stowed is filled completely and carries weight enough to lower it to its marks. If it is not completely filled, the cargo will not carry well, but will shift with the tossing by the waves and thereby perhaps damage the goods or endanger the vessel. If it is not completely weighted, it will not sail efficiently or perhaps even safely. And if neither the maximum volume or weight is carried the vessel will not earn maximum revenue for the voyage. This principle is of greater relative significance to the sailing vessel than to the modern steamer.

The average steamer is more stable than the sailing vessel, and it has the power of adjusting its stability by use of its water ballast tanks. Moreover, because of its greater speed, its earning capacity depends less than the sailing vessel on the freight carried on one voyage, and more on the "turn around," or the number of trips it can make in a year.

SELECTION OF A BALANCED CARGO

The question presented to the shipowner or master, then, is that of securing freight that will provide the ideal combination of volume and weight. Knowing the cubical contents of the cargo space and the deadweight tonnage, it is easy to figure for the individual ship the kind of freight that will fill the vessel and lower it to its marks. Take, for example, a vessel that has a cargo space, including spare bunkers, of 250,000 cubic feet and a deadweight of 5,000 tons. Since the deadweight capacity is the difference between the displacements of the vessel when light and when fully loaded, including fuel and stores, it is necessary to subtract from the 5,000 tons the weight of the fuel, stores, etc., in order to find the weight of the cargo. Assuming that the fuel, stores, etc., weigh 500 tons, 4,500 tons will represent the weight of cargo that can be carried, and dividing this into the cargo space gives 55½ cubic feet as the available space for each ton of cargo.

The shipowner then would endeavor to secure freight that had an average stowage factor of 55½.

It is a difficult matter to set up a figure that is an average for all vessels. Inquiry among shipping men leads to the conclusion that the ideal combination is obtained for the ordinary cargo steamer by articles having an average stowage of 52 to 55, and for the ordinary sailing vessel by articles having an average stowage of from 65 to 70.

CALCULATION OF WEIGHT AND VOLUME

A satisfactory combination of freight can be obtained by grouping commodities whose stowage factors will average the proper amount.

Thus, steel bars, whose stowage factor is about 11, may be shipped with cork, whose stowage factor is about 300. Any commodity that has a stowage factor of over 40 cubic feet per ton is called "measurement freight," and a commodity having a stowage factor of less than 40 cubic feet per ton is called "deadweight cargo." A simple calculation will show how much measurement and how much deadweight can be carried on a given vessel. Assume that the vessel is of 6,500 deadweight tons and has a cargo space of 360,000 cubic feet. After deducting 500 tons for fuel and stores, it is found that the number of cubic feet per deadweight ton is $\frac{360,000}{6,000}$, or 60. Assume that the measurement freight has a stowage factor of 80 and the deadweight a stowage factor of 20. Deduct from the average space per deadweight ton (60) the stowage factor of the deadweight cargo (20), and multiply the remainder (40) by the cargo tonnage of the vessel. This gives 40 times 6,000, or 240,000. Divide by the difference between the stowage factors of the two commodities, which is 60. The result (4,000) is the number of tons of measurement freight that should be carried, and the difference between this figure and the total cargo that can be carried, or 2,000, is the number of tons of deadweight cargo. Working backwards it will be seen that the vessel under this arrangement carries the maximum weight and volume, for the weight of the two commodities is 6,000 tons and the volume is 4,000 times 80 plus 2,000 times 20, or 360,000 cubic feet.

The formula which may be used for the above computation is as follows:

$$X \text{ equals } \frac{\left(\frac{V}{T} - a\right) T}{b - a}$$

In which—

X equals number of tons taken of the lighter of two commodities.

V equals cargo capacity in cubic feet.

T equals total number of tons of cargo that can be carried (deadweight tonnage less tonnage of fuel, stores, etc.).

a equals stowage factor of the heavier commodity.

b equals stowage factor of the lighter commodity.

In the illustration just given, substitution would be made as follows:

$$X \text{ equals } \frac{\left(\frac{360,000}{6,000} - 20\right) 6,000}{80-20} \text{ equals } \frac{(60-20)\ 6,000}{60} \text{ equals } 4,000 \text{ tons of measurement cargo.}$$

DOUGLAS FIR CARGO SHIPMENTS

POINTERS FOR SHIPOWNERS ON LUMBER CARRYING CAPACITY OF STEAMERS

When figuring on the lumber carrying capacity of steamers, allowance must be made for bunker coal, stores, provisions, boiler and feed water, water ballast, type of vessel, and height of deckload she will safely carry, also proportion of sizes and lengths in the lumber specifications suitable for stowage on deck and in the various compartments under deck, the number of timbers to be carried, and whether short lumber, pickets and or lath will be supplied for broken stowage.

In a large number of instances specifications contain every requisite for making good stowage, but it is of no avail if the lengths and sizes are not piled on the dock prior to shipment so as to be available at the right time and place to fill the various compartments.

If the lumber for shipment is not placed on the dock right, poor stowage and a great decrease in the amount of cargo the vessel should carry will be the result and the time of loading will often be increased several days.

Poor stowage under deck results in vessel becoming top heavy, and consequently the usual height of deckload cannot be carried, as extra ballast tanks have to be filled to stiffen vessel and keep her upright.

This seriously affects the cargo carrying capacity of a vessel; for instance, filling a ballast tank of 300 tons would decrease the amount of cargo carried by 200,000 board feet of lumber.

When a steamer lists before she has a reasonable deckload, the cause should be investigated. There are instances where the fuel for main or donkey boilers is taken from one side of the upper portion of bunkers, emptying or filling a boiler, feeding water in boilers from one side of an engine tank with a central division, filling or emptying ballast tanks, or slack water in ballast tanks; the latter being the principal cause.

TO COMPUTE LUMBER CARRYING CAPACITY UNDER DECK

To compute lumber carrying capacity of a steamer, ascertain from the builder's plan the cubical capacity (bale space) of the various compartments, add together and multiply the total by $8\frac{1}{3}$; the result will be the capacity in board feet.

Example: How much lumber in board feet will a steamer carry under deck with a total cargo carrying capacity of 300,000 cubic feet (bale space)?

Operation: 300,000 x $8\frac{1}{3}$ equals 2,500,000, the amount in board feet.

Note: To multiply by $8\frac{1}{3}$ add two ciphers and divide by 12.

TO COMPUTE LUMBER CARRYING CAPACITY OF A STEAMER

To ascertain the deadweight lumber carrying capacity of a steamer, the following particulars should be obtained:

Distance between sailing and discharging port.
Speed of vessel, and daily coal consumption.
Weight of ship's stores and provisions.
Estimate of water ballast required.
Bunker coal necessary for voyage.

The first thing to do is to find out from the builder's plan, owners or officers of vessel, the speed in knots per hour and daily coal consumption; then compute the bunker coal required for the voyage as follows:

Example: How much bunker coal will a steamer consume on a voyage from Seattle, Wash., U. S. A., to Sydney, N. S. W., Australia, the distance being 6829 nautical miles, speed 8 knots (nautical miles) per hour, and the daily consumption 29 tons of coal?

Multiply the knots (8) by 24; this gives the distance traveled per day. Then divide the result (192) into the distance between loading and discharging port. In this case it is 6829 nautical miles; the answer will be the number of days occupied on voyage. Now multiply the number of days by the coal consumption (29) and you will have the bunker coal required for the voyage.

Operation: 8x24 equals 192, the daily speed. 6829 divided by 192 equals 35.57, the number of days on voyage. 35.57x29 equals 1031.53, the amount of bunker coal in tons required for the voyage.

Note: It is customary to allow a few days reserve coal so that if steamer meets with an accident or bad weather the extra coal should enable her to reach port in safety. In this case an allowance of three days reserve coal should suffice.

METHOD OF ESTIMATING DEADWEIGHT TOTALS BEFORE OR AFTER LOADING

Capacity of vessel 7200 tons deadweight.	Tons
Bunker coal	1031
Bunker coal, reserve	87
Water ballast	400
Engine tank, fresh water	182
Stores and provisions	75
Fresh drinking water	25
	1800
3,600,000 ft. @ 1½ tons per 1000 ft.	5400
	7200

The ordinary tramp steamer with coal for bunker fuel will not stand up with a high deckload without water ballast, therefore in the foregoing estimate a fair allowance has been made.

TO COMPUTE LUMBER CARRYING CAPACITY OF A STEAMER ON DECK

This is practically impossible, as so much depends on the stowage of cargo under deck, and also the height at which the bunker coal is stowed, whether it is winter or summer loading, the type and beam of vessel and amount of water ballast required.

When estimating on the amount of deckload always take the possible height into consideration, and remember that a steamer cannot carry more than her deadweight according to displacement scale.

The trick in loading steamers with lumber is to load them with the minimum of water ballast, and that can only be done by having an expert supervise the assembling or piling of the cargo beforehand, and taking advantage of every point during loading. This will greatly assist the stevedore, the mill company and ship's officers, and be of immense benefit to all concerned.

POINTERS ON STABILITY AND FILLING BALLAST TANKS

Steamers engaged in the lumber trade should have a wide beam in proportion to their draft, this gives a fairly high position of the metacenter and enough margin of stability to enable a coal burning steamer to carry sufficient deckload to put her down to her marks with one or two of the double bottom ballast tanks filled with water ballast.

It is only under exceptionally favorable conditions, and in very rare instances, that a coal burning vessel, carrying a cargo of Douglas Fir can be safely loaded to her marks without filling one or more of her double bottom tanks.

The ordinary run of cargo steamers engaged in transporting Douglas Fir from the Pacific Coast to Foreign Ports will carry a total cargo of about 3,500,000 to 5,000,000 board feet. The ordinary summer deckloads range from 700,000 to 1,000,000 board feet, with an average height of from 10 to 16 feet. There are numerous instances of steamers having been loaded with a full cargo of lumber on the Pacific Coast with a sixteen foot deckload, upright when finished, and only slightly tender.

It is not policy to load a steamer with a very high deckload, unless she has reserve (empty) double bottom tanks, which can be filled if necessary, in case the coal consumed during the voyage should cause the steamer to become unduly tender. As it is expedient to first fill the large double bottom tanks in the body of the vessel before the under deck cargo is completed, it only leaves the smaller capacity tanks empty, thus minimizing the danger of filling tanks at sea should the emergency arise.

In filling double bottom tanks with a central division, it is a good idea to run up both sides at once, even in cases where the vessel has a decided list. As an example, assume a steamer has a list to port, it is not always advisable to try and take the list out by filling the starboard side of one or more tanks, for as soon as the added weight is sufficient to bring the vessel to an upright position she will then fall over to the opposite side, owing to the sudden shifting of the center of gravity, this usually causes a series of oscillations from side to side, often with such rapidity and violence of motion that the cargo will shift and the structure of the vessel become seriously strained.

Avoid filling the tanks of a tender steamer at a time when cargo is being worked, for should the vessel take a sudden list the lives of the crew and longshoremen would be endangered through tiers falling down or loads of lumber that are being hoisted aboard, getting out of control of the winch drivers and swinging from side to side of the vessel.

If it becomes necessary to fill the tanks of a steamer that has a deckload of about six feet or more in height, it is advisable as a precautionary measure to temporarily secure the deckload with a few lashings, as this may prevent cargo shifting or part of the deckload going over the side in case of the vessel taking a sudden list.

STOWAGE OF CROSSINGS

Orders of Douglas Fir railroad ties (sleepers) from Great Britain, usually contain about ten per cent crossings (switch ties), but they are not always shipped according to the foregoing percentage, some cargoes contain all ties, and some contain about thirty per cent crossings. In instances where a large percentage of crossings are shipped there will be a loss of ten to fifteen per cent in stowage under deck compared to ties, if they are not delivered to the vessel so that they can be stowed on the floor of the forward holds, preferably the number "2" and in the after holds above the level of the shaft alley (tunnel) and the floor of the 'tween decks. Ties should be reserved for small compartments, winging up and beamfilling.

A number of firms charter vessels and expect good stowage results when they do not give to the mill or mills supplying the cargo, any intelligent instructions regarding the segregation of orders, sizes, or lengths or the manner in which the lumber is to be piled or delivered to the vessel.

It is customary to blame the stevedore for poor stowage under deck when the fault in most instances lies in the shipper not delivering the cargo alongside at the right time and place to enable the stevedore to make decent stowage.

Western saw mills catering to the export trade are noted for their ability and willingness to do everything in their power to deliver orders for cargo shipment so as to facilitate the loading and despatch of vessels at their docks, but it frequently happens that their good work and intentions are nullified through their not receiving correct piling instructions or orders of loading, with the result that the vessel does not carry a capacity load and often leaves either on the lighters or dock of mills supplying the cargo amounts varying from one hundred thousand to half a million board feet of lumber that the vessel could easily have carried, had the cago been correctly piled and delivered.

HOW TO DUNNAGE AN IRON DECK

Before cargo is placed on an iron deck, the deck should be dunnaged with rough boards, one inch in thickness, placed diagonally on the deck, and spaced about three feet between pieces; lumber 6 to 12 inches wide is preferable to narrower widths, as the heavy weight of the deckload will press and cut into the first coarse of lumber laid on top of the dunnage, if narrow widths are used.

The reason for using rough sawn dunnage is that there is a possibility of the deckload shifting on the smooth surface of dressed lumber when the steamer rolls from side to side in heavy weather. Placing dunnage diagonally on deck is to equalize the pressure on the deck beams.

Decks are dunnaged to prevent the deck cargo from being stained by oil running from the winches and to guard against the cargo turning black from coming into contact with iron or steel.

The space between the dunnage boards gives enough clearance to allow the drainage water to run off the deck.

STANCHIONS FOR DECKLOAD

The ordinary size used for deck stanchions on steamers is 6x12 inches or its equivalent, they should be spaced 8 to 10 feet apart, and placed so as to have a slight incline inwards, and in such a position that they do not obscure the vessels side lights. Stanchions should exceed the height of the deckload by at least four feet, for instance, if it is expected that the vessel will carry a fourteen foot deckload, use stanchions 18 feet long, this allows sufficient height above the deckload to attach the regulation guard ropes.

Stanchions used for security of the deckload, and taken out of sizes that are tallied as cargo should not be charged to the ship. When stanchions of suitable size, length, and grade cannot be obtained from cargo; it is customary to order them from the mill company, and in this case they are charged to the ship's account.

DECKLOAD LASHING

The custom of a number of ship owners that cling to the old fashioned idea of using the ships running gear for lashing purposes is a costly one, as it not only destroys the wire cable for further use as ships gear, but it often delays the sailing of the vessel for several hours, owing to the length of time it takes to secure the deckload when wire cable is used for lashing purposes.

It takes the ordinary ships crew five to ten hours to lash a deckload with wire cable, when the same crew could do the work of lashing in less than an hour's time if chain lashing and deckload turnbuckles were substituted.

CHAINS AND TURNBUCKLES REQUIRED TO LASH DECKLOAD

The average length of an ordinary well deck steamer is as follows: Fore deck 100 feet, after deck 100 feet.

Chain lashings on deckloads should be spaced 10 feet apart, one end of chain should be secured to a ring bolt on deck and the other end run through the link on turnbuckle.

The following comprises a set of turnbuckles and chains necessary to secure a 16 foot deckload on a steamer with a forward and after deck, each 100 feet long.

16 Deckload Turnbuckles,
32 ⅝ Galvanized Chains, each 45 feet long with ring in one end.

DECKLOAD OF RAILROAD TIES

When shipping a straight deckload of railroad ties or short lumber of a uniform length, it is advisable to wall the outside or wing tiers of the deckload with long lengths if obtainable.

Sometimes the operators buy desirable lengths for this purpose and take the chance of selling them on arrival at destination.

A better proposition is, if possible, to arrange with the shippers to supply lengths in multiples of the size being shipped.

If this can be satisfactorily arranged, the captain or agents should give a written guarantee that the said long lengths will be sawn at ship's expense on arrival of vessel at port of discharge, into the shorter lengths called for in the specification.

ADVANTAGES OF OIL AS FUEL FOR STEAMERS CARRYING LUMBER

As the ordinary cargo steamer burning coal as fuel has not the stability to load to her summer marks with a cargo of Douglas Fir, it is necessary to fill one or more of the double bottom ballast tanks to enable her to carry a full deckload.

A fair average estimate of the amount of water ballast necessary to give the required stability would be six hundred long tons, this weight is equivalent to 400,000 board feet of Douglas Fir, which the vessel could carry under deck in the bunker or bridge space, if oil was used for fuel purposes instead of coal.

Allowing for broken stowage, the space required to stow 400,000 board feet of Douglas Fir would amount to 48,000 cubic feet. In this space 1143 tons of coal at 42 cubic feet per ton could be stowed, which is the usual amount of bunker coal required for a voyage from the North Pacific Coast to Australia.

DECKLOADS

ADVANTAGES OF OIL OVER COAL BURNING STEAMERS

The difference between the winter and summer draft of cargo steamers, is about six inches, and when computed at 45 tons per inch, gives 270 tons. This reduces the carrying capacity in winter by 180,000 board feet of Douglas Fir, and means that an oil burning vessel would save to the owners or time charterers the freight on the above, as the amount of cargo mentioned would be carried in the space utilized for bunker coal.

A most important point that must not be lost sight of and which greatly detracts from the winter carrying capacity is the British Government regulations on deckloads entering the United Kingdom during the winter months, which restricts the height of deckload to the rail, and the size of the largest piece to 15 cubic feet, the equivalent of 180 board feet.

The ordinary well deck cargo steamer would carry a deckload of 250,000 to 350,000 board feet of Douglas Fir if stowed to the top of the rail, or about 42 inches in height.

After considering the foregoing it is very apparent that the oil burning steamer has a decided advantage when carrying a cargo of lumber, over one burning coal and to better elucidate the subject, the following details of a modern steamer loaded with a fair average cargo of ties are given as an illustration.

Canadian Steamer Margaret Coughlan cleared from Genoa Bay, British Columbia, October 28, 1920, bound for England with a cargo of 5x10—8′ 6″ Douglas Fir Railroad Ties (Sleepers).

UNDER DECK

Under Deck Compartments	Capacity in Cubic Feet Bale Space	Amount of Cargo in Board Feet
No. 1 Tween Deck	26,520	274,796
No. 1 Hold	63,370	607,998
No. 2 Tween Deck	45,200	495,833
No. 2 Hold	71,409	719,313
No. 3 Tween Deck "Aft"	59,260	619,792
No. 3 Hold "Aft"	104,524	992,552
Forecastle	7,656	58,862
Bridge Space	39,500	395,923
Tween Deck Bunkers	14,995	99,946
Deep Tank	18,700	162,917
Hatches	5,000	54,932
Total Under Deck	456,134	4,482,864

ON DECK

Winter loading for the United Kingdom with deckload stowed to height of rail 277,915 Board Feet.

TOTALS

4,482,864 Board Feet Under Deck
277,915 Board Feet On Deck

4,760,779 Board Feet Total Cargo.

HOW THE S. S. "MARGARET COUGHLAN" STOWED UNDER DECK

The total cubic bale space multiplied by 9.83 equalled the amount of cargo loaded under deck.

One thousand board feet stowed in 101¾ cubic feet bale space.

The total cargo stowed under deck equalled 81.9 per cent of the total cubic bale space.

In computing capacity according to percentage of bale space, do not forget to multiply the cubic feet by 12 to bring same to board feet.

DEADWEIGHT COMPARISON

WINTER LOADING FOR UNITED KINGDOM

AS AN OIL BURNER

The Steamer "Margaret Coughlan" is used for an example showing amount of cargo actually carried and total deadweight when loaded to the rail.

