REPORT

ON

MARINE ENGINES AND STEAM VESSELS

IN THE

UNITED STATES MERCHANT SERVICE,

BY

CHARLES H. FITCH, D. E.,
SPECIAL AGENT.

TABLE OF CONTENTS.

TABLE OF CONTENTS.

LIST OF ILLUSTRATIONS.

LETTER OF TRANSMITTAL.

NEW HAVEN, CONNECTICUT, *October* 1, 1881.

SIR: In treating the subject of the Marine Engines and Steam Vessels of the United States Merchant Service I have, as a basis of comparison, classified the vessels in accordance with their registered tonnages. I have also made a cross-classification by geographical districts, viz, the Atlantic and Gulf service, the Pacific service, the Mississippi Valley service, and the Lake service, with several minor divisions of these classes. General statistical tables are presented of numbers of steam-vessels in active service, of the numbers of their engines and boilers, of the tonnages of the vessels, and the aggregate volumes of cylinders and boilers (excepting coil boilers, which are separately considered). The dimensions of steam vessels, engines, and boilers are in most cases those recorded by the United States steamboat inspectors.

The variety in dimensions and arrangement of boilers has rendered it impracticable to compute their aggregate heating surfaces, but the character and proportions of the boilers used in various sections and classes of service are so fully described as to permit of approximate estimates of these surfaces. The size of boiler as taken in these tables is the volume in cubic feet within the water-shell, including internal tubes, flues, and furnaces, but excluding external furnaces and fire-boxes. This "size of boilers" may be qualified by the detailed accounts of their dimensions and arrangement. Tables of averages are also given, which are believed to exhibit some interesting and instructive comparisons of practice. The average boiler-pressure allowed is stated for each district and class, and while there is no absolute measure of boiler capacity possible, the sizes as stated, taken in connection with the boiler pressures, will be found to convey as correct an idea of the steam-producing capacities as could well be furnished.

The manufacture of marine and river engines is involved both with the building of stationary engines and of steam vessels, but is more narrowly confined to manufacturing centers than the latter. The details of engine-building are considered in the report on stationary engines. Tables are herewith presented showing in detail how the various sections and places in the United States have contributed to the building up of the steam tonnage as inspected in 1879–1880.

The report then proceeds to consider, for the several grand geographical divisions, the details and character of engines and boilers used, and their relations to the arrangement, service, and speed of the steam vessels upon which they are employed. These details are freely illustrated, with the view of presenting a full and graphic record of the salient features of present practice.

Very respectfully,

CHARLES H. FITCH,
Special Agent.

Prof. WILLIAM P. TROWBRIDGE,
Chief Special Agent.

MARINE ENGINES AND STEAM VESSELS IN THE UNITED STATES MERCHANT SERVICE.

THE MARINE STEAM POWER OF THE UNITED STATES

TABLES OF AGGREGATES.

In preparing tables to exhibit the marine steam power of the United States, the steamers were first classified according to their registered tonnages, so as to bring steamers within certain limits of size in the same class, and thus to facilitate comparisons. The aggregates of these classes for the several inspection districts are given as follows, the boiler and cylinder volumes being calculated from data obtained from the records of the steamboat-inspection service through the courtesy of the supervising inspector-general, James A. Dumont.

The inspection districts are here designated not numerically, but so as to bring the geographical bearings of the statistics prominently before the mind of the reader. The first district embraces all waters and rivers of the United States west of the Rocky mountains, and is here designated as the Pacific district. The second district embraces the waters of the Atlantic coast, rivers and tributaries between the bay of Passamaquoddy and cape Charles. It may be designated as the North Atlantic district, and is here divided into two sections respectively, comprising the Atlantic seaboards of the New England and of the middle states. The third district embraces the waters of the Atlantic coast, rivers and tributaries between cape Charles and cape Sable. It is here designated as the south Atlantic district. The fourth district embraces the Mississippi river and tributaries, from the mouth of the Ohio river up to and including Keokuk, Iowa; the Illinois river below Peoria; the Missouri river up to and including Yankton, Dakota. It is here designated as the Saint Louis district. The fifth district embraces the upper Mississippi river and its tributaries above Keokuk, Iowa; the Red River of the North, and that part of the Missouri river and its tributaries above Yankton, Dakota. It is here designated as the upper Mississippi district. The sixth district embraces the Ohio river and tributaries up to and including Carrollton, Kentucky, and the Mississippi river and tributaries (below the Ohio) down to and including Greenville, Mississippi. It is here designated as the lower Ohio district. The seventh district, embracing the Ohio river and tributaries above Carrollton, Kentucky, is designated as the upper Ohio district. The eighth district embraces all the waters of the lakes north and west of lake Erie, their tributaries, and the upper portion of the Illinois river down to and including Peoria, Illinois. It is here designated as the Western lake district. The ninth district embraces all the waters of lakes Erie, Ontario, Champlain, Memphremagog, and George, with the river Saint Lawrence, and their tributaries, and the inland lakes of New York. It is here designated as the Eastern lake district. The tenth district embraces the coast and tributary waters of the gulf of Mexico between cape Sable and the mouth of the Rio Grande and the Mississippi river and tributaries to Greenville, Mississippi. It is here designated as the Gulf district.

	STEAMERS OF 1,000 TONS AND UPWARDS.						STEAMERS OF 500 TONS AND UPWARDS, UNDER 1,000 TONS. (a)					
	No. of steamers.	Tonnage.	No. of engines.	Volume, cylinders.	No. of boilers.	Volume, boilers.	No. of steamers.	Tonnage.	No. of engines.	Volume, cylinders.	No. of boilers.	Volume, boilers.
				Cubic feet.		*Cubic feet.*				*Cubic feet.*		*Cubic feet.*
The United States	307	480,906.17	407	41,205.26	770	1,030,464.43	396	277,434.00	535	27,684.40	770	651,341.75
The Pacific district	27	55,348.93	33	5,464.43	98	134,153.22	32	22,352.20	55	1,350.06	43	34,023.90
The North Atlantic (New England)	43	65,005.38	49	10,701.39	85	208,982.20	26	17,915.13	30	2,804.25	32	58,323.40
The North Atlantic (middle states)	91	160,571.93	105	14,308.82	222	386,758.93	133	91,455.47	136	14,040.08	168	278,093.62
The South Atlantic district	13	18,965.60	13	1,533.70	34	52,030.98	34	23,410.20	30	3,157.65	54	77,046.62
The Saint Louis district	10	13,943.67	20	679.36	51	13,986.70	26	18,414.87	52	951.95	98	21,770.49
The Upper Mississippi district	......	......	......	......	......	......	1	549.21	2	19.44	3	613.71
The Lower Ohio district	3	3,531.73	6	165.64	7	2,127.35	17	11,671.07	34	1,009.67	79	18,606.19
The Upper Ohio district	11	13,634.30	22	685.60	58	13,920.78	42	28,801.10	84	1,336.66	101	41,257.99
The Western Lake district	25	31,811.27	34	1,639.76	40	48,422.28	38	26,582.49	43	1,702.47	52	52,582.28
The Eastern Lake district	58	79,719.42	86	3,103.71	78	92,808.99	30	24,118.65	34	882.59	39	37,381.02
The Gulf district	26	38,373.85	39	2,802.85	97	76,655.00	17	12,073.45	26	870.18	41	30,243.24

	STEAMERS OF 100 TONS AND UPWARDS, UNDER 500 TONS.(a)						STEAMERS OF 50 TONS AND UPWARDS, UNDER 100 TONS.(a)					
	No. of steamers.	Tonnage.	No. of engines.	Volume, cylinders.	No. of boilers.	Volume, boilers.	No. of steamers.	Tonnage.	No. of engines.	Volume, cylinders.	No. of boilers.	Volume, boilers.
				Cubic feet.		*Cubic feet.*				*Cubic feet.*		*Cubic feet.*
The United States	1,362	332,717.43	2,056	27,434.41	2,875	914,047.41	808	59,209.62	1,096	3,557.94	911	275,445.00
The Pacific district	109	26,089.02	192	1,583.24	158	55,260.65	48	3,893.63	83	218.48	61	13,312.99
The North Atlantic (New England)	72	19,232.38	84	2,012.38	76	66,249.14	88	6,529.08	95	315.18	88	38,683.22
The North Atlantic (middle states)	281	70,202.26	314	10,159.74	311	266,002.99	202	14,227.78	207	1,314.27	203	97,278.68
The South Atlantic district	119	32,191.76	146	2,697.06	230	86,559.67	77	5,513.40	95	323.67	78	25,553.51
The Saint Louis district	90	25,306.81	150	1,685.47	239	48,386.94	35	2,059.68	58	183.00	46	8,424.26
The Upper Mississippi district	73	13,830.99	144	745.76	147	28,450.04	38	2,803.70	68	141.96	40	7,463.97
The Lower Ohio district	86	21,891.09	168	1,216.91	210	41,455.01	62	4,782.34	108	156.50	84	11,504.35
The Upper Ohio district	175	38,607.22	351	2,914.17	504	104,134.90	66	4,049.19	116	255.92	90	15,357.75
The Western Lake district	141	37,289.25	167	1,933.63	166	102,647.21	89	6,710.03	120	279.95	92	27,711.01
The Eastern Lake district	25	15,068.27	81	577.19	78	37,922.48	37	2,701.89	38	130.19	37	12,402.18
The Gulf district	141	32,108.38	250	1,908.86	256	96,078.38	66	4,768.90	108	238.22	74	17,753.08

	STEAMERS OF 25 TONS AND UPWARDS, UNDER 50 TONS.(a)						STEAMERS OF LESS THAN 25 TONS.(a)					
	No. of steamers.	Tonnage.	No. of engines.	Volume, cylinders.	No. of boilers.	Volume, boilers.	No. of steamers.	Tonnage.	No. of engines.	Volume, cylinders.	No. of boilers.	Volume, boilers.
				Cubic feet.		*Cubic feet.*				*Cubic feet.*		*Cubic feet.*
The United States	831	30,908.18	995	1,083.14	841	189,538.48	1,051	13,942.31	1,170	673.35	1,057	97,200.39
The Pacific district	38	1,484.60	53	58.10	39	6,131.97	47	506.84	58	13.70	48	2,817.77
The North Atlantic (New England)	93	3,485.00	102	169.82	93	22,900.81	107	1,352.17	117	55.05	107	9,084.32
The North Atlantic (middle states)	225	8,319.42	231	535.96	225	60,917.27	251	3,314.95	265	101.36	252	27,364.30
The South Atlantic district	100	3,741.70	108	226.04	100	27,084.56	119	1,542.30	127	72.17	119	11,506.40
The Saint Louis district	19	759.00	27	20.79	20	3,036.22	28	234.69	34	7.19	28	1,330.55
The Upper Mississippi district	25	809.28	43	41.07	26	3,135.79	18	314.26	25	13.01	19	1,425.06
The Lower Ohio district	34	1,333.02	50	35.87	35	4,435.44	39	693.47	51	33.42	39	3,424.65
The Upper Ohio district	42	1,600.61	61	65.74	44	5,194.65	32	520.59	48	25.05	34	2,515.86
The Western Lake district	149	5,442.45	186	322.83	149	34,881.93	201	2,920.22	218	134.74	202	19,632.93
The Eastern Lake district	54	1,901.52	66	92.65	55	11,372.81	132	1,640.13	141	80.27	132	12,416.64
The Gulf district	52	1,941.40	68	104.67	55	10,447.03	77	902.09	95	38.30	77	5,680.83

RECAPITULATION—THE UNITED STATES. (a)

Steamers—	No. of steamers.	Tonnage.	No. of engines.	Volume, cylinders.	No. of boilers.	Volume, boilers.
				Cubic feet.		*Cubic feet.*
The United States	4,755	1,195,207.71	6,268	102,328.50	6,724	3,158,037.46
Over 1,000 tons	307	480,906.17	407	41,205.26	770	1,030,404.43
500 to 1,000 tons	396	277,434.00	535	27,684.40	770	651,341.75
100 to 500 tons	1,362	332,717.43	2,056	27,434.41	2,875	914,047.41
50 to 100 tons	808	59,209.62	1,096	3,557.94	911	275,445.00
25 to 50 tons	831	30,908.18	995	1,083.14	841	189,538.48
Under 25 tons	1,051	13,942.31	1,170	673.35	1,057	97,200.39

a These aggregates do not include a small number of steamers having coil and other special types of boiler.

TABLES OF AVERAGES.

The following tables of averages are presented for convenience in comparison of the several classes of vessels. In the tables, a compound engine with high- and low-pressure cylinders is rated as one engine, but two high-pressure cylinders with connecting mechanism are rated as two engines. The tables exhibit conspicuously certain general tendencies, such, for example, as the increase of boiler volume for the same tonnage and cylinder capacity as we proceed from the larger to the smaller vessels. The extremes of cylinder volume and boiler pressure are exhibited by the horizontal engines of the western river boats on one side and the beam-engines of eastern river and sound boats on the other. These matters will be made the subject of further remark.

	AVERAGES FOR STEAMERS OF 1,000 TONS AND UPWARDS.							AVERAGES FOR STEAMERS OF 500 TONS AND UPWARDS, UNDER 1,000 TONS.						
	Average tonnage of steamers.	Cylinder volume per 100 tons.	Boiler volume per 100 tons.	Ratio of boiler to cylinder volume.	Average boiler pressure allowed to square inch.	Cylinder volume per single engine.	Boiler volume per single boiler.	Average tonnage of steamers.	Cylinder volume per 100 tons.	Boiler volume per 100 tons.	Ratio of boiler to cylinder volume.	Average boiler pressure allowed to square inch.	Cylinder volume per single engine.	Boiler volume per single boiler.
		Cu. ft.	*Cu. ft.*		*Lbs.*	*Cu. ft.*	*Cu. ft.*		*Cu. ft.*	*Cu. ft.*		*Lbs.*	*Cu. ft.*	*Cu. ft.*
The Pacific district	2,049.96	9.87	242.38	24.56	63	165.59	1,368.91	698.51	6.04	152.21	25.20	95	24.55	791.25
The North Atlantic district (New England)	1,511.75	10.60	321.48	19.36	33	220.23	2,199.79	689.04	13.10	325.55	24.68	35	78.81	1,822.01
The North Atlantic district (middle states)	1,764.52	8.95	240.86	26.92	40	136.84	1,742.15	688.39	15.35	304.95	19.87	34	103.24	1,660.08
The South Atlantic district	1,458.89	8.08	277.56	34.35	48	117.98	1,842.35	688.54	13.40	331.67	24.59	38	80.96	1,437.90
The Saint Louis district	1,394.37	4.87	100.31	20.18	138	33.97	274.25	708.24	5.17	118.23	22.87	141	18.31	222.15
The Upper Mississippi district	....	....	....	....	....	....	....	649.21	3.54	111.74	31.56	131	9.72	204.57
The Lower Ohio district	1,177.24	4.68	60.24	12.87	141	27.61	303.91	680.57	8.65	159.41	18.43	152	29.69	235.52
The Upper Ohio district	1,239.49	5.93	102.17	20.31	154	31.16	240.17	687.88	4.62	142.08	30.75	152	15.91	250.05
The Western Lake district	1,272.45	5.16	152.22	29.50	69	48.23	1,210.55	699.54	6.41	197.81	30.86	68	39.59	1,011.19
The Eastern Lake district	1,374.47	3.97	116.42	29.33	72	36.79	1,189.86	803.95	3.66	154.99	42.35	67	25.96	958.48
The Gulf district	1,475.92	7.30	199.76	27.30	93	71.86	790.26	710.20	7.21	250.40	34.74	98	33.47	737.64

	AVERAGES FOR STEAMERS OF 100 TONS AND UPWARDS, UNDER 500 TONS.							AVERAGES FOR STEAMERS OF 50 TONS AND UPWARDS, UNDER 100 TONS.						
	Average tonnage of steamers.	Cylinder volume per 100 tons.	Boiler volume per 100 tons.	Ratio of boiler to cylinder volume.	Average boiler pressure allowed to square inch.	Cylinder volume per single engine.	Boiler volume per single boiler.	Average tonnage of steamers.	Cylinder volume per 100 tons.	Boiler volume per 100 tons.	Ratio of boiler to cylinder volume.	Average boiler pressure allowed to square inch.	Cylinder volume per single engine.	Boiler volume per single boiler.
		Cu. ft.	*Cu. ft.*		*Lbs.*	*Cu. ft.*	*Cu. ft.*		*Cu. ft.*	*Cu. ft.*		*Lbs.*	*Cu. ft.*	*Cu. ft.*
The Pacific district	247.61	5.87	204.75	34.91	95	8.24	349.75	81.12	5.61	341.02	70.75	92	2.63	201.85
The North Atlantic district (New England)	267.12	10.46	344.46	32.93	56	23.96	871.09	74.10	4.83	692.47	132.40	78	3.32	490.58
The North Atlantic district (middle states)	249.83	14.47	378.99	26.10	52	32.35	655.31	70.43	9.24	683.72	75.70	69	6.33	470.20
The South Atlantic district	270.51	8.38	268.88	32.08	52	18.47	376.34	71.61	5.87	463.44	96.07	66	3.41	327.01
The Saint Louis district	281.18	6.66	191.20	28.71	136	10.60	202.46	75.99	6.90	316.74	58.59	121	3.16	183.14
The Upper Mississippi district	189.46	5.30	205.70	38.16	136	5.18	193.54	75.36	4.96	253.66	73.23	123	2.08	152.33
The Lower Ohio district	231.27	5.56	189.37	34.06	143	7.24	197.40	77.13	3.27	240.56	94.45	124	1.45	136.96
The Upper Ohio district	220.51	7.55	269.73	35.72	148	8.30	206.61	70.44	5.50	330.33	70.19	127	2.21	155.13
The Western Lake district	264.46	5.18	275.27	53.14	77	11.58	618.35	75.39	4.17	412.98	120.28	89	2.33	301.21
The Eastern Lake district	200.01	3.83	251.67	65.71	77	7.13	486.18	73.02	4.62	459.02	97.72	87	3.43	335.19
The Gulf district	227.72	5.94	239.75	40.35	113	7.03	300.69	72.25	5.00	372.27	108.55	100	2.21	239.91

	AVERAGES FOR STEAMERS OF 25 TONS AND UPWARDS, UNDER 50 TONS.							AVERAGES FOR STEAMERS OF LESS THAN 25 TONS.						
	Average tonnage of steamers.	Cylinder volume per 100 tons.	Boiler volume per 100 tons.	Ratio of boiler to cylinder volume.	Average boiler pressure allowed to square inch.	Cylinder volume per single engine.	Boiler volume per single boiler.	Average tonnage of steamers.	Cylinder volume per 100 tons.	Boiler volume per 100 tons.	Ratio of boiler to cylinder volume.	Average boiler pressure allowed to square inch.	Cylinder volume per single engine.	Boiler volume per single boiler.
		Cu. ft.	*Cu. ft.*		*Lbs.*	*Cu. ft.*	*Cu. ft.*		*Cu. ft.*	*Cu. ft.*		*Lbs.*	*Cu. ft.*	*Cu. ft.*
The Pacific district	30.07	3.91	413.02	142.93	93	1.10	157.23	10.78	2.72	553.97	244.58	103	0.24	58.70
The North Atlantic district (New England)	37.47	4.84	653.72	152.04	79	1.61	246.24	12.64	4.07	671.83	180.63	94	0.47	84.90
The North Atlantic district (middle states)	36.07	6.44	732.23	113.70	76	2.32	270.74	13.21	5.77	825.48	150.82	84	0.72	108.59
The South Atlantic district	37.42	6.06	723.86	128.98	69	2.10	270.85	12.90	4.68	740.06	169.63	79	0.57	96.69
The Saint Louis district	39.94	3.09	400.03	138.01	105	1.10	151.81	8.38	3.06	571.20	226.29	106	0.21	47.52
The Upper Mississippi district	35.97	4.57	348.70	126.96	120	0.95	120.61	17.46	4.14	453.75	144.32	115	0.52	75.05
The Lower Ohio district	30.21	2.69	332.73	178.49	116	0.71	126.73	17.78	4.82	493.84	135.09	111	0.65	87.81
The Upper Ohio district	38.11	4.11	324.54	100.31	116	1.08	118.06	16.27	4.81	483.27	142.25	118	0.52	73.97
The Western Lake district	36.52	5.93	640.92	134.54	91	1.74	234.11	14.53	4.62	672.31	156.76	92	0.62	97.19
The Eastern Lake district	35.21	4.87	598.09	147.70	98	1.40	206.78	12.43	5.44	757.05	149.32	99	0.63	94.07
The Gulf district	37.33	5.99	538.12	123.41	92	1.54	189.95	11.72	4.24	629.32	184.42	81	0.40	73.77

AVERAGES—THE UNITED STATES.(a)

Steamers.	Average tonnage of steamers.	Cylinder volume per 100 tons.	Boiler volume per 100 tons.	Ratio of boiler to cylinder volume.	Average boiler pressure allowed to square inch.	Cylinder volume per single engine.	Volume boiler per single boiler.
		Cu. ft.	*Cu. ft.*		*Lbs.*	*Cu. ft.*	*Cu. ft.*
Over 1,000 tons	1,566.47	8.58	214.27	24.96	65	101.43	1,339.57
500 to 1,000 tons	700.59	9.98	234.77	23.53	73	51.74	845.90
100 to 500 tons	244.28	8.25	274.72	33.30	94	13.34	384.86
50 to 100 tons	73.39	6.00	464.49	77.41	90	3.25	302.35
25 to 50 tons	37.19	5.32	612.94	115.21	87	1.65	225.37
Under 25 tons	13.27	4.83	697.18	144.34	92	0.58	91.96
All sizes	251.36	8.56	264.23	30.87	88	16.32	469.66

a These averages do not include a small number of steamers having coil and other special types of boiler.

STEAMSHIP BUILDING.

Within the past decade there has been a falling off in ship-building, but not in the building of steamships and other steam vessels, and the ratio of number of steam to number of sailing vessels built is now greater than ever before.

A small diagram has been prepared (Fig. 1) which exhibits the progress of the country for the past forty years

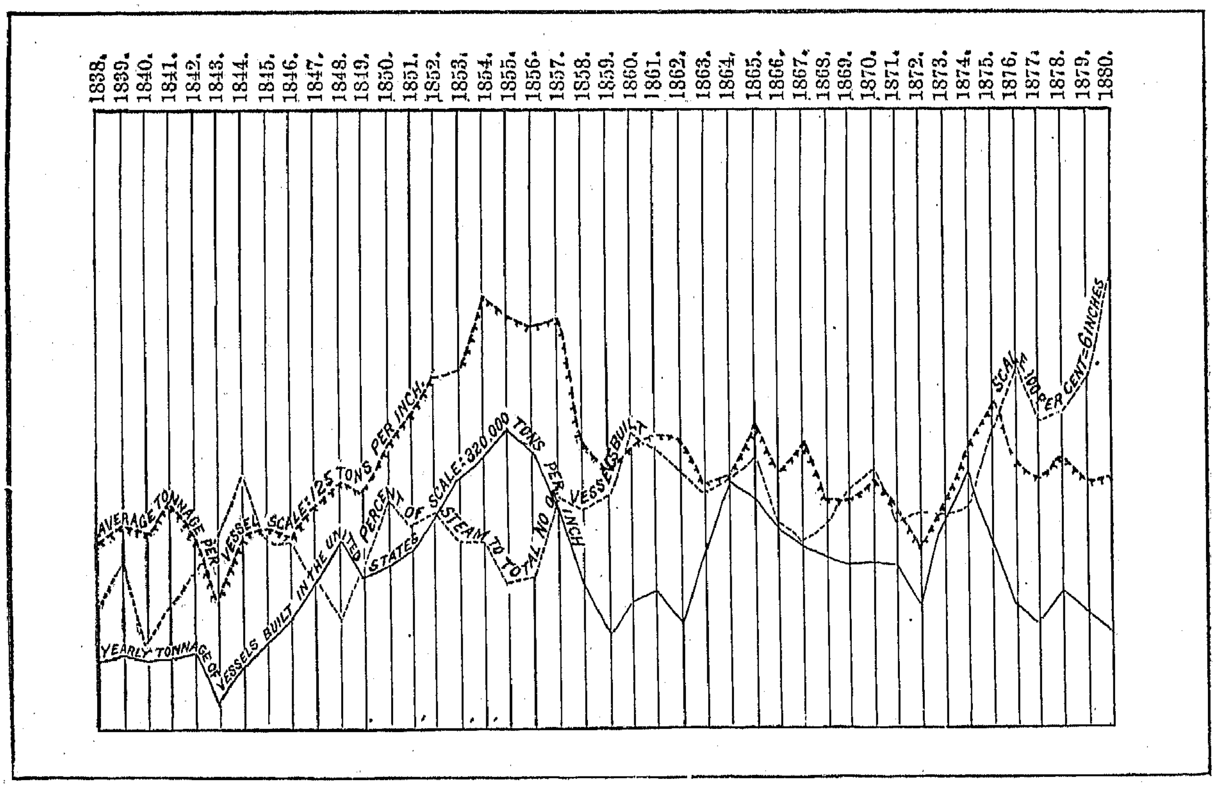


FIG. 1.

in this respect. The diagram may be considered an epitomized history in itself, but a few notes may be of value in recalling to the mind of the reader some of the industrial conditions prevailing at the several dates.

From 1838 to 1843 we find the ship-building interest small and diminishing, the average size of vessels becoming smaller, with an increased percentage of steamers, all being wooden vessels. In this period the revenues of the government were such that it was a question what should be done with the surplus. Iron steamships were fairly introduced in England, and the Cunard line was started.

From 1843 to 1854 we had a great growth in ship-building in this country, attending a growth of commerce. There was a marked increase in the national debt and in the revenue from duties, while the average percentage of tariff on dutiable imports fell off from about 35 to about 25 per cent. The relative proportion of steamers built declined, showing the ship-building growth to be mainly in sailing vessels. All the ocean-going steamers were wooden vessels. The Collins trans-Atlantic line was started. The period 1843–1854 was also of great commercial activity in England. Many iron steamers were built, and by 1845 marine tubular boilers had come into general use. In this country from 1854 to 1857 vessels of a larger average size were built than at any later period, but these large craft were mainly wooden sailing vessels. It may be noted that in 1846 the Mexican war began, while in 1849 the discovery of gold in California attracted the adventurous.

From 1854 to 1862 was a period of decadence, due to the fact that the wooden ships of American build were being supplanted in the carrying trade by iron steamers of foreign build. In 1860 52 wooden side-wheel steamers were the only ocean-going steamers of the United States, although large iron steamers had been built in this country over fifteen years previous.

The civil war now gave an impetus to the building of vessels, but they were still for the most part of wood, and only about one-fifth of them were steamers. Another period of decadence followed till 1872. Meanwhile from 1861 to 1864 alone England doubled her ship-building, which was nearly all in iron steamers. Other industrial enterprises flourished in this country; the "Great Eastern" brought us the Atlantic cable in 1866, and the Union Pacific railroad was finished in 1869, but ship-building continued to decline.