Under Deck	4,482,864 Board Feet	equals 6,724 Long Tons
On Deck	277,915 Board Feet	equals 417 Long Tons
Total Cargo	4,760,779 Board Feet	equals 7,141 Long Tons
Fresh Water in After Peak for Boiler Feed		equals 83 Long Tons
Fresh Water for Galley Purposes		equals 30 Long Tons
Ship's Stores		equals 75 Long Tons
Fuel Oil		equals 722 Long Tons
Deadweight when loaded, Draft 23 ft. 1 in.		**8,051 Long Tons**
Deadweight at winter marks, Draft 23 ft. 9 in.		**8,454 Long Tons**

AS A COAL BURNER

Estimated amount of cargo and total deadweight when loaded to the rail.

Under Deck	4,035,737 Board Feet	equals 6,054 Long Tons
On Deck	277,915 Board Feet	equals 417 Long Tons
Total Cargo	4,313,652 Board Feet	equals 6,471 Long Tons
Fresh Water after Peak for Boiler Feed		equals 83 Long Tons
Fresh Water for Galley Purposes		equals 30 Long Tons
Ships Stores		equals 75 Long Tons
Bunker Coal		equals 1,083 Long Tons
Estimated Total Deadweight		**7,742** Long Tons

By referring to the deadweight of fuel oil in the example, "As an oil burner" you will note that the amount is 722 tons, and that the deadweight of the bunker coal in the example, "As a coal burner" is 1083 tons, the reason for this is, that one ton of fuel oil gives the same result as 1.5 to 1.6 tons of coal, according to quality.

In this case the fuel oil is computed at 1.5, which equals 1083 tons.

Bunker coal is usually estimated at 42 cubic feet per ton, hence 1083 (the tons of coal) multiplied by 42 equals 45,486 cubic feet. Now to find the board feet amount of railroad ties that can be stowed in the space mentioned, we multiply the cubic feet by 9.83, the unit which multiplied by the cubic bale space, equalled the amount of cargo loaded under deck on the S. S. "Margaret Coughlan."

Therefore, 45,486x9.83 equals 447,127 board feet of rail road ties, which is the amount that a steamer of the S. S. "Margaret Coughlan" type would carry under deck as an oil burner in excess of the amount she would carry as a coal burner.

DEADWEIGHT COMPARISON

SUMMER LOADING

THE STEAMER "MARGARET COUGHLAN" IS USED FOR AN EXAMPLE

Estimated amount in board feet of a cargo of railroad ties (sleepers) and total deadweight when loaded to summer marks.

AS AN OIL BURNER

Under Deck	4,482,864 Board Feet	equals 6,724 Long Tons
On Deck	742,000 Board Feet	equals 1,113 Long Tons
Total Cargo	5,224,864 Board Feet	equals 7,837 Long Tons
Fresh Water After Peak for Boiler Feed		equals 83 Long Tons
Fresh Water for Galley Purposes		equals 30 Long Tons
Ship's Stores		equals 75 Long Tons
Fuel Oil		equals 551 Long Tons
Fuel Oil in Reserve		equals 124 Long Tons
No Ballast Necessary		0 Long Tons
Deadweight at Summer Load Line		**8,700** Long Tons

REMARKS ON DECKLOAD

With the deckload of 742,000 board feet of ties, which would average about nine feet in height, and deadweight distributed as shown in the foregoing example, the steamer would probably be tender, but not cranky when loaded. No anxiety need be felt on this account, as the reserve (empty) double bottom tanks, can be filled to replace the fuel oil when consumed, or at any time when the master thinks it necessary for the safety of the vessel, to fill a tank to aid stability or adjust the trim.

DEADWEIGHT COMPARISON—Continued

AS A COAL BURNER

Under Deck	4,065,050 Board Feet	equals	6,098 Long Tons
On Deck	535,000 Board Feet	equals	802 Long Tons
Total Cargo	4,600,050 Board Feet	equals	6,900 Long Tons
Fresh Water in After Peak for Boiler Feed		equals	83 Long Tons
Fresh Water for Galley Purposes		equals	30 Long Tons
Ship's Stores		equals	75 Long Tons
Bunker Coal		equals	826 Long Tons
Bunker Coal in Reserve		equals	186 Long Tons
Water Ballast in Double Bottom		equals	600 Long Tons
Deadweight at Summer Load Line			8,700 Long Tons

General Remarks

The foregoing estimates of a cargo of railroad ties (sleepers) for summer loading, are based on a voyage from Vancouver, British Columbia, to Liverpool, England, the distance being 8,705 nautical miles. The average speed of the steamer given in the examples is 10 knots an hour, on a consumption of 29 tons of fuel oil per day.

It is not necessary to carry sufficient fuel oil for the entire distance, but only for what is termed "the longest leg of the voyage" which in this case is from the Panama canal Zone to Liverpool, a distance of 4591 nautical miles. A steamer averaging ten knots an hour would cover the latter distance in nineteen days and use 551 tons of fuel oil on a consumption of 29 tons per day.

Owing to the possibility of encountering exceptionally bad weather during the voyage or meeting with engine or other trouble that would prevent the steamer making schedule time it is customary to carry a few days extra supply of fuel as a precautionary measure. This is the reason for showing in the deadweight estimates "Fuel oil in reserve." As in the other examples the coal required for voyage is computed by multiplying the fuel oil by 1.5, as a ton of oil gives the same results as 1½ tons of coal.

DIFFERENCE IN CARRYING CAPACITY BETWEEN OIL AND COAL BURNERS

S. S. "Margaret Coughlan"

CARRYING CAPACITY OF RAILROAD TIES

UNDER DECK

4,482,864 Board Feet as an Oil Burner
4,035,737 Board Feet as a Coal Burner.

447,127 Board Feet Difference.

An increase of 11.07 per cent more cargo Under Deck when fuel oil is used instead of coal.

UNDER AND ON DECK COMBINED AND LOADED TO SUMMER MARKS

5,224,864 Board Feet as an Oil Burner.
4,600,050 Board Feet as a Coal Burner.

624,814 Board Feet Difference.

An increase of 11.4 per cent more cargo when fuel oil is used instead of coal.

PRINCIPAL REASON FOR STEAMERS NOT CARRYING CAPACITY CARGOES

During all stages of loading a deckload keep it level, even if the steamer lists. A slight list can be controlled at sea by taking the fuel oil or coal from the tank or bunker on the heavy side of vessel, hence the reason for keeping the deckload level, as the fuel consumed during the voyage can be moved at will, but it would be no picnic moving a deckload.

At the first sign of a list, the owners or charterers representative should bring the matter to the attention of the Captain or Chief Officer, so that he can investigate the cause and take measures to counteract the list.

Should the list continue to increase without a satisfactory reason, the trouble can be put down to slack oil or water in the tanks. It is now time to take action and have an investigation which may necessitate the services of a marine surveyor, and if it is found that the tanks have been "monkeyed with" with the deliberate intention of listing the vessel, so as to prevent a capacity cargo being carried, those directly responsible for "monkeying" with the tanks, should be severely dealt with in justice to the officers who act "on the square" and use their best efforts to carry a good cargo and otherwise work for the interests of their owners and charterers.

Firms catering to the export lumber business, and especially time charters, keep a close record on the actual carrying capacity and steaming performances of vessels engaged in the lumber trade, and when competition is keen, or it is a matter of preference, it is only the steamers with a good cargo reputation, and manned with competent and reliable officers that are chartered.

PETROLEUM OIL

Crude petroleum as it comes from the well varies in physical and chemical properties according to districts and countries, and at the various depths in the same locality. It is invariably lighter than water.

Heavy Oils. As fuel oils expand when heated, about 1% for every 25 degrees of temperature, corrections being made to 60° F. If temperature is above 60°, subtract, and if below, add.

The Density of an oil is specified in degrees Beaume at a temperature of 60° F. For indicating the density, an instrument called a hydrometer (having an arbitrary scale, the readings of which are in degrees) is allowed to float freely in the oil.

The Beaume gravity value is then read at the point where the surface of the oil intersects the scale.

Specific Gravity is the ratio of the weight of a solid or liquid to an equal volume of water at 60° F.

To calculate the specific gravity of an oil at any temperature, having given its specific gravity at 60° F., take the number of degrees above or below 60° and multiply them by a constant, which for heavy oils of 20° Beaume and below, is .00034,—for those of 30° Beaume, .0004,—of 30° to 40° Beaume .00045, and for refined oil .00050. The product is to be added to or subtracted from the original specific gravity according as the temperature is below or above 60° F.

For reducing Beaume readings at 60° F. to specific gravity, use the formula:

$$\text{Specific Gravity } \frac{140}{130 \text{ plus degrees Beaume}}$$

Example: As an oil at a temperature of 60° F. has a reading of 22 on the Beaume scale. Find its specific gravity.

$$\text{Specific Gravity } \frac{140}{130 \text{ plus } 22} \text{ equals } .922$$

Color does not indicate the quality of an oil, neither does it show if it is suitable for any particular service.

Chill or Cold Test is the lowest temperature at which an oil will pour. It gives no idea of the lubricating properties of an oil.

Flash Point of an oil is the lowest temperature at which the vapors arising therefrom ignite, without setting fire to the oil itself, when a small test flame is quickly brought near its surface and quickly removed.

Fire Point is the lowest temperature at which an oil ignites from its own vapors when a small flame is quickly brought near its surface and quickly removed. The fire point is about 50° above the flash point.

The Vicosity of an oil is told by the number of seconds required for a certain quantity to flow through a standard aperture at constant temperatures, generally at 70°, 100° and 212° F. Gasoline is an example of a non-viscous oil.

Oil for Boilers. Oil between 15° and 30° Beaume is, as a rule, suitable for boilers. It should not be too heavy to be easily vaporized by a jet of steam or to cause trouble in cold weather, and not so light and volatile as to be flashy.

Heat Values of Oil. 14 to 15 pounds of water are evaporated into steam from and at 212° F. per pound of oil. Assuming 15 lbs. then one horse power will be developed with 2.3 pounds of oil.

Oil and Coal Comparison. Assume the average evaporation from and at 212° F. per pound of coal to be 7 pounds, and for oil 15, then the ratio of evaporation is 7 to 15 and the pounds of oil equivalent to 2000 pounds of coal will be 7:15 equals x:2000 or x equals 933 lbs., which divided by 335 (assume the oil in a barrel weighs 335 lbs.) equals 2.8 barrels of oil as being equivalent to one ton (2000 lbs.) of coal, or 3.12 barrels to one ton of 2240 pounds.

British Thermal Unit. From one pound of crude oil there can be obtained from 1.6 to 1.7 times as many British thermal units as from a pound of coal. In other words, one pound of oil is equivalent to 1.6 pounds of coal. If 37 to 38 cubic feet of oil weigh a ton (2240 lbs.), assuming that 42 cubic feet of coal weighs the same amount, there is thus saved in stowage space with oil, 10 to 15%.

Air required for the complete combustion of fuel oil is about 200 cubic feet per pound.

EQUIVALENTS FOR FUEL OIL

GRAVITY

Specific .9560		Beaume 16.5	
1 Ton (2240 pounds)	equals	6.69	American Barrels
1 Ton (2240 pounds)	equals	281.26	American Gallons
1 Ton (2240 pounds)	equals	234.31	English Gallons
1 Ton (2240 pounds)	equals	37.59	Cubic Feet
1 Barrel (American)	equals	5.62	Cubic Feet
1 Barrel (American)	equals	42.00	Gallons
1 Gallon (American)	equals	7.964	Pounds
1 Gallon (English)	equals	9.650	Pounds
1 Gallon (American)	equals	231.000	Cubic Inches
1 Gallon (English)	equals	277.274	Cubic Inches
1 Cubic Foot Oil	equals	59.75	Pounds
1 Barrel (American)	equals	335.00	Pounds.

Oil and water capacity of ballast tanks.

To determine capacities in barrels of oil, multiply tons of salt water by 6.23.
To determine capacities for fresh water multiply capacities for salt water by .975.
Salt water contains 35 cubic feet per ton (2240 pounds).
Fresh water contains 35.9 cubic feet per ton (2240 pounds).
To determine weight in lbs. of a cubic foot of oil, divide specific gravity by 16.
To determine weight in lbs. of one gallon (English) of oil multiply specific gravity by 10.
To determine weight in lbs. of one gallon (American) of oil multiply specific gravity by 8.328.
To convert Imperial gallons into U. S. gallons multiply by 1.2.
To convert U. S. gallons into Imperial gallons divide by 1.2.

TABLE OF EQUIVALENTS FOR FUEL OIL

This chart shows the equivalents for fuel oils at various gravities and is taken at 60° F. Naturally, a temperature adjustment must be made to determine true specific gravity. This adjustment is as follows:

FOR EVERY DEGREE ABOVE 60° F., SUBTRACT .0004.

FOR EVERY DEGREE BELOW 60° F., ADD .0004.

Specific Gravity	Beaume Gravity	Lbs. per Am. Gal.	Lbs. per Eng. Gal.	Cu. Ft. Amer. per Ton	Gal. Am. per Ton	Gal. Eng. per Ton	Bbls. Amer. Per Ton
1.0000	10.	8.331	10.	35.94	268.875	224.	6.40
.9956	10.5	8.302	9.995	36.09	269.81	224.75	6.42
.9930	11.	8.273	9.930	36.19	270.76	225.55	6.44
.9895	11.5	8.244	9.895	36.32	271.71	226.33	6.46
.9860	12.	8.214	9.860	36.45	272.57	227.13	6.49
.9825	12.5	8.185	9.825	36.57	273.66	227.96	6.51
.9790	13.	8.156	9.790	36.71	274.62	228.80	6.54
.9755	13.5	8.127	9.705	36.84	275.62	229.62	6.56
.9720	14.	8.098	9.720	36.97	276.67	230.49	6.58
.9685	14.5	8.069	9.685	37.10	277.47	231.16	6.60
.9655	15.	8.044	9.650	37.22	278.46	231.98	6.63
.9625	15.5	8.019	9.625	37.34	279.33	232.71	6.65
.9595	16.	7.994	9.595	37.46	280.19	233.42	6.66
.9560	16.5	7.964	9.560	37.59	281.26	234.31	6.69
.9530	17.	7.929	9.530	37.71	282.22	235.11	6.74
.9495	17.5	7.910	9.495	37.85	283.08	235.90	6.75
.9465	18.	7.885	9.465	37.97	284.08	236.66	6.76
.9430	18.5	7.856	9.430	38.11	285.13	237.52	6.76
.9400	19.	7.831	9.400	38.23	286.04	238.30	6.81
.9370	19.5	7.806	9.370	38.35	286.95	239.06	6.83
.9340	20.	7.781	9.340	38.47	287.88	239.82	6.85
.9310	20.5	7.756	9.310	38.60	288.88	240.60	6.87
.9280	21.	7.730	9.280	38.73	289.74	241.34	6.89
.9250	21.5	7.706	9.250	38.85	290.68	242.16	6.89
.9220	22.	7.680	9.220	38.98	291.62	242.95	6.94
.9195	22.5	7.660	9.195	39.09	292.42	243.61	6.96
.9165	23.	7.635	9.165	39.21	293.25	244.40	6.98
.9135	23.5	7.615	9.135	39.34	294.15	245.21	7.00
.9105	24.	7.585	9.105	39.47	295.31	246.01	7.03
.9045	25.	7.536	9.040	39.73	297.24	247.64	7.07
.8990	26.	7.490	8.990	39.97	299.06	249.15	7.08
.8930	27.	7.440	8.930	40.24	301.07	250.84	7.12
.8870	28.	7.390	8.870	40.51	303.11	252.53	7.21
.8815	29.	7.344	8.815	40.77	305.01	254.00	7.26
.8755	30.	7.294	8.755	41.04	307.10	255.85	7.31
.8700	31.	7.248	8.700	41.31	309.19	257.47	7.36
.8650	32.	7.206	8.650	41.54	310.85	258.94	7.40
.8595	33.	7.160	8.595	41.81	312.84	260.61	7.44
.8545	34.	7.119	8.545	42.05	314.65	262.14	7.46
.8490	35.	7.070	8.490	42.32	316.83	263.83	7.54
.8440	36.	7.031	8.440	42.58	318.58	265.40	7.58
.8395	37.	6.994	8.395	42.81	320.27	266.82	7.62
.8345	38.	6.952	8.345	43.06	322.67	268.42	7.70
.8295	39.	6.911	8.295	43.32	324.12	270.04	7.71
.8250	40.	6.873	8.250	43.56	325.90	271.51	7.78

Courtesy of The Texas Company, 17 Battery Place, New York.

SOME FACTORS OF ADVANTAGE OF FUEL OIL OVER COAL

Fuel oil saves a very considerable amount of deadweight. The amount is always great, but how great depends on the conditions.

One ton of oil can be safely relied on to give the same results as 1.6 tons of coal.

50 cubic feet of oil are equivalent in heating value to 80 cubic feet of coal, this allows the carrying of considerable larger cargoes and permits increase in the steaming radius through the carrying of more fuel.

Oil burning vessels make 10 to 20 per cent more mileage than coal burners.

Can carry fuel oil for round trip. Being a concentrated fuel and principally carried in double bottom tanks which are never used for cargo or bunker coal; it adds considerable cargo capacity.

Fuel oil makes possible the maintenance of a continuous and uniform speed.

The indicated horse power developed shows 18 per cent improvement in the case of oil fed vessels.

Great economies are effected in the wages and "keep" of the crew, as the operating staff is usually reduced about 70 per cent, thus, the labor problem in the fireroom is made simpler.

The machinery, labor, and wear and tear, due to the handling of ashes is entirely eliminated. Oil does not deteriorate like coal.

Fuel oil is clean aboard ship, and bunkering is a clean quick job. Smoke, soot and ashes are eliminated (a very desirable factor especially on passenger ships).

Time in port is saved through greater ease of taking oil than coal.

Steam is raised quickly and maintained steadily. Fires started and stopped instantly. As it is not necessary to open doors for firing, no cold air strikes furnace walls and back ends, resulting in better firing and longer life of furnace bricks.

Uniform circulation of water due to constant heat well distributed under boilers.

Improved circulation of water and the fact that furnace doors are always closed, and fires and drafts uniform, permits of at least 25 per cent more horse power and also reduces the maintenance cost and adds to the life of the boilers.

With fuel oil there is no corrosion of boiler protection plates, of floor plates or of angles.

ELIMINATES

- Banking of fires in port
- Fire risk from spontaneous combustion
- Frequent painting
- Ashes, ash conveyors and smoke and soot
- Expense of grate repairs
- Corrosion of boiler plates
- Fuel handling devices ashore and afloat.

NEWSPRINT PAPER

CARGO SHIPMENTS OF PAPER IN CONJUNCTION WITH DOUGLAS FIR AND REDWOOD

As the shipment of print paper in rolls from British Columbia and the Pacific ports of the United States to Australia, New Zealand and other countries will supplant this trade which formerly was held by Germany, the following information will be of considerable assistance to those interested in this particular line.

The ordinary tramp steamer of about 7000 tons deadweight can carry a full cargo of paper under deck, with Redwood doorstock and/or dry lath or pickets for stowage, also a deckload of lumber equal in capacity and height to the amount that the steamer would ordinarily carry with a straight cargo of Douglas Fir, provided that good stowage is made both under and on deck.

DIMENSIONS OF PAPER ROLLS

Paper rolls vary according to orders of foreign buyers, though they usually run from 21¼ inches to 84 inches in height, with a preponderance of 39-inch rolls. The diameter of rolls vary, but 34 to 36 inches could be considered a fair average. The height of roll is the net size (the width of paper) and an allowance of three inches extra in height should be made for wrapping paper.

In some cases the ends of rolls are wooded, which means that the top and/or bottom ends are protected by boards about three-quarters of an inch in thickness and shaped to conform to the circular area of the end of the roll. The length and gross weight in pounds is stencilled on the side of each roll.

Rolls about 21 inches in height are called cheese rolls at point of shipment. This is on account of their resembling a roll of cheese.

These rolls are a very valuable aid to stowage. They can be used on their bilge or flat side to great advantage in the wings, between the top course of paper and beams, or any place where a larger roll would not go.

The following is an original specification of a shipment of paper rolls for Sydney, Australia, which gives a very fair idea of the dimensions and weight of the average paper roll:

SPECIFICATIONS GIVING DIMENSIONS AND WEIGHT OF NEWSPAPER ROLLS FOR FOREIGN SHIPMENT

Number of Rolls	Height Inches	Diam. Inches	Average Weight in Pounds	Gross Weight in Pounds	Tare Weight in Pounds	Net Weight in Pounds
641	39	34	710	454,972	13,621	441,351
180	35	34	650	117,107	3,600	113,507
600	39	34	650	390,348	12,750	377,598
1,844	84	36	1,700	3,126,236	95,888	3,030,348
1,827	42	36	836	1,526,682	39,280	1,487,402
1,023	21¼	36	435	445,386	14,322	431,064
6,115				6,060,731	179,461	5,881,270

HOW TO DUNNAGE AND STOW PAPER ROLLS IN A SHIP'S HOLD

Stanchions, pillars, frames or any section of compartment composed of steel or iron should be covered with burlap or otherwise dunnaged so as to prevent paper from being damaged through coming in contact with or chafing against the steel or iron parts mentioned.

Before loading, the floors of the various holds should be dunnaged with lumber to prevent damage and levelled to make a solid foundation for the paper rolls. The after holds and especially the aftermost hold where the rise of the floor is very acute, should be filled with cargo other than paper if available to about the top of the shaft tunnel.

Paper rolls must be stowed on end on a practically level floor, if stowed on bilge (side) they would be crushed out of shape by the upper courses and rendered useless for the purpose for which they are intended as they would not then revolve evenly on the newspaper machine cylinder.

Cargo hooks must not be used to handle paper rolls, and extreme care must be used to guard against the rolls striking against side of vessel, hatch coamings or other obstructions during process of loading.

If order of loading permits, the longest rolls should be stowed first in the hold; then the next to the longest length in rotation, reserving the shorter rolls to be used where a long roll cannot be stowed.

SHORT STOWAGE REQUIRED

Short stowage which must be dry is required to fill spaces between paper rolls; also in wings (sides), against iron bulkheads and in vacant spaces between the top course of rolls and beams of vessel.

One hundred thousand board feet of dry doorstock, box shooks, dry lath or dry pickets is required to stow one thousand gross long tons of paper.

If lumber or stowage is loaded on steamer prior to taking paper cargo, it should be stowed in one end of each compartment only, preferably the narrow end.

If spread over the entire floor space it would have to be rehandled and thus delay the work of loading. When stowed in one end of a compartment, work of loading can commence in the vacant end immediately vessel arrives at paper mill, and the stowage in the other end can be used when required without retarding the work.

It is a cardinal rule never to use a short roll except for an emergency, as they are easily handled and if they are not all utilized during loading they will come in very handy to finish off with.

CUBIC STOWAGE PER TON OF PAPER ROLLS

Under favorable conditions such as a vessel with large compartments or when the orders contain a large quantity of medium sized rolls or of a length that will stow from floor to beams without loss of space, about ninety-one cubic feet bale space should be allowed for one gross long ton of paper.

When there is a great variety of sizes, or the lengths are such that good stowage cannot be made owing to build of vessel or for any reason that results in a loss of space between the upper course and beams an allowance of at least ninety-five cubic feet bale space should be made.

BUNKER SPACE

All available space under deck should be reserved for cargo, and only enough bunker capacity allowed to cover the run on the longest leg of the voyage. For instance, a steamer from British Columbia or the U. S. North Pacific Coast, with a cargo destined for Sydney, Australia, should not take coal for the entire voyage, but should replenish her bunkers at Honolulu, Hawaii, taking sufficient coal there to safely carry her to Sydney.

By referring to the following distances the benefit of replensihing bunkers at Honolulu will be apparent:

Distance from Victoria, B. C. to Honolulu, 2349 nautical miles.
Distance from Port Townsend, Wash., to Honolulu, 2366 nautical miles.
Distance from Honolulu to Sydney, Australia, 4420 nautical miles.

A vessel making nine knots per hour on a daily consumption of 28 tons of coal would be 20½ days on the voyage from Honolulu to Sydney, and would require a minimum of 574 tons of coal. To this amount should be added about four days extra supply of coal or 112 tons as a reserve against accident or bad weather.

STABILITY

Contrary to a general supposition a steamer with a full cargo of paper under deck, and broken spaces well filled with short stowage, and a full and complete deckload of about 800,000 board feet of Douglas Fir and averaging about eleven feet in height, will stand up as well at the finish as if the entire cargo was Douglas Fir.

The reason for this is, that with a paper cargo under deck all bottom ballast tanks would be full, and with a straight cargo of Douglas Fir about half of the bottom ballast tanks of a capacity of say 600 tons would be empty. Therefore the extra weight of ballast required for a paper cargo would be in the bottom of the vessel and offset the heavy weight of Douglas Fir at a higher elevation in the hold.

DEADWEIGHT

The ordinary tramp steamer loaded under foregoing conditions would probably be six to ten inches off her summer marks with all bottom ballast tanks full.

Therefore if it is possible to obtain as cargo about 500 tons deadweight of iron, lead, steel, tin, canned salmon or any commodity of a specific gravity several times heavier than water that can safely be stowed in bottom of vessel it would be an aid to stability and add to freight profits by replacing a large portion of water ballast with profitable cargo.

POINTERS ON FILLING BALLAST TANKS

In loading steamer with a combination of paper and lumber it is good policy to regulate the weight of cargo and stowage in such a manner that the vessel can be loaded to her marks with one or more small double bottom ballast tanks empty, so that in event of vessel becoming tender towards the end of the voyage, through burning the coal stowed in the lower part of bunkers, the bottom tanks could be filled and the steamer would retain her stability by substituting the water ballast for coal.

If possible leave tanks of small capacity empty, as they are only filled during voyage in case of emergency, it being considered a hazardous undertaking for a steamer with a high deckload to fill a large tank at sea, as the rolling of vessel would cause the slack water to rush to one side of the tank which would probably result in the steamer taking a very dangerous list.

CONVERSION OF U. S. AND ENGLISH MONEY

According to Act of Congress, March 8, 1873, the Pound Sterling of Great Britain equals \$4.8665; the value of one shilling equals \$0.21⅓; the value of one penny equals \$0.02.

Table of Sterling Money

4 Farthings (far) equal 1 penny (d.).
12 Pence equal 1 shilling (s.).
20 Shilling equal 1 pound (£).

A Simple Process to Change Pounds, Shillings and Pence to Dollars and Cents

Reduce pounds to shillings, add in the shillings, if any, and multiply the sum by .24⅓; if any pence are given, increase the product by TWICE as many cents.

Reduce £185, 17s. and 9d. to U. S. money:

```
        185x20 equals 3700
                        17
                      ----
           Shillings, 3717
                      ----
  3717x.24⅓ equals 904.47
    Plus 9d. equals    .18
                   -------
           Answer  $904.65
```

Another Simple Method to Reduce Pounds to Dollars, and Vice Versa Exchange Being at \$4.8665

Multiply the number of pounds by 73, and divide the product by 15; the result will express its equivalent in dollars and cents. Or,

Multiply dollars by 15 and dividing the product by 73, will give its equivalent in Pounds and decimals of a Pound.

How many dollars in £96?

£96 multiplied by 73 and divided by 15 equals \$467.20. Ans.

How many pounds in \$839.50?

\$839.50 multiplied by 15 and divided by 73 equals £172.5. Ans.

TO COMPUTE LUMBER SHIPMENTS IN POUNDS, SHILLINGS AND PENCE

In making up Bills of Lading for British countries, the rate per thousand is invariably figured in English money. The following method explains the usual way of computing the freight in pounds, shillings and pence.

Example No. 1: What will the total freight amount to in sterling money on a shipment of lumber containing 220,024 board feet at £3 10s. 0d. per thousand.

Operation:

```
220,024x£3½ (£3 10s.) equals £770.084
                                   20
                                -----
                      Shillings 1.680
                                   12
                                -----
                          Pence 8.160
        Answer:  £770 1s. 8d.
```

Explanation: As the rate of freight is per thousand feet, point off three figures and multiply by £3½, which is the equivalent of £3 10s. 0d. This gives £770 and decimal .084 of a pound. Multiply .084 by 20 to obtain the shillings and .680 by 12 to obtain the pence.

Example No. 2: What will the total freight amount to in sterling money on a shipment of lumber containing 86,976 board feet at £2 6s. 9d. per thousand?

In this instance it is advisable to bring the pounds and shillings to pence, which in this case amounts to 561 pence.

Operation:

```
      86.976 Board Feet
         561 Pence
      ------
       86976
      521856
     434880
    --------
 12)48793.536
    --------
    20)4066.128 (Multiply .128 by 12 to obtain the pence which is 1.536 or 1½d.)
       -------
       203.6
                Answer:  £203 6s. 1½d.
```

Explanation: As the rate of freight is per thousand, point off three figures and multiply by 561 (the pence). Divide the product by 12 which gives 4066 shillings and decimal point 128 of a shilling. Now divide 4066 shillings by 20, to obtain the pounds. This gives 203 pounds and six shillings. To obtain the pence multiply .128 by 12; this gives 1.536 or 1½ pence.

LONGITUDE AND TIME

Since the earth revolves around its axis in 24 hours, and its circumference is divided into 360 degrees, the sun apparently passes over 15 degrees in 1 hour (360 divided by 24 equals 15); and consequently over 1 degree in 4 minutes (60 divided by 15 equals 4). Hence, these simple Rules:

Rule—Multiplying the Longitude, expressed in degrees, by 4 gives the equivalent Time expressed in minutes.

Rule—Dividing the Time, expressed in minutes, by 4 gives the equivalent Longitude expressed in degrees.

The difference in Longitude between Boston and San Francisco is nearly 51¼ degrees; what is the difference in Time?

Answer—51¼x4 equals 205 min., or 3 h. 25 min.

The difference in Time between London and New York is nearly 4 h. and 51½ min.; what is the difference in Longitude?

Answer—4 h. 55½ min. equals 295½ min. 295½ divided by 4 equals 73⅞ deg.

Notes—A degree of Longitude at the equator is 69.16 miles; at ten degrees of Latitude, 68 miles; at twenty degrees, 65 miles; at thirty degrees 60 miles; at forty degrees, 53 miles; at fifty degrees, 44.5 miles; at sixty degrees, 34.6 miles, etc. Thus longitude gradually diminishes with each degree of latitude, till at the poles it runs to nothing, as all the meridians converge from the equator to a point at the poles.

The degrees of Latitude run parallel, and would be equally distant apart were the earth a perfect sphere, but owing to its polar diameter being 26½ miles shorter than its equatorial diameter, the first degree being 68.8 miles; the forty-fifth, 69 miles and the ninetieth, 69.4 miles.

The earth's equatorial diameter is 7925.6 miles. Its polar diameter. 7899.1 miles.

BENEFIT OF TABLE OF DISTANCES AND DIFFERENCE IN TIME TABLE

The table of distances and difference in time table included in this work will prove a valuable aid to shipowners and lumbermen engaged in the export cargo trade, as it will enable them to quickly arrive at the distance between loading and discharging ports, and the time that vessel would be due to arrive at destination.

Steamers on long voyages do not always go direct to destination but invariably stop at one or more coaling ports for bunkers.

The distances in this book are arranged with this object in view, thereby enabling the reader to ascertain the distance from the principal ports of the world to any Douglas Fir or Redwood cargo mill on the Pacific Coast.

Vessels destined for British Columbia ports usually stop first at Victoria, Vancouver Island, for Puget Sound ports at Port Townsend, Wash., for Portland and Columbia River ports at Astoria, Ore. This stop is made for any of the following reasons: To call for orders, pass quarantine, fumigate, enter, or take a local pilot if proceeding to inland waters.

To ascertain the distance between ports it is often necessary to refer to one or more route ports. As an illustration, presume you wish to find the distance from Seattle, Wash., to Liverpool, England, you would trace the distance by following the nearest navigable route which is as follows:

Seattle, Wash., to Port Townsend	39 Nautical Miles
Port Townsend to Panama, C. Z.	3985 Nautical Miles
Panama, C. Z., to Colon, C. Z.	43 Nautical Miles
Colon C. Z. to Liverpool via Mona Passage	4548 Nautical Miles
Total distance	8615 Nautical Miles

To trace the distance to the Mediterranean Sea ports, such as Barcelona, Spain; Marseilles, France; Genoa and Naples, Italy, and Alexandria and Port Said, Egypt, use the following route ports; Panama, Colon and Gibraltar.

LENGTH OF PANAMA CANAL

The distance from Panama Roads, Canal Zone, to Colon, Canal Zone is 43 nautical or 50 statute miles.

TO COMPUTE TIME OCCUPIED ON VOYAGE

To compute the number of days that a full powered steamer would occupy on a voyage, the following data is necessary.

Difference in time between port of departure and port of destination. Distance between ports, and the speed of steamer in knots (nautical miles) per hour.

Example: A steamer averaging 10 knots per hour leaves Sydney, New South Wales, Eastern Australia, at 6 a. m., January 2nd (Australian time), bound for Portland, Oregon. When is she due at destination?

Process: By referring to the "Difference in Time Table, you will note the difference in time between Eastern Australia and the U. S. Pacific Coast is 18 hours. Therefore the first thing to do is to adjust the Australian time to correspond to that of the U. S. Pacific Coast, which in this case will be noon, January 1st. The number of nautical miles from port to port is found by reference to the Honolulu "Distance Table, which gives the distance to both Sydney and Portland, the total being 6,752 nautical miles.

The number of knots per hour (10) is multiplied by (24) the hours per day, which equals 240 knots, or nautical miles, and is divided into 6752, the number of nautical miles covered by steamer on voyage, which gives 28.133 days, or the equivalent of 28 days 3 hours.

This is added to the Pacific Coast time of steamer's departure from Sydney, making January 29th three p. m. as the time vessel is due at Portland, Oregon, without allowing for stoppages.

Note: It is customary for a steamer destined for Portland, Oregon, to proceed to the entrance of the Columbia River, and there pick up a bar pilot, who takes the vessel to Astoria.

The services of the bar pilot are dispensed with at Astoria, where a Columbia River pilot is engaged to take the vessel to Portland.

DIFFERENCE IN TIME TABLE

When it is noon today from Vancouver, B. C., to San Diego, California:

In Washington, Boston, New York and Philadelphia	it is	3:00 p. m. today
In Chicago, St. Louis and New Orleans	it is	2:00 p. m. today
In Cheyene and Denver	it is	1:00 p. m. today
In Sitka, Alaska	it is	11:00 a. m. today
In Porto Rico	it is	4:00 p. m. today
In Panama Canal Zone	it is	3:00 p. m. today
In Honolulu, Hawaiian Islands	it is	9:30 a. m. today
In Tutuila, Samoa	it is	8:30 a. m. tomorrow
In Guam Islands	it is	5:30 a. m. tomorrow
In Manila, Philippine Islands	it is	4:00 a. m. tomorrow
In Argentine	it is	3:43 a. m. tomorrow
In Australia, Western	it is	4:00 a. m. tomorrow
In Australia, Central	it is	5:30 a. m. tomorrow
In Australia, Eastern	it is	6:00 a. m. tomorrow
In Austria-Hungary	it is	9:00 p. m. today
In Belgium	it is	8:00 p. m. today
In Borneo (British North) and Labuan	it is	4:00 a. m. tomorrow
In Brazil (Rio de Janeiro)	it is	5:00 p. m. today
In Chile	it is	3:30 p. m. today
In China (Hongkong)	it is	4:00 a. m. tomorrow
In China (Saigon)	it is	3:00 a. m. tomorrow
In Colombia (Bogota)	it is	3:00 p. m. today
In Costa Rica	it is	3:00 p. m. today
In Cuba	it is	3:30 p. m. today
In Denmark	it is	9:00 p. m. today
In Ecuador	it is	2:45 p. m. today
In Egypt	it is	10:00 p. m. today
In England	it is	8:00 p. m. today
In Fiji Islands (Suva)	it is	8:00 a. m. tomorrow
In France	it is	8:00 p. m. today
In Germany	it is	9:00 p. m. today
In Gibraltar	it is	8:00 p. m. today
In Greece	it is	9:30 p. m. today
In Holland	it is	8:00 p. m. today
In Honduras	it is	2:00 p. m. today
In India (Madras)	it is	1:30 a. m. tomorrow
In Ireland	it is	7:30 p. m. today
In Italy	it is	9:00 p. m. today
In Jamaica (Kingston)	it is	3:00 p. m. today
In Japan	it is	5:00 a. m. tomorrow
In Java	it is	3:00 a. m. tomorrow
In Korea	it is	5:00 a. m. tomorrow
In Madagascar (Tananarivo)	it is	11:00 p. m. today
In Malta	it is	9:00 p. m. today
In Mauritius	it is	midnight tonight
In Mexico	it is	1:30 p. m. today
In Newfoundland	it is	4:30 p. m. today
In New Zealand	it is	7:30 a. m. tomorrow
In Nicaragua	it is	2:15 p. m. today
In Nome, Dutch Harbor	it is	9:00 a. m. today
In Norway	it is	9:00 p. m. today
In Peru	it is	3:00 p. m. today
In Portugal	it is	7:30 p. m. today
In Russia (Irkutsk)	it is	3:00 a. m. tomorrow
In Russia (Pulkova)	it is	10:00 p. m. today
In Russia (Vladivostok)	it is	5:00 a. m. tomorrow
In Singapore	it is	3:00 a. m. tomorrow
In Spain	it is	8:00 p. m. today
In Sweden and Switzerland	it is	9:00 p. m. today
In Tunis	it is	8:00 p. m. today
In Turkey	it is	10:00 p. m. today
In Uruguay	it is	4:15 p. m. today
In Valdez, Fairbanks, Tanana	it is	10:00 a. m. today
In Venezuela	it is	3:30 p. m. today

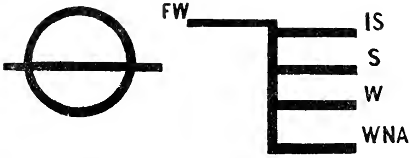
EXPLANATION OF THE LOAD LINE

The circular disc prescribed by section 438 of the British Merchant Shipping Act, 1894, shall be 12 inches in diameter, with a horizontal line 18 inches in length and drawn through its center. The disc shall be marked amidships on each side of the ship, the position of its center being placed at such level as is specified in the Board of Trade certificate of approval.

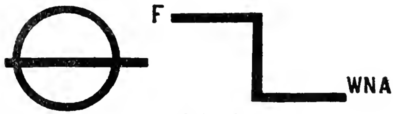
The lines to be used in connection with the disc in order to indicate the maximum load-line under different circumstances and at different seasons shall be horizontal lines 9 inches in length and 1 inch in thickness, extending from and at right angles to a vertical line marked 21 inches forward of the center of the disc.

The maximum load-line in fresh water shall be marked abaft such vertical line, and the maximum load-line in salt water shall be marked forward of such vertical line, as shown in the diagrams hereinafter mentioned.

Diagram Showing Load Line (Plimsoll Marks).



Steamer



Sailing Ship

Such maximum load-lines shall be as follows, and the upper edge of such lines shall respectively indicate:

For Fresh Water. The maximum depth, to which the vessel can be loaded in fresh water.

For Indian Summer. The maximum depth to which the vessel can be loaded for voyages during the fine season in the Indian seas, between the limits of Suez and Singapore.

For Summer. The maximum depth to which the vessel can be loaded for voyages(other than Indian summer voyages) from European and Mediterranean ports between the months of April and September, both inclusive, and as to voyages in other parts of the world (other than Indian summer voyages) the maximum depth to which the vessel can be loaded during the corresponding or recognized summer months.