The year 1872 appears to have been a temporary turning point in ship-building, coincident with a period of business stagnation and low wages in the United States. In 1874 the tonnage built approached that of 1855, being exceeded only in three years—1854, 1855, and 1856—and a much larger proportion of the vessels were steamers. But with the return of prosperity in the country labor appears to have been drawn into other callings and ship-building rapidly fell away. In 1871 a free-ship bill was defeated in Congress. The law passed in 1872 giving ship-builders the right to import free of duty materials to be used in ships for the foreign trade was practically inoperative. Nevertheless, the building of large iron steamships now began to be prosecuted with some success, and for the next seven years these were built, in four iron ship-yards on the Delaware, at an average rate of 11 large sea-going iron steamships a year, with an average tonnage of about 2,000 tons each. But the bulk of the steam tonnage built consisted of small tugs and river boats; and from 1874 to 1880 there was a further decline in ship-building, slightly checked only in 1878, in which year it may be remarked that an American line to Brazil was started with three steamers, the largest being of 3,548 tons burden. In this last period there has been a decided increase in the ratio by number of steam to sailing vessels.

We may say roundly that the ratio of number of steamers to total number of vessels built was, in 1840, about one-twelfth; in 1850, about one-fifth; in 1860, about one-fourth; in 1870, about two-ninths; in 1880, about three-eighths.

The number of steamers built, by years, is as follows, since 1840:

Years.	Number.	Years.	Number.	Years.	Number.	Years.	Number.
Total ten years	1,685	Total ten years	2,443	Total ten years	3,054	Total ten years	3,343
1841	78	1851	238	1861	264	1871	302
1842	137	1852	250	1862	183	1872	292
1843	79	1853	271	1863	367	1873	402
1844	163	1854	281	1864	408	1874	404
1845	163	1855	253	1865	411	1875	323
1846	225	1856	221	1866	348	1876	338
1847	198	1857	263	1867	180	1877	265
1848	175	1858	226	1868	236	1878	334
1849	208	1859	172	1869	277	1879	335
1850	250	1860	264	1870	200	1880	348

The aggregates, taken by decades, show a general increase in steamship building, but this no more than supplies the demand for coasting and river steamers. Indeed, the building of large steamers must within the next few years be considerably increased in order to supply the domestic demand.(*a*) The average life of a steamboat may be taken at from sixteen to twenty years, and many of the large steamers are old, especially the large wooden coasting vessels, not a few of these having been built at places in which the building of large ocean steamers may be said to have become almost a lost art. Thus of 129 large sea-going steamers 20 built in New York and Brooklyn average about fifteen years old, 4 of foreign build average nineteen years old, and 12 built in Connecticut average nearly fifteen years old. Such old wooden steamers are being replaced by iron steamers, which are built mainly at Chester, Pennsylvania; Wilmington, Delaware, and Philadelphia, Pennsylvania. Of the steam tonnage inspected in 1879 the following tables have been prepared, which show in what proportions the several states and places have contributed to the building up of the steam tonnage. The tables are deficient by about 2 per cent. of the whole number of steamers, these being mostly small craft, of which the data were not obtainable.

a In a recent issue of the *Nautical Gazette* the demand upon American ship-builders for steam tonnage is stated to be greater than it has been for ten years past.

STEAM VESSELS OF THE UNITED STATES.

NOTE.—This table is incomplete by the necessary omission of a very small percentage of steamers of unknown build and of small steamers of unmeasured tonnage. There are also 17 steamers of foreign build: 4 ocean passenger, 3,027.07 tons; 2 inland passenger, 229.17 tons; 4 ferry, 446 tons; 2 towing, 328.96 tons; 3 freight steamers, 1,808.94 tons, and 2 steam yachts, 16.77 tons.

Where built.	Ocean passenger steamers.		Inland passenger steamers.		Ferry boats.		Towing boats.		Freight steamers.		Other steamers.	
	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.
The United States	120	188,410.29	1,511	457,485.30	302	118,380.65	1,251	103,238.79	390	197,974.79	501	29,828.60
Alabama	1	508.05	4	606.32	1	17.00	8	272.81	5	576.62	1	3.00
Alaska	......	......	1	255.44	......	......	......	......	......	......	......	......
Arkansas	......	......	8	813.16	3	161.20	1	12.40	1	29.46	1	70.83
California	6	3,006.70	56	9,584.34	29	21,803.21	28	1,755.40	23	3,248.48	......	......
Connecticut	12	11,076.77	27	5,782.82	7	637.37	8	791.31	11	4,909.60	20	1,380.81
Dakota	......	......	1	217.77	1	44.91	......	......	......	......	......	......
Delaware	23	32,897.27	51	24,478.13	16	6,757.70	24	1,524.36	21	20,156.82	16	2,200.31
District of Columbia	......	......	3	386.14	......	......	......	......	......	......	2	70.13
Florida	1	1,073.95	13	1,358.96	......	......	7	374.25	2	171.05	1	19.58
Georgia	......	......	8	1,201.12	......	......	......	......	......	......	1	11.59
Illinois	......	......	19	4,525.78	33	4,064.93	50	3,274.55	8	715.05	34	2,301.61
Indiana	......	......	131	52,636.20	40	6,562.60	26	1,960.27	9	974.26	3	74.75
Iowa	......	......	18	1,413.82	10	604.79	21	1,651.26	1	4.00	......	......
Kansas	......	......	......	......	4	446.00	......	......	......	......	......	......
Kentucky	......	......	23	4,085.66	7	758.62	8	606.17	3	303.09	......	......
Louisiana	......	......	8	1,195.40	1	16.17	12	664.39	3	234.48	25	298.93
Maine	......	......	25	3,326.34	5	902.21	8	421.10	4	1,088.45	44	2,900.81
Maryland	2	723.63	46	12,046.37	3	675.52	15	1,020.47	3	250.90	4	100.14
Massachusetts	5	7,718.74	25	2,442.11	9	2,884.66	12	751.10	8	723.81	26	1,014.05
Michigan	1	387.92	40	18,421.53	4	636.13	90	6,278.59	73	38,140.16	50	959.89
Minnesota	......	......	15	1,480.44	1	63.76	9	1,003.07	......	......	1	7.02
Mississippi	......	......	7	645.03	......	......	2	53.56	5	218.62	2	25.22
Missouri	......	......	19	9,093.44	13	1,500.59	8	557.20	8	459.25	2	351.05
New Hampshire	......	......	4	216.21	......	......	......	......	......	......	......	......
New Jersey	4	2,250.67	74	17,936.86	20	9,305.51	68	4,016.77	10	3,380.28	39	2,404.08
New York	25	40,891.78	284	122,025.85	109	49,893.48	300	17,016.80	68	51,830.86	169	7,527.00
North Carolina	......	......	15	1,352.29	......	......	3	20.00	1	91.42	......	......
Ohio	......	......	158	70,585.34	27	2,131.08	79	9,382.11	46	42,625.30	35	1,390.37
Oregon	......	......	63	20,824.64	7	1,499.26	5	182.25	4	297.94	......	......
Pennsylvania	47	85,695.40	182	38,400.76	22	5,330.41	353	43,334.23	39	24,344.91	84	5,999.81
Rhode Island	......	......	4	143.50	......	......	1	8.39	......	......	12	292.18
South Carolina	......	......	6	1,251.65	......	......	3	44.47	......	......	1	13.10
Tennessee	......	......	19	2,003.81	1	314.84	4	47.71	2	72.37	......	......
Texas	......	......	1	185.05	......	......	5	157.93	1	65.83	......	......
Vermont	......	......	2	1,399.06	......	......	......	......	......	......	......	......
Virginia	1	1,437.96	25	3,492.99	3	445.94	17	379.32	8	527.37	2	17.70
Washington Territory	1	732.30	31	3,279.88	1	181.81	1	110.59	3	63.01	......	......
West Virginia	......	......	27	4,683.80	10	532.19	14	2,010.21	2	78.49	1	3.00
Wisconsin	......	......	59	12,746.39	5	148.76	61	2,049.75	18	2,332.22	15	207.95

Steam vessels of the United States—Continued.

Where built.	Ocean passenger steamers.		Inland passenger steamers.		Ferry boats.		Towing boats.		Freight steamers.		Other steamers.	
	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.
ALABAMA	1	508.05	4	606.32	1	17.00	8	272.81	5	576.62	1	3.00
Cheney's Landing									1	73.00		
Fish River							1	25.43				
Gadsden			1	57.05			2	57.65				
Mobile	1	508.05	2	357.40			5	189.73	2	361.47		
Portland									1	112.00		
Selma					1	17.00			1	30.15		
Stockton											1	3.00
Whitesburg			1	191.18								
ALASKA, Sitka			1	255.44								
ARKANSAS			8	813.16	3	161.20	1	12.40	1	29.46	1	70.83
Arkansas Post											1	70.83
Dardanelles					1	72.45						
Fort Smith			1	89.74								
Helena			1	130.25			1	12.40				
Jacksonport			1	115.35								
Little Rock			3	277.18								
Madison									1	29.46		
Pine Bluff			1	70.09	1	24.93						
Spadra			1	124.55								
Van Buren					1	63.82						
CALIFORNIA	6	3,006.70	56	9,584.84	29	21,803.21	28	1,755.40	23	3,248.48		
Eureka	1	388.92	1	90.00			2	138.82				
Fair Haven					1	104.07						
Humboldt							1	133.18				
Lapham's Landing			1	68.14								
Martinez					1	102.00						
Marysville									1	168.03		
Oakland					2	5,116.12						
Roland's Landing							1	10.00				
Sacramento			1	176.02					2	302.99		
San Francisco	5	2,617.78	37	6,321.70	25	16,481.02	18	1,201.67	16	2,256.04		
Stockton			12	2,630.61			5	205.63	4	521.42		
Tahoe City			1	28.00								
Union City			1	96.06								
Vallejo			1	21.70								
Washington							1	6.10				
Wilmington			1	102.02								
CONNECTICUT	12	11,076.77	27	5,782.82	7	637.37	8	791.31	11	4,900.69	20	1,380.81
East Haddam	2	2,068.99	3	1,345.35	1	14.40			1	132.08		
Glastonbury					1	12.68						
Guilford											1	19.17
Hartford					1	104.32	1	86.37			1	19.27
Middletown			1	293.24			1	35.93				
Mystic	6	5,949.42	9	2,223.04	1	127.15	3	207.29	7	3,604.38	9	791.74
New Haven			4	531.85					1	417.94		
New London			2	54.95			1	23.20			2	157.42
Noank			5	1,212.83							5	325.03
Norwich	2	963.73					1	206.19	1	566.83		
Portland	2	2,094.63			1	329.28			1	188.46		
South Norwalk			2	51.88			1	52.33			2	68.18
Suffield			1	68.98	2	49.59						
DAKOTA			1	217.77	1	44.91						
Fargo			1	217.77								
Yankton					1	44.91						
DELAWARE	23	32,897.27	51	24,478.13	16	6,757.70	24	1,524.36	21	20,156.82	16	2,200.31
Concord											1	14.14
Fennimore									1	131.41		
New Castle							1	173.50				
Wilmington	23	32,897.27	51	24,478.13	16	6,757.70	23	1,350.86	20	20,025.41	15	2,186.17

Steam vessels of the United States—Continued.

Where built.	Ocean passenger steamers.		Inland passenger steamers.		Ferry boats.		Towing boats.		Freight steamers.		Other steamers.	
	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.
DISTRICT OF COLUMBIA			3	386.14							2	70.13
Georgetown			1	26.99								
Washington			2	359.15							2	70.13
FLORIDA	1	1,073.95	13	1,358.96			7	374.25	2	171.65	1	19.58
Cedar Keys							1	48.80	1	139.65		
Jacksonville			7	996.40			1	11.53				
Leesburg			1	76.48								
Mayport Mills											1	19.58
Milton							1	25.42				
Palatka			5	286.08								
Pensacola	1	1,073.95					2	158.85				
Perdido							1	85.48				
Sinnabel's island									1	32.00		
Wilmington							1	44.17				
GEORGIA			8	1,201.12							1	11.50
Columbus			2	412.77								
Rome			2	458.00								
Saint Mary's			2	246.15								
Savannah			2	84.20							1	11.50
ILLINOIS			19	4,525.78	33	4,064.93	50	3,274.55	8	715.05	34	2,301.64
Cairo			1	7.80			2	95.82				
Carmi									2	111.89		
Chicago			3	542.37			27	951.04	4	196.86	21	1,080.95
Galena							1	38.79				
Golconda							1	23.01				
Grafton			1	132.74	8	614.33	2	323.63	1	180.44		
Grand Tower					1	92.26	1	83.36				
Grayville					1	23.31						
Griggsville Landing					2	48.44						
Havana			1	3.00								
Joliet					1	93.09						
Keithsburg			1	49.21								
Lockport											10	1,069.64
Meredosia			1	4.83	1	24.04						
Metropolis City			4	2,086.07	9	1,723.99	9	1,290.20				
Mound City			3	1,085.26	5	1,161.72			1	225.86		
Peoria			2	8.80	1	43.40					2	111.81
Peru							1	71.04			1	90.21
Pleasant Valley					1	23.74						
Port Byron					1	33.79						
Quincy			1	440.47	1	165.07	1	7.61				
Rock Island					1	17.15	3	302.83				
Saint Bernard							1	18.71				
Savannah							1	61.52				
Warsaw			1	150.23								
INDIANA			131	52,636.37	40	6,562.60	26	1,960.27	9	974.26	3	74.75
Aurora			2	53.12								
Bridgeport					1	49.60						
Evansville			12	2,224.73	5	183.22	9	527.30	1	78.15		
Hazelton							1	22.79	1	58.21		
Jeffersonville			80	39,365.59	10	2,173.31	4	370.04	3	407.92	1	5.00
La Fayette			2	86.58			1	60.84	2	97.44	1	42.20
Logansport							1	66.11				
Madison			26	9,821.84	11	1,940.39	6	769.24	1	83.83	1	27.55
Michigan City									1	248.71		
Mount Carmel							1	10.58				
Mount Vernon					2	44.16						
New Albany			4	664.38	10	2,151.92	1	54.11				
Shoals			1	90.23			1	58.60				
Terre Haute			2	143.83								
Vevay			1	96.81	1	20.00						
Vincennes			1	89.26								
Washington							1	21.16				

Steam vessels of the United States—Continued.

Where built.	Ocean passenger steamers.		Inland passenger steamers.		Ferry boats.		Towing boats.		Freight steamers.		Other steamers.	
	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.
IOWA			18	1,413.82	10	604.79	21	1,651.26	1	4.00		
Bellevue			3	105.34			1	52.74				
Burlington			4	201.50			2	84.78				
Clayton			1	32.00								
Clinton			1	176.73	1	155.97	4	410.05	1	4.00		
Davenport			1	14.04			1	2.16				
Dubuque			3	658.77	3	154.37	3	100.59				
Gilbert Town					1	18.00						
Le Claire			1	168.38	1	65.44	6	555.35				
Lyons			3	49.87	1	142.72	1	4.15				
Maquoketa							2	102.39				
Montrose					1	54.50						
Muscatine			1	7.13	1	61.79						
Pleville					1	12.00						
Saint Claire							1	230.15				
KANSAS					4	446.00						
Leavenworth					3	388.93						
Wyandotte					1	57.07						
KENTUCKY			23	4,985.66	7	758.62	8	606.17	3	363.09		
Ashland			2	78.30								
Carrsville			1	20.20								
Caseyville			2	130.84								
Catlettsburg			2	161.51								
Constance					1	21.25						
Covington			2	100.87								
Hudson					2	38.13						
Louisville			8	3,743.10	3	584.58	3	294.40	2	217.36		
Newport							1	4.80				
Owensborough			1	37.36								
Paducah			4	678.93	1	114.66	1	140.51	1	145.73		
Proctor			1	34.46								
Rockport							1	13.30				
Westonburgh							1	55.80				
West Point							1	97.18				
LOUISIANA			8	1,195.40	1	16.17	12	664.39	3	234.48	25	298.93
Alexandria					1	16.17						
Algiers											1	18.08
Baton Rouge							1	34.94				
Bayou Boeuf									2	75.40		
Berwick							1	52.68			2	24.30
Breaux's Bridge											1	28.08
Franklin							2	162.81	1	159.08		
Gosport			1	69.85								
Houma											2	37.80
Jefferson											1	37.65
Lake Charles							2	69.00				
Madisonville			3	511.53								
Mountain Bayou			1	42.35								
New Iberia											1	8.53
New Orleans			3	572.17			5	288.11			13	111.48
Plaquemine							1	56.85			2	23.75
Shreveport											1	7.89
Trinity											1	11.22
MAINE			25	3,326.34	5	902.21	8	421.10	4	1,088.45	44	2,900.81
Bangor							1	190.49				
Bath			4	527.31	4	886.24	1	48.25	1	420.50	10	529.02
Belfast			1	41.07								
Booth Bay											3	223.38
Brewer			2	207.93								
Bristol											4	250.14
Bucksport					1	15.97						
Calais			1	4.00			1	32.18				

Steam vessels of the United States—Continued.

Where built.	Ocean passenger steamers.		Inland passenger steamers.		Ferry boats.		Towing boats.		Freight steamers.		Other steamers.	
	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.
MAINE—Continued.												
Cape Elizabeth			2	58.03								
Cherryfield							1	8.72				
Damariscotta											4	323.47
East Deering											11	738.14
Hogdon's Mills											3	231.60
Kennebunk			2	730.42							3	228.20
Millbridge			1	102.57								
Portland			8	1,510.82			2	80.07	2	548.38		
Richmond			1	14.05								
Rockland			1	37.80								
Round Pond											1	52.53
Saco			1	72.04					1	119.57		
South Bristol											5	324.24
Thomaston							1	11.75				
Upton			1	18.50								
Wiscasset							1	40.64				
MARYLAND	2	723.63	46	12,046.87	3	675.52	15	1,020.47	3	250.90	4	100.14
Annapolis					1	45.04						
Baltimore	1	493.00	44	11,676.27	2	630.48	14	1,001.03			3	39.94
Cambridge							1	19.44				
Crumpton			1	326.52								
Cumberland									2	120.00	1	60.20
Havre de Grace	1	230.63							1	130.90		
Solomon's Island			1	43.58								
MASSACHUSETTS	5	7,718.74	25	2,442.11	9	2,884.66	12	751.10	8	723.81	26	1,044.05
Agawam			1	95.32								
Boston	5	7,718.74	12	1,102.49	7	2,743.46	6	209.00	3	219.27	7	105.67
Charlestown											1	9.62
Chelsea			2	890.82							1	9.77
Dighton			1	50.82								
Dorchester							1	37.85				
East Boston							1	248.19			1	103.48
Fall River			1	34.18			1	84.78	2	170.96	7	503.10
Gloucester			1	30.83	1	26.14	2	53.01			1	33.95
Haverhill			1	35.16							1	26.03
Ipswich			1	16.56								
Lynn											1	10.33
Nantucket											1	7.18
New Bedford											1	10.46
Newburyport			1	45.51	1	115.06			2	323.88		
North Weymouth											1	46.77
Salisbury			2	64.96							1	6.67
Sheldonville			1	20.54					1	9.70		
Springfield							1	27.28			1	15.26
Taunton											1	5.16
Westport			1	39.97								
MICHIGAN	1	387.92	40	18,421.53	4	636.13	90	6,278.50	73	38,140.16	50	959.89
Algonac			1	263.37			3	209.40	1	636.99		
Allegan			1	160.61					2	414.61		
Alpena											2	9.07
Bangor							3	111.08	2	2,206.08	1	8.80
Bay City							2	161.53			1	6.49
Berlin									1	78.82		
Cadillac											1	37.37
Cheboygan							2	59.54				
Crockery							2	28.40			1	9.54
Detroit			9	4,085.05	4	636.13	12	2,156.49	13	8,135.48	11	201.52
Eastmanville							1	335.30				
East Saginaw			2	299.73			12	408.64	3	1,342.40	1	29.72
Fair Haven									1	244.46		
Ferrysburg			1	42.91			4	137.23			1	28.30
Gibraltar									7	3,281.13		
Grand Haven			3	617.75			13	384.65			5	170.49

Steam vessels of the United States—Conitnued.

Where built.	Ocean passenger steamers.		Inland passenger steamers.		Ferry boats.		Towing boats.		Freight steamers.		Other steamers.	
	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.
MICHIGAN—Continued.												
Grand Rapids			2	257.30							1	26.66
Houghton											1	8.37
Ionia											2	50.30
Lake Harbor											2	6.00
Lincoln							1	34.16				
Ludington							1	40.24				
Manistee											1	11.73
Marine City			13	7,434.21			8	808.20	17	9,327.30		
Marquette											1	6.86
Marysville									1	801.40		
Menominee											1	7.28
Monroe											1	6.80
Mount Clemens			2	225.70					2	140.63	3	78.78
Muskegon			1	16.88			11	274.00	1	56.58	2	16.73
New Baltimore							1	51.02				
Newport							1	33.74			1	41.83
Port Huron							7	1,088.03	5	4,420.32		
Rockwood									1	36.23		
Saginaw			1	381.81			3	93.25	1	884.03	1	61.50
Saint Clair									4	2,733.53		
Saint Joseph			1	90.17			1	25.48			1	7.00
Saint Martin's island							1	20.01				
Salsburg									1	1,456.11		
Saugatuck			2	358.60			4	80.17	1	57.78	4	71.31
Sault Ste. Marie									1	72.90	1	17.94
Sebewaing			1	78.24								
Spring Lake											2	25.96
Sugar Island							1	75.03			1	18.30
Trenton			5	2,978.16					7	1,921.60		
Vicksburg									1	249.55		
Winona			3	208.89								
Wyandotte	1	387.92	1	312.00			1	45.00				
MINNESOTA			15	1,480.44	1	63.76	9	1,003.07			1	7.02
Arcola			3	303.52								
Brainard							1	19.00				
Breckenridge			1	117.75								
Carver							1	135.94				
McCauleyville			1	119.08								
Minneapolis							1	50.88				
Osceola							1	188.21				
Ottawa			1	78.88								
Reed's Landing			3	267.35			2	110.10				
Saint Anthony			1	60.42								
Saint Paul							1	131.00			1	7.02
Stillwater			3	434.44			1	133.60				
Wabasha			1	60.50								
Wacouta							1	218.86				
Winona			1	38.50	1	63.76						
MISSISSIPPI			7	645.03			2	53.50	5	218.03	2	25.22
Aberdeen									1	64.00		
Bay Saint Louis							1	18.00				
Biloxi			1	76.39								
Columbus									1	22.20		
Gainesville			3	343.81					1	46.94		
Grand Gulf											1	4.97
Logtown			1	46.14								
Pearl River							1	35.50				
Rodney											1	20.25
Vicksburg			1	104.50					2	85.39		
Wolf River			1	74.19								
MISSOURI			10	9,903.44	13	1,500.59	8	557.20	8	459.25	2	354.65
Boonville									2	109.14		
Brunswick					1	72.18						

Steam vessels of the United States—Continued.

Where built.	Ocean passenger steamers.		Inland passenger steamers.		Ferry boats.		Towing boats.		Freight steamers.		Other steamers.	
	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.
MISSOURI—Continued.												
Carondelet					1	277.08						
Clarksville							1	51.48				
Forest City							1	54.80				
Gasconade River					1	33.60						
Glasgow					1	81.14						
Harlem							1	91.66				
Kansas City									1	47.72		
Lime Creek									1	70.52		
Missouri City					1	27.83						
Osage City			1	64.44								
Poplar Bluff									2	59.62		
Rocheport			1	240.72	1	63.66						
Saint Joseph					1	180.00						
Saint Louis			16	8,785.23	5	737.32	5	350.26	2	166.25	2	354.65
Washington			1	3.00								
Waverly					1	27.78						
NEW HAMPSHIRE			4	216.21							2	14.73
Dover			1	17.12								
Manchester											1	5.00
Portsmouth			3	199.00							1	9.73
NEW JERSEY	4	2,259.07	74	17,936.86	20	9,805.51	68	4,916.77	10	3,380.28	39	2,404.08
Alloway's Creek							1	17.90			3	255.84
Atlantic City							1	16.78				
Belleville			1	23.16			2	61.03	2	317.16		
Bordentown			4	120.03			8	113.83	2	346.13	6	186.50
Bull's Ferry			2	1,053.60					1	71.02		
Camden	2	1,492.31	18	1,932.08	8	2,488.04	20	1,794.36	1	84.54	14	1,114.32
Elizabethport							2	43.93				
Fort Lee			1	444.17								
Gloucester											2	253.08
Hoboken			2	290.40	7	4,945.25	5	1,116.03	2	2,362.64	1	317.07
Jersey City			14	4,734.04	1	300.05	2	47.34			4	33.11
Kaighn's Point	1	637.87	1	198.70			2	125.53				
Keyport			28	8,366.25	3	1,561.75	5	600.91	1	76.08	3	21.41
Millville			1	218.60								
Newark			1	5.57								
New Brunswick	1	129.49	5	349.75	1	10.42	14	831.96			1	103.42
North Belleville							2	34.53	1	122.11		
Passaic							1	30.14				
Perth Amboy											2	24.90
Petty's Island							2	78.00			2	18.66
Saltersville											1	15.02
Shadyside			1	103.82								
Washington							1	4.50				
NEW YORK	25	40,891.78	284	122,025.85	109	49,893.48	300	17,016.80	68	51,830.86	169	7,527.00
Albany			7	2,070.30	1	16.23	16	775.20	1	62.92	6	40.35
Alexandria Bay			1	82.54							2	35.00
Athens			7	3,213.85	7	1,498.11	5	129.94				
Black River											1	8.39
Brewerton											1	18.70
Brooklyn	8	11,266.04	62	27,362.93	46	29,750.21	23	1,627.29	11	7,219.20	35	2,590.94
Buffalo			56	13,039.74	12	749.29	104	5,381.14	30	30,890.75	30	1,501.63
Caldwell			2	97.95								
Cape Vincent			1	53.08								
Carthage			1	37.73								
Chaumont											1	9.47
City Island									1	80.97	1	11.36
Clayton			3	1,346.78			1	110.09	1	128.78	1	9.38
Depauville			1	31.60								
Dunkirk							1	15.18				
Eddyville							1	15.37	1	3.00	2	14.63
Ellenville							1	26.60				
Essex			1	125.18								

Steam vessels of the United States—Continued.