For Winter. The maximum depth to which the vessel can be loaded for voyages (other than Indian summer voyages, and summer voyages) from European and Mediterranean ports between the months of October and March, both inclusive, and as to voyages in other parts of the world, the maximum depth to which the vessel can be loaded during the corresponding or recognized winter months.

For Winter (North Atlantic). The maximum depth to which the vessel can be loaded for voyages to, or from, the Mediterranean, or any European port, from, or to, ports in British North America, or eastern ports in the United States, north of Cape Hatteras, between the months of October and March, both inclusive.

Such maximum load-lines shall be distinguished by initial letters conspicuously marked opposite each horizontal line as aforesaid, such initial letters being as follows:

F. W.—Fresh Water.
W.—Winter.
I. S.—Indian Summer.
W. N. A.—Winter North Atlantic.
S.—Summer.

BRITISH LAW RELATIVE TO LUMBER DECKLOADS

(1) **Loading of Timber.** If a ship, British or foreign, arrives between the last day of October and the 16th day of April in any year at any port in the United Kingdom from any port out of the United Kingdom carrying any heavy or light wood goods as deck cargo (except under the conditions allowed by this section), the master of the ship and also the owner, if he is privy to the offense, shall be liable to a fine not exceeding £5 for every 150 cubic feet of space in which wood goods are carried in contravention of this section.

(2) The conditions under which heavy wood goods may be carried as deck cargo are as follows:

(a) That they must only be carried in covered spaces; and

(b) That they must be carried only in such class of ships as may be approved by the Board of Trade for the purpose; and

(c) That they must be loaded in accordance with regulations made by the Board of Trade with respect to the loading thereof.

(3) The conditions under which light wood goods may be carried as deck cargo are as follows:

(a) **Each unit of the goods must be of a cubic capacity not greater than 15 cubic feet; and**

(b) The height above the deck to which the goods are carried must not exceed—

(i) In the case of an uncovered space on a deck forming the top of a break, poop, or other permanent closed-in space on the upper deck, 3 feet above the top of that closed-in space; and

(ii) In the case of an uncovered space, not being a space forming the top of any permanent closed-in space on the upper deck or a space forming the top of a covered space, the height of the main rail, bulwark, or plating or one-fourth of the inside breadth of the ship, or 7 feet, whichever height is the least; and

(iii) In the case of a covered space the full height of that space.

(c) Regulations may be made by the Board of Trade for the protection of seamen from any risk arising from the carriage of the goods in any uncovered space to the height allowed under this section, and those regulations must be complied with on the ship.

(4) A master or owner shall not be liable to any fine under this section—

(a) In respect of any wood goods which the master has considered it necessary to place or keep on deck during the voyage on account of the springing of any leak or of any other damage to the ship received or apprehended; or

(b) If he proves that the ship sailed from the port at which the wood goods were loaded as deck cargo at such time before the last day of October as allowed a sufficient interval according to the ordinary duration of the voyage for the ship to arrive before that day at the said port in the United Kingdom, but was prevented from so arriving by stress of weather or circumstances beyond his control; or

(c) If he proves that the ship sailed from the port at which the wood goods were loaded as deck cargo at such time before the 16th day of April as allowed a reasonable interval according to the ordinary duration of the voyage for the ship to arrive after that day at the said port in the United Kingdom and by reason of an exceptionally favorable voyage arrived before that day.

(5) For the purposes of this section—

(a) The expression "heavy wood goods" means—

(i) Any square, round, waney, or other timber, or any pitch pine, mahogany, oak, teak, or other heavy wood goods whatever; or

(ii) Any more than five spare spars or store spars, whether or not made, dressed, and finally prepared for use; and

(b) The expression "light wood goods" means any deals, battens, or other light wood goods of any description; and

(c) The expression "deck cargo" means any cargo carried either in any uncovered space upon deck or in any covered space not included in the cubical contents forming the ship's registered tonnage; and

(d) The space in which wood goods are carried shall be deemed to be the space limited by the superficial area occupied by the goods and by straight lines inclosing a rectangular space sufficient to include the goods.

(6) Nothing in this section shall affect any ship not bound to a port in the United Kingdom which comes into any port of the United Kingdom under stress of weather, or for repairs, or for any purpose other than the delivery of her cargo.

(7) This section shall come into operation on the passing of this act.

Rules Made by the Board of Trade Under Section 10 of the Merchant Shipping Act, 1906, as Amended in 1907

In pursuance of the provisions of section 10 of the Merchant Shipping Act, 1906, the Board of Trade hereby approve the classes of ships shown in the annexed Rule I for the purpose of carrying heavy wood goods as deck cargo, and do hereby make the regulations shown in the annexed Rules Nos. II and III.

The board direct that these three rules shall come into effect on the 7th day of February, 1907.

Rule I—Classes of Ships Approved for the Purpose of carrying Heavy Wood Goods as Deck Cargo

The classes of ships which are approved for the purpose of carrying heavy wood goods as deck cargo are iron or steel steamships having covered spaces; that is to say, poops, bridges, forecastles, or shelter decks, which form part of the permanent structure of the ship, and which comply with the following conditions:

(a) The space must be within an erection which extends from side to side of the ship.

(b) The outside plating must be continuous from deck to deck and throughout the full length of the space.

(c) The length must be bounded by iron or steel partitions, and the total area of the openings in any such partition must not exceed one-fourth of the area of the partition itself.

Rule II—Regulations with Respect to the Loading of Heavy Wood Goods as Deck Cargo

1. Heavy wood goods may only be loaded in covered spaces which form part of the permanent structure of the ship, and which comply with the conditions specified in the preceding Rule I.

2. Heavy wood goods must not be loaded in any covered space in such a manner as to make the ship unfit, by reason of instability, to proceed to sea and to perform the voyage safely, having regard to the nature of the service for which she is intended.

3. Heavy wood goods must be properly stowed and secured so as to prevent shifting.

Rule III—Regulations for the Protection of Seamen from Risk Arising from the Carriage of Wood Goods as Deck Cargo in Uncovered Spaces on Board Ship

1. When wood goods are carried in an uncovered space there shall be fitted on each side of the ship temporary rails or bulwarks of a substantial character for the full length within which the deck cargo is stowed, extending to a height of not less than 4 feet above the line of the top of the deck cargo.

2. The uprights of such temporary rail or bulwark shall be of substantial scantling and be placed not more than 4 feet apart; the heels of the uprights shall extend down to and rest on the deck of the vessel.

3. There shall be attached longitudinally to these uprights for the full length of the deck cargo spars, deals, battens, guard ropes, or chains at intervals of not more than 12 inches apart in a vertical direction. If ropes or chains are used, they shall be set taut and securely attached to each upright.

4. The temporary rails or bulwarks may consist of closely spaced vertical deals, provided they are properly secured and that there are protected openings at intervals for water clearance.

5. Where light wood is carried in an uncovered space (not being a space forming the top of any permanent closed-in space on the upper deck or a space forming the top of a covered space) and the uncovered space is bounded by an open rail formed of wood, iron, or steel stanchions and longitudinal rods, battens, or chains, no measures for the protection of the seamen shall be deemed sufficient if the height of such rail exceeds 3 feet 6 inches.

INLAND WATERS

PUGET SOUND, WASHINGTON AND BRITISH COLUMBIA PORTS

Nautical Miles

From Undermentioned Ports to	Bellingham	Cape Flattery	Comox, B. C.	Dupont	Everett	Nanaimo, B. C.	Port Angeles	Port Blakeley	Port Gamble
Anacortes	15	96	126	107	62	75	43	67	45
Bellingham	---	111	130	122	77	60	58	82	59
Blaine	36	110	105	132	88	54	62	93	75
Bremerton	84	129	194	39	35	127	73	10	39
Cape Flattery	111	---	190	155	117	141	56	121	102
Comox, B. C.	130	190	---	208	170	53	143	175	157
Dungeness	44	72	136	84	46	88	15	51	33
Departure Bay	75	141	52	165	127	7	91	132	115
Dupont	122	155	208	---	56	165	98	35	59
Everett	77	117	170	56	---	127	60	28	24
Esquimalt, B. C.	50	59	132	102	64	90	19	69	50
Friday Harbor	38	80	110	95	57	65	42	62	44
James Island	52	78	114	105	67	70	36	72	54
Mukilteo	73	113	165	52	4	120	53	23	22
Nanaimo, B. C.	60	141	53	165	127	---	94	132	114
Neah Bay	97	7	183	148	110	134	50	115	97
Olympia	133	168	221	16	76	178	111	49	82
Port Angeles	58	56	143	98	60	94	---	65	47
Point Atkinson	64	133	74	159	121	28	88	126	108
Port Blakeley	82	121	175	35	28	132	65	---	30
Port Crescent	63	44	146	108	71	88	12	76	58
Port Gamble	59	102	157	59	24	114	47	30	---
Port Ludlow	53	98	153	56	22	110	43	26	6
Point No Point	59	103	156	50	14	113	46	19	11
Port Townsend	42	89	141	69	31	97	30	36	17
Point Wilson	39	85	138	70	32	95	28	37	19
Powell River, B. C.	118	180	20	210	172	50	138	171	159
Seattle	81	123	179	34	28	134	69	7	33
Steilacoom	114	160	206	5	52	162	98	30	61
Tacoma	100	144	196	20	46	153	87	25	51
Union Bay, B. C.	125	185	5	203	165	54	140	170	152
Vancouver, B. C.	70	140	27	165	128	35	94	132	114
Victoria, B. C.	43	59	129	100	62	84	18	67	50
Possession Point	62	108	159	53	8	116	49	19	16

CHEMAINUS, B. C.

TO		TO	
Bellingham, Wash.	70	Port Angeles, Wash.	65
Comox, B. C.	70	Port Townsend, Wash.	78
Esquimalt, B. C.	67	Powell River, B. C.	110
Genoa Bay, B. C.	15	Seattle, Wash.	120
Nanaimo, B. C.	20	Tacoma, Wash.	144
Nanoose, B. C.	32	Union Bay, B. C.	65
New Westminster, B. C.	65	Vancouver, B. C.	65
Ocean Falls, B. C.	287	Victoria, B. C.	63
Port Alberni, B. C.	185		

INLAND WATERS

PUGET SOUND, WASHINGTON, AND BRITISH COLUMBIA PORTS

Nautical Miles

From Undermentioned Ports to	Port Ludlow	Port Townsend	Powell River, B. C.	Seattle	Tacoma	Union Bay, B. C.	Vancouver, B. C.	Victoria, B. C.
Anacortes	45	30	116	69	88	121	68	31
Bellingham	53	42	118	81	100	125	70	43
Blaine	69	58	98	94	114	100	49	53
Bremerton	36	44	184	13	25	190	139	74
Cape Flattery	98	89	180	123	144	185	140	59
Comox, B. C.	153	141	20	179	196	5	27	129
Dungeness	28	17	130	53	72	131	80	19
Departure Bay	109	98	48	135	150	45	34	82
Dupont	56	69	210	34	20	203	165	100
Everett	22	31	172	28	46	165	128	62
Esquimalt, B. C.	43	33	129	71	89	128	86	4
Friday Harbor	37	28	106	65	83	106	57	30
James Island	50	37	112	72	93	115	67	23
Mukilteo	18	24	167	25	43	160	120	55
Nanaimo, B. C.	110	97	50	134	153	54	35	84
Neah Bay	93	80	177	117	136	179	129	49
Olympia	78	81	223	50	24	216	178	115
Port Angeles	43	30	138	69	87	140	94	18
Point Atkinson	104	92	66	128	148	69	7	76
Port Blakeley	26	36	171	7	25	170	132	67
Port Crescent	54	41	143	78	97	148	106	19
Port Gamble	6	17	159	33	51	152	114	50
Port Ludlow	---	14	155	31	50	148	111	46
Point No Point	7	18	158	22	40	151	115	50
Port Townsend	14	---	143	39	58	136	97	31
Point Wilson	16	3	140	40	60	133	95	30
Powell River, B. C.	155	143	---	180	198	24	73	126
Seattle	31	39	180	---	24	173	135	68
Steilacoom	60	69	208	35	16	201	130	98
Tacoma	50	58	198	24	---	191	155	68
Union Bay, B. C.	148	136	24	173	191	---	77	125
Vancouver, B. C.	111	97	73	135	155	77	---	84
Victoria, B. C.	46	31	126	68	68	125	84	---
Possession Point	13	20	160	19	39	154	116	52

	Nautical Miles
Ocean Falls, Vancouver Island, B. C., to Port Townsend	372
Ocean Falls, Vancouver Island, B. C., to Seattle, Wash.	410
Port Alberni, Vancouver Island, B. C., to Victoria, B. C.	130
Port Alberni, Vancouver Island, B. C., to Chemainus, B. C.	185

GENOA BAY, B. C.

TO		TO	
Bellingham, Wash.	52	Port Angeles, Wash.	50
Comox, B. C.	83	Port Townsend, Wash.	55
Chemainus, B. C.	15	Powell River, B. C.	91
Esquimalt, B. C.	35	Seattle, Wash.	95
Nanaimo, B. C.	33	Tacoma, Wash.	119
Nanoose, B. C.	45	Union Bay, B. C.	88
New Westminster, B. C.	52	Vancouver, B. C.	52
Ocean Falls, B. C.	302	Victoria, B. C.	33
Port Alberni, B. C.	170		

TABLE OF DISTANCES

ACAPULCO

Acapulco, Mexico, to—	Nautical Miles
Antofagasta, Chile	2,984
Arica, Chile	2,768
Caldera, Chile	3,130
Callao, Peru	2,198
Coquimbo, Chile	3,259
Corinto, Nicaragua	792
Esmeraldas, Ecuador	1,527
Guayaquil, Ecuador	1,708
Honolulu, Hawaii	3,289
Iquique, Chile	2,834
Lota, Chile	3,573
Magdalena Bay, Mexico	853
Mollendo, Peru	2,643
Pacasmayo, Peru	1,895
Paita, Peru	1,725
Panama, C. Z.	1,426
Pichilinque Harbor (U. S. coal depot) Mexico	778
Pisco, Peru	2,309
Punta Arenas, Chile	4,582
Punta Arenas, Costa Rica	1,011
Salina Cruz, Mexico	314
San Jose, Guatemala	574
Tahiti (Papeete), Society Is.	3,595
Talcahuano, Chile	3,558
Valdivia, (Port Corral), Chile	3,712
Valparaiso, Chile	3,406

ANTWERP

Antwerp, Belgium, to—	Route—	Nautical Miles
Acapulco, Mexico	Via Panama Canal	6,277
Do	Via Magellan Strait	12,010
Aden, Arabia	Via Suez Canal	4,710
Callao, Peru	Via Panama Canal	6,197
Do	Via Magellan Strait	10,099
Coronel, Chile	Via Panama Canal	7,673
Do	Via Magellan Strait	8,621
Danzig, Germany	Via Kiel Canal	734
Do	Via Skagerrak	1,054
Guayaquil (Puna), Ecuador	Via Panama Canal	5,644
Do	Via Magellan Strait	10,701
Honolulu, Hawaii	Via Panama Canal	9,536
Do	Via Magellan Strait	13,798
Iquique, Chile	Via Panama Canal	6,838
Do	Via Magellan Strait	9,629
Panama, C. Z.	Via Mona Passage	4,851
Pernambuco, Brazil		4,181
Portland, Ore., U. S. A.	Via Panama Canal and San Francisco	8,746
Do	Via Magellan Strait and San Francisco	14,271
Port Townsend, Wash., U. S. A.	Via Panama Canal and San Francisco	8,866
Do	Via Magellan Strait and San Francisco	14,391
Punta Arenas, Chile	Via Panama Canal	8,794
Do	East of South America	7,433
San Diego, Cal., U. S. A.	Via Panama Canal	7,694
Do	Via Magellan Strait	13,229
San Francisco, Cal., U. S. A.	Via Panama Canal	8,096
Do	Via Magellan Strait	13,621
San Jose, Guatemala	Via Panama Canal	5,737
Do	Via Magellan Strait	11,724
Sitka, Alaska	Via Panama Canal and San Francisco	9,398
Do	Via Magellan Strait and San Francisco	14,923
Ushant I. (lat. 48° 40′ N., long. 5° 30′ W.)		441
Valparaiso, Chile	Via Panama Canal	7,467
Do	Via Magellan Strait	8,866
Vancouver, B. C.	Via Panama Canal	8,883
Do	Via Magellan Strait	14,406

ASTORIA

Astoria, to—	Nautical Miles
Columbia River Bar	10
Dutch Harbor, Alaska	1,688
Grays Harbor Bar	53
Port Townsend, Wash.	214
San Francisco	555
Seattle, Wash.	252
Tacoma, Wash.	279
Tatoosh, Wash.	126
Willapa Bar	38

INLAND WATERS

ASTORIA

DISTANCES FROM ASTORIA, ORE., TO COLUMBIA RIVER AND WILLAMETTE RIVER LOADING POINTS

The distances are from Astoria at a point known as the Mack Dock, where all bearings are taken. The Portland distance terminates at the Steel Bridge.