Where built.	Ocean passenger steamers.		Inland passenger steamers.		Ferry boats.		Towing boats.		Freight steamers.		Other steamers.	
	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.
New York—Continued.												
Fayettville			1	24.46								
Frankfort											2	239.10
Geneva			1	26.12							1	6.08
Glenwood			2	20.91					1	25.04		
Grand Island			1	16.23							1	15.61
Greenbush							2	78.83				
Green Point	5	8,838.53	16	10,739.07	6	3,208.00	1	111.71			3	214.42
Havana											5	633.24
Hunter's Point			1	186.00								
Ilion											1	119.90
Ithaca											2	254.27
Kingston							1	65.40	1	124.61		
Lansingburg					1	39.06	3	52.03			1	5.20
Lockport			2	574.58			2	16.68			1	128.40
Malden							3	77.62	1	880.03		
Massena			1	42.95								
New Baltimore			5	942.36	3	711.32	11	713.78	1	1,232.51	1	10.37
Newburgh			11	999.86	1	418.86	14	1,044.53			6	48.23
New York	12	20,787.21	65	54,835.93	25	12,616.10	21	5,292.49	11	10,140.70	12	132.89
Northport			3	256.38								
Nyack			1	87.76			2	807.76			1	15.35
Ogdensburg			8	2,419.34	1	181.24	1	35.16			9	411.20
Olean							1	27.70				
Oswego			1	207.42			1	32.03	1	465.00		
Peekskill							1	12.03			2	26.49
Pillar Point											1	10.46
Port Jervis			1	8.86								
Poughkeepsie			1	36.37							8	100.66
Pultneyville			1	56.00								
Randolph			1	15.44								
Red Hook					1	28.08						
Rhinebeck											1	11.00
Rochester			2	156.80			1	53.00			1	11.75
Rockaway									1	20.90		
Rome									1	85.10		
Roundout			1	71.06	2	479.99	10	447.35	1	40.90	6	481.37
Schenectady											1	23.81
Seneca Lake							1	17.00				
Shooter's Island			1	146.87								
Sodus											1	80.84
South Brooklyn			1	40.08			1	10.77				
Staten Island			4	287.34			1	74.41	2	150.10		
Stratsburg			1	208.12								
Syracuse									1	161.83	4	131.20
Ticonderoga			1	643.14								
Tonawanda			1	529.01	1	23.28					1	21.08
Tottenville							3	118.70	1	99.83	1	18.51
Troy and West Troy			2	143.75	1	18.54	5	70.10				
Wappinger's Falls											1	16.68
Waterford							1	30.21				
Watertown											5	31.43
Watkins			2	173.02								
Whitehall							1	236.25				
Williamsburg			3	635.27	1	64.48					1	119.71
North Carolina			15	1,352.20			3	26.00	1	91.42		
Chowan			1	120.66								
Drummond's Point							2	16.71				
Elizabeth City									1	91.42		
Fayetteville			3	330.25								
Kinston			1	62.87								
Leachville			1	52.90								
New Berne			1	194.56								
Port Caswell			1	48.76								
Washington			3	197.24								
Wilmington			2	295.21								
Windsor			1	42.62								
Winton			1	7.22			1	9.29				

Steam vessels of the United States—Continued.

Where built.	Ocean passenger steamers.		Inland passenger steamers.		Ferry boats.		Towing boats.		Freight steamers.		Other steamers.	
	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.
OHIO			158	70,585.34	27	2,131.08	79	9,382.11	46	42,625.30	35	1,390.37
Aberdeen			1	26.22								
Akron							1	59.58				
Ashtabula							1	108.06			1	0.38
Beverly			1	61.23	1	22.27						
Black River			2	453.83					2	2,337.02	1	18.71
Buffalo											1	21.05
Chambersburg			2	186.35								
Chillicothe							2	99.37			1	106.23
Cincinnati			70	45,780.45	11	1,454.97	16	3,128.98	1	45.01	2	107.96
Cleveland			22	14,528.86			25	2,507.30	36	37,743.10	9	303.04
Conneaut			1	4.25			6	1,276.43				
Defiance											1	68.17
Fairport									1	37.88		
Gallipolis					1	80.36						
Hockingport			1	133.65								
Huron			1	1,101.81			1	87.37	1	1,272.34	2	38.31
Ironton			10	1,215.29			1	359.86				
Lorain											2	36.58
Madison Dock											1	4.24
Manchester			3	292.14								
Marietta					1	20.69	2	185.86				
Maumee											1	8.56
Matamoras			1	96.65								
Middleport			2	307.12	3	105.19	3	575.57				
Minersville			1	21.29								
New Jerusalem			3	675.18			1	76.49				
Peninsula			1	59.60			2	119.76				
Perrysburg							1	169.17				
Point Carmen			1	121.94								
Point Harmar			8	1,838.63								
Pomeroy			1	78.52								
Portage River							1	18.15			1	4.50
Portland					1	36.66						
Portsmouth			10	1,002.27	2	116.02	3	100.20			1	88.99
Port Union											1	134.63
Racine					2	59.44						
Rock River											1	14.52
Sandusky			5	1,034.12					3	210.96	6	203.08
South Point			1	43.64			1	80.60			3	75.42
Steubenville					2	103.23						
Toledo			1	502.30			10	199.33	1	926.54		
Vermillion							1	20.98				
Wellsville					3	182.25	1	110.05	1	52.45		
OREGON			63	20,824.64	7	1,499.26	5	182.25	4	297.94		
Astoria			3	54.68								
Cape Hancock			1	5.68								
Cascades			6	4,113.70					1	51.64		
Celilo					1	84.05			1	45.29		
Conemah			6	1,037.75								
Coos			1	22.58								
Coquille River			1	30.46								
Corvalis			1	143.36								
Dallas			3	2,170.12	1	97.94			1	178.44		
Empire City			3	103.39			1	40.93				
Gardiner			2	104.02								
Marshfield			2	104.87								
Myrtle Point			1	85.56								
Oregon City			2	1,109.14								
Pioneer City			1	95.33								
Portland			26	10,321.01	4	1,256.56	3	127.88				
Saint Helen's			1	75.23								
Salem			1	47.14								
Skipanon			1	18.31								
Westport			1	204.31	1	110.71	1	13.44	1	22.57		
Yaquina Bay												

Steam vessels of the United States—Continued.

Where built.	Ocean passenger steamers.		Inland passenger steamers.		Ferry boats.		Towing boats.		Freight steamers.		Other steamers.	
	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.
PENNSYLVANIA	47	85, 095. 49	182	38, 460. 76	22	5, 330. 41	353	43, 334. 23	39	24, 344. 91	84	5, 990. 81
Belle Vernon					1	172. 37						
Brownsville			10	2, 905. 57	2	245. 05	1	159. 00	1	203. 52		
California			2	291. 79			1	147. 89				
Chester	24	53, 399. 17	13	2, 509. 50	2	1, 806. 55	15	781. 93	11	6, 220. 02	8	518. 57
Erie			2	21. 59			3	82. 01	1	311. 23		
Espy											5	347. 34
Freedom			3	456. 51	1	312. 04						
Gray's Ferry			1	10. 45								
Hamburg									1	127. 70		
McKeesport			1	64. 60	2	152. 95	1	105. 72				
Marcus Hook											1	34. 02
Middletown											3	216. 20
Newton Hamilton											1	49. 32
Philadelphia	23	32, 296. 32	88	8, 098. 72	9	2, 055. 98	181	9, 583. 03	17	13, 618. 19	63	4, 342. 06
Pittsburgh			60	22, 901. 61	5	585. 47	148	32, 446. 05	9	3, 704. 15	2	482. 30
Pittston			1	5. 37								
Reading							2	17. 75	1	94. 10	1	10. 00
Shorestown			1	1, 105. 05								
Titusville							1	10. 70				
RHODE ISLAND			4	143. 59			1	8. 39			12	292. 18
Apponaug			1	23. 64							1	38. 24
Bristol							1	8. 39			11	253. 94
East Providence			2	35. 48								
Westerly			1	84. 47								
SOUTH CAROLINA			6	1, 251. 05			3	44. 47			1	13. 19
Charleston			4	926. 84			3	44. 47			1	13. 19
Georgetown			2	324. 81								
TENNESSEE			19	2, 003. 81	1	314. 84	4	47. 71	2	72. 37		
Calhoun			1	55. 45								
Chattanooga									1	48. 18		
Clarksville			1	55. 75								
Dandridge			1	49. 40								
Dyersburg			2	201. 11								
Henry's Mill			1	162. 17								
Kingston			4	772. 96								
London			1	146. 16								
Memphis			3	174. 29	1	314. 84	4	47. 71				
Nashville			5	386. 52					1	24. 19		
TEXAS			1	185. 95			5	157. 93	1	65. 83		
Galveston			1	185. 95								
Houston							1	35. 65				
Lynchburg							4	122. 28				
Orange									1	65. 83		
VERMONT			2	1, 399. 06								
Burlington			1	274. 53								
Shelburne			1	1, 124. 53								
VIRGINIA	1	1, 487. 96	25	3, 492. 99	3	445. 94	17	379. 32	8	527. 37	2	17. 70
Accotink			1	207. 70					1	51. 14		
Alexandria			2	89. 91	1	49. 94	4	77. 94			1	9. 10
Atlantic City			1	938. 65								
Berkeley			2	63. 58			3	56. 95				
City Point							1	80. 40				
Cole's Ferry			1	40. 00								
Cottsville									1	42. 47		
Gilmington Locks			1	116. 62								
Neabsco									1	60. 77		
Norfolk			12	1, 522. 86	1	116. 06	4	104. 26	2	138. 33	1	8. 60
Occoquan			1	51. 33								

Steam vessels of the United States—Continued.

Where built.	Ocean passenger steamers.		Inland passenger steamers.		Ferry boats.		Towing boats.		Freight steamers.		Other steamers.	
	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.
VIRGINIA—Continued.												
Portsmouth			1	37.35	1	279.94						
Port Walthall							1	15.95				
Richmond	1	1,437.00					4	93.82	2	70.87		
Smithfield									1	163.79		
Washington Point			3	334.90								
WASHINGTON TERRITORY	1	732.36	31	3,279.88	1	181.81	1	110.59	3	63.01		
Bell Town			1	96.10								
Columbus			1	356.18								
Knappton			1	7.34			1	110.59				
Olympia			2	133.33					1	24.23		
Point Blakeley			1	176.01								
Point Discovery			1	194.35								
Port Gamble			1	173.54								
Port Madison	1	732.36	2	103.25								
Point Orchard			1	39.18								
South Bend			1	76.09								
Seattle			10	1,014.80					2	38.78		
Seabeck			1	83.31	1	181.81						
Snohomish City			1	37.62								
Turnwater			1	96.72								
Utsalady			4	540.17								
Vancouver			1	130.05								
Waterford			1	21.75								
WEST VIRGINIA			27	4,683.80	10	532.19	14	2,010.21	2	78.49	1	3.00
Burning Springs			1	83.32								
Charleston			4	196.07								
Guyandotte			1	55.71								
Hinton			1	146.00								
Leon			1	60.95								
Mason City			1	50.50	1	48.08						
Murraysville			4	820.40	1	49.05	1	52.19				
New Cumberland					1	25.00						
Parkersburg			5	554.90			1	8.60				
Peyton							1	23.91				
Point Pleasant			1	50.57	1	55.91						
Ravenswood									1	18.76		
West Columbia					1	30.31						
Wheeling			8	2,654.73	5	323.84	11	1,925.51	1	59.73	1	3.00
WISCONSIN			50	12,746.39	5	148.76	61	2,049.75	18	2,332.22	15	207.95
Ahnapee							2	42.20				
Baytown					1	33.04						
Berlin							2	146.44				
Chippewa Falls							1	37.59				
De Pere							1	13.55	1	90.08		
De Soto			1	51.64								
Eureka							1	20.00				
Fort Howard			5	144.15			4	70.80				
Green Bay			4	759.65			2	123.81	1	75.25	3	52.23
Hudson			1	61.73	1	26.98						
La Crosse			10	2,802.45			7	639.71				
Little Sturgeon							1	50.00				
Little Wolf									1	80.00		
Maiden Rock			1	98.78								
Manitowoc			9	5,654.15			2	29.24	1	68.68	1	10.65
Manistee									1	305.38		
Menasha									1	70.00		
Menominee			2	170.66								
Milwaukee			4	898.03	1	25.00	13	564.30	4	313.86	5	106.82
Montello			1	30.00								
Oconta			1	28.40								
Oshkosh			6	606.89			11	371.97	4	674.08		
Packwaukee									1	90.00		
Pensaukee							1	34.06	1	118.95		
Prescott			4	236.86			1	111.52				

Steam-vessels of the United States—Continued.

Where built.	Ocean passenger steamers.		Inland passenger steamers.		Ferry boats.		Towing boats.		Freight steamers.		Other steamers.	
	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.
Port Washington			1	66.51								
Pepin			2	162.83	1	24.74						
Peshtigo							1	50.00				
Prairie du Chien			1	242.14			1	24.03				
Racine											1	8.00
Red River							1	22.58				
Shawano			1	69.87								
Sheboygan			1	433.05			2	46.65	1	285.94	3	99.80
Sturgeon Bay							1	75.25				
Superior City											1	5.24
Two Rivers							1	18.49			1	15.21
Wabasha					1	30.00						
Winneconne			4	226.00			5	157.56	1	100.00		

STEAM VESSELS OF THE ATLANTIC AND GULF DISTRICTS.

GEOGRAPHICAL DISTRIBUTION.—In order to furnish a comprehensive view of the disposition and service of the steam tonnage, the steamers have been classified according to their usual routes and service in the following summary. Such route or service is sometimes indeterminate or a matter of question, but by the aid of occasional explanations and qualifying remarks the whole subject is believed to be fairly outlined.

FOREIGN TRADE.—There are few steamers plying to foreign ports. From Philadelphia to Liverpool, England, the American line has four steamers running, which are inspected in this country. They aggregate 12,408.12 tons, and have four engines, cylinder capacity, 1,010.44 cubic feet. The following steamers may be specified as plying to South American ports, the West Indies, Panama, Honduras, Mexico, and Central America:

[These are aggregate figures. The number of cubic feet will be understood as the aggregate cylinder capacity.]

Where from.	Steamers.	Tons.	Engines.	Cubic feet.
New England	4	4,625.10	6	274.25
New York	20	46,930.32	22	3,170.55
Philadelphia and ports southward on the Atlantic coast	3	979.70	4	25.51
New Orleans and Gulf ports	1	508.05	1	14.58
	2	706.86	3	30.85

A number of other large steamers in the coasting trade, routes unspecified, run to the West Indies. (See coasting from New York and Philadelphia, unspecified, and coasting between Gulf and Atlantic ports.)

A few steamers are specified as running to Canadian ports on the Atlantic seaboard:

Where plying.	Steamers.	Tons.	Engines.	Cubic feet.
Running to Canadian ports on the Atlantic seaboard	4	4,538.66	4	627.45
	1	935.28	1	138.23
	1	282.68	1	25.64
	3	115.13	3	8.15
	3	37.51	3	14.68

Nearly all of these, and all of the small ones run from New England ports. The steamers are grouped by sizes according to the system of classification which has been previously explained. Some run both to the West Indies and to Halifax.

COASTING TRADE.—Under this head are grouped the principal elements of the coasting trade by steam vessels. This is more or less merged with sound, bay, and river service, which are separately considered, and the many large steamers plying through Long Island sound do not appear under this head.

Where plying.	Steamers.	Tons.	Engines.	Cubic feet.
Coasting from New York, not otherwise specified	6	9,158.56	9	539.50
	4	2,927.73	4	331.01
	6	1,198.74	7	108.29
	15	1,103.19	15	69.84
	1	49.86	1	1.43
	1	4.00	1	0.23
Coasting from Philadelphia, not otherwise specified	12	16,089.16	13	454.39
	14	10,236.66	14	328.31
	11	3,526.12	11	179.04
Coasting from Boston and other New England ports to specified points south of New York	9	13,061.64	11	700.19
	5	4,062.70	6	181.91
	1	188.46	1	8.62
	16	1,284.24	16	44.21
Specified as coasting from New York to Baltimore, Charleston, Savannah, and other Atlantic ports of the southern states.	14	26,076.82	15	2,476.94
	6	5,410.20	6	769.30
	11	4,174.22	11	186.58
Specified as coasting from Philadelphia and Baltimore to Atlantic ports of the southern states (see also Baltimore to Norfolk and coasting from Philadelphia, unspecified).	3	1,825.47	5	162.59
	1	432.43	1	9.97
	1	65.86	1	3.99
Between Charleston, Wilmington, and Savannah, specified. (See also the following)	6	1,216.82	7	135.86
	1	52.61	1	3.63
	2	74.32	2	3.76
	1	7.74	1	0.36
Coasting between Atlantic ports of the southern states, not otherwise specified	3	3,424.03	3	532.83
	1	678.06	1	121.50
	4	548.72	4	40.14
	4	270.54	4	10.48
	4	155.85	4	7.17
	1	21.00	2	0.53
Running from Gulf and Atlantic ports to Key West. Most of these are from Gulf ports	6	1,419.66	8	57.93
	1	36.84	1	3.63
Plying between Gulf and Atlantic ports, mainly between New York and New Orleans	13	24,991.63	15	1,072.02
	1	508.68	1	113.09
	1	105.01	2	11.98
	1	85.50	1	11.34
Coasting upon the Gulf of Mexico, not otherwise specified. (See also bays, rivers, and coasting)	11	14,166.98	12	1,318.69
	6	4,627.96	6	452.71
	1	70.09	2	2.48
Coasting from Boston to points northward in New England	5	6,131.45	5	947.71
	1	80.84	1	2.46
	2	75.86	2	3.57

PRINCIPAL SOUND AND COASTING SERVICE.

Where plying.	Steamers.	Tons.	Engines.	Cubic feet.
New York to ports on Long Island sound and tributaries	15	20,519.84	16	3,060.51
	4	3,124.41	4	567.50
	13	3,525.41	13	332.72
	9	645.00	10	48.97
	2	79.79	2	4.63
	4	32.83	4	0.41
New York to ports in New England beyond Long Island sound	9	19,669.91	10	3,928.77
	5	3,964.04	9	189.40
	4	1,371.97	5	98.29
	1	92.17	1	12.28
Long Island sound, and coasting, not otherwise specified	1	1,420.52	1	138.23
	2	1,301.39	2	106.70
	13	2,611.05	15	243.04
	27	2,009.75	29	82.01
	18	672.44	10	27.41
	30	393.19	33	14.51
Plying upon Albemarle and Pamlico sounds, and from Chesapeake bay to the sounds of North Carolina.	18	3,896.23	21	105.22
	16	1,194.33	22	30.71
	11	353.75	11	11.01
	23	285.45	24	9.21
Sounds and inlets of Florida and Georgia, and upon Saint John's river	13	3,144.59	19	347.45
	13	896.77	20	66.65
	6	216.51	9	20.06
	18	142.94	21	4.46

The sounds to which reference is made have, as will be seen, a considerable and a characteristic body of steam shipping, The steamers of other sounds, inlets, and bays will be found classified under other heads.

PRINCIPAL BAY SERVICE.

Where plying.	Steamers.	Tons.	Engines.	Cubic feet.
Narragansett and Buzzard bays, rivers, and coasting	1	1, 001. 53	1	377. 69
	8	5, 120. 46	8	918. 81
	13	3, 315. 83	13	415. 23
	20	1, 377. 30	22	61. 71
	10	396. 14	10	18. 90
	26	269. 30	30	10. 83
Massachusetts bay, local and coasting	1	1, 372. 29	2	63. 34
	7	3, 643. 73	7	547. 44
	23	7, 200. 33	27	935. 14
	7	480. 17	8	22. 44
	32	1, 164. 10	34	56. 55
	26	312. 74	28	14. 95
New York bay, and bays and inlets of the New Jersey coast. This is exclusive of the regular ferry boats (see also New York and inland).	9	13, 851. 31	12	1, 854. 53
	7	4, 366. 44	7	663. 25
	59	12, 001. 32	81	1, 242. 93
	88	5, 883. 40	89	478. 43
	110	4, 388. 21	121	277. 57
	76	1, 089. 50	81	67. 52
Chesapeake bay and tributaries, not otherwise specified (see also Potomac river, Patapsco river, Baltimore and inland, and Chesapeake bay to North Carolina sounds).	13	8, 359. 50	15	1, 262. 23
	19	5, 969. 45	20	734. 45
	9	629. 53	9	50. 87
	27	1, 019. 36	28	70. 84
	11	159. 20	11	8. 57

PRINCIPAL GROUPS OF FERRY BOATS AND STEAMERS ON SHORT RIVER ROUTES.

Where plying.	Steamers.	Tons.	Engines.	Cubic feet.
New York bay ferries	7	7, 341. 04	7	1, 123. 18
	56	38, 420. 82	56	5, 431. 42
	21	7, 063. 36	21	1, 088. 95
Hudson river ferries	12	2, 971. 14	12	472. 01
	4	295. 33	5	19. 85
	1	39. 06	2	1. 08
	5	70. 40	7	2. 00
Delaware river ferries and short routes (see also Philadelphia to Delaware bay and river)	1	536. 51	1	70. 69
	13	4, 710. 43	13	815. 27
	1	97. 25	1	7. 98

PRINCIPAL RIVER AND CANAL SERVICE.

Where plying.	Steamers.	Tons.	Engines.	Cubic feet.
Rivers and coasting north of Massachusetts bay	1	1, 127. 52	1	102. 14
	1	874. 98	1	138. 30
	14	2, 851. 01	10	244. 09
	13	957. 15	14	76. 46
	28	1, 060. 23	34	54. 36
	34	398. 11	38	14. 68
New York to Hudson river points specified. (See also New York to Troy and Albany)	5	8, 784. 39	5	1, 888. 07
	11	7, 024. 98	11	1, 070. 75
	19	5, 235. 87	20	1, 050. 62
	3	251. 00	3	30. 08
	1	29. 57	1	1. 01
	7	51. 98	8	2. 68
Specified as plying between New York and Troy and Albany	4	5, 380. 09	4	1, 047. 24
	5	3, 306. 16	5	1, 336. 90
	6	1, 942. 12	6	1, 026. 18
	1	57. 12	1	12. 58
	1	40. 17	1	2. 62
Plying between specified Hudson river ports. (See also Hudson river ferries)	2	1, 204. 71	2	200. 57
	6	1, 896. 94	6	421. 10
	2	157. 32	3	8. 71
	1	4. 00	1	0. 04
Running from New York inland by sound, river, and canal routes unspecified. (See also Buffalo and New York).	15	10, 149. 50	15	1, 715. 47
	39	8, 811. 70	41	1, 300. 98
	37	2, 642. 03	38	325. 94
	23	807. 44	25	50. 08
	22	207. 77	26	13. 52

PRINCIPAL RIVER AND CANAL SERVICE—Continued.

Where plying.	Steamers.	Tons.	Engines.	Cubic feet.
Running from Hudson river points inland by river and canal routes unspecified	8	1, 653. 20	8	472. 58
	13	910. 57	13	147. 85
	23	792. 73	24	72. 55
	61	795. 38	61	50. 07
Philadelphia to Delaware bay and specified points on Delaware river. (See also Delaware river ferries.)	1	637. 20	2	245. 98
	12	2, 723. 01	16	790. 28
	5	349. 72	6	41. 13
	3	89. 85	3	3. 93
	46	413. 03	47	25. 10
Philadelphia, Camden, Wilmington, and Trenton inland by routes unspecified	3	3, 464. 84	4	603. 23
	8	5, 051. 35	9	1, 066. 84
	47	11, 317. 17	47	767. 10
	26	1, 935. 70	26	126. 22
	52	1, 983. 13	52	123. 70
	31	569. 38	32	30. 11
Plying upon the James river, and between Norfolk and Richmond and Baltimore	7	5, 094. 03	7	657. 76
	7	2, 550. 41	7	241. 89
	6	387. 90	6	15. 82
	14	497. 44	15	26. 56
	11	159. 28	11	7. 11
Patapsco river, Baltimore harbor, and to points inland	6	4, 163. 36	7	701. 62
	12	3, 864. 50	13	311. 07
	6	424. 62	6	17. 45
	6	221. 73	6	13. 57
	30	428. 81	31	26. 65

A number of the larger steamers ply from Baltimore to Fredericksburg, on the Rappahannock river. See also Norfolk and Richmond to Baltimore and Chesapeake bay and tributaries. Under this last head are a number of steamers specified as plying from points on the Choptank, Nanticoke, York, and Patuxent rivers.

Where plying.	Steamers.	Tons.	Engines.	Cubic feet.
Upon the Potomac river and from Washington and Georgetown, District of Columbia, to points inland. (Not comprised under any previous head and not duplicated in the classification.)	8	2, 253. 74	9	286. 17
	5	296. 47	6	9. 59
	11	468. 54	12	20. 58
	9	131. 50	9	8. 58
Winyah bay, Santee, Pedee, and Cape Fear rivers, and South Carolina harbors	13	3, 117. 45	22	200. 02
	8	630. 16	10	40. 87
	11	425. 19	13	23. 64
	13	174. 98	14	5. 83
Altamaha and Savannah rivers	5	886. 57	10	71. 84
	8	664. 61	10	40. 61
	7	272. 17	7	24. 02
	7	53. 79	9	1. 36
Rivers and bays of the Gulf of Mexico west of the Mississippi	1	892. 51	1	150. 33
	15	3, 498. 38	27	126. 64
	7	475. 98	10	17. 62
	10	366. 64	12	18. 20
	10	125. 67	10	4. 34
Rivers and bays of the Gulf of Mexico east of the Mississippi	1	592. 20	2	5. 12
	33	8, 022. 05	55	552. 06
	24	1, 746. 07	34	129. 00
	15	573. 08	20	30. 01
	24	311. 94	29	17. 08

This last group is comprised mainly in the steamers plying on Mobile bay and the Alabama and Tombigbee rivers, the Apalachicola and Chattahoochee rivers to Columbus, Georgia, and a smaller number plying on Pensacola bay, Escambia river, Choctawhatchie bay, and from Cedar Keys to points on the Suwanee river. West of the Mississippi the steamers above specified ply mainly on Galveston bay, but some upon the Sabine and Calcasieu lakes and rivers.

The following table exhibits the distribution of steamers inspected at New England ports. It is covered by the foregoing classification. It is believed that a better general idea of the distribution and service of the steam tonnage of the United States can be obtained by thus grouping the steamers than in any other manner.

	Steamers of 1,000 tons and over.				Steamers of 500 to 1,000 tons.				Steamers of 100 to 500 tons.			
	No. of steamers.	Tonnage.	No. of engines.	Cylinder capacity.	No. of steamers.	Tonnage.	No. of engines.	Cylinder capacity.	No. of steamers.	Tonnage.	No. of engines.	Cylinder capacity.
Long Island sound, rivers and coasting	1	1,420.52	1	138.23	2	1,391.39	2	106.70	13	2,011.05	15	243.04
Specified as running from points in Connecticut to New York	14	18,939.89	14	3,019.65	2	1,985.25	2	325.28	3	1,312.05	3	41.43
Narragansett and Buzzard bays, rivers and coasting	1	1,601.53	1	377.66	8	5,120.46	8	918.81	13	3,315.83	13	415.23
Specified as running to New York from New England ports beyond Long Island sound	9	19,669.91	10	3,028.77	5	3,964.04	9	189.40	4	1,371.97	5	98.20
Massachusetts bay, local and coasting	1	1,372.29	2	63.34	7	3,643.73	7	547.44	23	7,209.38	27	935.14
Specified as plying between Boston and points northward in New England	5	6,131.45	5	947.71	......	......	......	......	......	......	......	......
Specified as running to the West Indies from New England ports	4	4,625.10	6	274.25	......	......	......	......	......	......	......	......
Specified as running to Canada from New England ports	3	3,292.48	3	575.80	1	935.28	1	138.23	1	282.68	1	25.64
Rivers and coasting north of Massachusetts bay	1	1,127.52	1	102.14	1	874.98	1	138.30	14	2,851.01	19	244.99
Specified as coasting to southward of New York from New England ports	4	6,734.69	6	403.75	......	......	......	......	1	188.46	1	8.63

	Steamers of 50 to 100 tons.				Steamers of 25 to 50 tons.				Steamers of less than 25 tons.			
	No. of steamers.	Tonnage.	No. of engines.	Cylinder capacity.	No. of steamers.	Tonnage.	No. of engines.	Cylinder capacity.	No. of steamers.	Tonnage.	No. of engines.	Cylinder capacity.
Long Island sound, rivers and coasting	27	2,009.75	29	82.91	18	672.44	19	27.41	39	393.19	33	14.51
Specified as running from points in Connecticut to New York	4	204.46	5	16.25	1	40.39	1	3.68	3	13.32	3	0.88
Narragansett and Buzzard bays, rivers and coasting	20	1,377.39	22	61.71	10	396.14	10	18.90	26	269.39	30	10.83
Specified as running to New York from New England ports beyond Long Island sound	1	91.27	1	12.28	......	......	......	......	......	......	......	......
Massachusetts bay, local and coasting	7	480.17	8	22.44	32	1,104.10	34	56.55	26	312.74	28	14.95
Specified as plying between Boston and points northward in New England	1	86.84	1	2.46	2	75.86	2	3.57	......	......	......	......
Specified as running to the West Indies from New England ports	......	......	......	......	......	......	......	......	......	......	......	......
Specified as running to Canada from New England ports	......	......	......	......	3	115.13	3	8.15	3	37.51	3	1.25
Rivers and coasting north of Massachusetts bay	13	957.15	14	76.40	29	1,114.89	35	55.59	34	398.11	38	14.68
Specified as coasting to southward of New York from New England ports	16	1,284.24	16	44.21	......	......	......	......	......	......	......	......