	Statute Miles
Knappton, Wash.	12
Wauna, Ore.	28
Westport, Ore.	30
Oak Point, Wash.	40
Stella, Wash.	42½
Rainier, Ore.	54½
Prescott, Ore.	57
Goble, Ore.	60
Kalama, Wash.	60
Saint Helens, Ore.	73
Linnton, Ore.	92½
Vancouver, Wash.	94
Saint Johns, Ore.	95
Portland, Ore.	100

BORDEAUX

Bordeaux, France, to—	Route—	Nautical Miles
Acapulco, Mexico	Via Panama Canal	6,067
Do	Via Magellan Strait	11,651
Aden, Arabia	Via Suez Canal	4,351
Callao, Peru	Via Panama Canal	5,987
Do	Via Magellan Strait	9,740
Colon, C. Z.	Via Mona Passage	4,598
Coronel, Chile	Via Panama Canal	7,463
Do	Via Magellan Strait	8,262
Guayaquil (Puna), Ecuador	Via Panama Canal	5,434
Do	Via Magellan Strait	10,342
Habana, Cuba	Via NE. Providence Channel	4,188
Honolulu, Hawaii	Via Panama Canal	9,326
Do	Via Magellan Strait	13,439
Iquique, Chile	Via Panama Canal	6,628
Do	Via Magellan Strait	9,270
New York, U. S. A.	Winter; westbound	3,216
Do	Summer; westbound	3,280
Panama, C. Z.	Via Mona Passage	4,641
Pernambuco, Brazil		3,823
Portland, Ore., U. S. A.	Via Panama Canal and San Francisco	8,536
Do	Via Magellan Strait and San Francisco	13,912
Port Townsend, Wash., U. S. A.	Via Panama Canal and San Francisco	8,656
Do	Via Magellan Strait and San Francisco	14,032
Punta Arenas, Chile	East of South America	7,074
Do	Via Panama Canal	8,584

BORDEAUX—Continued

Bordeaux, France, to—	Route—	Nautical Miles
San Diego, Cal., U. S. A.	Via Panama Canal	7,484
Do	Via Magellan Strait	12,870
San Francisco, Cal., U. S. A.	Via Panama Canal	7,886
Do	Via Magellan Strait	13,262
San Jose, Guatemala	Via Panama Canal	5,527
Do	Via Magellan Strait	11,365
Sitka, Alaska	Via Panama Canal and San Francisco	9,188
Do	Via Magellan Strait and San Francisco	14,564
Valparaiso, Chile	Via Panama Canal	7,257
Do	Via Magellan Strait	8,507
Vancouver, B. C.	Via Panama Canal	8,673
Do	Via Magellan Strait	14,047

BREST

Brest, France, to—	Route—	Nautical Miles
Colon, C. Z.	Via Mona Passage	4,420
Gravesend, England		392
Guantanamo Bay (Caimanera), Cuba		3,791
New York (The Battery), N. Y., U. S.	Winter; westbound	2,994
Do	Summer; westbound	3,072
Rio de Janeiro, Brazil		4,841
San Francisco, Cal., U. S. A.	Via Rio de Janero and Magellan Strait	13,271
Do	Via Mona Passage and Panama	7,708

BUENOS AIRES

Buenos Aires, Argentina, to—	Route—	Nautical Miles
Asuncion, Paraguay		827
Colon, C. Z.	North of South America	5,450
Los Angeles Hbr. (San Pedro), Cal., U.S.	Via Panama Canal	8,406
Punta Arenas, Chile		1,383
Rosario, Argentina		210
Southampton, England		5,762
Victoria, Brazil		1,372

CALLAO

Callao, Peru, to—	Nautical Miles
Antofagasta, Chile	813
Arica, Chile	593
Caldera, Chile	980
Chimbote, Peru	206
Coquimbo, Chile	1,136
Honolulu, Hawaii	5,161
Iquique, Chile	659
Los Angeles Harbor (San Pedro), Cal., U. S. A.	3,655
Lota, Chile	1,530
Magdalena Bay, Mexico	3,008
Mollendo, Peru	468
Panama, C. Z.	1,346
Pisco, Peru	128
Punta Arenas, Chile	2,671
Talcahuano, Chile	1,508
Valdivia (P. Corral), Chile	1,691
Valparaiso, Chile	1,306

COLON

Colon, Canal Zone, to—	Route—	Nautical Miles
Antilla, Cuba		844
Aux Cayes, Haiti		645
Apalachicola, Fla., U. S. A.		1,287
Bahai, Brazil		3,668
Bahia Blanca, Argentina		5,733
Balboa, C. Z.		38
Baltimore, Md., U. S. A.	Via Windward and Crooked I. Passages	1,901
Barbados (Bridgetown), W. I.		1,237
Bishops Rock, England	Via Anegada Passage	4,395
Do	Via Mona Passage	4,356
Bluefields, Nicaragua		276
Bocas del Toro, Panama		144
Bordeaux, France	Via Mona Passage	4,598
Boston, Mass., U. S. A.	Via Windward and Crooked I. Passages; outside Nantucket Lightvessel.	2,157
Brunswick, Ga., U. S. A.	Via Windward and Crooked I. Passages	1,550
Buenos Aires, Argentina	North of South America	5,450
Campeche, Mexico		1,167
Cape Haitien, Haiti		817
Carmen, Mexico		1,246
Cartagena, Colombia		281
Cayenne, Guiana		2,265
Ceiba, Honduras		666
Charleston, S. C., U. S. A.	Via Windward and Crooked I. Passages	1,564
Do	Via Yucatan Channel; northbound	1,636
Culebra I. (The Sound), W. I.	Outside Crab I. and via South Channel	1,018
Curacao (Santa Ana Harbor), W. I.		699
Fort de France, Martinique, W. I.		1,159
Galveston, Texas, U. S. A.		1,493
Georgetown, B. Guiana		1,515
Gibraltar	Via St. Thomas	4,343
Do	Via Anegada Passage	4,332
Gibraltar, Strait of (lat. 35° 57′ N., long. 5° 45′ W.)	Via Anegada Passage	4,308
Glasgow, Scotland	Via Mona Passage	4,523
Gracias a Dios, Nicaragua		399
Grijalva (Tabasco) River, Mexico		1,280
Guantanamo Bay (Caimanera), Cuba		696
Gulfport, Miss., U. S. A.	Northbound	1,388
Habana, Cuba	Via Yucatan Channel	1,003
Halifax, Nova Scotia	Via Windward and Crooked I. Passages	2,317
Hamburg, Germany	Via Mona Passage	5,070
Hampton Roads, Va., U. S. A.	Via Windward and Crooked I. Passages	1,768
Havre, France	Via Mona Passage	4,614
Horn I. Arch., Gulf of Mexico	Northbound	1,373
Hull, England	Via Mona Passage	4,884
Iriona, Honduras		566
Jacmel, Haiti		683
Jacksonville, Fla., U. S. A.	Via Yucatan Channel; northbound	1,535
Key West, Fla., U. S. A.		1,065
Kingston, Jamaica, W. I.		551
La Guaira, Venezuela		841
Liverpool, England	Via Mona Passage	4,548
Livingston, Guatemala		772
Los Angeles Hbr. (San Pedro), Cal., U.S.		2,956
Manzanillo, Cuba		689
Maracaibo, Venezuela		600
Margarita I. (La Mar Bay), Venezuela		1,012
Matagorda Bay (Entr.), Tex., U. S. A.		1,515
Mississippi River (South Pass; lat. 28° 59′ N., long. 89° 07′ W.)	Northbound	1,308
Mississippi River (S. W. Pass; lat. 28° 53′ N., long. 89° 27′ W.)	Northbound	1,309

Colon, Canal Zone, to—	Route—	Nautical Miles
Mobile, Ala., U. S. A.	Northbound	1,393
Mona Passage (lat. 18° 03′ N., long. 67° 47′ W.), W. I.		880
Monte Cristi, D. R.		838
Monkey Pt. Harbor, Nicaragua		259
Montevideo, Uruguay		5,336
Nassau, New Providence I.		1,376
New Orleans, La., U. S. A.	Northbound; via South Pass	1,403
Do	Northbound; via S. W. Pass	1,410
New York (The Battery), N. Y., U. S.	Via Windward and Crooked I. Passages	1,974
Newport, R. I., U. S. A.	Via Windward and Crooked I. Passages	2,028
Newport News, Va., U. S. A.	Via Windward and Crooked I. Passages	1,776
Norfolk, Va., U. S. A.	Via Windward and Crooked I. Passages	1,779
Do	Via Yucatan Channel; northbound	2,006
Panama Roads, C. Z.	Via Panama Canal	43
Para, Brazil		2,309
Pensacola, Fla., U. S. A.	Northbound	1,369
Pernambuco, Brazil		3,277
Philadelphia, Pa., U. S. A.	Via Windward and Crooked I. Passages	1,946
Plymouth, England	Via St. Thomas	4,500
Do	Via Mona Passage	4,455
Do	Via Anegada Passage	4,494
Ponce, Porto Rico		933
Port Antonio, Jamaica		582
Port Arthur, Texas		1,485
Port Castries, St. Lucia, W. I.		1,160
Port Limon, Costa Rica		192
Port Morelos, Yucatan		828
Port of Spain, Trinidad, W. I.		1,159
Port Royal, Jamaica, W. I.		546
Port Tampa, Fla., U. S. A.		1,212
Porto Plata, D. R.		899
Portsmouth, N. H., U. S. A.	Via Windward and Crooked I. Passages; outside Nantucket Lightvessel	2,174
Provincetown, Mass., U. S. A.	Via Windward and Crooked I. Passages	2,126
Puerto Barrios, Guatemala		780
Puerto Cabello, Venezuela		802
Puerto Cortes, Honduras		733
Puerto Mexico, Mexico		1,377
Rio de Janeiro, Brazil		4,348
Rio Grande (Entr.)		1,484
Roatan Island (Coxen Hole)		641
Roseau, D. R.		1,152
Sabine, Texas, U. S. A.		1,476
St. George, Grenada		1,118
St. Thomas, W. I.		1,029
Samana Bay, D. R.		955
San Juan, P. R.		993
Sanchez, D. R.		967
Sandy Hook, N. J., U. S. A.	Via Windward and Crooked I. Passages	1,964
Santiago, Cuba		683
Santos, Brazil		4,536
Savannah, Ga., U. S. A.	Via Yucatan Channel; northbound	1,607
Savanilla, Colombia		314
Southport, N. C., U. S. A.	Via Windward and Crooked I. Passages	1,592
Tampico, Mexico		1,485
Tela, Honduras		706
Trinidad (Dragons Mouths; lat. 10° 43′ N., long. 61° 45′ W.), W. I.		1,142
Trujillo, Honduras		622
Tuxpam, Mexico		1,455
Vera Cruz, Mexico		1,420

COLON—Continued

Colon, Canal Zone, to—	Route—	Nautical Miles
Virgin Passage (lat. 18° 20′ N., long. 65° 07′ W.), W. I.		1,021
Williamsted, Curacao		697
Wilmington, N. C., U. S. A.	Via Yucatan Channel; northbound	1,730
Windward Passage (lat. 20° 10′ N., long. 74° 00′ W.), W. I.		734
Yucatan Channel (lat. 21° 50′ N., long. 85° 03′ W.)		812

EUREKA

Eureka, Humboldt Bay, Cal., to—	Route—	Nautical Miles
Astoria, Oregon		343
Bellingham, Wash.		594
Cape Flattery, Wash.		464
Coos Bay, Oregon		159
Grays Harbor, Wash., "Whistle Buoy"		371
Honolulu, Hawaii		2,139
Los Angeles Harbor (San Pedro), Cal.		584
Manilla, P. I.	Via Honolulu	6,906
Panama Roads, Canal Zone		3,461
Port Townsend, Wash.		548
San Francisco, Cal.		216
San Diego, Cal.		668
Seattle, Wash.		588
Tacoma, Wash.		610
Union Bay, B. C.		659
Vancouver, B. C.		617
Victoria, B. C.		534
Willapa Harbor, Wash., "Whistle Buoy"		355

GENOA, ITALY

Genoa, Italy, to—	Route—	Nautical Miles
Baltimore, Md., U. S. A.	G. C., C. St. Vincent to C. Charles Light-vessel	4,343
Boston, Mass., U. S. A.	Winter; westbound	3,876
Do	Summer; westbound	3,899
Buenos Aires, Argentina		6,135
Galveston, Texas, U. S. A.	Via N. E. Providence Channel and south of Dry Tortugas	5,600
Gibraltar		860
Gibraltar, Strait of (lat. 35° 57′ N., long. 5° 45′ W.)		877
London, England		2,204
Malta (Valetta Harbor)		587
Messina, Sicily		488
New Orleans, La., U. S. A.	Via N. E. Providence Channel, south of Dry Tortugas, and S. W. Pass	5,440
New York (The Battery), N. Y., U. S.	Winter; westbound	4,054
Do	Summer; westbound	4,060
Newport News, Va., U. S. A.	G. C., C. St. Vincent to C. Charles Light-vessel	4,219
Philadelphia, Pa., U. S. A.	Winter; westbound	4,207
Do	Summer; westbound	4,213
Rio de Janeiro, Brazil		5,022
St. John, N. B.	Winter; westbound	3,776
Do	Summer; westbound	3,802
Smyrna, Turkey in Asia	Via Messina and Athens	1,116

GIBRALTAR

Gibraltar, to—	Route—	Nautical Miles
Acapulco, Mexico	Via Anegada Passage and Panama Canal	5,801
Do	Via Magellan Strait	10,960
Aden, Arabia		3,321
Alexandria, Egypt		1,810
Algiers, Algeria		425
Barcelona, Spain		516
Callao, Peru	Via Anegada Passage and Panama Canal	5,721
Do	Via Magellan Strait	9,049
Colon, C. Z.	Via Anegada Passage	4,332
Do	Via St. Thomas, W. I.	4,343
Constantinople, Turkey	Via Messina Strait and Corinth Canal	1,823
Do	Via South of Sicily and Cervi and Duro Channels	1,824
Coronel, Chile	Via Anegada Passage and Panama Canal	7,197
Do	Via Magellan Strait	7,571
Fayal (Horta), Azores		1,133
Genoa, Italy		860
Guayaquil (Puna), Ecuador	Via Anegada Passage and Panama Canal	5,168
Do	Via Magellan Strait	9,651
Hongkong	Via Anegada Passage and Panama Canal	13,570
Do	Via Suez Canal	8,409
Honolulu, Hawaii	Via Anegada Passage and Panama Canal	9,060
Do	Via Magellan Strait	12,748
Iquique, Chile	Via Anegada Passage and Panama Canal	6,362
Do	Via Magellan Strait	8,579
Lisbon, Portugal		304
Liverpool, England		1,294
Livorno (Leghorn), Italy		875
London, England		1,351
Malta (Valetta Harbor)		990
Manila, P. I.	Via Anegada Passage, Panama Canal, and San Bernardino Strait	13,745
Do	Via Anegada Passage, Panama Canal and Balintang Channel	13,722
Do	Via Suez, Aden, Colombo, Singapore, S. of Sokotra I.	8,372
Marseille, France		693
Naples, Italy		982
New York (The Battery), N. Y., U. S.	Winter; westbound	3,201
Do	Summer; westbound	3,207
Odessa, Russia	Via Messina Strait and Corinth Canal	2,170
Do	Via South of Sicily and Cervi and Duro Channels	2,171
Panama, C. Z.	Via Anegada Passage	4,375
Plymouth, England		1,060
Port Said, Egypt		1,925
Port Townsend, Wash., U. S. A.	Via Anegada Passage, Panama Canal and San Francisco	8,390
Do	Via Magellan Strait and San Francisco	13,341
Portland, Ore., U. S. A.	Via Anegada Passage, Panama Canal and San Francisco	8,270
Do	Via Magellan Strait and San Francisco	13,221
Punta Arenas, Chile		6,383
San Diego, Cal.	Via Anegada Passage and Panama Canal	7,218
Do	Via Magellan Strait	12,179
San Francisco, Cal.	Via Anegada Passage and Panama Canal	7,620
Do	Via Magellan Strait	12,571
San Jose, Guatemala	Via Anegada Passage and Panama Canal	5,261
Do	Via Magellan Strait	10,674
Sfax, Tunis		1,060
Sitka, Alaska	Via Anegada Passage, Panama Canal and San Francisco	8,922
Do	Via Magellan Strait and San Francisco	13,873

Gibraltar, to—	Route—	Nautical Miles
Smyrna, Turkey	Via Messina Strait and Corinth Canal	1,672
Do	Via South of Sicily and Cervi and Duro Channels	1,676
Sydney, Australia	Via Panama and Tahiti	12,169
Do	Via Suez Canal	10,237
Toulon, France		705
Trieste, Austria-Hungary		1,693
Tripoli, Tripoli		1,118
Valparaiso, Chile	Via Anegada Passage and Panama Canal	6,991
Do	Via Magellan Strait	7,816
Vancouver, B. C.	Via Anegada Passage and Panama Canal	8,407
Do	Via Magellan Strait	13,356
Wellington, New Zealand	Via Anegada Passage, Panama Canal and Tahiti	11,209
Do	Via Suez Canal	11,156
Yokohama, Japan	Via Anegada Passage and Panama Canal	12,057
Do	Via Anegada Passage, Panama Canal and San Francisco	12,156
Do	Via Suez, Hongkong, Shanghai and Van Diemen Strait	10,302
Do	Via Suez, Aden, Colombo and Singapore	9,907
Do	Via Suez Canal	9,859

GRAYS HARBOR

Grays Harbor, Wash., "Whistle Buoy," to—	Route—	Nautical Miles
Astoria, Oregon		53
Eureka, Humboldt Bay		371
Honolulu, Hawaii		2,281
Los Angeles Harbor (San Pedro), Cal.		972
Manila	Via Honolulu	7,084
Port Townsend, Wash.		179
San Francisco, Cal.		604
Seattle, Wash.		218
Tacoma, Wash.		243
Vancouver, B. C.		232
Victoria, B. C.		155
Willapa Harbor, Wash., "Whistle Buoy"		15½

HONOLULU

Honolulu, Hawaii, to—	Route—	Nautical Miles
Astoria, Ore., U. S. A.		2,246
Auckland, New Zealand		3,820
Brisbane Roads, Australia		4,169
Callao, Peru		5,161
Cape Horn, South America		6,472
Chimbote, Peru		5,015
Christmas I., N. Pacific Ocean		1,161
Dutch Harbor, Unalaska I., Alaska		2,046
Fanning Island		1,056
Guam (Port Apra), Marianas		3,337
Do	Via Tarawa I., Gilbert Is.	3,944
Gulf of Fonseca (Monypenny Point) Nicaragua		4,038
Hobart, Tasmania		4,930
Hongkong	Rhumb	4,939
Jaluit, Marshall Is.		2,096
Johnston I., Hawaii		717
Juan Fernandez I. (San Juan Bautista Bay)		5,595
Kusaie I., Caroline Is.		2,467
Laysan Island, H. I.		820
Levuka, Fiji Is.		2,730

Honolulu, Hawaii, to—	Route—	Nautical Miles
Los Angeles Harbor (San Pedro), Cal., U. S.		2,228
Magdalena Bay, Mexico		2,543
Manila, P. I.	Via north end of Luzon, P. I.	4,869
Do	Via Guam and north end of Luzon, P. I.	5,079
Do	Via Guam and San Bernardino Strait	4,838
Do	Via San Bernardino Strait	4,767
Marquesas Is., Nuku Hiva (Taiohae)		2,102
Marshall Is. (Eniwetok Atoll)		2,375
Melbourne, Australia	Via South Channel	4,942
Midway Is. (Welles Harbor)		1,149
New Hebrides (St. Philip and St. James Bay)		3,014
New York (The Battery), N. Y., U. S.	Via Magellan Strait	13,312
Do	Via Panama Canal, and Windward and Crooked I. Passages	6,702
Nonuti, Gilbert Is.		2,100
Noumea, New Caledonia		3,373
Nukonono, Union Is.		2,009
Pago Pago, Samoa Is.		2,276
Panama, C. Z.		4,685
Pelew Is. (Korror Harbor)		3,997
Petropavlovsk, Kamchatka		2,762
Point Conception, Cal., U. S. A.		2,126
Ponape, Caroline Is.		2,685
Port Lloyd, Ogasawa, Is.		3,283
Port Townsend, Wash., U. S. A.		2,366
Portland, Ore., U. S. A.		2,332
Punta Arenas, Chile		6,370
Raoul I., Kermadec Is.		3,246
Rarotonga, Cook Is.		2,553
Salina Cruz, Mexico		3,580
San Bernardino Strait (Entr.), P. I.		4,457
San Diego, Cal., U. S. A.		2,278
San Francisco, Cal., U. S. A.		2,091
Sandakan, Borneo		5,044
Seattle, Wash., U. S. A.		2,409
Sitka, Alaska		2,386
Sydney, Australia		4,420
Tahiti (Papeete), Society Is.		2,381
Tarawa Island, Gilbert Is.		2,100
Tongatabu (Nukualofa), Tonga Is.		2,749
Ugi I. (Selwyn Bay), Solomon Is.		3,047
Valparaiso, Chile		5,919
Vancouver, B. C.		2,423
Victoria, British Columbia		2,349
Vladivostok, Siberia		3,725
Wake Island		2,004
Wellington, New Zealand		4,113
Yap (Tomill Harbor), Caroline Is.		3,757
Yokohama, Japan	Rhumb	3,445
Do	Great Circle	3,394

IQUIQUE

Iquique, Chile, to—	Nautical Miles
Antofagasta, Chile	224
Caldera, Chile	420
Coquimbo, Chile	602
Lota, Chile	1,033
Punta Arenas, Chile	2,201
Talcahuano, Chile	1,008
Valdivia (P. Corral), Chile	1,205
Valparaiso, Chile	782
Yokohama, Japan	9,026

Liverpool, England, to—	Route—	Nautical Miles
Acapulco, Mexico	Via Panama Canal	6,017
Do	Via Magellan Strait	11,891
Adelaide, Australia	Via Panama, Tahiti, Sydney and Melbourne	13,478
Do	Via Suez Canal, Aden, Colombo and King George Sound	11,108
Aden, Arabia	Via Suez Canal	4,608
Baltimore, Md., U. S. A.	Winter; westbound	3,373
Do	Summer; westbound	3,454
Boston, Mass., U. S. A.	Winter; westbound	2,895
Do	Summer; westbound	3,010
Buenos Aires, Argentina		6,243
Callao, Peru	Via Panama Canal	5,937
Do	Via Magellan Strait	9,980
Cape Town, Africa		6,080
Colombo, Ceylon	Via Suez Canal, south of Sokotra I.	6,694
Colon, C. Z.	Via Mona Passage	4,548
Coronel, Chile	Via Panama Canal	7,413
Do	Via Magellan Strait	8,502
Disko (Godhavn), Greenland		2,137
Funchal, Madeira		1,428
Galveston, Texas, U. S. A.	Winter; westbound; via NE. Providence Channel and south of Dry Tortugas	4,749
Do	Summer; westbound; via NE. Providence Channel and south of Dry Tortugas	4,766
Gibraltar		1,294
Guayaquil (Puna), Ecuador	Via Panama Canal	5,384
Do	Via Magellan Strait	10,582
Hongkong	Via Panama and direct	13,764
Do	Via Panama, San Francisco and Yokohama	13,957
Do	Via Suez Canal, Aden, Colombo and Singapore	9,743
Do	Via Magellan Strait, Pago Pago and Guam	17,432
Honolulu, Hawaii	Via Panama Canal	9,276
Do	Via Magellan Strait	13,679
Iquique, Chile	Via Panama Canal	6,578
Do	Via Magellan Strait	9,510
Ivigtut, Greenland		1,621
Kinchow, Kwantung Bay, China	Via Suez Canal	10,924
Las Palmas, Canary Is.		1,661
Manila, P. I.	Via Magellan Strait, Pago Pago and Guam	17,111
Do	Via Panama Canal and San Bernardino St.	13,961
Do	Via Panama, San Francisco and Yokohama	14,129
Do	Via Suez Canal, Aden, Colombo and Singapore	9,659
Do	Via Suez Canal, Colombo and Singapore	9,649
Melbourne, Australia	Via Cape of Good Hope	12,137
Do	Via Cape Town	12,157
Do	Via Panama Canal	12,519
Do	Via Suez Canal	11,084
Do	Via Panama, Tahiti and Sydney	12,966
Do	Via Suez Canal, Aden, Colombo, King George Sound and Adelaide	11,620
Mobile, Alabama, U. S. A.	Winter; westbound; via NE. Providence Channel and south of Dry Tortugas	4,520
Do	Summer; westbound; via NE. Providence Channel and south of Dry Tortugas	4,537
New Orleans, La., U. S. A.	Winter; westbound; via NE. Providence Channel, south of Dry Tortugas and SW. Pass	4,589
Do	Summer; westbound; via NE. Providence Channel, south of Dry Tortugas and SW. Pass	4,606

Liverpool, England, to—	Route—	Nautical Miles
New York (The Battery), N. Y., U. S.	Winter; westbound	3,073
Do	Summer; westbound	3,171
Newport News, Va., U. S. A.	Winter; westbound	3,249
Do	Summer; westbound	3,330
Panama, C. Z.	Via Mona Passage	4,591
Pensacola, Fla., U. S. A.	Winter; westbound; via NE. Providence Channel and south of Dry Tortugas	4,480
Do	Summer; westbound; via NE. Providence Channel and south of Dry Tortugas	4,497
Pernambuco, Brazil	Direct	4,062
Do	Via Scilly Is. (St. Marys Anch.)	4,078
Philadelphia, Pa., U. S. A.	Winter; westbound	3,226
Do	Summer; westbound	3,324
Port Nelson, Saskatchewan, Canada		3,009
Port Townsend, Wash., U. S. A.	Via Panama and San Francisco	8,606
Do	Via Magellan Strait and San Francisco	14,272
Portland, Ore., U. S. A.	Via Panama and San Francisco	8,486
Do	Via Magellan Strait and San Francisco	14,152
Punta Arenas, Chile	Direct	7,314
Do	Via Scilly Is. (St. Marys Anch.)	7,329
St. Thomas, W. I.		3,574
San Diego, Cal., U. S. A.	Via Panama Canal	7,434
Do	Via Magellan Strait	13,110
San Francisco, Cal., U. S. A.	Via Panama Canal	7,836
Do	Via Magellan Strait	13,502
San Jose, Guatemala	Via Panama Canal	5,477
Do	Via Magellan Strait	11,605
San Juan del Norte, Nicaragua	Via Mona Passage	4,683
Do	Via Windward Passage	4,605
Scilly Is. (St. Marys Anch.)		291
Shanghai, China	Via Panama Canal, Apia and Guam	15,068
Do	Via Panama Canal and Honolulu	13,606
Do	Via Suez Canal, Aden, Colombo, Singapore and Hongkong	10,595
Singapore, Straits Settlements	Via Suez Canal	8,241
Sitka, Alaska	Via Panama and San Francisco	9,138
Do	Via Magellan Strait and San Francisco	14,804
Sydney, Australia	Via Panama and Tahiti	12,385
Do	Via Suez Canal, Aden, Colombo, King George Sound, Adelaide and Melbourne	12,201
Tientsin, China	Via Panama, San Francisco and Yokohama	13,837
Do	Via Suez Canal, Aden, Colombo, Singapore, Hongkong and Shanghai	11,335
Do	Via Suez Canal, Colombo and Singapore	11,103
Valparaiso, Chile	Via Panama Canal	7,207
Do	Via Magellan Strait	8,747
Vancouver, British Columbia	Via Panama Canal	8,623
Do	Via Magellan Strait	14,287
Vigo, Spain		786
Vladivostok, Siberia	Via Suez Canal, Colombo and Singapore	11,282
Wellington, New Zealand	Via Cape Town	13,353
Do	Via Panama Canal and direct	11,096
Do	Via P. nama and Tahiti	11,425
Do	Via Suez Canal, Aden, Colombo, King George Sound and Melbourne	12,955
Do	Via Suez Canal and direct	12,462
Yokohama, Japan	Via Magellan Strait and Pago Pago	16,584
Do	Via Panama Canal and direct	12,273
Do	Via Panama and San Francisco	12,372
Do	Via Suez Canal, Aden, Colombo, Singapore, Hongkong and Shanghai	11,636

LONDON

London, England, to—	Route—	Nautical Miles
Baltimore, Md., U. S. A.	Winter; westbound	3,610
Do	Summer; westbound	3,681
Bishops Rock (lat. 49° 50′ N., long. 6° 27′ W.)		407
Boston, Mass., U. S. A.	Winter; westbound	3,132
Do	Summer; westbound	3,237
Cape Town, Africa		6,139
Christiana, Norway		658
Copenhagen, Denmark		704
Danzig, Germany	Via Kiel Canal	760
Do	Via Skagerrak	1,078
Gibraltar		1,351
Havre, France		203
Helsingfors, Finland	Via Kiel Canal	1,064
Hongkong	Via Suez Canal	9,749
Lisbon, Portugal		1,062
Melbourne, Australia	Via Panama	12,734
New York (The Battery), N. Y., U. S.	Winter; westbound	3,310
Do	Summer; westbound	3,398
Newport News, Va., U. S. A.	Winter; westbound	3,486
Do	Summer; westbound	3,557
Pernambuco, Brazil		4,136
Petrograd, Russia		1,519
Do	Via Kiel Canal	1,209
Philadelphia, Pa., U. S. A.	Winter; westbound	3,463
Do	Summer; westbound	3,551
Plymouth, England		321
Port Arthur, Texas, U. S. A.	Winter; westbound; via NE. Providence Channel and south of Dry Tortugas	4,963
Do	Summer; westbound; via NE. Providence Channel and south of Dry Tortugas	4,970
Riga, Russia	Via Kiel Canal	988
Southampton, England		215
Stockholm, Sweden		1,251
Sydney, Australia	Via Cape of Good Hope	12,663
Do	Via Suez Canal	11,603
Tornea, Russia		1,659

LOS ANGELES HARBOR (San Pedro)

Los Angeles Harbor (San Pedro), Cal., U. S., to—	Route—	Nautical Miles
Adelaide, Australia		7,420
Antofagasta, Chile		4,430
Arica, Chile		4,219
Auckland, New Zealand		5,658
Bankok, Siam	Via San Bernardino Strait	7,957
Batavia, Java	Via Makassar Strait	7,917
Bombay, India	Via Makassar Strait	10,639
Brisbane, Australia		6,260
Buenos Aires, Argentina	Via Panama Canal	8,406
Calaca, P. I.		6,537
Callao, Peru		3,655
Colombo, Ceylon		9,756
Colon, C. Z.	Via Panama Canal	2,956
Freemantle, Australia		8,525
Guayaquil, Ecuador		3,182
Hakadote, Japan		4,576
Hongkong, China		6,507
Honolulu, Hawaii		2,228
Kobe, Japan		5,185
Manila, P. I.	North of Luzon I.	6,530
Do	Via Honolulu and San Bernardino Strait	6,995
Do	Via San Bernardino Strait	6,588

Los Angeles Harbor (San Pedro), Cal., U. S. to—	Route—	Nautical Miles
Melbourne, Australia		7,032
Mollendo, Peru		4,094
Monterey, Cal.		288
Nagasaki, Japan	Via Yokohama	5,572
Newcastle, Australia		6,456
Noumea, New Caledonia		5,521
Pago Pago, Samoa		4,163
Paita, Peru		3,191
Panama, C. Z.		2,913
Perth, Australia		8,540
Portland, Ore., U. S. A.		989
Punta Arenas, Costa Rica		2,499
Rio de Janeiro, Brazil	Via Panama Canal	7,305
Saigon, China		7,403
Salina, Cruz, Mexico		1,803
San Diego, Cal., U. S. A.		97
San Francisco, Cal., U. S. A.		368
Santa Cruz, Cal., U. S. A.		295
Shanghai, China	Via Yokohama	5,956
Singapore, Straits Settlements	Via San Bernardino Strait	7,866
Surabaya, Java	Via Makassar Strait	7,622
Sydney, Australia		6,511
Tahiti, Society Islands		3,571
Tientsin, China	Via Yokohama	6,221
Tsingtau, China	Via Yokohama	6,025
Valparaiso, Chile		4,808
Victoria, B. C.		1,091
Vladivostok, Siberia		4,991
Wellington, New Zealand		5,858
Yokohama, Japan		4,839

MANILA

Manila, P. I., to—	Route—	Nautical Miles
Batavia, Java	Via Palawan Passage	1,559
Borongan, Samar, P. I.		435
Bremen, Germany	Via Suez Canal and Singapore	9,955
Brisbane Roads, Australia	Via Mindoro and Torres Straits and inside route	3,552
Cairns, Australia	Via Mindoro and Torres Straits and inside route	2,723
Cebu, P. I.	Via Verde I. and Jintotolo Passages	391
Colombo, Ceylon		2,952
Friederich Wilhelmshafen, Papua	Via San Bernardino Strait	2,011
Guam (Port Apa), Marianas	Via north end of Luzon, P. I.	1,742
Do	Via San Bernardino Strait	1,501
Honolulu, Hawaii	Via north end of Luzon, P. I.	4,869
Do	Via San Bernardino Strait	4,767
Do	Via north end of Luzon, P. I. and Guam	5,079
Iloilo, P. I.	Via Verde I. and Jintotolo Passages	361
Jolo, Jolo I., P. I.	Via West Apo Channel	550
Limay, Luzon, P. I.		22
Liverpool, England	Via Singapore, Colombo and Suez Canal	9,649
Do	Via Guam, Pago Pago and Magellan Strait	17,111
London, England	Via Suez Canal	9,656
Mangarin, Mindoro, P. I.		170
Melbourne, Australia	Via Mindoro and Torres Straits and inside route	4,528
Moji, Japan		1,436
Newcastle, Australia	Via Mindoro and Torres Straits and inside route	3,917
Olongapo, Luzon, P. I.		64
Pago Pago, Samoa Is.	Via San Bernardino Strait	4,505
Panama, C. Z.	Via Balintang Channel and Cape San Lucas	9,347
Do	Via San Bernardino Strait	9,370

Manila, P. I., to—	Route—	Nautical Miles
Pelew Is. (Korror Harbor)	Via Verde I. Passage and between Maranjos Gr. and Copul I.	1,044
Port Darwin, Australia	Via Mindoro, Basilan, Banka and Manipa Straits	1,834
Port Townsend, Wash., U. S. A.	Composite Great Circle	5,931
Rabaul, Neu Pommern	Via San Bernardino Strait	2,281
Saigon, Cochin-China		907
San Francisco, Cal., U. S. A.	Via Balintang Channel	6,221
Do	Via San Bernardino Strait	6,301
Seattle, Wash., U. S. A.	Via Yokohama	6,012
Do	Via San Bernardino Strait, Guam and Honolulu	7,247
Singapore, Straits Settlements		1,370
Southampton, England	Via Singapore and Suez Canal	9,488
Sydney, Australia	Via Mindoro and Torres Straits and inside route	3,967
Torres Strait (Thursday Island)	Via Mindoro Strait	2,227
Townsville, Australia	Via Mindoro and Torres Straits and inside route	2,881
Wake Island	Via San Bernardino Strait	2,772
Wyndham, Australia	Via Mindoro, Basilan, Banka and Manipa Straits	1,982
Yap I. (Tomill Harbor), Caroline Is.	Via San Bernardino Strait	1,154
Yokohama, Japan	Via Balintang Channel	1,757
Do	Via Hongkong, Shanghai, Nagasaki, Inland Sea and Kobe	2,683
Zamboanga, Mindanao, P. I.	Via East Apo Channel	532

NEWPORT NEWS, VA., U. S. A.

As the distance between Newport News, Va., and Norfolk, Va., is only three miles, use the Norfolk table as it is close enough for all practical purposes.

NORFOLK

Norfolk, Va., U. S. A., to—	Route—	Nautical Miles
Acapulco, Mexico	Via Panama Canal	3,248
Do	Via Magellan Strait	11,476
Adelaide, Australia	Via Panama, Tahiti, Sydney and Melbourne	10,709
Do	Via St. Vincent and Cape Town	12,709
Algiers, Algeria		3,784
Amsterdam, Netherlands	Winter; eastbound	3,575
Do	Summer, eastbound	3,659
Antwerp, Belgium	Winter; eastbound	3,551
Do	Summer; eastbound	3,635
Baltimore, Md., U. S. A.		172
Barcelona, Spain	Great Circle C. Charles Lightvessel to C. St. Vincent	3,881
Belize, British Honduras	Via Straits of Florida; southbound; outside	1,503
Bocas del Toro, Panama	Via Crooked I. and Windward Passages	1,853
Boston, Mass., U. S. A.	Via Vineyard South and Pollock Rip Slue	518
Bremen, Germany	Winter; eastbound	3,793
Do	Summer; eastbound	3,877
Buenos Aires, Argentina		5,824
Callao, Peru	Via Panama Canal	3,168
Do	Via Magellan Strait	9,565
Cartagena, Colombia	Via Crooked I. and Windward Passages	1,658
Colombo, Ceylon	Great Circle, C. Charles Lightvessel to C. St. Vincent	8,769
Colon, C. Z.	Via Crooked I. and Windward Passages	1,779
Constantinople, Turkey		5,188
Copenhagen, Denmark	Winter; eastbound	4,093
Do	Summer; eastbound	4,177
Coronel, Chile	Via Magellan Strait	8,087
Do	Via Panama Canal	4,644
Funchal, Madeira		2,907

Norfolk, Va., U. S. A., to—	Route—	Nautical Miles
Genoa, Italy	Great Circle, C. Charles Lightvessel to C. St. Vincent	4,222
Georgetown, British Guiana		2,090
Georgetown, S. C., U. S. A.		388
Gibraltar	Great Circle, C. Charles Lightvessel to C. St. Vincent	3,369
Guam (Port Apra), Marianas	Via Magellan Strait	14,921
Do	Via Panama Canal	9,810
Do	Via Suez Canal and Sunda Strait	13,234
Guayaquil (Puna), Ecuador	Via Panama Canal	2,615
Do	Via Magellan Strait	10,167
Habana, Cuba	Southbound; outside	985
Halifax, Nova Scotia		790
Hamburg, Germany	Winter; eastbound	3,813
Do	Summer; eastbound	3,897
Hampton Roads (off light), Va., U. S.		11
Hongkong	Via Panama, San Francisco, Yokohama and Shanghai	11,496
Do	Via Panama, Honolulu, Yokohama and Shanghai	11,794
Hongkong	Via Panama, Honolulu, Guam and Manila	11,976
Do	Via Suez Canal, Colombo and Singapore	11,808
Honolulu, Hawaii	Via Panama Canal	6,507
Do	Via Magellan Strait	13,264
Iquique, Chile	Via Panama Canal	3,809
Do	Via Magellan Strait	9,095
Key West, Fla., U. S. A.	Outside; southbound	927
Kingston, Jamaica	Via Crooked I. and Windward Passages	1,279
Las Palmas, Canary Is.		3,130
Liverpool, England	Winter; eastbound	3,272
Do	Summer; eastbound	3,367
Livingston, Guatemala	Via Straits of Florida; southbound; outside	1,595
London, England	Winter; eastbound	3,506
Do	Summer; eastbound	3,590
Malta (Valetta Harbor)		4,352
Manila, P. I.	Via Panama, San Francisco and Yokohama	11,360
Do	Via Panama, Honolulu, Yokahama, Shanghai and Hongkong	12,425
Do	Via Panama, Honolulu and Yokohama	11,658
Do	Via Panama, Honolulu and Guam	11,345
Do	Via Suez Canal, Colombo and Singapore	11,724
Marseille, France		4,057
Melbourne, Australia	Via Panama, Tahiti and Sydney	10,197
Do	Via St. Vincent, Cape Town and Adelaide	13,221
New York (The Battery), N. Y., U. S.		292
Panama, C. Z.	Via Crooked I. and Windward Passages	1,822
Philadelphia, Pa., U. S. A.		260
Ponta Delgada, Azores		2,408
Port Antonio, Jamaica	Via Crooked I. and Windward Passages	1,228
Port Banes, Cuba	Via Crooked I. Passage	1,018
Port Castries, W. I.		1,620
Port Limon, Costa Rica	Via Crooked I. and Windward Passages	1,852
Port Said, Egypt		5,287
Port Townsend, Wash., U. S. A.	Via Panama and San Francisco	5,837
Do	Via Magellan Strait and San Francisco	13,857
Portland, Ore., U. S. A.	Via Panama and San Francisco	5,717
Do	Via Magellan Strait and San Francisco	13,737
Preston, Cuba	Via Crooked I. Passage	1,021
Providence, R. I., U. S. A.		398
Puerto Barrios, Guatemala	Via Straits of Florida; southbound; outside	1,603
Puerto Cortes, Honduras	Via Straits of Florida; southbound; outside	1,568
Puerto Mexico, Mexico		1,743
Punta Arenas, Chile	East of South America	6,900
Do	Via Panama Canal	5,765

NORFOLK—Continued

Norfolk, Va., U. S. A., to—	Route—	Nautical Miles
Quebec, Canada		1,515
Queenstown, Ireland	Winter; eastbound	3,041
Do	Summer; eastbound	3,136
Rio de Janeiro, Brazil		4,723
Rotterdam, Netherlands	Winter; eastbound	3,552
Do	Summer; eastbound	3,636
St. Thomas, W. I.		1,296
St. Vincent (Porto Grande), C. Verde Is.		2,973
San Diego, Cal., U. S. A.	Via Panama Canal	4,665
Do	Via Magellan Strait	12,695
San Francisco, Cal., U. S. A.	Via Panama Canal	5,067
Do	Via Magellan Strait	13,087
San Jose, Guatemala	Via Panama Canal	2,708
Do	Via Magellan Strait	11,190
San Juan, Porto Rico		1,252
San Juan del Norte [Greytown], Nicaragua	Via Crooked I, and Windward Passages	1,837
Do	Via Straits of Florida; southbound; outside	1,846
Santa Marta, Colombia	Via Crooked I. and Windward Passages	1,588
Savannah, Ga., U. S. A.		499
Shanghai, China	Via Panama, San Francisco and Tsugaru Strait	10,454
Do	Via Panama, Honolulu and Yokohama	10,942
Do	Via Suez Canal, Colombo, Singapore and Hongkong	12,660
Sitka, Alaska	Via Panama and San Francisco	6,369
Do	Via Magellan Strait and San Francisco	14,389
Sydney, Australia	Via Panama and Tahiti	9,616
Do	Via St. Vincent, Cape Town, Adelaide and Melbourne	13,802
Valparaiso, Chile	Via Panama Canal	4,438
Do	Via Magellan Strait	8,332
Vera Cruz, Mexico		1,794
Washington, D. C., U. S. A.	Inside Tail of Horseshoe Lightvessel	173
Do	Outside Tail of Horseshoe Lightvessel	187
Wellington, New Zealand	Via Panama and Tahiti	8,656
Do	Via Magellan Strait	11,296
Do	Via St. Vincent, Cape Town and Melbourne	14,500
Wilmington, N. C., U. S. A.		358
Yokohama, Japan	Via Panama and San Francisco	9,603
Do	Via Panama and Honolulu	9,901
Do	Via Suez, Colombo, Singapore, Hongkong and Shanghai	13,701