STEAMERS IN FOREIGN TRADE.

The engines of the steamers of the American Steamship company (plying between Philadelphia and Liverpool) are of the most usual compound type, and will hereafter be more fully described. The cylinders are 57 and 90 inches in diameter with 4 feet stroke of piston.

Of steamers running to Panama, West Indies, Mexico, and South America the following examples of engines may be cited:

The "United States", 1,180.10 tons, plying from Boston, has two simple engines, vertical, surface-condensing, 40 inches diameter of cylinder, 40 inches length of stroke. The "City of Vera Cruz", 1,874.36 tons, of the New York and Havana Mail Steamship company's line, has one simple surface-condensing engine, 4 feet diameter of cylinder, 6 feet length of stroke. This engine has some peculiar features. The valve-gear is of the Corliss type, and was designed by George Reynolds, of New York. The pumps are operated by an auxiliary engine, which is bolted upon the starboard (right hand looking forward) side of the frame. This auxiliary engine is a beam-engine, the beam extending across the top of the condenser and driving the pumps, which are all located upon the port side, an arrangement somewhat different from that of the Pacific Mail steamships, in which the auxiliary engines and the pumps are both located upon the starboard side below the main engine-cylinders. The feed from the hot-well passes through a filter 10 feet long by 6 feet wide by $3\frac{1}{2}$ feet deep. This filter contains 5 wooden frames, covered with heavy wool blankets and wire netting, between which is a filling of coke. The feed has a temperature of 120°. The "City of Merida", 1,492.45 tons, running between New York and Vera Cruz, has one vertical condensing-engine, cylinder 56 inches by $4\frac{1}{2}$ feet.

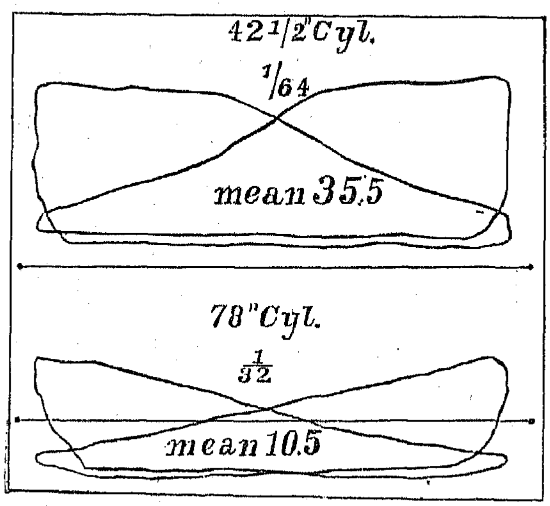


FIG. 2.

The "City of Para", of the Brazilian line (tonnage of steamer 3,532.25), has one compound engine, $42\frac{1}{2}$- and 74-inch cylinders by 5-foot stroke, built by Messrs. John Roach & Son. The "Newport", 2,735.29 tons, running between New York and Cuba, has one compound engine, 48- and 90-inch cylinders by $4\frac{1}{2}$ foot stroke. The "City of Alexandria", 2,480.32 tons, of F. Alexandre Sons, Havana and Mexican Mail line, has one compound engine, $42\frac{1}{2}$- and 78-inch cylinder diameters by 54-inch stroke. Cards of the engine are shown in Fig. 2, and the data of performance are as follows:

Area, high-pressure cylinder	square inch..	1,418.63
Area, low-pressure cylinder	do	4,778.37
Ratio of cylinders		3.3683
Stroke	feet..	$4\frac{1}{2}$
Boiler pressure per square inch	pounds..	70
Receiver pressure per square inch	do	10
Vacuum	inches..	26
Revolutions per minute		60
Mean pressure, high-pressure cylinder	pounds..	35.5
Mean pressure, low-pressure cylinder	do	10.5
Indicated horse-power, high-pressure cylinder		824
Indicated horse-power, low-pressure cylinder		821
Total		1,645

The absolute terminal pressure is stated at 9.56 pounds.

The "Tropic", 379.77 tons, plying between Philadelphia and the West Indies, has two 24- by 24-inch engines, simple condensing. The "Acadia", 387.26 tons, has one 32- by 30-inch simple condensing-engine.

The "Margaret", 508.05 tons, plying between New Orleans and Havana, has one simple condensing-engine, 32-inch cylinder by 32-inch stroke, and the "E. B. Ward, jr.", 387.92 tons, running to Honduras, has two 30- by 30-inch simple condensing-engines.

SMALL NUMBER OF COMPOUND ENGINES IN THE ATLANTIC AND GULF SERVICE.

Upon the large steamers of New England there may be said to be scarcely any compound engines, the only considerable proportion of them being in the small steam yachts. The practice is so diametrically opposed to that of the Pacific district, that it is emphasized by the following table of the percentages of compound to total number of engines in the two districts:

Tonnage of steamers.	New England.	Pacific.
	Per cent.	*Per cent.*
Over 1,000 tons	4	45
500 to 1,000 tons	0	11
100 to 500 tons	1½	10
50 to 100 tons	2	2
25 to 50 tons	2	5
Under 25 tons	9	0

In the Pacific district 45 compound engines propel 40,075.10 tons of shipping, the engines having an aggregate cylinder capacity of 2,914.24 cubic feet, and employing a boiler volume of 95,225.15 cubic feet; while 256 simple engines propel 70,496.21 tons of shipping, the engines having an aggregate cylinder capacity of 5,773.86 cubic feet, and employing a boiler volume of 150,475.04 cubic feet. In the New England district, comprising steamers inspected at the ports of Portland, Maine; Boston, Massachusetts; and New London, Connecticut, 17 compound engines propel 2,719.99 tons of shipping, the engines having an aggregate cylinder capacity of 111.71 cubic feet, and 10 of these have small coil boilers. The remaining 7 propel 2,565.21 tons of shipping, and employ a boiler-volume of 6,010.11 cubic feet, while 471 simple engines propel 110,999.09 tons of shipping, the engines having a cylinder capacity of 15,605.08 cubic feet, and employing a boiler volume of 398,389.81 cubic feet.

The percentage of tonnage of steam shipping propelled by compound engines is, for the Pacific district .3624, and for New England, .0024, river service included.

The cylinder capacity per 100 tons shipping is:

	Cubic feet.
For the compound engines:	
Pacific district	7.27
New England district	4.10
For the simple engines:	
Pacific district	8.19
New England district	14.05

The boiler volume per 100 tons is:

For steamers with compound engines (exclusive of steamers with coil boilers):	
Pacific district	237.59
New England district	234.29
For the steamers with simple engines:	
Pacific district	213.45
New England district	358.91

Designating as classes I, II, III, IV, V, and VI the groups of steamers of over 1,000, 500 to 1,000, 100 to 500, 50 to 100, 25 to 50, and under 25 tons respectively, we find among steamers inspected at Albany that none have compound engines in Class I, none in Class II, none in Class III, 3 out of 19 in Class IV, 1 out of 25 in Class V, and 1 out of 67 in Class VI.

Among steamers inspected at New York we find compound engines in only 19 out of 65 steamers of Class I, although this class includes many of the largest coasters. It may be remarked that of the remaining 46 steamers, 20 have beam-engines condensing and 26 simple-condensing direct-acting engines. From this it will be seen that there are 45 propellers to 20 side-wheel boats.

On steamers in Class II (500 to 1,000 tons) inspected at New York there is not, strange as it may appear, a single compound engine; but in Class III we find 12 steamers out of 162 with such engines, several being of the three-cylinder type. In Class IV, we find 4 out of 149 steamers with compound engines; in Class V, 6 out of 145; in Class VI, 6 out of 115.

Steamers inspected at Philadelphia having compound engines: Class I, 5* out of 21; Class II, 1 out of 30; Class III, 9 out of 88; Class IV, 6 out of 34; Class V, none; Class VI, none.

The remaining steamers in the Atlantic and Gulf service having compound engines may be very briefly enumerated: 4 or 5 inspected at Baltimore (small vessels), 1 inspected at Charleston, the 4 large steamers of the (Savannah) Ocean Steamship company,† the "Chalmette", of New Orleans, and a few small steamers upon the Gulf.

* Four steamships of the American line and the collier Perkiomen. † Not including the City of Augusta, which was inspected at New York.

COMPOUND ENGINES OF AN OCEAN STEAMER AS BUILT BY MESSRS. NEAFIE & LEVY, PHILADELPHIA.

The dimensions of machinery of a compound engine of American build are very fully given in the following figures:

Main steam-cylinders: Diameters, 30" and 50"; stroke, 3 feet; stuffing-box, 10½" diameter.

Ports and valves: 3" by 20" high-pressure steam-port, 3" by 36" low-pressure steam-port, 4½" by 20" high-pressure exhaust-port, 4½" by 36" low-pressure exhaust-port.

Relative area of ports: High-pressure steam, 60 square inches, as 1; low-pressure steam, 108 square inches, as 1.8; high-pressure exhaust, 90 square inches, as 1.5; low-pressure exhaust, 162 square inches, as 2.7; 2" slide-valve lap, 5½" depth of slide-valve, 5½" upper width cut-off valve, 5" lower width cut-off valve.

Valve-gear measurements: 9" center to center front links; journals 2¼" diameter, 2¼" long; 6½" steam-valve motion; 2¼" diameter of valve-stem; journals 2¼" diameter, 3" long; 1⅞" diameter of cut-off valve-stem, journals 1½" diameter, 2" long; 8' 1½" radius of slotted link; dimensions of slotted link, 16½" cross motion, 3" width, 1½" thickness, 2½" and 3" diameters of eyes; reversing-shaft, 3⅝" diameter.

Valve-chests: 2' 6" center cylinder to valve-face (high pressure); 2' 10" center cylinder to valve-face (low pressure); 3' 6" center cylinder to chest-face (high pressure); 3' 8" center cylinder to chest-face (low pressure); depth of chests, 12⅝" and 10⅝"; centers of cylinders to centers of valve-stems, 32½" and 36"; 3' 4" center cylinder to cut-off stem.

Piston: 8" depth of piston at center, 7" depth of piston at edge, ⅝" thickness of rings, 4½" diameter of piston-rod.

Cross-head: 11" main diameter, 9" long; journal 5" diameter, 5½" long.

Connecting-rod: 7' 6" long, center to center of journals, neck diameters 4" and 5".

Crank and shaft: Crank-pin 8½" diameter, 11½" long; main-shaft journals 9½" in diameter, length 15½" forward, 15" aft; 17" diameter of upper end of crank, 18" diameter of lower end of crank; 8" thickness of crank.

Pinch-wheel: 4 feet diameter, 5" face; shaft-couplings 16½" diameter, 10" depth, 24½" diameter of flange.

Eccentrics: 9½" diameter of eccentric eye, 3½" eccentric face, 6½" eccentric throw, 19½" eccentric diameter.

Bed-plate and housings: Bed-plate 9' 8" long, 6' 9" broad, 6½" center of shaft to top of bed-plate; housings 9' 9" high, 23½" by 32" at base, 20" by 24" at top.

Stern-bearing: 10½" diameter, 48" long.

Main guides: 9" face, 1" side depth.

Gibs: 18" long, 1½" thick.

Air-pump: 17" diameter of cylinder, 15" stroke, 4⅛" depth of piston at center, 3⅞" depth of piston at edge, 2" diameter of pump-rod, 8" diameter injection-side; air-pump cross-head 5¼" diameter, journals 3" diameter, 3" long; air-pump links 3' 9" center to center; air-pump levers 1½" thick, journal cylinder end 2½" diameter, 2½" long; air-pump end 3" diameter, 3" long, center diameter 4" by 15" length.

Other pumps: Centrifugal circulating-pump 120" diameter, with 5½" by 6" steam-cylinder, 8" discharge- and 10" receiving-pipe. A feed- and a bilge-pump each 3½" diameter by 15" stroke.

Propeller: 10' 9" diameter, 4' 8" length of blade, 15' 9" pitch.

The cylinder volume swept by pistons per revolution is 111.45 cubic feet, 26.43 per cent. in the high-, 73.57 per cent. in the low-pressure cylinders. The air-pump passes 1.97 cubic feet, the feed- and bilge-pumps each nearly 0.075 cubic feet per stroke.

COMPOUND ENGINES OF THE AMERICAN STEAMSHIP COMPANY'S VESSELS.

These engines, built by W. Cramp & Sons, Philadelphia, have been frequently described, and were illustrated in the London journal *Engineering*, in 1876. The following description of the machinery and its performance may be cited:

The engines are independent, compound, and surface-condensing, with the cranks set at right angles. The cylinders are 57¼" and 90⅛" in diameter respectively, and the stroke of pistons is 4 feet. The main slide-valves are on the outside of the high- and low-pressure cylinders, which are both inclosed in a jacket connecting them together and forming a receiver. The high-pressure cylinder is also steam-jacketed, but the low-pressure cylinder is not. The pistons are 16¾" deep; the rod for the high-pressure cylinder is 8", and that of the low-pressure 8½" in diameter, and both are carried upwards through the cylinder-heads. The cross-heads are of wrought iron, with cast-iron slides bolted to their ends. The main slide-valves have double ports; each is fitted with an independent cut-off valve on the back, no provision being made for counterbalancing the pressure on the valve-faces. The weight of the main valves is counterbalanced by the steam-pressure in a cylinder on the top of the steam-chest. Both main valves are driven by motion of the double-bar-link type.

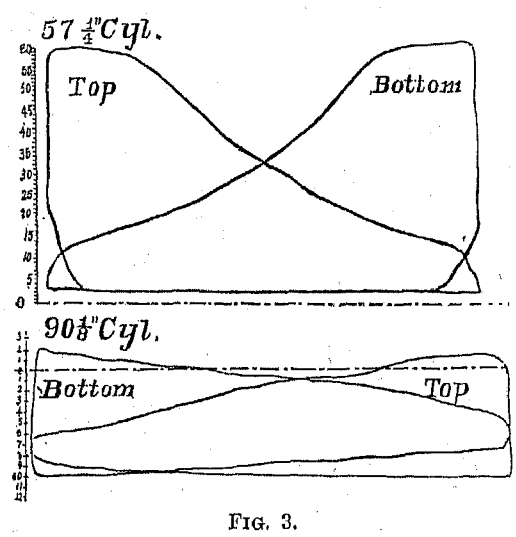


FIG. 3.

The engines are reversed by direct-acting steam-gear, the reversing-cylinder being 20" in diameter, with a slide-valve on top, which is thrown open by hand and closed by the motion of the piston-rod in any position. A screw is also provided, which can be clamped to the piston-rod of the cylinder so as to move the links by hand if there is a want of steam.

Relief-valves are fitted at the end of each cylinder with gear to use them as starting-valves. The connecting-rods are forked at the cross-heads and are fitted with strap ends. The cross-head journals are 10½" in diameter and 10½" long, and the crank-pins are of steel, 15½" in diameter and 20" length of journals. The crank-shafts are built up in two lengths and are made interchangeable; the main journals are 15½" in diameter and 30" long, except the forward journal, which is 24" long. The cranks are counterbalanced.

The bed-plate is made in two parts and is bolted up to the condenser. This latter is in two pieces, and contains 1,492 tubes ¾" in diameter and 14 feet long, the surface exposed being thus 4,786 square feet. The water from one circulating-pump passes through them three times and from the other twice. The pumps are worked from the main cross-heads through wrought-iron levers, as shown. Each air- and circulating-pump is cast separately and bolted to the condenser. A feed- and bilge-pump are bolted to each air-pump. The latter are 26″ in diameter, the circulating-pumps are 18″ in diameter, and the feed- and bilge-pumps are each 6″. The stroke of all is 26″.

A vertical turning-engine is bolted to the side of the condenser and gears into a worm-wheel fastened to the intermediate shaft-coupling between the two cylinders. The propeller-shaft is 15½″ in diameter and is sheathed in the stern-pipe. The propeller is four-bladed, with the blades cast separately and bolted to the bars; the diameter is 17 feet and the pitch 24 feet.

Figure 3 exhibits an indicator diagram taken during the second trip of one of these steamers (the "Ohio"), and under the following conditions:

Pressure of steam in boilers .... pounds..	60
Pressure of steam in receiver .... do....	1.5
Vacuum in condenser .... inches..	25.5
Revolution of engines per minute	60
Temperature of water in hot-well .... degrees..	130
Steam cut off at 19″ in the high-pressure cylinder.	
Indicated horse-power in high-pressure cylinder	1,237.44
Indicated horse-power in low-pressure cylinder	740.1
Total	1,977.54

The running of the "Ohio" during the voyage from Queenstown to Breakwater, when the above diagrams were taken, was as follows:

Date.	Knots run by screw.	Knots run by observation.	Running time.	Remarks.
1873.			h. m.	
October 17	240.8	226.0	18 50	
October 18	323.8	280.7	24 23	
October 19	338.5	322.0	24 15	
October 20	335.7	294.0	24 23	
October 21	331.0	(*)	24 0	15 minutes' detention.
October 22	341.5	(*)	24 24	
October 23	336.7	946 in 3 days.	23 43	18 minutes' detention.
October 24	339.5	333.7	24 22	
October 25	343.2	321.0	24 21	
October 26	142.0	140.0	10 30	
Total	3,075.7	2,863.4	9d 7h 20m	

* No observation.

The slip of the screw amounted to 212.3 knots, or 6.8 per cent., while the average speed was 12.8 knots. The weather was calm.

That the performance of the engines we have described has been most satisfactory is proved by the great regularity of the passages made by the vessels to which they are fitted, while their workmanship and general finish well deserve praise.

ENGINES OF NEW ENGLAND STEAMERS.

Of the engines of steamers of Class I the greater number are beam-engines with surface-condensers. There are 10 simple direct-acting engines used in pairs. There is one compound engine 24 and 54 inches by 4 feet. Considering the high-pressure cylinder in this engine, we may say for all that the ratio of stroke to diameter is from 2 to 3 in 15 engines, 1½ to 2 in 13 engines, 1 to 1½ in 5 engines, and 1 or less in 16 engines. The "Bristol" and the "Providence," of the Fall River line, have each cylinders 110 inches by 12 feet, and the "Rhode Island" and the "Massachusetts" have each cylinders 90 inches by 14 feet. The boats having direct-acting vertical engines are almost without exception freight-boats, coasting to New York and southward. Their cylinders range from 62 by 48 inches (stroke) to 44 by 36 inches (stroke). The beam-engines are low-pressure, the "Bristol" carrying a maximum boiler-pressure of only 25 pounds.

The "Electra" and the "Galatea", each of 1566.70 tons, and built in 1864, are stated to have been the first high-speeded propellers used on Long Island Sound. The "Galatea" is classed as an inland passenger and the "Electra" as a freight boat. The "Electra" is 232 feet long, 40.3 feet broad, 15.3 feet deep, and has two condensing-engines, each 3 feet 8 inches diameter by 3 feet stroke.

The "Decatur H. Miller", 2296.14 tons, plying between Baltimore and Boston, has two compound engines; diameters of cylinders, 2 feet and 4 feet 6 inches; length of stroke, 4 feet. These engines are of the steeple type, the high-pressure being placed above the low-pressure cylinder; an arrangement similar to that illustrated in the engines of the "Buffalo" and the "Chicago", of the Western Transportation line, but not usual in the Atlantic district. This arrangement of compound engines is also approved in the most modern English practice, but the great majority of compound engines have the cylinders side by side, fore and aft. In the engines of the "Decatur H. Miller" the cranks are set at quarter angles.

In Class II there are no non-condensing engines, nor are there any paired engines, all being simple non-condensing engines either of the beam or direct-acting types. In ferry service in the Boston district there are several examples of direct-acting inclined engines, cylinders 40 inches diameter by 9 feet stroke. The rarity of horizontal engines upon New England steamers is in marked contrast with their common employment upon the bays and rivers of the Pacific coast. Of 29 engines, the ratio of stroke to diameter is from 3 to 4 in 3 engines, 2 to 3 in 17 engines, 1 to 1½ in 1 engine, and 1 or less in 9 engines.

In Class III there are 10 non-condensing engines, the rest being generally provided with surface-condensers, but sometimes with jet or outside-pipe condensers. Of the non-condensing engines, there are two pairs of horizontal engines, one direct-acting inclined and one beam-engine. There is one compound engine 8 and 16 inches by 16 inches stroke. Twenty-four engines are used in pairs. Of 84 engines, the ratio of stroke to diameter of cylinders is over 3 in 9 engines, between 2 and 3 in 29, between 1½ and 2 in 2 engines, between 1 and 1½ in 19 engines, and 1 or less in 25 engines. In 22 engines the diameter equals the stroke.

In Class IV, about one-fourth of the engines are non-condensing. Of the condensing-engines a large proportion have condensers of the kind known as keel or outside-pipe condensers. Fourteen engines are used in pairs, and out of 95, 25 are of the so-called "square" type, the stroke and diameter of cylinders being equal. Ratios of stroke to diameter 2 to 3 in 12, 1½ to 2 in 4, 1 to 1½ in 43, and 1 or less in 36 engines. The diameters and strokes are equal or nearly equal in 80 per cent. of the engines. The engines are nearly all vertical direct-acting or vertical back-acting; beam, horizontal, and inclined engines being the exception. The change of engines from long-stroke beam to short-stroke direct-acting engines accompanies a change in the method of propulsion from side-wheels to screws.

In Class V, nearly half of the engines are non-condensing. There are a few horizontal engines, but the vertical direct-acting and back-acting types are the rule. The ratio of stroke to diameter in cylinders is between 2 and 3 in 3 engines, between 1½ and 2 in 12, 1 and 1½ in 27, and 1 or less in 62 engines. Eighteen engines are used in pairs.

In Class VI, 10 out of 117 engines are compound. Eight of these have the cylinder dimensions 3½ and 6 inches by 7 inches stroke. The ratio of stroke to diameter of cylinders is between 2 and 3 in 1 engine, 1½ and 2 in 24, 1 and 1½ in 52, and 1 or less in 58. This considers only the high-pressure cylinder of compound engines. There is one oscillating-engine, an unusual type in America.

In 1859, the "Dawn", a small propeller, commenced running with a rotary engine, stated to be the first used in the merchant service. After two years' trial it was displaced by a simple cylinder-engine (*Nautical Gazette*).

ENGINE OF THE SOUND STEAMER "PILGRIM".

This new steamer of the Fall River line, in the great magnitude of its machinery, furnishes so notable an example of American practice that it has been thought best to include its description in this report, although, not being launched until after the close of the census year, it does not appear in the tables of statistics. A side view of the arrangement of machinery is shown in the skeleton sketch, Fig. 6. This merely indicates the position of the principal parts: A A, the poppet-valves on one side; B, the steam-cylinder; C, the condenser; D, the air-pump, and E, the centrifugal circulating-pump. The frame is not shown, fixed bearings being indicated by heavy open circles. In Figures 4 and 5 we have in detail illustrations of the cylinder and valves with connections, a front view, and a side elevation in section.