PAITA

Paita, Peru, to—	Nautical Miles
Antofagasta, Chile	1,299
Apia, Samoa Is.	5,365
Arica, Chile	1,080
Caldera, Chile	1,461
Callao, Peru	505
Coquimbo, Chile	1,609
Honolulu, Hawaii	4,725
Iquique, Chile	1,146
Lota, Chile	1,983
Mollendo, Peru	955
Pascasmayo, Peru	201
Pisco, Peru	617
Punta Arenas, Chile	3,101
Tahiti (Papeete), Society Is.	4,082
Talcahuano, Chile	1,963
Valdivia (Port Corral), Chile	2,141
Valparaiso, Chile	1,774

Panama Roads, Canal Zone, to—	Route—	Nautical Miles
Acajutla, Salvador		833
Acapulco, Mexico		1,426
Amapala, Honduras		745
Antofagasta, Chile		2,140
Antwerp, Belgium	Via Mona Passage	4,851
Apalachicola, Florida, U. S. A.		1,330
Apia, Samoa Is.		5,710
Arica, Chile		1,921
Auckland, New Zealand		6,512
Baltimore, Md., U. S. A.	Via Windward and Crooked I. Passages	1,944
Barbados (Bridgetown), W. I.		1,280
Belize, British Honduras		859
Bishops Rock (lat. 49° 50′ N., long. 6° 27′ W.)	Via Anegada Passage	4,438
Do	Via Mona Passage	4,399
Blanche Bay, Neu Pommern		7,807
Bluefields, Nicaragua		319
Bocas del Toro, Panama		187
Bombay, India	Via San Bernardino Strait	12,957
Bordeaux, France	Via Mona Passage	4,641
Boston, Mass., U. S. A.	Via Windward and Crooked I. Passages and outside Nantucket Lightvessel	2,200
Brunswick, Ga., U. S. A.	Via Windward and Crooked I. Passages	1,593
Buenaventura, Colombia		352
Calcutta, India	Via San Bernardino Strait	12,148
Caldera, Chile		2,302
Caleta Buena (Buena Cove), Chile		1,977
Callao, Peru		1,346
Campeche, Mexico		1,210
Cape Engano, Luzon I., P. I.		8,965
Cape Haitien, Haiti		860
Cape San Lucas, Mexico		2,100
Caragues River, Ecuador		571
Carmen, Mexico		1,289
Cartagena, Colombia		324
Ceiba, Honduras		709
Charleston, S. C., U. S. A.	Via Windward and Crooked I. Passages	1,607
Chimbote, Peru		1,158
Christmas I., N. Pacific Ocean		4,752
Cienfuegos, Cuba		815
Colombo, Ceylon	Via San Bernardino Strait and Iloilo	12,087
Coquimbo, Chile		2,451
Corinto, Nicaragua		683
Coronel, Chile		2,822
Curacao (Santa Ana Harbor), W. I.		742
Dutch Harbor, Alaska		5,245
Enderbury I., Phoenix Is.		5,599
Esmeraldas, Ecuador		474
Eten Head, Peru		1,012
Fakarava, Tuamotu Archipelago		4,256
Fort de France, Martinique, W. I.		1,202
Funafuti I., Ellice Is.		6,217
Galapagos Is., San Cristobal I. (Wreck Bay)		864
Galveston, Texas, U. S. A.		1,536
Gibraltar	Via Anegada Passage	4,375
Do	Via St. Thomas, W. I.	4,386
Gracias a Dios, Nicaragua		442
Grijalva [Tabasco R.], Mexico		1,323
Guam (Port Apra), Marianas		7,988
Guantanamo Bay (Caimanera), Cuba		739
Guayaquil (Puna), Ecuador		793
Guaymas, Mexico		2,370
Gulfport, Miss., U. S. A.	Northbound	1,431

Panama Roads, Canal Zone, to—	Route—	Nautical Miles
Havana, Cuba		1,046
Hakodate, Japan		7,418
Halifax, N. S.	Via Windward and Crooked I. Passages	2,360
Hamburg, Germany	Via Mona Passage, direct	5,113
Do	Via St. Thomas, W. I.	5,158
Hampton Roads (off light), Va., U. S.	Via Windward and Crooked I. Passages	1,811
Havre, France	Via Mona Passage	4,653
Hilo, Hawaii		4,527
Hongkong, China		9,195
Honolulu, Hawaii		4,685
Iquique, Chile		1,987
Iriona, Honduras		609
Jacksonville, Fla., U. S. A.	Via Windward and Crooked I. Passages	1,559
Jaluit, Marshall Is.		6,666
Johnston I., Hawaii		5,359
Junin, Chile		1,967
Key West, Fla., U. S. A.		1,108
Kingston, Jamaica, W. I.		594
Kiska I., Alaska		5,819
Kusaie I. (Lollo Hbr.), Caroline Is.		7,059
La Guaira, Venezuela		884
La Union, Salvador		748
Levuka, Fiji Is.		6,288
Libertad Anch., Sonora, Mexico		2,534
Liverpool, England	Via Mona Passage	4,591
Livingston, Guatemala		815
Los Angeles Hbr. (San Pedro), Cal., U.S.		2,913
Lota, Chile		2,825
Magdalena Bay, Mexico		2,265
Manila, P. I.	Via Cape San Lucas and Balintang Channel	9,347
Do	Via San Bernardino Strait	9,370
Manta Bay, Ecuador		594
Marquesas Is., Naku Hiva (Taiohae)		3,826
Marshall Is., (Eniwetok Atoll)		7,041
Matagorda Bay (Entr), Texas, U. S. A.		1,558
Mazatlan, Mexico		2,006
Mejillones Del Sur, Chile		2,109
Melbourne, Australia	Via Foveaux Strait	7,928
Midway Is. (Welles Harbor)		5,707
Mobile, Ala., U. S. A.	Northbound	1,436
Mollendo, Peru		1,796
Monkey Pt. Harbor, Nicaragua		302
Montreal, Canada	Via Windward and Crooked I. Passages and Gut of Canso	3,203
Naples, Italy	Via Anegada Passage	5,351
New Hebrides (St. Philip and St. James Bay)		6,956
New Orleans, La., U. S. A.	Via South Pass; northbound	1,446
Do	Via Southwest Pass; northbound	1,453
New York (The Battery), N. Y., U. S.	Via Windward and Crooked I. Passages	2,017
Newport News, Va., U. S. A.	Via Windward and Crooked I. Passages	1,819
Nonuti I., Gilbert Is.		6,439
Norfolk, Va., U. S. A.	Via Windward and Crooked I. Passages	1,822
Noumea, New Caledonia		6,982
Nukonono, Union Is.		5,688
Pacasmayo, Peru		1,040
Pago Pago, Samoa Is.		5,656
Paita, Peru		857
Pelew Is. (Korror Harbor)		8,674
Pensacola, Fla., U. S. A.	Northbound	1,412
Philadelphia, Pa., U. S. A.	Via Windward and Crooked I. Passages	1,989
Pisagua, Chile		1,962
Pisco, Peru		1,458
Plymouth, England	Via St. Thomas, W. I.	4,543

Panama Roads, Canal Zone, to—	Route—	Nautical Miles
Point a Pitre, Guadeloupe, W. I.		1,211
Ponape, Caroline Is.		7,321
Port Arthur, Texas, U. S. A.		1,528
Port au Prince, Haiti		817
Port Castries, S. Lucia, W. I.		1,203
Port Limon, Costa Rica		235
Port Lloyd, Ogasawara Is.		7,766
Port Morelos, Yucatan		871
Port Royal, Jamaica, W. I.		589
Port of Spain, Trinidad, W. I.		1,202
Port Taltal, Chile		2,225
Port Tampa, Fla., U. S. A.		1,255
Port Townsend, Wash., U. S. A.		3,985
Portland, Me., U. S. A.	Via Windward and Crooked I. Passages; outside Nantucket Lightvessel	2,241
Portland, Ore., U. S. A.		3,869
Prince Rupert, B. C.		4,425
Puerto Barrios, Guatemala		823
Puerto Cabello, Venezuela		845
Puerto Cortes, Honduras		776
Puerto Mexico, Mexico		1,420
Punta Arenas, Chile		3,943
Punta Arenas, Costa Rica		471
Quebec, Canada	Via Windward and Crooked I. Passages and Gut of Canso	3,065
Raoul I. (East Anch.), Kermadec Is.		6,125
Rarotonga I. (Avarua Harbor)		5,095
Rio de Janeiro, Brazil		4,392
Rio Grande (Entr.)		1,527
Roatan I. (Coxen Hole)		684
Sabine, Texas, U. S. A.		1,519
Seattle, Wash., U. S. A.		4,021
St. Thomas, W. I.		1,072
Salaverry, Peru		1,109
Salina Cruz, Mexico		1,170
San Bernardino Strait (Entr.), P. I.		9,060
San Blas, Mexico		1,914
San Diego, Cal., U. S. A.		2,843
San Francisco, Cal., U. S. A.		3,245
San Jose, Guatemala		886
San Juan, P. R.		1,036
San Juan del Norte, Nicaragua		289
San Juan del Sur, Nicaragua		590
Santa Barbara, Cal., U. S. A.		2,980
Santo Domingo, Dominican Rep.		845
Savannah, Ga., U. S. A.	Via Windward and Crooked I. Passages	1,606
Seattle, Wash., U. S. A.		4,021
Shanghai, China	Via Honolulu	9,015
Do	Via Osumi [Van Diemen] Strait	8,650
Do	Via Tsugaru Strait	8,556
Singapore, Straits Settlements	Via San Bernardino Strait	10,505
Southport, N. C., U. S. A.	Via Windward and Crooked I. Passages	1,635
Strait of Gibraltar (lat. 35° 57′ N., long. 5° 45′ W.)	Via Anegada Passage	4,351
Sydney, Australia		7,674
Tacoma, Wash., U. S. A.		4,041
Tahiti (Papeete), Society Is.		4,486
Talcahuano, Chile		2,805
Tampico, Mexico		1,528
Tela, Honduras		749
Tocopilla, Chile		2,068
Tongatabu (Nukualofa), Tonga Is.		5,953
Trujillo, Honduras		665
Tumaco, Colombia		422
Tuxpam, Mexico		1,498

Panama Roads, Canal Zone, to—	Route—	Nautical Miles
Ugi I. (Selwyn Bay, Solomon Is.		7,248
Uracas I., Marianas		7,797
Valdivia (P. Corral), Chile		2,983
Valparaiso, Chile		2,616
Vancouver, B. C.		4,032
Vera Cruz, Mexico		1,463
Victoria, B. C.		3,962
Vladivostok, Siberia	Via Tsugaru Strait	7,833
Wellington, New Zealand		6,505
Yap I. (Tomill Hbr.), Caroline Is.		8,430
Yokohama, Japan	Via Cape San Lucas and G. C.	7,682
Do	Via Mazatlan	7,788
Do	Via San Francisco	7,781

PORT TOWNSEND

Port Townsend, Wash., U. S., to—	Route—	Nautical Miles
Amoy, China	Via Tsugaru Strait and Composite route	5,450
Do	Via Osumi (Van Diemen) Strait and Composite route	5,477
Do	Via Unimak Passage and Tsugaru St.	5,442
Do	Via Unimak Passage, Amphitrite Straits and La Perouse	5,434
Antwerp, Belgium	Via San Francisco and Panama Canal	8,866
Do	Via San Francisco and Magellan Strait	14,391
Apia, Samoa Is.		4,577
Auckland, New Zealand		6,134
Baltimore, Md., U. S. A.	Via San Francisco and Panama Canal	5,959
Do	Via San Francisco and Magellan Strait	13,979
Batavia, Java	Via Balintang Channel and Composite route	7,323
Blanche Bay, Neu Pommern		5,462
Bordeaux, France	Via San Francisco and Panama Canal	8,656
Do	Via San Francisco and Magellan Strait	14,032
Boston, Mass., U. S. A.	Via San Francisco and Panama Canal	6,215
Do	Via San Francisco and Magellan Strait	13,876
Calcutta, India	Via Rhumb to Yokohama	8,970
Canton, China	Via Osumi (Van Diemen) Strait and Composite route	5,814
Do	Via Tsugaru St. and Composite route	5,792
Do	Via Unimak Passage and Tsugaru St.	5,764
Cape Ergano, Luzon I., P. I.		5,515
Cebu, Cebu Island, P. I.		5,870
Charleston, S. C., U. S. A.	Via San Francisco and Panama Canal	5,622
Do	Via San Francisco and Magellan Strait	13,856
Chefoo, China	Via Tsugaru St. and Composite route	5,102
Do	Via Unimak Passage and Tsugaru Strait	5,074
Do	Via Osumi (Van Diemen) Strait	5,340
Do	Via Unimak Passage, Amphitrite and La Perouse	5,084
Christmas Island, N. Pacific Ocean		3,344
Colombo, Ceylon	Via Balintang Channel, Malakka Straits and Composite route	8,616
Comox, B. C.	Via Active Passage	145
Dutch Harbor, Unalaska I., Alaska		1,670
Enderbury I., Phoenix Is.		4,012
Fakarava I., Tuamotu Archipelago		4,120
Foochow, China	Via Osumi (Van Diemen) Strait and Composite route	5,364
Do	Via Tsugaru St. and Composite route	5,328
Do	Via Unimak Passage and Tsugaru St.	5,300
Do	Via Unimak Passage, Amphitrite Straits and La Perouse	5,313

Port Townsend, Wash., U. S., to—	Route—	Nautical Miles
Funafuti I., Ellice Is.		4,692
Galapagos Is., San Cristobol I., (Wreck Bay)		3,734
Galveston, Texas	Via San Francisco and Panama Canal	5,551
Do.	Via San Francisco and Magellan Strait	14,497
Gibraltar	Via San Francisco, Panama Canal and Anegada Passage	8,390
Do	Via San Francisco and Magellan Strait	13,341
Guam (Port Apra) Marianas		4,913
Hakodate, Japan	Composite	3,915
Do	Via Unimak Passage	3,887
Hamburg, Germany	Via San Francisco, Panama and Mona Passage	9,128
Do	Via San Francisco and Magellan Strait	14,653
Hongkong	Via Osumi (Van Diemen) Strait and Composite route	5,731
Do	Via Rhumb to Yokohama	5,992
Do	Via Tsugaru Strait and Composite route	5,709
Do	Via Unimak Passage and Tsugaru Strait	5,681
Honolulu, Hawaii		2,366
Iloilo, P. I.		5,892
Jacksonville, Florida, U. S. A.	Via San Francisco and Panama Canal	5,574
Do	Via San Francisco and Magellan Strait	13,875
Jaluit, Marshall Is.		4,259
Jinsen (Chemulpo)	Via Unimak Passage, Amphitrite Straits and La Perouse	4,977
Do	Via Unimak Passage and Tsugaru Strait	4,967
Do	Via Tsugaru St. and Composite route	4,995
Do	Via Osumi (Van Diemen) Strait	5,242
Johnson Island, Hawaii		2,978
Kiska I. (Kiska Harbor), Alaska	Via Unimak Passage	2,257
Kobe, Japan	Composite	4,500
Kodiak, Alaska		1,229
Kusaie I. (Lollo Harbor), Caroline Is.		4,542
Levuka, Fiji Is.		5,083
Liverpool, England	Via San Francisco and Panama Canal	8,606
Do	Via San Francisco and Magellan St.	14,272
Manila, P. I.	Composite Great Circle	5,931
Marquesas Is., Nukuhiva (Taiohae)		3,628
Marshall Islands (Eniwetok Atoll)		4,315
Mobile, Alabama, U. S. A.	Via San Francisco and Panama Canal	5,429
Do	Via San Francisco and Magellan Strait	14,268
Nagasaki, Japan	Via Tsugaru St. and Composite	4,700
Do	Via Osumi (Van Diemen) St. and Composite	4,832
New Hebrides (St. Philip and St. James Bay)		5,344
New Orleans, La., U. S. A.	Via San Francisco, Panama and southwest Pass	5,457
Do	Via San Francisco, Magellan St. and south Pass	14,321
New York, N. Y., U. S. A.	Via Panama Canal	6,002
Do	Via Magellan Strait	13,873
Nonuti Island, Gilbert Islands		4,395
Norfolk, Va., U. S. A.	Via San Francisco and Panama Canal	5,837
Do	Via San Francisco and Magellan St.	13,857
Noumea, New Caledonia		5,729
Nukonono, Union Is.		4,345
Panama Road, C. Z.		3,985
Pelew Is. (Korror Harbor)		5,587
Pensacola, Florida, U. S. A.	Via San Francisco and Panama	5,402
Do	Via San Francisco and Magellan St.	14,288
Petropavlovsk, Kamchatka	Via Unimak Passage	2,905

Port Townsend, Wash., U. S., to—	Route—	Nautical Miles
Philadelphia, Pa., U. S. A.	Via San Francisco and Panama Canal	6,004
Do	Via San Francisco and Magellan St.	13,952
Port Lloyd, Ogasawara Is.		4,416
Port Tampa, Florida, U. S. A.	Via San Francisco and Panama Canal	5,270
Do	Via San Francisco and Magellan St.	14,023
Portland, Maine, U. S. A.	Via San Francisco and Panama Canal	6,256
Do	Via San Francisco and Magellan St.	13,907
Punta Arenas, Chile		6,931
Raoul Island (East Anch.), Kermadec Islands		5,547
Rarotonga I. (Avarua Hbr.), Cook Is.		4,665
Ryojun (Port Arthur), Kwangtung, Manchuria	Via Tsugaru St. and Composite route	5,143
Do	Via Unimak Passage and Tsugaru St.	5,115
Do	Via Unimak Passage, Amphitrite Sts. and La Perouse	5,125
Do	Via Osumi (Van Diemen) St.	5,381
San Bernardino Strait (Entr.), P. I.		5,714
San Francisco, Cal., U. S. A.		770
Savannah, Georgia, U. S. A.	Via San Francisco and Panama Canal	5,621
Do	Via San Francisco and Magellan St.	13,888
Seattle, Wash.		38
Shanghai, China	Via Unimak Passage, Amphitrite Sts. and La Perouse	5,035
Do	Via Osumi (Van Diemen) St. and Composite	5,186
Do	Via Tsugaru St. and Composite	5,053
Do	Via Unimak Passage and Tsugaru	5,025
Shimonoseki, Japan	Via Composite route from Yokohama and Bungo Channel	4,689
Do	Via Tsugaru St. and Composite route	4,583
Singapore, Straits Settlements	Via Composite route and Balintang Channel	7,034
Sitka, Alaska	Via Juan de Fuca Strait and outside	772
Swatow, China	Via Composite route and Osumi (Van Diemen) Strait	5,581
Do	Via Composite route and Tsugaru St.	5,559
Do	Via Unimak Passage and Tsugaru St.	5,531
Tahiti (Papeete), Society Islands		4,260
Taku, China	Via Unimak Passage, Amphitrite Sts. and La Perouse	5,278
Do	Via Osumi (Van Diemen) Strait	5,534
Do	Via Composite route and Tsugaru Strait	5,296
Do	Via Unimak Passage and Tsugaru Strait	5,268
Tansui Harbor, Taiwan (Formosa)	Via Unimak Passage, Amphitrite Strait and La Perouse	5,272
Do	Via Osumi (Van Diemen) St. and Composite	5,292
Do	Via Composite and Tsugaru St.	5,283
Do	Via Unimak Passage and Tsugaru St.	5,255
Ugi I. (Selwyn Bay), Solomon Is.		5,310
Uracas I., Marianas		4,585
Vancouver, B. C.		95
Victoria, Vancouver Island, B. C.		35
Vladivostok, Siberia	Via Akutan Passage and Tsugaru St.	4,300
Do	Via Unimak Passage, Amphitrite Sts. and La Perouse	4,183
Do	Via Composite route and Tsugaru St.	4,330
Do	Via Unimak Passage and Tsugaru St.	4,302
Weihaiwei, China	Via Unimak Passage and Tsugaru St. and La Perouse	5,050
Do	Via Osumi (Van Diemen) St.	5,306
Do	Via Composite route and Tsugaru St.	5,068
Do	Via Unimak Passage and Tsugaru St.	5,040
Yap I. (Tomill Hbr.), Caroline Is.		5,346
Yokohama, Japan	Composite; south of Aleutian Islands	4,218
Do	Via Rhumb	4,469