The cylinder is 110 inches in diameter and 14 feet in stroke. It is the largest ever cast, the rough casting weighing 30 tons. The metal is 1¾ inches thick at the thinnest point, and the flanges are 2⅝ inches thick by 5¾ inches wide. The piston is of cast iron, plano-convex box form, with 12 ribs. The follower-bolts are of wrought-iron, with brass nuts screwed into the piston. The piston-rod is a foot in diameter, with a 17-inch head. It is driven in by a ram, and held by a nut a foot high. The piston-ring sections are jointed diagonally and connected by means of filling-blocks. There is a surface-condenser placed under the cylinder. This contains about 12,000 square feet of condensing-surface in ⅝-inch seamless brass tubes, tinned inside and out. There are two circulating-pumps with independent engines, and the air-pump is 60 inches in diameter and 6 feet in stroke, with a reservoir above it (not shown in the skeleton sketch). There are also two copper bilge-pumps. The balanced poppet-valves are 24½ and 25½ inches in diameter, of cast iron, with 2½-inch steel valve-stems. The side pipes are 33½ inches in diameter. The scale of the large drawings of the cylinder is about ⅓ inch to the foot, or $\frac{1}{36}$. The shafts are 39 feet 5 inches long, and together weighed 81,200 pounds in the rough. The dimensions of the several steps or diameters are as follows:

Part.	Diameter.	Length.	Part.	Diameter.	Length.
	Inches.	*Inches.*		*Inches.*	*Inches.*
Crank	26½	24	Paddle-flange boss .	28	20
Collar...........	32	6	Step	26 to 24	43
Main journal	26	29	Paddle-flange boss.	28	20
Collar...........	32	6	Step	23 to 21	38
Step	26½	37	Paddle-flange boss .	28	20
In gangway......	26	148	Outboard journal ..	19	31
Spring-bearing...	27	51			

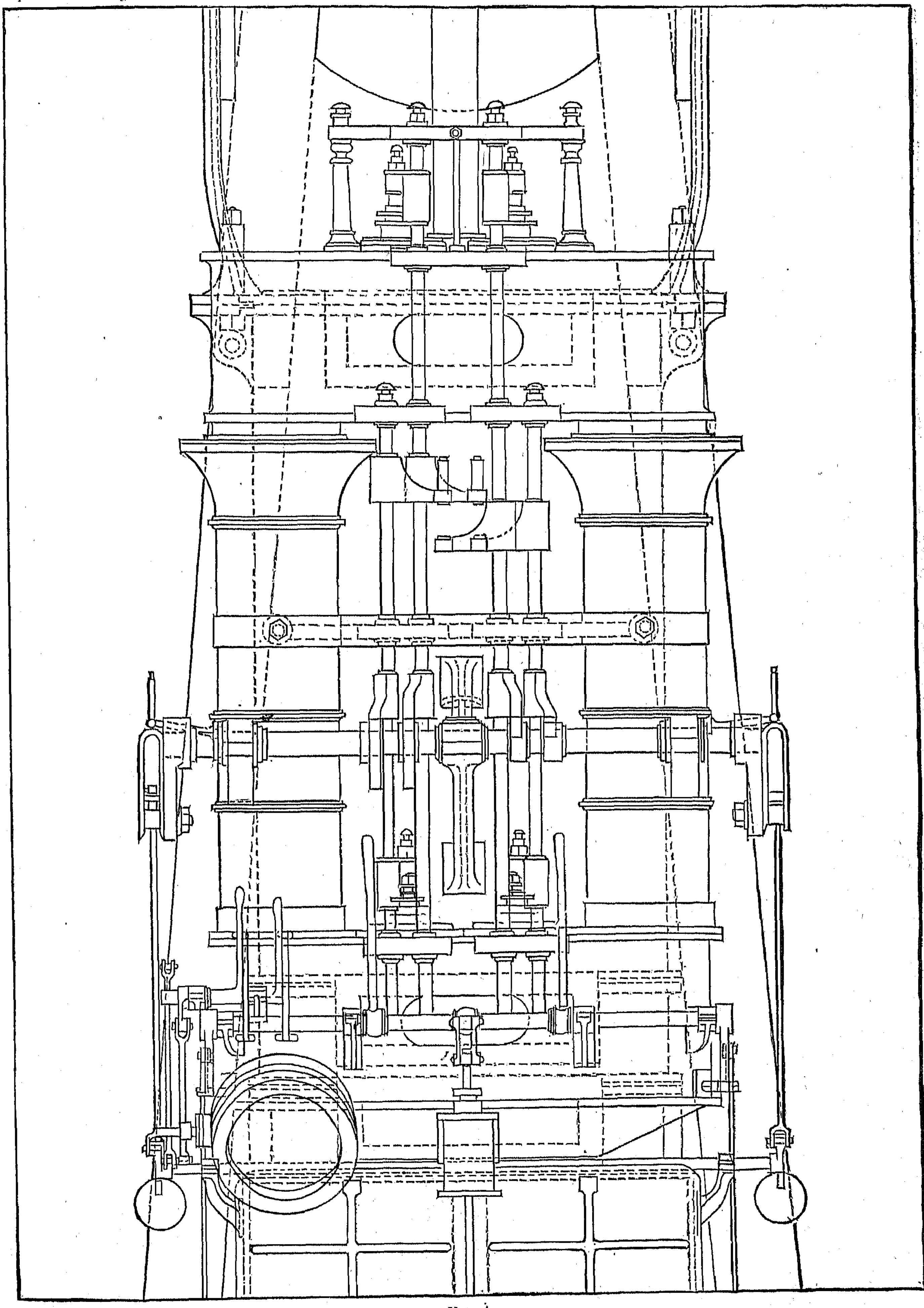


FIG. 4

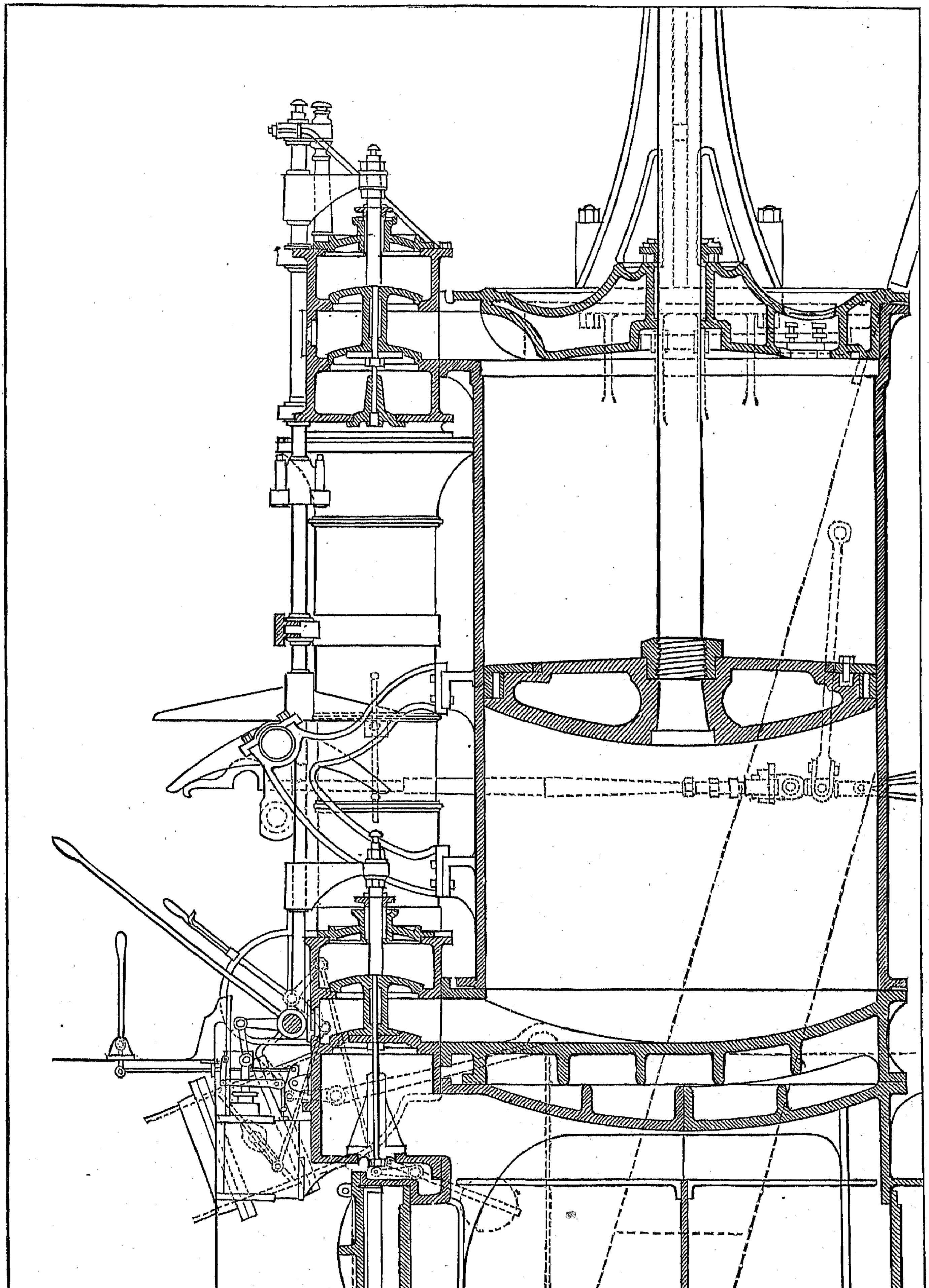


FIG. 5.

The wheels are 45 feet outside diameter, 13 feet face, buckets in two lengths, stepped. Each wheel has three cast-iron flanges 10′ 6″ in diameter, made in halves, and bolted together. Each flange has twenty-eight wrought-iron arms, each arm tapering from $8\frac{1}{2}''$ by $1\frac{3}{4}''$ at the flange to 5″ by $1\frac{1}{4}''$ at the outer rim. The outer rims are 6″ by $1\frac{1}{4}''$. Each wheel has twenty-eight oak buckets.

The cranks are 7 feet between centers; shaft-hub, $46\frac{1}{2}''$ diameter; pin-hub, 31″ diameter; shaft-hub, 24″ deep; pin-hub, 19″ deep; arm tapered from 17″ to 13″ in depth, 29″ to 21″ in width. The cranks were shrunk upon the $25\frac{1}{2}''$ shafts, with an allowance of $\frac{3}{128}$ for shrinking. The crank-pins are tapered from 17″ to $15\frac{1}{2}''$ diameter in the

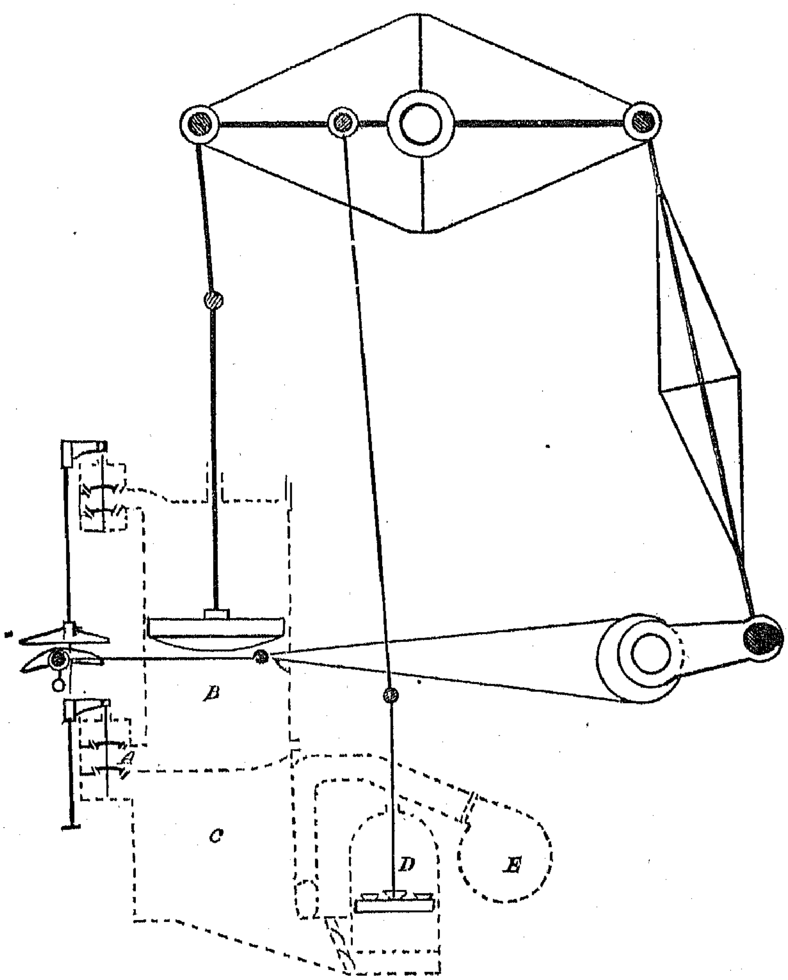


FIG. 6.

pin-hub, and are secured by a 6″ by $2\frac{1}{2}''$ key in one crank and by four brass chock-blocks bolted to the pin in the other. These chock-blocks allow some freedom of movement between the two shafts, and serve the same purpose as a drag-link. The connecting-rod is 33′ 9″ between centers, and the largest ever constructed; journals, 17″ by 23″ and $11\frac{1}{2}''$ by 12″; yoke, $18\frac{1}{2}''$ clear; $9\frac{1}{2}''$ by $12\frac{1}{2}''$ arms; upper neck of rod $11\frac{1}{2}''$, lower neck $12\frac{1}{2}''$ diameter; center band, $15\frac{3}{4}''$ diameter, with 3″ diameter struts set out 27″ from center of rod on either side, and with two $2\frac{1}{2}''$ diameter truss-rods. The main key is 57″ long, and tapers from 6″ to 3″. The forked end is forged solid, and the weight of the whole forging in the rough was over 13 tons. The maximum strain possible upon the smallest section of the rod is stated at considerably less than 5,000 pounds per square inch.

The walking-beam of the "Pilgrim" is an immense construction, 28′ 10″ center to center of pins, and 31′ 2″ long over all. It is the largest ever put into a steamer. The strap is 14′ 6″ from top to bottom at the center, and weighs 26,800 pounds, being made in two parts, and, each being bent in the middle, they are welded together at the ends. The value of the rough strap was $5,300. The beam center is a green sand casting, weighing 28,000 pounds, and is fastened to the main shaft by smaller straps passing over the latter and keyed through the casting and by keys between the beam center and the main strap, nine at each end, four at the top, and four at the bottom. The center pin is 7′ 6″ long, with 18″ diameter by 22″ long journals. The end pins are 3′ 5″ long, and have $11\frac{1}{2}''$ diameter bearings. The center pin is secured by 12 and the end pins each by 8 keys, and the hub is re-enforced by two wrought-iron draw-bands 3″ square in section. The keys between strap and center are 3″ by 1″ at ends, 2″ by 1″ at top and bottom. The center pin keys are 3″ by 1″ in section and 3 feet long. Under a pressure of 40 pounds per square inch in the cylinder the main center will have a pressure of about 950 pounds per square inch, the speed of rubbing surface being 24 feet a minute. The end pins will have a pressure of over 1,300 pounds per square inch and a rubbing speed of 15 feet a minute. The foregoing data are derived mainly from recent numbers of the journal *Mechanics*, in which the details of construction of this great engineering work have been very fully discussed.

SMALL YACHT ENGINES.

These are in most cases inverted-cylinder direct-acting engines, accompanied by vertical tubular boilers. They are similar in type to many small portable and semi-portable engines used in light manufacturing work, both classes of engines being made by many manufacturers with similar patterns for the principal parts. The yacht-engines differ from the small manufacturing engines principally in dispensing with the throttle-valve, governor, governor-pulley, and fly-wheel, and substituting a simple link motion for reversing the engine and determining the point of cut-off. A starting-wheel is also necessary, and the feed-pump is operated by an eccentric upon the main shaft. The valves are sometimes slide and sometimes rotary. The following data are given of the reversing-engines for yachts and tug-boats, as built by the Fitchburg Steam Engine Company, of Fitchburg, Massachusetts, with the corresponding data of suitable hulls and boilers. The engines are of a design similar to the Haskins portable engine adapted for marine service, and are made with interchangeable parts to standard gauges and templates:

Engine-cylinder.	Maker's nominal horse-power.	Shaft, length.	Shaft, diameter.	Screw, diameter.	Boilers,* diameter.	Boilers, height.	Heating-surface.	Weight, engine, screw, and shaft.	Weight, boiler.	Hull, tonnage, carpenters' measurement.	Hull, length, feet.	Hull, breadth, feet.	Hull, draft, feet.
Inches.		*Feet.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. feet.*	*Pounds.*	*Pounds.*		*Feet.*	*Feet.*	*Feet.*
3 by 4	2	12	1¼	24	28	45	60	380	1,100	4	26	5½	2¼
4 by 4	4	15	1½	26	28	48	90	500	1,200	6	32	6½	2½
5 by 5	5	16	1¾	30	32	56	120	700	1,300	9	38	7⅛	3⅛
6 by 6	6	17	2	32	32	58	150	1,000	1,600	12	40	7½	3⅓
6½ by 6½	8	18	2⅛	36	36	58	170	1,100	2,200	14	45	8½	3½
7 by 7	10	18	2¼	39	36	66	200	1,350	2,650	16	50	9	3½
8 by 8	12	20	2½	42	42	66	230	1,800	3,000	21	55	9½	3¾

a The boilers are of steel.

This table affords scope for a number of comparisons relative to the economy of material in the machinery of large and small vessels. Large marine engines are not made in lots, nor with interchangeable parts, nor in such numbers as to make trade schedules necessary, but we may easily cite such data as will suffice to indicate general conditions and exhibit some striking contrasts.

A large propeller, having about 55 cubic feet of cylinder capacity and an 18″ shaft 90 feet long: As compared with the machinery of the 8″ by 8″ yacht-engine, we find that while the cylinder capacity is 242 times greater, the section of shaft is about 52 times greater, and its cubical contents are about 233 times greater. With shaft $7\frac{7}{10}$ times as great in diameter and 4½ times as long, the screw-propeller is less than 4 times the diameter. The 8″ by 8″ yacht-engine has one 42″ by 66″ vertical boiler, while the 48″ by 72″ engine of the "Vera Cruz" has two 156″ by 238″ vertical boilers. With the boiler volume about 100 times as great the cylinder volume is about 330 times as great, and the heating surface being 230 and 5,290 square feet respectively, the heating surface is only 23 times as great in the large boilers as in the small ones. Comparing the steamers, the larger is nearly 5 times as long and nearly 4 times as broad as the smaller, and the registered tonnage would be about 100 times as great.

An example of a somewhat larger yacht than those tabulated is as follows: Length, 77′ 6″ on water line and 84 feet on deck, 15 feet breadth of beam, 6 feet deep, drawing 4′ 6″ water, engines 10″ by 10″, supplied with steam at 125 pounds, and making 200 revolutions a minute. The propellers are 5 feet diameter and 8 feet pitch. A yacht of 450 tons has a propeller 9 feet in diameter and 13 feet long, and a 10-inch shaft.

BACK-ACTING ENGINES.

For small propellers, steam yachts and launches, the back-acting engine is a type introduced within the past ten years in considerable numbers in New England and upon the Atlantic seaboard. These engines may be conveniently employed in sets of two or three or more, set closely together, as shown in the illustration (Fig. 7). The figure exhibits the arrangement of link and reversing motions and other details. The main cross-head ends of the connecting-rods are seen to be yoked or divided into two parts, which pass up on either side of the cylinders, the cross-heads moving in slide-guides in neat frames or housings above the cylinders. It would be hard to design a more compact arrangement. Its most obvious merit consists in the lowering of the frame which supports the

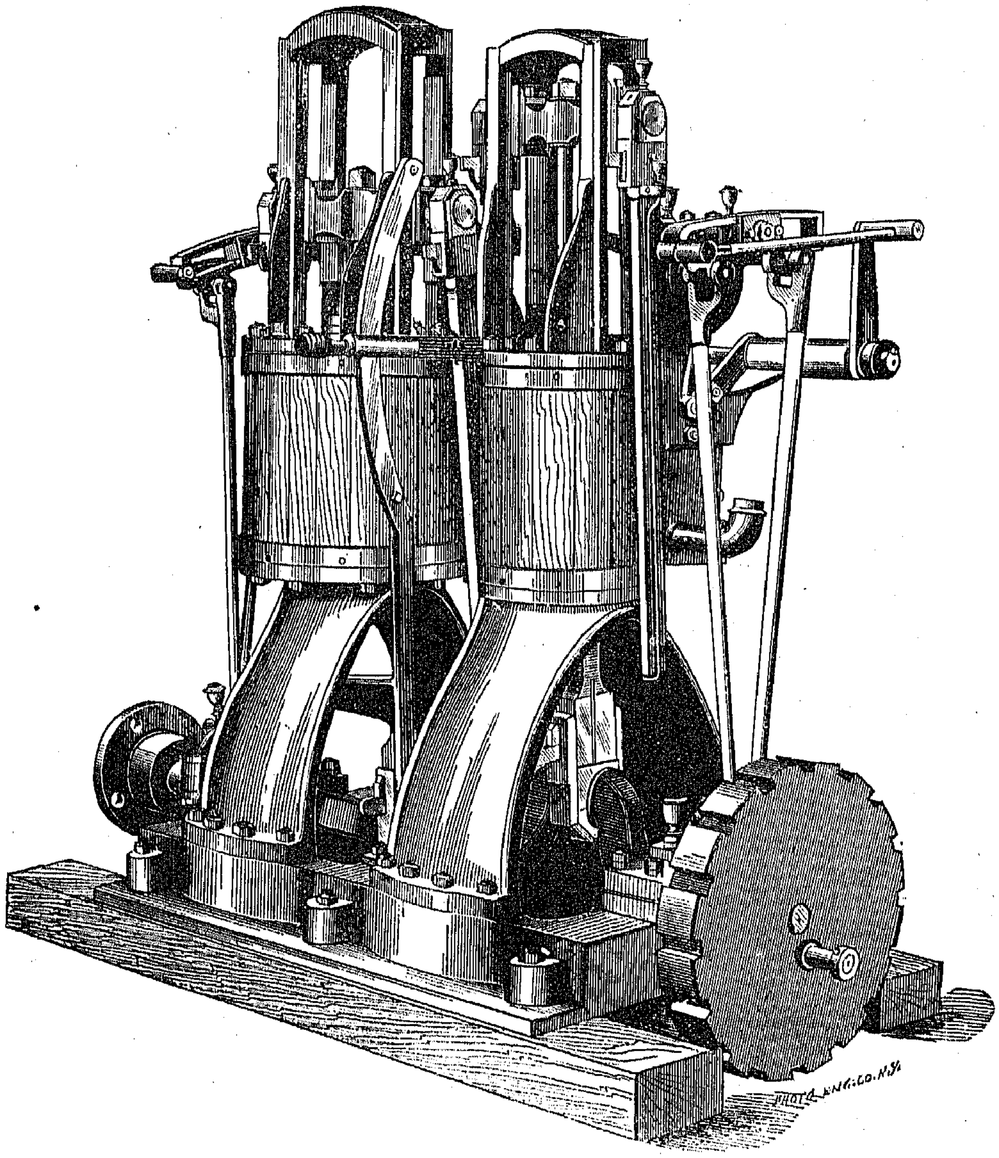


FIG. 7.

cylinders, making a much lighter and more stable construction than can be had with the inverted cylinders and permitting a greater length of connecting-rod, which in the engine shown is about four times the length of stroke. With long connecting-rods there is of course less wear and friction upon the slides. The piston-rods passing through the upper cylinder-head makes the stuffing-boxes easily accessible, and the larger area of the piston being below, the pressure upon the space occupied by the piston-rod helps to balance the weight of the reciprocating parts. The engines illustrated are made by James H. Paine, of Boston. They may be used in pairs simply or compounded, with a saving of fuel (stated at 25 to 35 per cent.) over the simple engine. Examples of steamers with back-acting engines: The "Adelita", 15.03 tons (49.4 feet long, 53 feet over all, and 10.2 feet beam), has two 7″ by 7″ engines, with keel-condenser, and 5″ by 4½″ air-pump; the "Psyche" (72 feet long, 12 feet beam) has two cylinders 9″ and 15″ by 9″, placed as a pair, with cranks at right angles, and constituting one compound engine.

SMALL COMPOUND ENGINES.

A popular form of compound engine for small boats is that used in connection with the Herreshoff coil-boiler. This type of engine is illustrated in Fig. 8, and the following description of the engine and screw, as applied in connection with a coil-boiler to the steam yacht "Leila", is taken from a report of the United States Navy Department. The "Leila" is of 37.27 tons displacement; length of deck, 100 feet; breadth of deck, 15′ 4″; depth of hull, 5′ 10″; draft (greatest) at stern, 3′ 1½″:

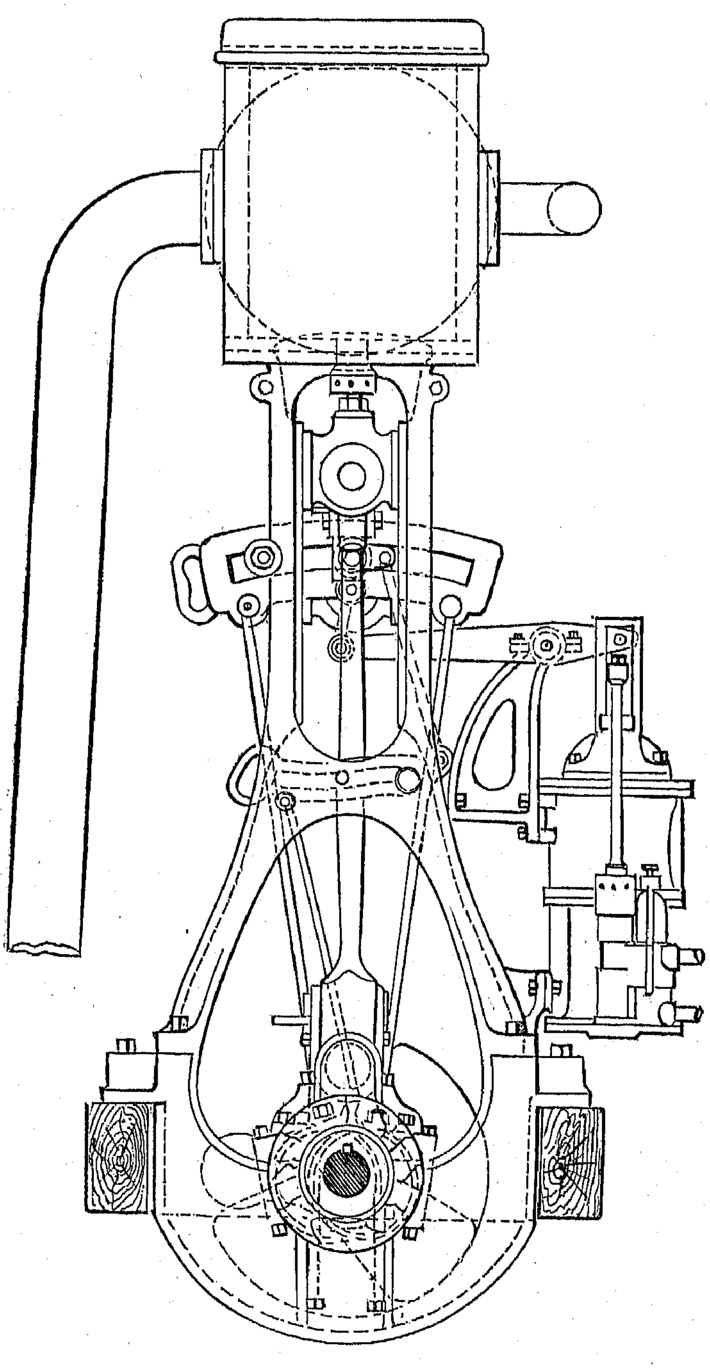


FIG. 8.

There is one compound condensing-engine with vertical cylinders placed side by side above the crank-shaft and having their axes in the vertical plane passing through its axis. The cylinders are direct-acting, the outer end of the piston-rod being secured into a cross-head working between guides in the engine-frame, while the connecting-rod lies in direct extension between the cross-head journal and the crank-pin journal.

The forward or small cylinder operates a lever, which works the air-pump, the feed-pump, and the circulating-pump, all of which are vertical, single-acting, and have the same stroke of piston. The axes of these three pumps are in the same vertical plane, which is parallel to the vertical plane passing through the axis of the crank-shaft. The feed-pump and the circulating-pump are plunger-pumps, with brass receiving- and delivering-valves. The air-pump is a lifting-pump, without a foot-valve; its receiving-valve is brass, circular, and placed in the piston; its delivering-valve is also of brass, and discharges into an open-topped hot-well or reservoir placed above the outboard water-line, the top of the air-pump being closed. The air-pump piston is not packed, but ground to a metallic fit in the brass barrel.

The cylinders are separated to allow the valve-chests to be placed between them, with sufficient additional space for the removal of their covers. The valves of each cylinder are a plain three-ported slide with a slide cut-off on its back; these valves are not counterbalanced, but work with the full steam-pressure on their backs. The three-ported slides or steam-valves are operated each by a Stephenson link and two eccentrics, which serve as a reversing gear. The cut-off valves are each operated by an eccentric. The three eccentrics of each cylinder are immediately beneath its valve-chest. The cut-off valve of the small cylinder is adjustable; that of the large cylinder is fixed to cut off at about one-third of the stroke of the piston from the commencement.

The engine-frames, four in number, are each in a single casting and bolted to a bed-plate, which is also a single casting extending under the entire length and breadth of the engine. The cross-head guides are on these frames, to the top of which the cylinders are bolted. The bed-plate has a semicircular bottom, and its side flanges are bolted to side keelsons. The crank-shaft has three bearings or pillow-blocks cast in the bed-plate, the forward crank being overhung.

The engine works with surface condensation. The surface-condenser is composed of a single copper pipe placed on the outside of the vessel, beneath the water, and just about at the garboard strake. This pipe commences on one side of the vessel abreast of the after or large cylinder, extends to and around the stern-post, and thence along the opposite side of the vessel until abreast of the air-pump and forward cylinder. The diameter of the pipe continuously decreases from the end at which it receives the exhaust-steam from the large cylinder to the end at which it delivers the water of condensation and the uncondensed vapor and air into the air-pump, whence they are thrown into the hot-well, from which the feed-pump forces the water of condensation into the top of the boiler-coil, where it is revaporized, and the steam, passing first into the small cylinder and thence into the large one, is finally exhausted into the condensing-tube. It is essential for satisfactory working that the delivering end of this tube should not exceed one-half the diameter of its receiving end; for if a larger diameter be given to the delivering end, a part of the exhaust steam will pass directly to the air-pump over the water of condensation in the tube. The delivering end of the tube must be small enough to remain completely filled with water for the exclusion of the steam from the pump.

The after main pillow-block serves also as the thrust pillow-block, the after journal of the crank-shaft being made with the necessary thrust-rings upon it.

The cylinders and their valve-chests, including covers of both, are incased with polished brass, between which and the iron are air spaces.

The following are the principal dimensions of the engine:

Number of cylinders	2
Diameter of the small cylinder ..... inches..	9
Diameter of the piston-rod of the small cylinder ..... inches..	$1\frac{5}{8}$
Net area of the piston of the small cylinder ..... square inches..	62.58045
Stroke of the piston of the small cylinder ..... inches..	18
Space displacement of the piston of the small cylinder, per stroke ..... cubic foot..	0.65188
Space in clearance, and steam passage at one end of small cylinder ..... cubic foot..	0.05752
Fraction which the space in clearance and steam passage at one end of the small cylinder is of the space displacement of the piston of the small cylinder, per stroke	0.08824
Length of steam-port of small cylinder ..... inches..	7.5
Breadth of steam-port of small cylinder ..... inches..	$1\frac{1}{16}$
Area of steam-port of small cylinder ..... square inches..	7.97
Length of exhaust-port of small cylinder ..... inches..	7.5
Breadth of exhaust-port of small cylinder ..... inches..	1.75
Area of exhaust-port of small cylinder ..... square inches..	13.125
Clearance of piston of small cylinder ..... inch..	$\frac{3}{16}$
Aggregate area of the inner cylindrical surface of the small cylinder, of its two steam passages, of its two ends, of the two faces of its piston, and of half its piston-rod ..... square inches..	690
Diameter of the large cylinder ..... inches..	16
Diameter of the piston-rod of the large cylinder ..... inches..	$1\frac{5}{8}$
Net area of the piston of the large cylinder ..... square inches..	200.02545
Stroke of the piston of the large cylinder ..... inches..	18
Space displacement of the piston of the large cylinder, per stroke ..... cubic feet..	2.08360
Space in clearance and steam passage at one end of large cylinder ..... cubic foot..	0.14066
Fraction which the space in clearance and steam passage at one end of the large cylinder is of the space displacement of the piston of the large cylinder, per stroke	0.06751
Length of steam-port of large cylinder ..... inches..	13
Breadth of steam-port of large cylinder ..... inches..	$1\frac{7}{16}$
Area of steam-port of large cylinder ..... square inches..	18.69
Length of exhaust-port of large cylinder ..... inches..	13
Breadth of exhaust-port of large cylinder ..... inches..	2.5
Area of exhaust-port of large cylinder ..... square inches..	32.5
Clearance of piston of large cylinder ..... inch..	$\frac{3}{16}$
Aggregate area of the inner cylindrical surface of the large cylinder, of its two steam passages, of its two ends, of the two faces of its piston, and of half its piston-rod ..... square inches..	1,515
Diameter of the air-pump ..... inches..	7
Diameter of the piston-rod of the air-pump ..... inches..	$1\frac{1}{2}$
Stroke of the piston of the air-pump ..... inches..	6
Space displacement of the air-pump piston, per stroke ..... cubic foot..	0.1275
Diameter of the plunger of the feed-pump ..... inches..	$1\frac{1}{2}$
Stroke of the plunger of the feed pump ..... inches..	6
Space displacement of the plunger of the feed-pump, per stroke ..... cubic foot..	0.0061358
Diameter of the plunger of the circulating-pump ..... inches..	$1\frac{1}{8}$
Stroke of the plunger of the circulating-pump ..... inches..	6
Space displacement of the plunger of the circulating-pump, per stroke ..... cubic foot..	0.0034515
Width of all eccentric straps ..... inches..	$2\frac{1}{8}$
Depth of the packing-ring in both steam-pistons ..... inch..	$\frac{7}{8}$
Length of the condensing-pipe ..... feet..	53
Inside diameter of condensing-pipe at exhaust-steam end ..... inches..	5
Continuously decreasing to inside diameter at air-pump end of ..... inches..	2
Thickness of the metal of the condensing-pipe (copper) ..... inch..	$\frac{1}{16}$
Exterior surface of the condensing-pipe ..... square feet..	50.2983
Interior surface of the condensing-pipe ..... square feet..	48.5639
Length of the connecting-rods between centers ..... inches..	$49\frac{1}{2}$
Diameter of the necks of the connecting-rods ..... inches..	$1\frac{9}{16}$
Diameter of cross-head journals ..... inches..	$2\frac{1}{4}$
Length of cross-head journals ..... inches..	$3\frac{1}{4}$
Diameter of forward crank-pin journal (overhung) ..... inches..	$2\frac{1}{4}$
Length of forward crank-pin journal ..... inches..	$4\frac{1}{2}$
Diameter of after crank-pin journal ..... inches..	$3\frac{7}{8}$
Length of after crank-pin journal ..... inches..	$3\frac{1}{2}$
Number of crank-shaft journals	3
Diameter of crank-shaft journals ..... inches..	$3\frac{3}{4}$
Length of crank-shaft journals ..... inches..	8
Diameter of screw-shaft inside of brass casing ..... inches..	$3\frac{3}{4}$
Number of thrust-rings on crank-shaft	5
Breadth of each thrust-ring ..... inch..	$\frac{1}{4}$
Projection of each thrust-ring from shaft ..... inch..	$\frac{9}{16}$
Length in the vessel occupied by the engine ..... inches..	66
Breadth in the vessel occupied by the engine ..... inches..	48
Height of engine above center of crank-shaft ..... inches..	96
Ratio of the space displacement of the piston of the large cylinder, per stroke, to that of the small cylinder	3.196293

SCREW.—There is one true screw of brass with uniform pitch and four blades equispaced around the axis. The blades are at right angles to the axis; their forward and after edges when viewed in projection on a plane parallel to the axis are parallel. The outboard end of the screw-shaft is cased with brass and supported by a lignum-vitæ bearing.

The following are the dimensions of the screw:

Diameter .... feet..	$4\frac{7}{12}$
Diameter of the hub .... inches..	7
Pitch (uniform) .... feet..	8
Number of blades	4
Length of the screw (uniform from hub to periphery) .... inches..	$9\frac{3}{4}$
Fraction of the pitch used	0.40625
Helicoidal area of the screw-blades .... square feet..	9.4564
Projected area of the screw-blades on a plane at right-angles to axis .... square feet..	6.5941

The single view of the engine presented in Fig. 8 does not fully explain its arrangement, but a clear idea of this may be given in a few words. The view is looking forward showing the large cylinder, back of which is the small one. The main exhaust-pipe appears at the left and the exhaust-pipe from the high-pressure cylinder leading to the large cylinder appears at the right of the cylinders. Each cylinder has a main and a cut-off slide-valve, and the high-pressure cylinder a variable cut-off. The valve-chests are placed between the cylinders instead of on the opposite sides of them, as in the large engines of the American Steamship Company's vessels. There are, in all, six eccentrics, and, to avoid confusion with the details of cranks and pinch-wheel, not all of their details are dotted in upon the view shown. The pumps are worked by the usual beam arrangement, the air-pump being in line with and opposite the high-pressure cylinder, and the feed- and circulating-pumps on either side of it, operated from the same cross-head. The arrangement of the engine is compact and workmanlike, and, although so small that the links may, as shown, be shifted by handles, it is seen to embody all the essential features of the largest compound engines.

ENGINES OF ALBANY STEAMERS.

Class I: All the engines of this class are beam condensing engines of 12′ stroke, diameters of cylinders ranging from 4′ 8″ to 6′. The general arrangement of these engines is similar to that of the steamer Pilgrim, of which a special account is given.

Class II: There are 14 engines, all used singly, and all condensing. Twelve are beam-engines driving side-wheels. The swift steamer "Mary Powell" is a familiar example of a boat with this style of engine. The two remaining engines are short-stroke direct-acting engines, driving the screw-propellers of the boats "Thomas McManus" and "Andrew Hardee". These are passenger-boats plying from New York to Coxsackie and Poughkeepsie respectively, and are thus in the same class of service as most of the beam-engine boats. But they represent no new innovation in the service, the boats being 15 or 20 years old, while many of the side-wheel boats are of more recent build. The "Mary Powell" has a 6′ by 12′ engine. The "Armenia," a side-wheel steamer built in 1847, and now plying between New York and Albany, has a 40-inch by 14 foot engine, an unusually long stroke for the bore.

Class III: Of 31 engines, 2 are inclined condensing (a ferry-boat type), 1 vertical condensing, 1 vertical non-condensing, 26 beam condensing, and 1 beam non-condensing. Some of the beam-engines are as small as 2′ or 3′ in diameter of cylinder by 5′ or 6′ stroke. These are for the most part upon the Hudson-river ferry and short-route boats.

Class IV: There are 20 engines, 3 compound, 5 beam condensing, 8 short-stroke non-condensing, 2 beam non-condensing, 1 inclined non-condensing, and 1 vertical non-condensing. The "Riverside," plying between Rondout and Sleightville, is a small paddle-wheel boat driven by two 6″ by 15″ engines. Twelve out of 19 of the boats are screw-propellers.

Class V: Nearly all of the boats are river tugs with vertical non-condensing engines. The only exceptions are the tug "John S. Ide," with a 2′ by 4′ beam-engine, the tug "John S. Winslow," with a 17″ by 20″ condensing-engine, the tug "Charles P. Grout," with a $22\frac{1}{4}$″ by 36″ inclined condensing-engine, and the yacht "Dashaway," 28.56 tons, with two 9″ and 16″ by 9″ stroke compound engines.

Class VI: The yacht "Presto," 16.68 tons, has one compound engine 5″ and 15″ by 6″ stroke. The tug-boat "May Flower" has a 14″ by 12″ stroke vertical condensing-engine. The small ferry-boats "Wm. H. Frear" and "Wm. C. Winne" have each a pair of horizontal engines, dimensions 7″ by 12″ for the former and 5″ by $9\frac{1}{2}$″ for the latter boat. These are paddle-wheel steamers. But 63 out of 69 engines are of the simple vertical non-condensing type.

It may be noted that there are in this inspection district only 5 pairs of engines, and these are upon comparatively small craft.

ENGINES OF NEW YORK STEAMERS.

Class I: Of 77 engines, 22 are beam-engines, driving side-wheels, and the remainder are direct-acting engines driving screws. All are condensing. The employment of compound engines is elsewhere specially considered. The compound engines are slide-valve engines, as are most engines of screw-propellers. The "Hudson," "New Orleans," "Knickerbocker," and "Louisiana," of the Cromwell line, are poppet-valve engines, which by their successful performance militate against the prejudice that poppet-valves are inapplicable to the high rotative speeds used in screw propulsion.

As typical steamers we may mention—

The excursion steamer "Plymouth Rock:" 1,810.16 tons; engines, 76″ by 12′; boiler-pressure allowed, 35 pounds.

The "Knickerbocker," of the Cromwell line: 1,642.48 tons; engines, 44″ by 6′; boiler-pressure allowed, 60 pounds.

The New York and Albany river-steamer "Drew:" 2,902.24 tons; engine, 81″ by 15′ (the engines of this steamer and the "Saint John" are among the longest-stroke engines in the world); boiler-pressure allowed, 35 pounds.

The transfer steamer "Maryland:" 1,093.03 tons; two engines, 40″ by 8′; boiler-pressure allowed, 32 pounds.

The ferry-boat "Plainfield:" 1,051.21 tons; one 53″ by 12′ engine; boiler-pressure allowed, 30 pounds.

The Old Dominion line steamer "Manhattan:" 1,525.19 tons; plying between New York and Richmond; one compound engine, 28″ and 53″ by 48″; boiler pressure allowed, 80 pounds.

The New York and Galveston steamer "Rio Grande:" 2,656.29 tons; one compound engine, 34″ and 60″ by 54″; boiler-pressure allowed, 80 pounds.

The New York and Charleston steamer "Morro Castle:" 1,713.61 tons; one 50″ by 5′ engine; boiler-pressure allowed, 50 pounds.

Class II: Of 90 engines in this class 85 are beam and inclined engines driving paddle-wheels, and 5 are short-stroke engines driving screw-propellers. The beam-engines are the prevailing type. The East river ferry-boats have inclined engines with Sickle's cut-off. The "Rockaway," 520.83 tons, plying to Hunter's Point, has one 44″ by 9′ engine, suction-condensing. All of the engines in this class are condensing-engines.

The inland passenger screw-propeller "Holmdel," 500.65 tons, has one 34″ by 34″ engine; boiler-pressure allowed, 35 pounds.

The Pavonia ferry-boat "Delaware," 985.88 tons, has one 50″ by 10′ engine; boiler-pressure allowed, 25 pounds.

With this we may compare the "Mary Powell," 983.57 tons, of the Albany district, one of the fastest boats in the world. This has one 6′ by 12′ engine; boiler-pressure allowed, 35 pounds. The power capacity in proportion to the tonnage is seen to be much greater in the latter steamboat.

Class III: Of 188 engines 123 may be considered as short- and 65 as long-stroke engines, while 10 are compound to 178 simple, and 40 non-condensing to 148 condensing. Surface-condensers are the rule, but there are also jet, ejector, and outside-pipe condensers.

The "Relief," 338.18 tons, a coasting steamer, has two 26″ by 26″ engines with an ejector-condenser. The boiler-pressure allowed is 45 pounds.

The freight-boat "Pioneer," a screw-propeller of 329.85 tons, has two horizontal engines 16″ by 3′; boiler-pressure allowed, 50 pounds.

There are several three-cylinder compound engines, the largest being upon the yacht "Polynia," but most of them are upon canal-boats plying between New York and Buffalo. The canal-boat "City of Troy," 124.16 tons, has one compound engine 5″, 14″, and 14″ by 14″ stroke; boiler pressure allowed, 100 pounds.

The "George U. Beale," 114.01 tons, coasting between Eastport and Sandy Hook, has one 22″ by 22″ engine with outside-pipe condenser; boiler-pressure allowed, 80 pounds.

Class IV: The types of engines are similar to those of the short-stroke engines of the preceding class. There are more non condensing engines, over half being non-condensing, and with the condensing-engines jet- and keel-condensers are most commonly used. The few compound engines are upon yachts and canal-boats. Simple short-stroke engines in which the bore equals the stroke outnumber all others, and of 152 engines there are only half a dozen of long stroke. These are used on small side-wheel boats, of which the "James A. Stevens," "Only Son," "George Birkbeck," and "Rattler" are examples familiarly known in New York harbor. The small ferry-boat "Surf," plying between Babylon, Long Island, and Fire Island, has a pair of oscillating engines driving side wheels. Non-condensing engines are employed not only on many of the harbor tugs but upon some coastwise vessels such as the fishing-boat "Eugene F. Price." Many of the inland passenger boats have condensers.

The fishing-boat "Eugene F. Price," 55.33 tons, has one 16″ by 18″ engine; boiler-pressure allowed, 75 pounds.

The ferry-boat "Surf," 64.48 tons, has two 13″ by 18″ oscillating engines; boiler-pressure allowed, 80 pounds.

The tug-boat "Rattler," 51.42 tons, has one 28″ by 8′ beam-engine, condensing; boiler-pressure allowed, 30 pounds.

The yacht "Fra Diavolo," 51.43 tons, has one compound engine 13″ and 16″ by 12″; boiler-pressure allowed, 100 pounds.

Class V: Of 149 engines about four-fifths are of the short-stroke non-condensing type. The compound engines and the surface-condensers are found mainly upon yachts and fishing-boats. Of the tug-boat engines the following examples are cited:

Name of tug.	Tonnage.	Engines.	Boiler-pressure allowed.
		Inches.	
Don Juan	45.86	20 by 20	65
Gorilla	44.90	18 by 16	70
Sadie E. Ellis	42.66	14 by 14	90
Frank Pidgeon	34.45	18 by 18	65
S. E. Babcock	33.49	18 by 18	80
Spray	32.15	18½ by 18	70
General George G. Meade	30.99	17 by 17	95
William Cramp	30.76	17 by 15	70
General William Cook	25.83	18 by 18	60
William H. Taylor	25.09	18 by 16	100

Class VI: In this class there are more yachts and relatively fewer tug-boats than in the preceding. There is in consequence a somewhat greater variety in the types of engines. There are more paired engines and relatively more compound and condensing engines. One boat, the tug "Sunbeam," 8.75 tons, has a Root engine, a peculiar form of engine in which one "cylinder" with its piston is placed within the piston of a larger "cylinder". The cylinders so-called are of rectangular section. The pistons moving at right angles, by their combined movement communicate a rotary motion to the shaft. The arrangement is ingenious and very compact, but subject to objection on other grounds.

Of 115 engines enumerated in this class only 38 have the diameter of cylinder equal to the stroke of piston, but scarcely any of them deviate more than an inch or two from this proportion.

POPPET-VALVE ENGINES FOR OCEAN SERVICE.

The most notable development in American marine engineering practice of the past decade has been the introduction of the poppet-valve engine into successful ocean service for screw propulsion. Mr. John Baird has designed these engines, and should be credited with the genius of departing from stereotyped models and making a successful application of novel principles. The poppet-valve was applied in the direct-acting engines of the New Orleans, Knickerbocker, and Hudson, of the Cromwell line. The steamship "Hudson" was built by Messrs. Pusey & Jones, of Wilmington, Delaware, in the space of six or seven months, being launched in the spring of 1874. The engine is simple, direct-acting, inverted, with poppet-valves, Sickel's cut-off, and surface-condenser. The dimensions of cylinder are 48″ diameter and 72″ stroke. There is one air-pump, 30″ in diameter by 18″ stroke, and there are two double-acting feed-pumps, each 5¾″ in diameter by 15″ stroke. There is an independent centrifugal circulating-pump, 5′ diameter of fan, and making 50 revolutions per minute.

The following dimensions are given of the steamer "Hudson:" Registered tonnage, 1,872.68; length on water-line, 280 feet (from aft side of inner stern-post to aft side of stern); width, 34 feet; draught as follows, first, with water in boilers and no coal; second, with 379 tons of coal on board:

Part.	First.		Second.
	Ft.	*in.*	*Feet.*
Forward	6	2	10
Mean amidships	9	11	12
Aft	13	8	14

Gross depth of vessel, 23 feet; displacement, 2,100 tons with coal, 1,700 tons without coal.

The weight of material in the engine proper is as follows:

Part.	Pounds.
Iron forgings	108,613
Cast iron	246,998
Steel castings	1,433
Steel forgings	1,018
Angle iron	695
Sheet iron	607
Babbitt metal	1,118
Cast brass and copper	12,140
Copper pipes	4,005
	376,627

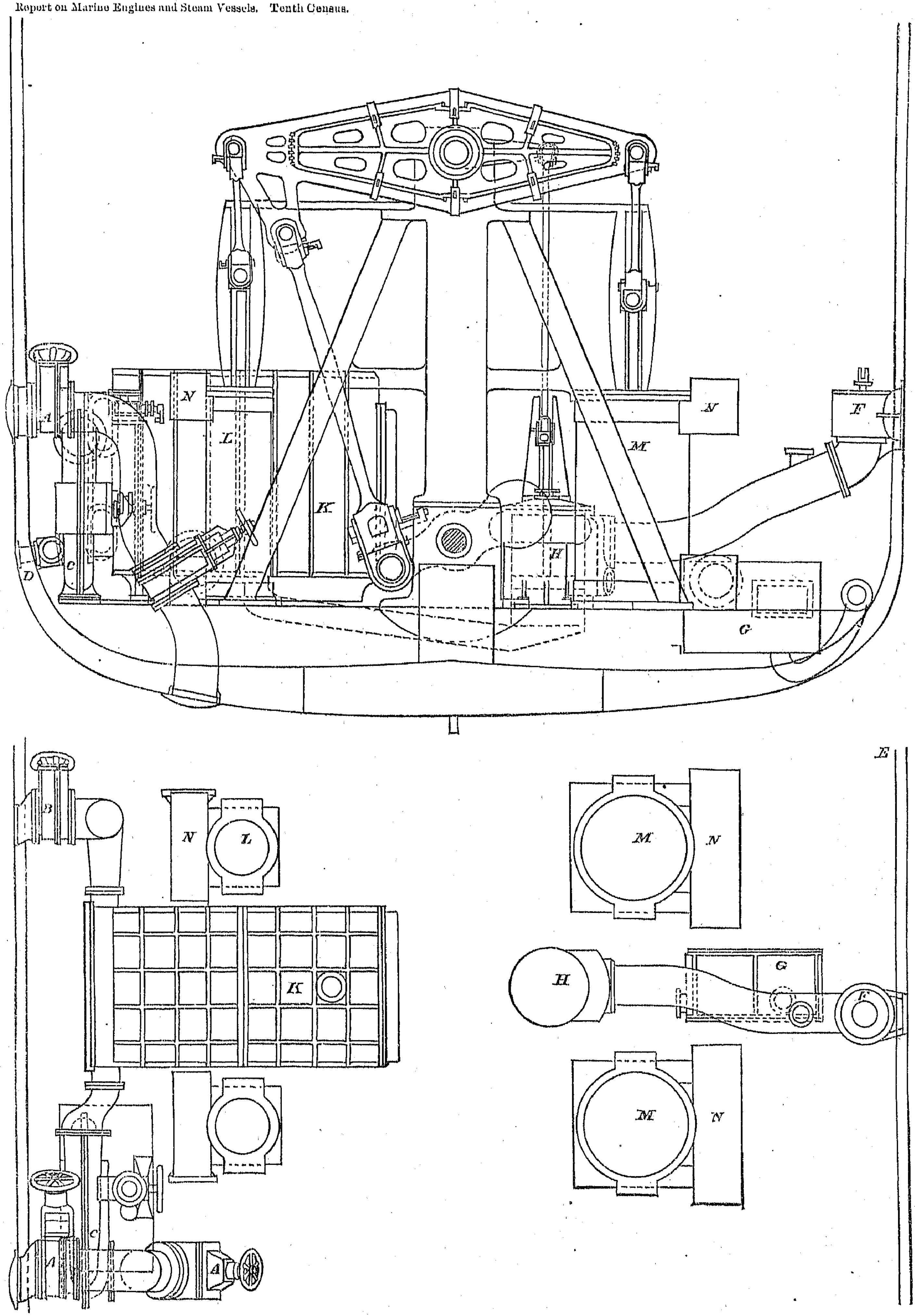


Fig. 9.

The condensing-surface is 3,271.66 square feet, measured as usual outside the tubes. The tubes are $\frac{5}{8}''$ diameter outside, being $\frac{1}{2}''$ inside.

The speed of the vessel is stated at 13 knots (not miles) an hour. The following brief is given of the captain's log in running from New York to New Orleans, the sails not being set during the voyage:

Time.	Average revolutions.	Boiler-pressure.	Knots run.
		Pounds.	
First day	56¼	62	240
Second day	60¼	73	281
Third day	60½	73	279
Fourth day	60⅝	74	294
Fifth day	60 11/16	74	307
Sixth day (19 hours to bar)	62¼	74	235
Total			1,636

On this trip the mean pressure shown by cards was 27½ pounds per square inch; indicated horse-power, 1,131; piston speed as high as 750 feet per minute; coal burned per hour per square foot of grate, 13¾ pounds; coal per day, 29.76 tons; per indicated horse-power per hour, 2.19 pounds. This, however, does not give the best economy of the engines. It is stated in the London *Engineering* that a rating of coal per indicated horse-power of only 1.36 pounds has been attained, the engines of the "Hudson" developing upwards of 1,150 horse-power with 19 tons of anthracite in twenty-four hours, and the similar but smaller engines of the Knickerbocker developing upwards of 780 horse-power with 17 tons anthracite in twenty-four hours. The economy is equal to that of the best compound engines and exceeds that of many of them.

With the present practice in compound engines 1½ to 2½ pounds coal per indicated horse-power is consdered good economy, but over 3 pounds is considered an economical failure. The diagrams from the "Hudson" (Fig. 10) show very forcibly the peculiar operation of the engine as controlled by the valve movement, viz, an excellent expansion and no cushioning. The data for diagram No. 1 are: Date, November 13, 1874; revolutions, 62½; steam-pressure, initial, 74 pounds; mean, 25½ pounds; scale, 40 pounds per inch; vacuum, 26 inches; temperature of hot-well, 136° Fahr., throttle open. For diagram No. 2, the initial pressure was 75 pounds; mean pressure, 29½ pounds. The cut-off for diagram No. 1 was 9 inches in a 72-inch stroke. The cut-off was then at $\frac{1}{8}$, but the regular cut-off is from $\frac{1}{12}$ to $\frac{1}{16}$ of the stroke.

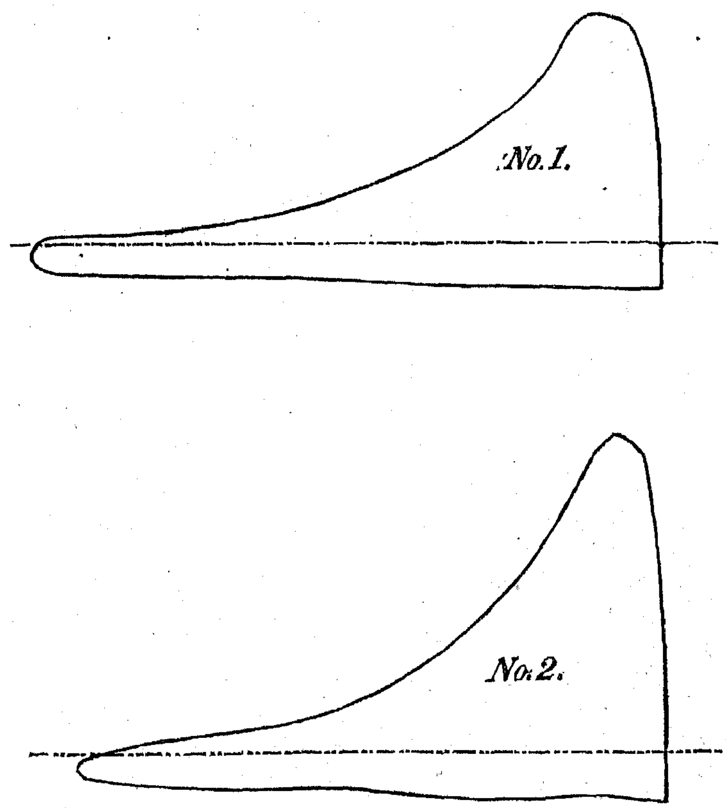


FIG. 10.

The poppet-valves are of great size, but balanced so that there is much less pressure upon their seats than with the ordinary slide-valve. The necessary lift is very slight, and the valves are held in equilibrium with dash-pots. The valve-gears of these engines work silently, and the valves do not hammer upon the seats. There are four poppet-valves operated by wipers upon rock-shafts. The admission-valves are provided with suitable gears for varying the cut-off and reversing the engines, which will be better understood from the drawings of the engines of the "Louisiana," which have similar details.