SAN DIEGO

San Diego, Cal., U. S. A., to—	Nautical Miles
Acapulco, Mexico	1,431
Antofagasta, Chile	4,360
Arica, Chile	4,149
Caldera, Chile	4,492
Callao, Peru	3,585
Chimbote, Peru	3,402
Coquimbo, Chile	4,605
Corinto, Nicaragua	2,211
Esmeraldas, Ecuador	2,940
Guayaquil (Puna), Ecuador	3,112
Guaymas, Mexico	1,088
Hilo, Hawaii	2,175
Iquique, Chile	4,218
Los Angeles Harbor, Cal., U. S. A.	97
Lota, Chile	4,881
Magdalena Bay, Mexico	600
Manzanillo, Mexico	1,136
Mazatlan, Mexico	939
Midway Is. (Welles Harbor)	3,097
Mollendo, Peru	4,024
Pacasmayo, Peru	3,286
Paita, Peru	3,121
Panama, C. Z.	2,843
Pisco, Peru	3,695
Portland, Ore., U. S. A.	1,073
Punta Arenas, Chile	5,801
Punta Arenas, Costa Rica	2,429
Salina Cruz, Mexico	1,733
San Blas, Mexico	1,015
San Jose, Guatemala	1,993
Talcahuano, Chile	4,869
Valdivia (Port Corral), Chile	5,007
Valparaiso, Chile	4,738

SAN FRANCISCO

San Francisco, Cal., U. S. A., to—	Route—	Nautical Miles
Acajutla, Salvador		2,446
Acapulco, Mexico		1,833
Amapala, Honduras		2,586
Antilla, Cuba	Via Panama Canal	4,132
Antofagasta, Chile		4,762
Antwerp, Belgium	Via Panama Canal	8,096
Arica, Chile		4,551
Aux Cayes, Haiti	Via Panama Canal	3,933
Bahia, Brazil	Via Panama Canal	6,956
Bahia Blanca, Argentina	Via Panama Canal	9,021
Baltimore, Md., U. S. A.	Via Panama Canal	5,189
Belize, British Honduras	Via Panama Canal	4,104
Bermuda Island	Via Panama Canal	4,931
Bishops Rock (lat. 49° 50′ N., long. 6° 27′ W.)	Via Panama Canal and Mona Passage	7,644
Bluefields, Nicaragua	Via Panama Canal	3,564
Bocas del Toro, Panama		3,432
Boston, Mass., U. S. A.	Via Panama Canal	5,445
Bremen, Germany	Via Panama Canal	8,338
Bremerton (U. S. Naval Sta.), Wash.		815
Bridgetown, Barbados	Via Panama Canal	4,525
Buenos Aires, Argentine	Via Panama Canal	8,738
Buenaventura, Colombia		3,644

San Francisco, Cal., U. S. A., to—	Route—	Nautical Miles
Caldera, Chile		4,894
Caleta Buena (Buena Cove), Chile		4,608
Callao, Peru		3,987
Cape Haitien, Haiti	Via Panama Canal	4,105
Cape Wrangell, Attu I., Alaska		2,798
Caragues, River, Ecuador		3,366
Cartagena, Colombia	Via Panama Canal	3,569
Cayenne, Guiana	Via Panama Canal	5,553
Charleston, S. C., U. S. A.	Via Panama Canal	4,852
Chimbote, Peru		3,804
Copenhagen, Denmark	Via Panama and Mona Passage	8,638
Coquimbo, Chile		5,007
Corinto, Nicaragua		2,613
Dutch Harbor, Alaska	Via Sitka	2,386
Esmeraldas, Ecuador		3,342
Eten, Peru		3,656
Flavel, Ore., U. S. A.		561
Fort de France, Martinique	Via Panama Canal	4,443
Georgetown, British Guiana	Via Panama Canal	4,803
Guayaquil (Puna), Ecuador		3,514
Guaymas, Mexico		1,490
Havana, Cuba	Via Panama Canal	4,291
Halifax, N. S.	Via Panama Canal	5,605
Hamburg, Germany	Via Panama Canal	8,358
Havre, France	Via Panama Canal	7,898
Hongkong		6,306
Honolulu, Hawaii		2,091
Iquique, Chile		4,620
Jacksonville, Fla., U. S. A.	Via Panama Canal	4,804
Jacmel, Haiti		3,971
Junin, Chile		4,598
Key West, Fla., U. S. A.	Via Panama Canal	4,353
Kingston, Jamaica	Via Panama Canal	3,839
Kiska I., Alaska		2,629
La Guaira, Venezuela	Via Panama Canal	4,129
La Union, Salvador		2,586
Liverpool, England	Via Panama Canal	7,836
Do	Via Magellan Strait	13,502
London, England	Via Panama and Mona Passage	8,051
Lota, Chile		5,282
Magdalena Bay, Mexico		1,002
Manila, P. I.	Via Balintang Channel	6,221
Do	Via San Bernardino Strait	6,301
Do	Via Honolulu and N. end of Luzon, P. I.	6,960
Do	Via Honolulu, Guam and N. end of Luzon, P. I.	7,170
Do	Via Honolulu, Guam and San Bernardino Strait	6,929
Do	Via Honolulu, Yokohama and Balintang Channel	7,242
Do	Via Yokohama and Balintang Channel	6,293
Do	Via Yokohama, Osumi [Van Diemen] Str., and Hongkong	6,752
Do	Via Yokohama, Inland Sea and Nagasaki	6,575
Do	Via Yokohama, Osumi [Van Diemen] Str., and Nagasaki	6,522
Do	Via Osumi [Van Diemen] Str., and Nagasaki	6,457

San Francisco, Cal., U. S. A., to—	Route—	Nautical Miles
Manta, Ecuador		3,370
Manzanillo, Mexico		1,538
Maracaibo, Venezuela	Via Panama Canal	3,888
Mare I. (Navy Yard), Cal., U. S. A.		23
Mazatlan, Mexico		1,337
Mejillones del Sur, Chile		4,734
Midway Is. (Welles Harbor)		2,792
Mollendo, Peru		4,426
Monte Cristi, D. R.	Via Panama Canal	4,126
Monterey, Cal., U. S. A.		95
Montevideo, Uruguay	Via Panama Canal	8,624
Nagasaki, Japan	Via Yokohama and Inland Sea	5,269
Naples, Italy	Via Panama Canal	8,596
Nassau, New Providence Island	Via Panama Canal	4,664
Newcastle, Australia		6,467
New Orleans, La., U. S. A.	Via Panama Canal and South Pass	4,691
Do	Via Panama Canal and Southwest Pass	4,698
Newport News, Va., U. S. A.	Via Panama Canal	5,064
New York (The Battery), N. Y., U. S.	Via Cape Horn	13,328
Do	Via Magellan Strait	13,135
Do	Via Panama Canal	5,262
Norfolk, Va., U. S. A.	Via Panama Canal	5,067
Pacasmayo, Peru		3,688
Pago Pago, Samoa Is.		4,150
Paita, Peru		3,523
Panama, C. Z.		3,245
Para, Brazil	Via Panama Canal	5,597
Paramaribo, Guiana	Via Panama Canal	4,936
Pernambuco, Brazil	Via Panama Canal	6,565
Philadelphia, Pa., U. S. A.	Via Panama Canal	5,234
Pichilinque, Mexico		1,300
Pisagua, Chile		4,593
Pisco, Peru		4,097
Plymouth, England	Via Panama and Mona Passage	7,788
Pointe a Pitre, Guadaloupe	Via Panama Canal	4,456
Ponce, Porto Rico	Via Panama Canal	4,221
Port Antonio, Jamaica	Via Panama Canal	3,870
Port au Prince, Haiti	Via Panama Canal	4,062
Port Castries (St. Lucia), W. I.	Via Panama Canal	4,448
Port Limon, Costa Rica	Via Panama Canal	3,480
Port of Spain	Via Panama Canal	4,447
Port Taltal, Chile		4,838
Port Townsend, Wash., U. S. A.		770
Porto Plata	Via Panama Canal	4,187
Portland, Me., U. S. A.	Via Panama Canal	5,486
Portland, Ore., U. S. A.		650
Prince Rupert, British Columbia		1,204
Progreso, Mexico	Via Panama Canal	4,314
Puerto Barrios, Guatemala	Via Panama Canal	4,068
Puerto Cabello, Venezuela	Via Panama Canal	4,090
Puerto Cortez, Honduras	Via Panama Canal	4,021
Punta Arenas, Chile		6,193
Punta Arenas, Costa Rica		2,831
Quebec, Canada	Via Panama Canal	6,301
Rio de Janeiro, Brazil	Via Panama Canal	7,637
Do	Via Magellan Strait	8,430

San Francisco, Cal., U. S. A., to—	Route—	Nautical Miles
Roseau, Dominica	Via Panama Canal	4,440
St. George, Grenada	Via Panama Canal	4,406
St. John, New Brunswick	Via Panama Canal	5,606
St. John, Newfoundland	Via Panama Canal	5,987
Salaverry, Peru		3,750
Salina Cruz, Mexico		2,135
Samana Bay, D. R.	Via Panama Canal	4,239
San Blas, Mexico		1,417
Sanchez, D. R.	Via Panama Canal	4,255
San Diego, Cal., U. S. A.		452
San Jose, Guatemala		2,395
San Juan, P. R.	Via Panama Canal	4,281
Santa Barbara, Cal., U. S. A.		288
Santiago, Cuba	Via Panama Canal	3,971
Santo Domingo, D. R.	Via Panama Canal	4,090
Santos, Brazil	Via Panama Canal	7,824
Savanilla, Colombia	Via Panama Canal	3,602
Savannah, Ga., U. S. A.	Via Panama Canal	4,851
Seattle, Wash., U. S. A.		804
Seward, Alaska		1,701
Sitka, Alaska		1,302
Southampton, England	Via Panama Canal	7,863
Stockholm, Sweden	Via Panama Canal	9,185
Sydney, Australia	Via Honolulu, Pago Pago and Auckland	7,212
Do	Via Honolulu and Pago Pago	6,744
Tacoma, Wash., U. S. A.		826
Talcahuano, Chile		5,270
Tampico, Mexico	Via Panama Canal	4,773
Tientsin, China	Via Yokohama, Bungo Channel and north of Quelpart I.	5,918
Tocopilla, Chile		4,699
Tumaco, Colombia		3,356
Valdivia (Port Corral), Chile		5,407
Valparaiso, Chile		5,140
Vancouver, B. C.	Via Haro Strait	823
Do	Via Active Pass	812
Vera Cruz, Mexico	Via Panama Canal	4,708
Victoria, B. C.		745
Williamsted, Curacao	Via Panama Canal	3,985
Yokohama, Japan	Great Circle	4,536
Do	Rhumb	4,799

WILLAPA HARBOR

Willapa Harbor, Wash., "Whistle Buoy," to—	Route—	Nautical Miles
Astoria, Ore.		38
Eureka, Humboldt Bay		355
Grays Harbor, "Whistle Buoy"		15½
Honolulu, Hawaii		2,268
Los Angeles Harbor (San Pedro), Cal.		956
Manila, P. I.	Via Honolulu	7,035
Port Townsend, Wash.		194
San Francisco		588
Seattle, Wash.		233
Tacoma, Wash.		258
Vancouver, B. C.		254
Victoria, B. C.		170

YOKOHAMA

Yokohama, Japan, to—	Route—	Nautical Miles
Amoy, China	Via Osumi [Van Diemen] Strait	1,331
Batavia, Java		3,194
Canton, China		1,668
Cebu, P. I.	Via San Bernardino Strait	1,762
Chefoo, China	Via Bungo Channel and Shimonoseki Strait	1,140
Do	Via Inland Sea	1,177
Do	Via Osumi [Van Diemen] Strait	1,194
Chemulpo, Chosen [Korea]	Via Bungo Channel and Shimonoseki Strait	1,033
Chemulpo, Chosen [Korea]	Via Inland Sea	1,070
Colombo, Ceylon		4,487
Columbia River Entr., Ore., U. S. A.		4,208
Foochow, China		1,217
Guam (Port Apra), Marianas		1,353
Hakodate, Japan		532
Hongkong		1,585
Honolulu, Hawaii		3,394
Iloilo, P. I.	Via San Bernardino Strait	1,784
Iquique, Chile		9,026
Kobe, Japan		346
Liverpool, England	Via Pago Pago and Magellan Strait	16,584
Los Angeles Hbr., (San Pedro), Cal.		4,839
Manila, P. I.	Via Balintang Channel	1,757
Do	Via Kobe, Inland Sea, Nagasaki, Shanghai and Hongkong	2,683
Mazatlan, Mexico		5,782
Nagasaki, Japan	Via Inland Sea	733
Do	Via Osumi [Van Diemen] Strait	680
Pago Pago, Samoa Is.		4,133
Panama, C. Z.	Via Great Circle to Cape San Lucas	7,682
Do	Via Mazatlan, Mexico	7,788
Do	Via San Francisco	7,781
Petropavlovsk, Kamchatka		1,425
Port Townsend, Wash., U. S. A.	Composite; south of Aleutian Islands	4,218
Prince Rupert, B. C.	Composite; south of Aleutian Islands	3,862
Ryojun [Port Arthur], Kwangtung, Manchuria	Via Bungo Channel and Shimonoseki St.	1,181
Do	Via Inland Sea	1,218
San Francisco, Cal., U. S. A.	Great Circle	4,536
Seattle, Wash., U. S. A.	Composite; south of Aleutian Islands	4,255
Shanghai, China	Via Inland Sea	1,117
Do	Via Osumi [Van Diemen] Strait	1,041
Do	Via Kobe and Nagasaki	1,200
Shimonoseki, Japan	Via Bungo Channel	544
Do	Via Inland Sea	581
Singapore, Straits Settlements		2,905
Sitka, Alaska	Via Dutch Hbr., Alaska	3,631
Swatow, China		1,435
Sydney, Australia		4,375
Taku, China	Via Bungo Channel and Shimonoseki St.	1,334
Do	Via Inland Sea	1,371
Do	Via Inland Sea and south of Quelpart I.	1,417
Tansui Harbor, Taiwan [Formosa]	Via Osumi [Van Diemen] Strait	1,146
Tientsin, China	Via Inland Sea and south of Quelpart I.	1,465
Vancouver, B. C.	Composite; south of Aleutian Is.	4,262
Victoria, Vancouver I., B. C.	Composite; south of Aleutian Is.	4,194
Vladivostok, Siberia	Via Tsugaru Strait	949
Wake I., N. Pacific Ocean		1,740
Weihaiwei, China	Via Bungo Channel and Shominoseki St.	1,106
Do	Via Inland Sea	1,143
Wunsung, China	Via outside route	1,029
Do	Via Inland Sea	1,105
Do	Via Kobe and Nagasaki	1,188
Yingkow (Newchwang), China	Via Inland Sea	1,362
Zamboanga, Mindanao I., P. I.	Via Guam and south of Mindanao I.	2,820
Do	Via Guam and Surigao Strait	2,837

SAN FRANCISCO

DISTANCES FROM SAN FRANCISCO, CAL., U. S. A., TO DOMESTIC, MEXICAN AND BRITISH COLUMBIA PORTS AND COAST POINTS

	Nautical Miles
Anacortes, Wash.	796
Anchorage, Alaska	1,872
Astoria, Ore.	555
Bellingham, Wash.	810
Bodega Head	51
Bolinas	16
Bremerton, Wash.	815
Cape Arago	372
Cape Blanco	341
Cape Disappointment	545
Cape Flattery, Wash.	680
Cape Fortuna	200
Cape Foulweather	464
Cape Lookout	486
Cape Mendocino	195
Cape Perpetua	433
Cape San Martin	147
Cape St. George	276
Carpenteria	312
Cayucos	193
Columbia River Bar	540
Coos Bay	375
Coquille River	360
Crescent City	274
Destruction Island	634
Douglas Island	1,593
Dutch Harbor	2,051
Dutch Harbor via Sitka	2,386
Onsenada	496
Eureka (Humboldt Bay)	216
Everett, Wash.	797
False Tillamook	511
Flattery Rocks	667
Flavel, Ore.	561
Gaviota	275
Goleta	296
Grays Harbor	558
Guaymas, Mexico	1,490
Hueneme	337
Humboldt Bay	216
Juneau, Alaska	1,596
Killisnoo	1,299
Kiska Island, Alaska	2,629
Klawak	1,472
Kotzebue Sound	2,927
Ladysmith, B. C.	804
La Paz	1,722
Lompoc Landing	241
Loring	1,381
Los Angeles Harbor	368
Magdalena Bay	1,002
Mazatlan	1,478
Mendocino	123
Monterey	93
Moro Bay	198
Nanaimo, B. C.	828
Newport	411
New Westminster, B. C.	829
Nome, Alaska	2,705

	Nautical Miles
Olympia, Wash.	862
Pigeon Point	45
Pillar Point	26
Point Arena	100
Point Arguello	252
Point Bonita	7
Point Buchon	206
Point Conception	263
Point Cypress	100
Point Duma	360
Point Fermin	391
Point Gorda	184
Point Lobos	7½
Point Loma	475
Point New Year	50
Point Pedro	19
Point Piedras Blancas	166
Point Reyes	33
Point Sal	232
Point San Luis	215
Point Sur	115
Point Tomales	46
Point Vincent	384
Port Clarence	2,723
Portland, Ore.	650
Port Orford	336
Port San Luis	216
Port Townsend	770
Powell River, B. C.	868
Redondo	379
Rogue River	313
San Diego	482
San Jose del Cabo	1,192
San Luis Obispo	226
San Simeon	172
Santa Barbara	288
Santa Cruz	71
Santa Monica	372
San Pedro	393
Santa Rosalia	1,895
Seattle, Wash.	804
Shelter Cove	165
Shoalwater Bay	569
Sitka, Alaska	1,302
St. Michael	2,705
Table Bluff	212
Tacoma, Wash.	826
Tillamook Bay	499
Tillamook Head	523
Trinidad	233
Umpqua River	394
Unalaska	2,051
Union Bay, B. C.	875
Vancouver, B. C.	833
Ventura	327
Victoria, B. C.	750
Willapa Hbr. "Whistle Buoy"	588
Wrangle, Alaska	1,448
Yakuina Bay	454

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