The weight of the engine is of interest, because for the power as good an economy is effected as in many compound engines of double the weight.

The following data are given of the engine of the "New Orleans," also built by Pusey & Jones: The cylinder is 48″ by 54″; air-pump, 35″ by 15″. There is one single-acting feed-pump, $5\frac{3}{4}''$ by 15″, and one 34″ rotary circulating-pump. The condensing-surface is 2,800 square feet.

The tonnage (registered) of the "New Orleans" is 1,442, the speed 11.2 knots per hour. The average number of revolutions is 64, horse-power indicated about 794, with a consumption of coal of less than 3 pounds per indicated horse-power per hour. The weight of engines (including circulating engine and attachments) is 153 net tons, and the weight of boilers is 91 tons.

Within the past few years Mr. Baird has made a new adaptation of this poppet-valve gear in the engines of the steamer "Louisiana," which were built by C. H. Delamater & Co., of New York.

The "Louisiana" is one of the largest coasting steamers, registered tonnage, 2,840.33; length, 320 feet; breadth, 39 feet; draught (loaded), about 21 feet; depth, lower hold, 14.9 feet; between decks, 11 feet; from base line to top main-deck beams, 28.6 feet. The engines remind one of two former types, the old form of side-lever engine, in that they have a pair of walking-beams, and the McNaught engine, in that they are of the compound-beam type. It is needless to say that they are quite different from either, in that they are designed for screw and not for paddle-wheel propulsion. The side-lever engine with its poppet-valves, once a popular English type, went out of vogue when side wheels were superseded by screws. The application of a smaller (high-pressure) cylinder on the crank side of the beam-engine of a river boat was made by McNaught as early as 1845, thus making a compound beam-engine, but practice failed to vindicate this type of engine for river service, and it has passed entirely out of existence.

The beam compound poppet-valve screw-propelling engines of the "Louisiana" are thus unique, as are also the boilers. The hull of the vessel was designed by Mr. Baird. Novelty involves such risks of failure that in marine engineering, as in other arts, men cling long to established precedents and hesitate to seek for further advantages, but the result in this case is one of the fastest, and, perhaps, for long runs the fastest ocean-going steamer in the world operated with a good economy of fuel.

Of the engines of the "Louisiana" two illustrations are presented. Fig. 9 exhibits their arrangement and connection upon shipboard, in elevation, looking forward and in plan. In this the valve-gear details are omitted, as well as the small bolts and panels, and such details of the frame and of the plating of the hull. For the same reason, to avoid confusion, the principal moving parts are not shown in the plan, but only in the elevation. Their position in the plan is, however, sufficiently obvious from the positions of the cylinders and the center line of the vessel. Fig. 11 exhibits the valve-gearing of the low-pressure cylinder.

From Fig. 9 we see that the beams are centered directly over the crank-shaft and the cranks are driven from the longer arms of the beams. The high-pressure cylinder being under the longer arm has a longer stroke than the low-pressure cylinder, which is upon the opposite side. The dimensions are—

	Diameter.	Stroke.
	Inches.	*Inches.*
High-pressure cylinder	30	88
Low-pressure cylinder	56	72

There are two 10″ diameter by 16″ stroke double-acting feed-pumps. These are independent of the engine.

The machinery occupies 68 feet of the length of the vessel, 26 feet being taken up by the engines and 42 feet by the boilers, the machinery being in the hold with deck-room above. Of the boilers there are 8, set athwartship and fired in the middle of the boat. The plan of Fig. 9 represents the 26 feet of length occupied by the engines and their connections. The sea connections are very clearly shown. A A are inlet-valves, and B is the outlet-valve for the centrifugal circulating-pump. The pipes are 2 feet in diameter at the largest point and 18 inches in diameter just before entering the fan. This is shown at C. It is 6 feet in diameter and has a speed of 80 revolutions per minute. D is the sea-valve for salt-water injection, and just beyond E (out of the plan) is the sea-valve for salt-water feed. F is the air-pump delivery-valve, and a 20-inch copper pipe leads to the air-pump, which is 38″ in diameter by 3′ stroke, and is operated from a crank-arm upon a shaft which connects the beam centers of the two engines. G is the filter, H the air-pump, and K the condenser, which has a surface of 7,960 square feet outside tubes. This is almost exactly half as much as the total heating-surface below the water-line of boilers, viz, 15,840 square feet, the grate-surface being 374 square feet. The heating-surface is relatively great. The coal-bunkers have a capacity of about 800 tons. The coal consumed per indicated horse-power per hour is about 2 pounds. The machinery weighs about 600 tons. The screw is of 17 feet diameter, 26 feet pitch.

The high-pressure cylinders are indicated by the letter L, low-pressure cylinders by the letter M. The letters N N N N indicate the steam-chests. The valve-gearing is actuated from the rock-shaft F in Fig. 11, to which we will now refer. This rock-shaft is in the center line of the vessel, and is driven from the main shaft. A trussed rod, L L, actuates a rock-shaft and rocker, A, whose arms B B operate, respectively, a wiper, C, for the steam- and a wiper, D, for the exhaust-valves. There are for each cylinder at each end a steam- and an exhaust-valve. The mechanism is shown for operating the lower exhaust- and the upper steam-valve. In each case there is a lifting-arm and a dash-pot, H, but the steam-valve connections (shown also in part for the lower steam-valve) are distinguished by a train of rock-shafts, rocker-arms, and links K K K (K′ for the lower valve), and other connections for cutting off by dropping the valve upon its seat and for reversing the engine. The rock-shaft G is for disconnecting the trussed rod L by throwing out the gab at A. The lower part of the cylinder and lower poppet-valve are shown in section. For the upper valve the exterior of the chest is shown, and to avoid confusion of lines the poppet-valve is not dotted in, being the same as the lower valve.

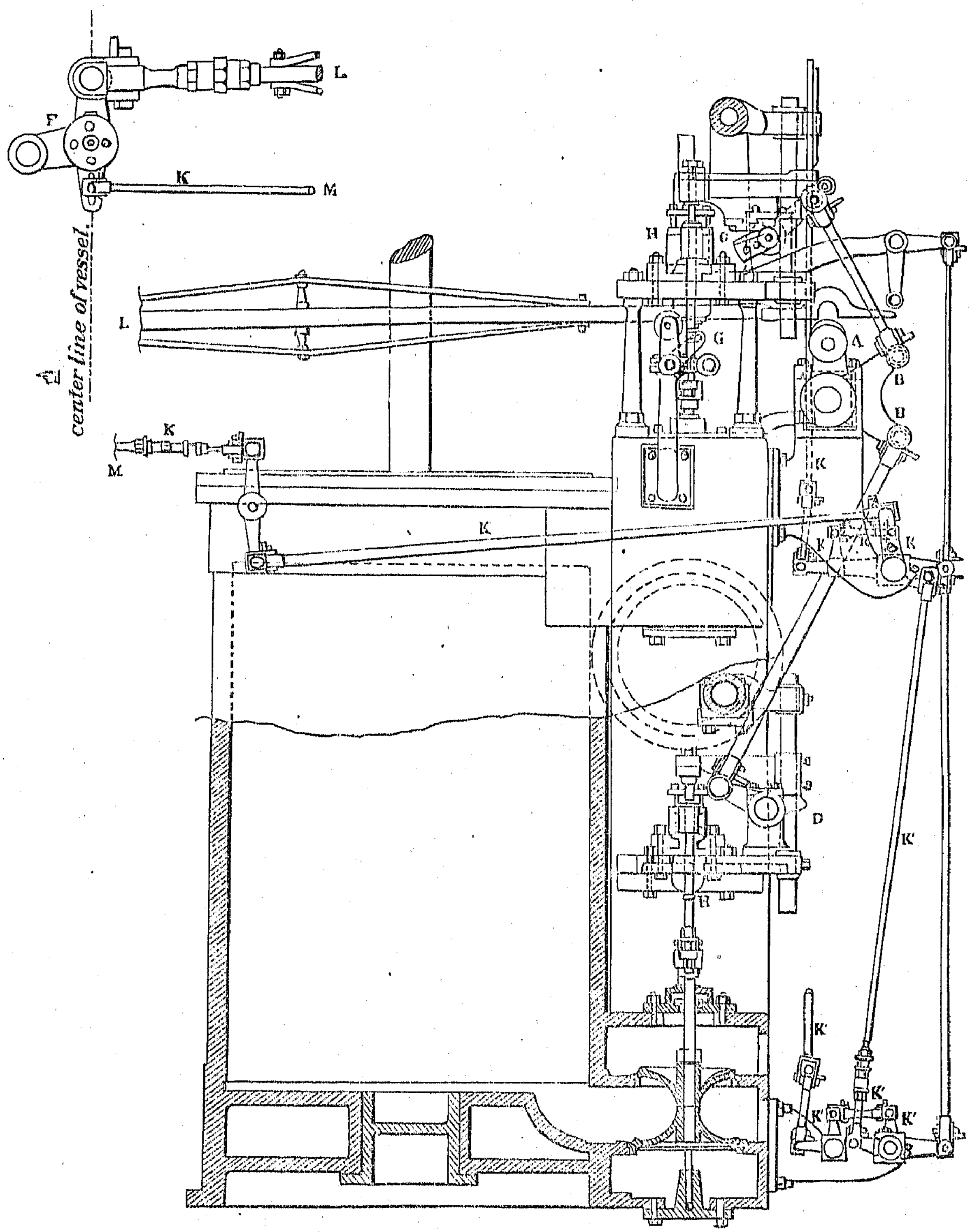


FIG. 11.

The maximum working speed of the "Louisiana" is 70 revolutions. This gives a very high piston speed for marine practice, over a thousand feet a minute for the high-pressure piston. But in a trip to New Orleans the average number of revolutions was only 58 per minute.

BEAM-ENGINES.

At the North River Iron Works (W. & A. Fletcher), New York, commencing in 1856, there have been built over 100 large beam-engines, comprising a majority of all the noted high-speed beam engines in the country. These engines were largely for fresh-water service, and are to be found not only upon the sound and river steamers of the Atlantic seaboard, but upon lake Michigan, lake George, lake Erie, and lake Champlain. Of the first 100 engines, 92 were high-pressure or non-condensing engines, 6 had jet-, and 2 had surface condensers. Nos. 101, 102, 103, and 104 have surface-condensers, and there thus appears an increasing tendency to employ condensers. Most of these engines were built for river and harbor use, and for comparatively short routes, and the practice has been in many cases to provide them with fresh-water tanks.

Now that many of the troubles first experienced with surface-condensers, not the least of which was the deterioration of the iron in the boilers (where water from surface-condensers has been used), have been overcome, only the additional first cost prevents many from having the surface-condenser.

W. & A. Fletcher's one hundredth engine was built for a new steamer of the New York, Catskill, and Athens Steamboat Company. The steamer is 265 feet long, 38 feet beam, and 10 feet depth of hold. The engine has a 63″ cylinder and a 12′ stroke. The boilers have 9′ diameter shells, and are 34′ long, the steam-chimneys being 48″ inside and 88″ outside shell diameter, and 13′ high.

Of these hundred engines, ninety-nine had the Stevens and one the Sickels cut-off. (The former is shown in the illustrations of the engines of the "Pilgrim," built by John Roach & Son, and the latter in the illustration of the engines of the "Louisiana," built by C. H. Delamater & Co.) While the method of operating the poppet-valves by means of rock shafts, wipers, and lifters is similar in both forms of cut-off, the Sickels is distinguished by the release of the lifters and valves from the lifting toes or cams at a point of the stroke, when the valves drop lightly upon their seats, being restrained from striking them heavily by connection with a piston working in a dash-pot of oil or water.

As an example of the beam-engines of river steamers, we may take that of the "Mary Powell." This has the Stevens cut-off, with two eccentrics and two rock-shafts, one for steam- and one for exhaust-valves, and four lifter-rods, bearing eight arms or lifters. The cylinder is 6′ in diameter by 12′ in stroke. The diameter of the piston-rod is 8″; of main shaft, 1′ 3″; journals, 1′ $3\frac{5}{8}$″ in diameter and 1′ 5″ long. The crank-pin is $8\frac{3}{4}$″ in diameter and $10\frac{3}{4}$″ long. The air-pump is 40″ diameter by 62″ stroke. The steam- and exhaust-valve openings in the steam-chest are 1′ $2\frac{3}{4}$″ in diameter. Displacement of piston per revolution, 676 cubic feet; clearance at both ends of cylinder, 25 cubic feet. The following data are given of a trial in 1877:

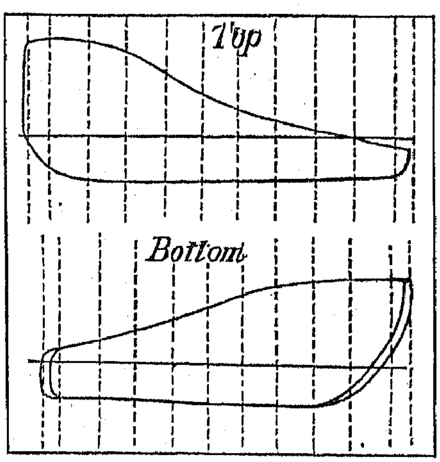


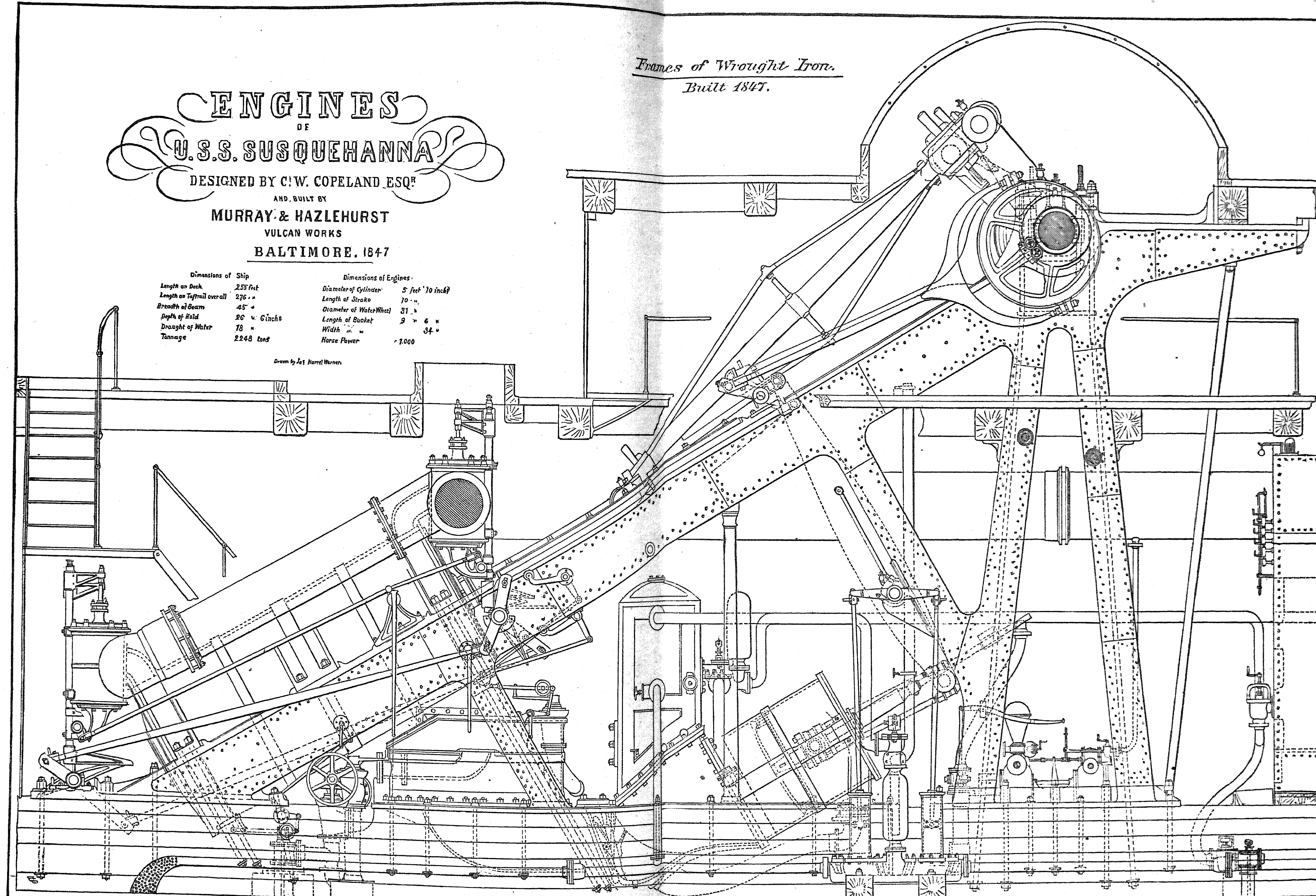
FIG. 12.

Per hour—speed of vessel, 19.3 miles; revolutions, 1,306 ($21\frac{2}{3}$ per minute); coal, 5,970 pounds, combustible (coal less ash), 4,870 pounds; coal per square foot of grate, 39.3 pounds; per square foot of heating-surface, 2.25 pounds. The temperature of atmosphere was 70°; of hot-well 120°; of chimney gases, hot enough to melt zinc (over 782°). Indicator diagrams are shown in Fig. 12, with the following particulars: Steam-pressure above atmosphere, 28 pounds; vacuum, 25 inches (mercury); initial pressure, 40 pounds; pressure at cut-off, 31.2 pounds; at end of stroke, 16.4 pounds; mean back pressure, 5.6 pounds; at end of cushioning, 40 pounds; mean total pressure, 29.94 pounds; mean indicated pressure, 24.34 pounds; net indicated pressure, allowing for friction, 22.84 pounds. Cut-off, 0.47, and cushioning at 0.8 in fractions of the stroke. Horse-power, total, 1,899; indicated, 1,540; net, 1,446. Pounds steam per hour for diagrams, 42,000. Economy of boiler, 7 pounds water per pound coal from 120°, 7.8 pounds from 212°. Economy of engine, pounds steam per hour per total horse-power, 22.1; per net indicated horse-power, 28.9. Coal per horse-power, total, 3.14 pounds; indicated, 3.87; net indicated, 4.13 pounds.

INCLINED MARINE ENGINES.

The "inclined" marine engine was designed by Charles W. Copeland, mechanical engineer, in 1839, and a patent for it was issued to him June 11, 1841. Before the successful introduction of the screw-propeller it became a favorite engine for side-wheel sea-going steamers. It was and still is preferred by many ferry companies for their ferry-boats, for which purpose it is peculiarly adapted. The following is a general description of its arrangement and a copy of the claims of the patent:

The cylinders in this arrangement of the engine are inclined at an angle dependent upon the depth of the hold and the length of stroke, and they are fastened to inclined beams extending from the paddle-wheel shaft to the keelsons, said beams being connected with the keelsons along their whole length by other beams and by bolts, the whole constituting truss-frames, which may be of wood or iron, which sustain and divide the weight and jar of the engines.


ENGINES
OF
U.S.S. SUSQUEHANNA
DESIGNED BY C! W. COPELAND ESQ!
AND BUILT BY
MURRAY & HAZLEHURST
VULCAN WORKS
BALTIMORE. 1847
Dimensions of Ship
Length on Deck 255 feet
Length on Taffrail over all 276 "
Breadth of Beam 45 "
Depth of Hold 26 " 6 inches
Draught of Water 18 "
Tonnage 2248 tons
Dimensions of Engines.
Diameter of Cylinder 5 feet 10 inches
Length of Stroke 10 "
Diameter of Water Wheel 31 "
Length of Bucket 9 " 6 "
Width " 34 "
Horse Power 1,000
Drawn by Jas. Harrel Warner.
Frames of Wrought Iron.
Built 1847.

The condensers are directly under the upper end of the cylinders, and the channel-plates run between the keelsons. The lower ends of air-pumps, which are inclined as well as the cylinders, are secured to the ends of the said channel-plates, and the hot-wells to their upper parts. The delivery-valves are placed on the upper side of the channel-plates. The pistons of the air-pumps in this arrangement are solid, and the whole apparatus is rendered compact, and the whole placed within the observation and reach of the engineer.

The side pipes are placed above the cylinders, the steam-chests at each end thereof, and the valve-stems running either down in front of the head of the cylinder to the rock-shafts or extended above with rock-shafts above the chest. The feet are attached directly to the stems, instead of to lifting-rods, and are acted upon by the toes of the rock-shaft, the two rock-shafts being connected together by a rod.

Claim: What I claim as new and constituting my invention is—First. The placing of the cylinder in an oblique direction, with the lower end near to the bottom of the vessel, and allowing it to stand at such an angle as is required for the connecting of its piston-rod with the crank on the shaft of the paddle-wheels, in combination with the condenser, channel-plate, and air-pump, arranged and located as described. I do not claim the mere placing of the cylinder of a steam-engine obliquely, as this has been done for other purposes, but as I produce a new and useful effect by so placing the steam-cylinder and its appendages in the combination above claimed, on board of vessels for navigating the ocean, I limit my claim to the so placing them under the said combination as to obtain the object fully made known.

Secondly. I claim the manner of arranging and working the steam- and exhaust-valves as set forth, the same being effected by a direct action, that is to say, without the employment of the lifting-rods and lifters usually required for that purpose.

Thirdly. I claim the manner of combining and arranging the condensing apparatus, the air-pump being placed at the same angle, or nearly so, with the cylinder, and attached by its lower end to the channel-plate, the delivery-valve being also placed on the upper part of the said plate; the combination intended to be claimed under the last head consisting in the arranging of the several parts enumerated, that is to say, the air-pump, the channel-plate, the delivery-valve, substantially in the way described.

From this description it will be seen that all parts of the engine are below the paddle-wheel shaft, and that all parts are immediately under the eye of the engineer, and perfectly accessible for adjustment and lubrication, even when the engine is in operation. It is also more simple and direct in its operation, and the center of gravity is much lower than in a beam-engine. Its weight and cost and expense of repairs are also less. For a sea-going vessel it has the advantage that any "working" of the vessel affects the alignment less than in either the beam or the side-lever engine. It has the further advantage that any ordinary length of stroke may be adapted to the vessel without respect to the depth of the vessel's hold, and without materially affecting the height of the center of gravity.

For ferry-boats the engine has the further advantage that it occupies less deck-room, which is valuable for the accommodation of carriages and teams, the whole of the engine being placed in the hold, thus occupying room which otherwise has no value for a ferry-boat.

Both the Stevens and the Sickels cut-offs have been used on this engine, the former generally on sea-going vessels and the latter from its convenience on ferry-boats. The difference in these two styles of cut-off is that in the former, as usually constructed, when the engine is in operation, the point of cut-off can only be changed so as to *increase* the admission by taking a part of the motion from the exhaust-valve movement, whereas with the latter it can be either increased or decreased at will. In the former the valve follows the valve mechanism in returning to its seat and cutting off steam, but in the latter the valve is detached from the valve mechanism and returns or falls to its seat by the action of gravity aided by the pressure of the atmosphere or of springs.

The inclined engine has been used in the following steamers of the United States navy: The "Susquehanna," "Saranac," "Michigan," "Scorpion," "Harriet Lane," "Missouri," and several others, and on a number of merchant steamers; also on ferry-boats at Boston, New York, Albany, Newburgh, Philadelphia, and Detroit. It has also been used for ferry-boats in South America and in Cuba. The inclined engines of the "Susquehanna" were at one time run for 24 consecutive days without stopping, a run probably never equaled in any other steam vessel.

In Fig. 13 we have an illustration of the inclined engine with Stevens' cut-off as described. The ferry-boat engines differ from this in having the Sickels cut-off. The frame of the engine shown is of wrought iron; cast iron being the material ordinarily used.

AUXILIARY ENGINES.

The statistical tables of engines and boilers have reference only to principal engines used in propulsion, but the report would be incomplete without allusion to the great numbers of auxiliary engines which are coming more and more into use upon all large American steamers. These engines are used for pumping, freight-handling, steering, winding-in chains and rope, and for other purposes. The pumping-engines are in most cases properly auxiliary to the main engines, and some have been described in that connection, but the freight handling engines, and even more, the steam capstans and windlasses, are to be ranked among those new labor-saving developments which are gaining a foothold in modern practice. A few words will point the value of labor-saving contrivances on shipboard. In handling freight the value of promptness in loading and unloading is illustrated by the Reading Railroad Company, whose colliers save time by loading and discharging cargoes at night, aided by electric lights. This company pays premiums for prompt unloading, and the report of Mr. John L. Howard, its superintendent, states that during 1879 $59,483 was paid in premiums for prompt unloading, and in 1878 $61,481 was paid in premiums. The smaller sum was the value of 878 days saved above the stipulated allowance of time for a fleet of 13 steamers.

The "Chalmette," beside 9 other auxiliary engines, has 5 freight-hoisting engines, built by Williamson Brothers, Philadelphia, which are arranged so as to work the after capstan and handle the sails, and to perform other kinds of work; and a steam-windlass and forward capstan by the American Ship Windlass Company, Providence. It becomes simply a matter of letting on steam to a single cylinder, and any desired amount of power may be obtained for a purchase for any kind of work. For steering, reversing, and handling a steamer, steam attachments not only give greater facility but often greater safety. Steam machinery works readily in severe and inclement weather. Captain Lefevre, of the (Savannah) Ocean Steamship Company, says of the steam-capstan: "It takes up but little room, and can be worked effectually where men could not exert their force with bars or cranks on decks covered with ice and snow." It is said by experienced navigators that a large steamer "rigged with a steam-windlass forward and a steam-capstan aft can be handled as easily as a row-boat". Steam-capstans or capstans and windlasses are used on the "City of Pekin," "Decatur H. Miller," "Louisiana," "Bristol," "Providence," "City of Augusta," "Manhattan," and many other steamers mentioned in this report. They are largely employed upon the lake propellers. The steam yachts "Corsair," "Stranger," and "Polynia" have steam windlasses. The Mississippi river stern-wheel boat "Joseph B. Williams" has several steam-capstans.

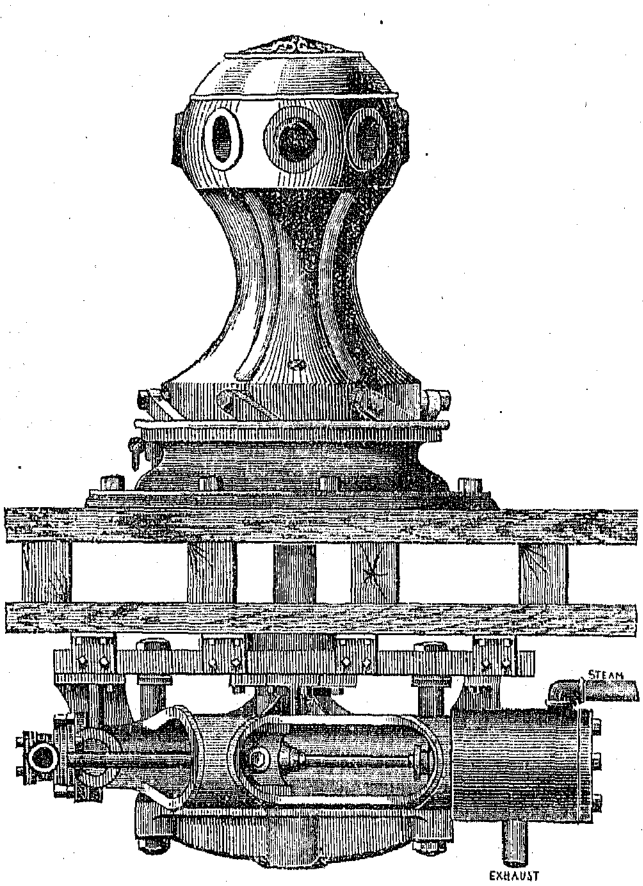


FIG. 14.

In Fig. 14 is illustrated the form of steam-capstan used by several large Oregon steamers. It is also used upon tug-boats at Pittsburgh and at New Orleans, and very generally upon the Atlantic steamers. Steam is also applied in operating the pump-brake windlass, and the Providence steam capstan-windlass is a popular style. In this the piston-rods of two horizontal cylinders at right angles, bolted under the capstan-deck, operate a single crank upon a vertical shaft. A screw on this shaft gears into a worm-wheel on the windlass-shaft on the lower deck, and the standing-shaft of the capstan is driven by a bevel-wheel gearing into one on the windlass-shaft. A later style of steam-windlass has the advantage over the former that all the machinery is attached to one deck, and thus is less liable to get out of line. The steam-valve is operated by an eccentric, and a screw on the crank shaft drives a worm on the windlass-shaft.

The American Ship Windlass Company, Providence, Rhode Island, began to introduce steam-windlasses eighteen years ago. To-day they are almost essential to large steamers. American steamers are better equipped in this respect than English, or any other foreign vessels, and American steam-windlasses have been applied on some of the Cunard steamers, the French yacht "Bretagne," and other foreign vessels. One instance will suffice to illustrate their advantage in handling a steamer. The steamship "City of Tokio" carries 7,000-pound anchors, using a $2\frac{5}{16}$-inch chain. It would take forty men an hour to get in sixty fathoms of chain with the best hand-windlass made, but with the steam-windlass used (a Providence windlass), one man and a boy will take in the same quantity of chain in six minutes. The labor saved for equal times is more than two hundred fold, but this is not the most important consideration. In backing steamers into the wharf, in maneuvering in harbors or in narrow channels, in cases where a steamer gets aground, and in many other situations, promptness of action may make a little time almost invaluable.

ENGINES OF PHILADELPHIA STEAMERS.

In Class I all of the engines are condensing, and of 21 steamers, 18 are screw-propellers or screw-steamships. The "Canton," 1,178.55 tons, plying inland from Philadelphia, has two 3′ by 9′ beam-engines, and the "Republic," 1,285.02 tons, also plying upon inland routes, has one 66″ by 12′ beam-engine.

The engines of the steamers of the American line to Liverpool are elsewhere considered. Apart from these, the Reading colliers constitute the most notable group of large steamers in the Philadelphia district. These are typical American freight-boats, and have done an immense service. The following list comprises the fleet of colliers, with the tonnages, dimensions of engines, and boiler-pressure allowed. The dates when each vessel commenced to run are also given, from which it will be seen that the shipping has been built up almost entirely within the past decade:

Name of collier.	When first run.	Registered tonnage.	Engines. No.	Engines. Dimensions.	Boiler-pressure allowed.
Rattlesnake	June, 1869	417.44	1	34″ x 28″	27
Centipede	Sept., 1869	436.88	1	34″ x 28″	33
Achilles	Mar., 1870	703.51	1	40″ x 30″	33
Hercules	May, 1870	704.33	1	40″ x 30″	25
Leopard	July, 1870	....	....	....	....
Panther	Aug., 1870	699 10	1	40″ x 30″	33
Reading	Apr., 1874	1,283 00	1	42″ x 42″	33
Harrisburg	June, 1874	1,283 00	1	42″ x 42″	33
Lancaster	July, 1874	1,283.00	1	42″ x 42″	33
Perkiomen (a)	July, 1874	1,035.35	1	27″ & 45″ x 30″	60
Berks (a)	Aug, 1874	553.09	1	20½″ & 34″ x 30″	60
Williamsport	Sept., 1874	1,283.00	1	42″ x 42″	33
Allentown	Oct, 1874	1,283.00	1	42″ x 42″	33
Pottsville	Dec., 1874	1,283.00	1	42″ x 42″	33

a Compound.

In Class II there are 33 engines, 15 beam and 18 direct-acting. All of the screw-propeller engines are upon coasting vessels, and nearly all of the beam-engines are in the river service. All are condensing.

The "Excelsior," 774.43 tons, an inland steamer, has two beam-engines, each 40″ by 10′; boiler-pressure allowed, 55 pounds. The coasting steamer "Santee," 658.64 tons, has one 40″ by 3′ engine; boiler-pressure allowed, 23 pounds. The ferry-boat "General J. S. Schultz," 536.51 tons, plying between Philadelphia and Camden, has one 36″ by 10′ beam-engine; boiler-pressure allowed, 45 pounds. The steamer "Admiral," 508.68 tons, coasting upon the Atlantic and the gulf of Mexico, has one 48″ by 9′ beam-engine; pressure allowed in boiler, 30 pounds.

In Class III 34 out of 95 engines are non-condensing, and 33 out of 95 are engines of boats having paddle-wheels. The "City Ice-Boat No. 2," of 458.02 tons, is a side-wheel boat, driven by two 48″ by 8′ non-condensing engines. The boiler-pressure allowed is 60 pounds. The engines are of great power, which is required for cutting and crushing through ice to keep navigation open in the Delaware river.

The ferry-boat "Barclay," 166.84 tons, plying between Tuckerton and Beach Haven, has side-wheels driven by two 17″ by 36″ non-condensing engines. The boiler-pressure allowed is 60 pounds.

In this class the great majority of the engines are simple short-stroke engines driving-screw propellers. In the next class all but two or three are of this type, and 20 out of 35 are non-condensing. In Class V nearly every engine is of the short stroke type, and only one is condensing. In Class VI all are non-condensing, and two or three very small paddle-wheel boats furnish the only exceptions to the usual short-stroke type of engine.

The canal-boat "Triplet," 338.79 tons, has one 22″ by 36″ engine; boiler-pressure allowed, 75 pounds.

ENGINES OF BALTIMORE STEAMERS.

In Class I there are 8 engines, all condensing, 2 beam-engines on passenger-boats plying on Chesapeake bay, and 6 vertical screw-propeller engines on coasting steamers. The "Johns Hopkins," 1,470.97 tons, has one 60″ by 44″ engine; boiler-pressure allowed, 33 pounds. The "Louise," 1,023.20 tons, has one 50″ by 11′ engine; boiler-pressure allowed, 36 pounds.

In Class II there are 30 engines, only 2 non-condensing and only 8 screw-propeller engines, the rest being beam-engines on steamers plying on Chesapeake bay. The propeller "Shirley," 576.30 tons, plying between Baltimore and Richmond, has one 31″ by 34″ engine; boiler-pressure allowed, 30 pounds. The "Carolina," 984.18 tons, plying between Richmond and Norfolk, has one 60″ by 11′ engine; boiler-pressure allowed, 38 pounds. The "Carolina" is a swift boat, about the size of the "Mary Powell," of the Hudson river, but not as swift. The following comparison is made between the two boats:

	Carolina.	Mary Powell.
Tonnage	984.18	983.57
Length ... feet	257	288.7
Breadth ... feet	34.7	34.4
Depth ... feet	7.9	9.0
Engine	60″×11′	72″×12′
Speed ... miles per hour	15½	19½*a*

a At high speeds the engine of the "Mary Powell" exerts 1,500 horse-power. The speed given is for a 90-mile run, and has been exceeded in short runs.

The screw-steamer "William Kennedy," 974.57 tons, has one 44″ by 6′ engine; boiler-pressure allowed, 35 pounds.

In Class III, of 56 engines there are 23 long-stroke engines, generally peculiar to ferry and inland passenger-boats. The "William Allison," a large towing-boat with a beam-engine, is an exception to this rule. The majority of the engines are condensing, only 22 out of 56 being non-condensing. But in Class IV out of 21 engines only 4 are condensing, the boats being screw-propellers excepting one, the steamer "Arlington." In Class V 2 out of 46 are condensing-engines, while in Class VI all are non-condensing and short-stroke of the usual type for small tugs and yachts.

The Pennsylvania canal-boat "No. 222", 73.40 tons, has one 14″ by 14″ engine; boiler-pressure allowed, 72 pounds. The passenger-boat "Arlington," 51.33 tons, has one 16″ by 4′ engine; boiler-pressure allowed, 80 pounds. The passenger-boat "Convoy," 78.93 tons, has one 32″ by 30″ condensing-engine; boiler-pressure allowed, 40 pounds. The "A. S. Kapella," 21.55 tons, has one 14″ by 14″ engine; boiler-pressure allowed, 80 pounds.

ENGINES OF NORFOLK, CHARLESTON, AND SAVANNAH STEAMERS.

The "City of Macon," 2,092.80 tons, of the New York and Savannah line, has one 38″ and 68″ by 54″ compound engine, with a boiler-pressure allowed of 80 pounds. The ferry-boat "Manhausett," 512.43 tons, plying between Norfolk and Portsmouth, has one 38⅝″ by 8′ engine, with a boiler-pressure allowed of 30 pounds. The "City Point," 678.06 tons, plying between Charleston and Palatka, has one 45″ by 11′ engine; boiler-pressure allowed, 40 pounds. The steamer "Calvert," 637.37 tons, plying between Charleston and Baltimore, has two 40″ by 36″ engines; boiler pressure allowed, only 18 pounds.

Of the smaller steamers inspected at Norfolk a large proportion run to points on the North Carolina sounds, and these, with a smaller number running to Richmond and points on the James river, constitute nearly all of the steamers. Most of the passenger-boats have long-stroke beam-engines, while the freight-boats and tugs have short-stroke propeller-engines. The freight-boat "Benjamin Meinder," 127.70 tons, plying from Plymouth, North Carolina, as far north as Philadelphia, has one 18″ by 18″ non-condensing engine; boiler-pressure allowed, 50 pounds. The tug-boat "Tredegar," 34.12 tons, plying between Norfolk and Plymouth, has one non-condensing engine 13″ by 13″; boiler-pressure allowed, 60 pounds. The tug-boat "Vulcan," 50.90 tons, plying upon James river, has one non condensing engine 20″ by 20″; boiler-pressure allowed, 40 pounds. In Class III, 16 out of 29; in Class IV, 2 out of 31, and in Class V, 1 out of 28 engines are condensing. There are two boats with oscillating engines. The tug-boat "Annie Wood," 15.26 tons, plying between Franklin and Edenton, has one 6″ by 9″ oscillating engine, and the "Chipoax," 43.92 tons, plying between Petersburg, Norfolk, and Richmond, has two oscillating engines, each 8″ by 8″.

Of the smaller steamers inspected at Charleston, in Class III, 7 out of 22; in Class IV, 5 out of 13; in Class V, 2 out of 18, and in Class VI, 1 out of 17 engines are non condensing. In Class III the engines are mostly long-stroke, driving paddle-wheels, but in Class VI there are only two such engines.

The freight-boat "Mingo," 26.40 tons, plying upon the Santee and Pedee rivers, is a paddle-wheel boat with one 8″ by 30″ engine; boiler-pressure allowed, 80 pounds. The "Flora," 86.48 tons, a side-wheel passenger-boat, of Jacksonville, Florida, has two inclined engines, each 10″ by 11″; boiler-pressure allowed, 67 pounds.

Of the small steamers inspected at Savannah, in Class III, 7 out of 29; in Class IV, 7 out of 30; in Class V, 5 out of 16, and in Class VI, 4 out of 30 engines are condensing. The Savannah district is characterized by a great number of paired engines, for of the classes of steamers below the second we find in the Norfolk district about 18 per cent., in the Charleston district about 40 per cent., and in the Savannah district about 61 per cent. of the engines used in pairs. Excepting in the smallest boats, such paired engines are usually of long stroke for driving paddle-wheels. In Class III, of Savannah, 22 out of 29 engines are used in pairs, and 28 out of 29 are used in driving paddle-wheels. The "Gazette," a screw-boat of 117.98 tons, in passenger service on the Saint John's river, has one 14″ by 16″ engine; boiler-pressure allowed, 70 pounds. The "Fox," a paddle-wheel tug-boat of 117.98 tons, plying between Salt Lake and Jacksonville, Florida, has one 8″ by 18″ engine; boiler-pressure allowed, 75 pounds.

ENGINES AND BOILERS OF THE "CITY OF AUGUSTA."

The engines of this fine steamer were built at the Delaware Iron Shipbuilding and Engine Works, Chester, Pennsylvania. There is one principal compound engine 42½″ and 82″ by 54″ (stroke) cylinders. The surface-condenser has 4,200 square feet of surface, and, as is often the case on ocean steamers, may be arranged to work as a jet-condenser if desired. Separate engines work the air-, feed-, and bilge-pumps, and the circulating-pumps. The air-pump is independent of the circulating-pump, and the bilge-pumps connected with the air-pump may be disconnected if desired. There is also a starting- or reversing-engine supplied with steam from a separate donkey-boiler. The shaft is 14½″ in diameter, journals 24″ long with 2½″ deep by 2″ thick collars. The propeller is of the Hirsch pattern, 16′ in diameter, 24′ pitch, with a 15½″ shaft. The boilers are six in number, return-tubular, 12′ 6″ in diameter and 11′ 5″ long. The tubes are 8′ long and 3¼″ diameter. Each boiler has three furnaces, 33″ in diameter, with grate-bars 6′ 6″ long. Small steam-engines are employed for hoisting, steering, and other purposes.

ENGINES OF GULF STEAMERS.

In the Apalachicola district long-stroke engines in pairs are the most common type for all but the smallest vessels. The river boat "Rebecca Everingham," 592.20 tons, has two 10¼″ by 4′ 6″ engines, which at the boiler-pressure allowed, 183 pounds, will develop a high power in proportion to the size of cylinders. The "Laurel," 320 tons, has two inclined direct-acting engines 21″ by 27″ each; boiler-pressure allowed, 30 pounds. The paddle-wheel boat "Alpha," 93.73 tons, has two slide-valve engines each 6½″ by 24″; boiler-pressure allowed, 80 pounds. In this district four-fifths of the engines are non-condensing, and two-thirds of them are used in pairs.

At Mobile no steamers of over 500 tons are inspected. The larger steamers are of the regular river type, with stern-wheels driven by pairs of horizontal (or slightly inclined) engines of long stroke. This class of engines will be more fully considered under the head of "Steamers of the Mississippi Valley". The smaller steamers are screw-propellers with short-stroke engines. The engines of both classes are almost uniformly non-condensing, there being only 7 condensing-engines in a total of 104 engines in the district, and these with one exception being upon the propellers. The tug-boat "Juno," 80.31 tons, has a compound engine 16″ and 28″ by 20″. In Class III, 40 out of 46; in Class IV, 12 out of 24; in Class V, 8 out of 14, and in Class VI, 8 out of 20 engines are used in pairs.

In the Galveston district there are four compound engines, the tug-boat "Estelle," 84.78 tons, having two 12″ and 21″ by 24″ engines, and the "Louise," 105.01 tons, having two similar engines. This district differs from that of Mobile in the considerable and increasing employment of condensing-engines. Thirteen out of 41 engines were condensing in 1880, and in 1881 17 out of 40 engines were condensing. In the interval of a year specified some steamers had been transferred, 8 had gone out of service, and 11 new steamers had come into service, 5 of them with condensing-engines.

In Class I, New Orleans, 15 out of 39 engines are condensing, and 26 out of 39 are paired. In Class II, 7 out of 23 are condensing and 16 are used in pairs, that is to say, all the side-wheel and propeller engines are condensing, while all the stern-wheel engines are paired. The "Garden City," 982.10 tons, a stern-wheel boat, has two 22½″ by 8′ engines; boiler-pressure allowed, 156 pounds. The "Morgan," 994.31 tons, a side-wheel boat, has one 50″ by 11′ engine; boiler-pressure allowed, 30 pounds. The cylinder capacity of the "Garden City" is 42.92 cubic feet, of the "Morgan" 150.33 cubic feet, but the former uses the greater power.

In Class III, New Orleans, 19 out of 163 engines are condensing and 138 are paired. Also one steamer, the ferry-boat "Porter," a propeller of 280.35 tons, has four 16″ by 16″ engines; the boiler-pressure allowed being 45 pounds. In Class IV 4 engines out of 71 are condensing, 56 are paired, and one steamer has four engines. It will be seen that these classes are almost entirely composed of stern-wheel boats.

In Class V 18 out of 39 engines are paired and 38 are non-condensing. In Class VI 18 out of 59 are paired, beside which there is one set of four engines (upon the tug "Ruby"), and all the engines are non-condensing.

Only engines used in propulsion are specified above. We speak, for example, of the "Chalmette" as having one compound engine, but counting small engines for all purposes it has no less than 15 engines on board.

The steamship "Algiers," of the Lone Star line, plying between New Orleans and New York, has a long-stroke poppet-valve engine with Sickels' cut-off. The "Algiers" is a vessel of 2,287.34 tons; length, 281 feet; breadth, 38.7 feet; depth, 20.2 feet. It has one 50″ bore by 5′ stroke simple-condensing engine. Cutting off at 6″ (one-tenth) the economy is stated to equal that of a compound engine. The "Algiers" has a 4″ by 20″ feed-pump and two 11′ 4″ diameter 17′ long return-tubular boilers, shells iron $\frac{6}{16}$ thick, carrying 60 pounds pressure.

CONDENSERS.

Surface-condensers have played a very important part in increasing the economy of marine service. It may almost be said that they have rendered long ocean voyages practicable, for the chief obstacle to higher speeds lies in the necessity for carrying a great weight of coal to obtain the requisite power. But without surface-condensers twice as much coal would have to be carried, and indeed the best results obtained with marine engines to-day show a consumption of about one-fourth as much coal per horse-power as the best results of forty years ago. The chief factor of this improvement has been the employment of surface-condensers. We might say, roundly, that, going back one, two, three, and four decades, the best economy in marine steam-power has been the consumption of 3, 4, 5, and 6 pounds coal per horse-power per hour. Now it is less than 2, and in some cases is claimed to be less than 1½ pounds. Estimating 10,000,000 tons of coal to be annually used in the work of marine propulsion, it would cost $30,000,000 or $40,000,000 a year, and occupy over 6,000,000 cubic feet of cargo-space the year round, the use of which would be worth nearly as much as the cost of the coal that fills it. Granted that the saving is equal to the use, and we have an impressive showing of the world's annual indebtedness to the surface-condenser and the improved usage of steam machinery which followed its introduction. Of American steamers surface-condensers are used upon only a small percentage by number, but upon a large percentage by tonnage. The common form of surface-condenser for large engines consists of a great number of small parallel tubes so arranged within a casing that the exhaust-steam passing through the tubes is condensed by cold water flowing through the spaces between them.

The efficiency of surface in condensing and the proportionment of areas for surface-condensers are dependent upon conditions which may be exactly determined in any given case, but which are subject to much variation.

Condensing, like heating-surfaces should therefore be made ample enough to cover all probable conditions. A condensing-engine, under various grades of expansion, may be expected to require between 16 and 30 pounds of water per horse-power per hour. The vacuum in a condenser being 13 pounds per square inch, a square foot of condensing-surface suffices to condense 3 or 4 pounds of steam per hour, according to experiments upon a marine engine cited by Rankine. According to Peclet, 21½ pounds of steam are condensed per square foot per hour, the tubes being of copper and the initial temperature of the cooling water being between 68° and 77° Fahr. As a matter of practice, we find that surface-condensers are made to condense 8 to 12 pounds of steam per square foot of area. A number of examples of good practice with large marine engines give the number of square feet of condensing-surface per actual indicated horse-power at 3.73, 2.74, 2.66, 2.66 (another engine), 2.07, 2.00, 2.00, 1.83, 1.81, and 1.68 square feet. The consumption of water per indicated horse-power varied in these cases, but supposing the steam dry and 20 pounds of steam consumed per indicated horse-power, the weight of steam condensed per square foot of surface would range between 5¼ and 12 pounds. With greater economy of steam there would be less power and a greater relative area of condensing-surface, say 1 square foot for 4 pounds per hour. Under favorable conditions, over 2 square feet of condensing-surface per indicated horse-power is redundant surface, and involves little or no economical advantage for the best engines, but for engines wasteful of steam much more surface would be necessary.

Making the condensing-surface five-eighths as great as the heating-surface is stated by Mr. Henry Levrat to be an ordinary rule of practice. Examples have been noted in which the condensing-surface varies from seven-eighths to little more than half the heating-surface, and two thirds is a very common and effective ratio. It is obvious that the temperature of the water used and the efficiency of the circulating-pumps affect the vacuum obtained.

The surface-condenser was first successfully introduced in English marine service between forty and fifty years ago by Mr. Samuel Hall. A practical difficulty in its introduction was due to the leakage of the tubes, which are held at the ends in tube sheets, in which it is necessary that they should be packed steam and water tight. The variations in temperature, and the consequent expansion and contraction of the tubes, commonly called "creeping", have always caused more or less trouble. Hall used packing held in place with a screw-ring, without a creep-flange. For making the surface-condenser a practical success in American marine service the chief credit is due to Horatio Allen, of the Novelty Iron Works, New York. He introduced the wood packing, which was originally used as shown in Fig. 15. A wood ring or ferrule was driven over the tube, passing between it and the tube-sheet. Driven in dry, it became swollen by the moisture and expanded, making a tight joint and spreading out at the ends like the flanges of a spool. The tubes were nicked out to prevent "creeping". Wood packing was first applied in the steamers of the Pacific Mail Steamship Company. Another approved method of packing is by brass rings with creep-flanges. Brass plates are sometimes used instead of cast iron, being more expensive, but less subject to corrosion from distilled water. Double sheets or plates have also been used, one sheet acting as a "closer" to prevent the tubes from creeping. Three forms of packing are illustrated in Fig. 16. At *a* is shown a cast-iron tube-sheet, the tubes packed with paper packing. The "City of San Francisco" has condenser-tubes packed in this way. Vulcanized fiber makes a very tight packing. At *b* is shown a double-tube sheet, a cast-iron sheet, with a brass following- or closing-sheet. This follower presses down brass rings which encircle the tubes, pressing upon rubber rings which constitute the packing. At *c* is shown the method of packing, with creep-flanged glands screwed into the cast-iron tube-plate. The internal flange restrains the tube from "creeping". In this case the packing used is made of corset lacing. The tubes are commonly of brass, tinned inside, and ½″ to ¾″ in diameter.

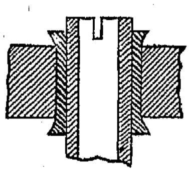


FIG. 15.

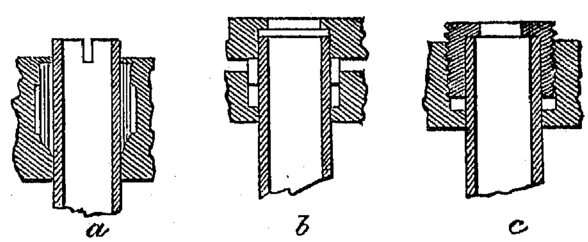


FIG. 16.—CONDENSER TUBE PACKING.

It can hardly be said that the problem of packing condenser tubes has been fully solved until recently. The device of Mr. Frederick M. Wheeler employs two sets of tubes, the large tubes encircling the small with an annular passage for the flow of the water between them. The two sets are secured by screw joints in separate heads at one end of the condenser, and the large tubes being capped and the small tubes open at the opposite end an efficient course of flow is provided. The tubes being entirely free to expand, do away with the trouble of "creeping" and straining the tube joints, which has so long been an annoyance in marine engineering.

The vacuum obtained with surface-condensers is usually $26\frac{1}{2}''$ (equal to about 13 pounds), or 27″ for large marine condensers, but sometimes this vacuum is exceeded. The keel surface condenser is simply a pipe, or, if more surface is needed, several pipes, which pass outside the vessel, and lay along the keel of the after part. A good vacuum is produced with a smaller surface than is required in proportion to the power for large marine condensers. Its efficiency depends on the speed of the boat. Thus a keel-condenser applied in a small tug of 45 tons obtains a vacuum of $27\frac{1}{2}''$ when running free and only of 24″ when towing at a low speed.

For large marine surface-condensers the arrangement of the tubes was formerly vertical, but is now in many cases horizontal. Their efficiency depends in some degree upon the course given the condensing-water in passing through the tubes.

Of other forms of condenser the general types may be described as jet- and ejector-condensers. Jet-condensers are mainly employed on river boats, but many large ocean steamers have engines arranged to be used either as surface-condensing or jet-condensing engines. Ejector-condensers of the Morton, Korting, and other types are also used sometimes upon large steamers. The coasting steamer Relief, 338.18 tons, has two 26″ by 26″ engines with ejector-condensers. In the injector- or jet-condenser the exhaust-steam passes into a vessel in which it is condensed by the injection of water. In the ejector-condenser the steam is condensed by a cold stream of water impinging upon a jet of steam as it passes out of a nozzle. The vacuum formed gives the fluids an impetus, and the use of an air-pump may be obviated, precisely as a Giffard injector may do the work of a pump in boiler-feeding.

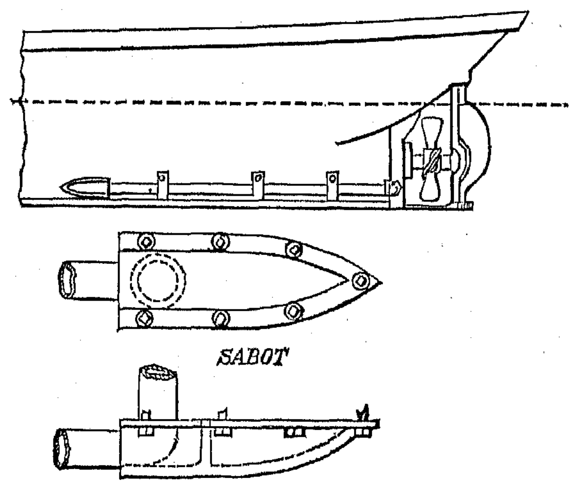


FIG. 17.—KEEL-CONDENSER.

In jet-condensers the vessel in which condensation takes place is sometimes as much as three-fourths the volume of the cylinder In Watt's original engines it was one-eighth, but is now usually over one-fourth the volume of the steam-cylinder. The area of the injection-valve for admitting water of condensation is taken at $\frac{1}{250}$ of the area of the piston, or $\frac{1}{15}$ of a square inch per cubic foot evaporated by the boiler per hour.

The air-pump, as made by Watt, was one-half the diameter and one-half the stroke of the steam-cylinder. It was thus one-eighth of the volume of the cylinder. According to Rankine the proper volume is one-fifth to one-sixth the volume of the cylinder when single- and one-tenth to one-twelfth when double-acting. This is for jet-condensers.

With the surface-condenser and compound engine the volume of the air-pump (single-acting) is stated to be rated in American practice at about one-twelfth the volume of the low-pressure steam-cylinder, the circulating-pumps having about half the acting capacity of the air-pumps. For jet-condensers larger air-pumps are required than for surface-condensers. We may cite the following examples of relative volumes of cylinders and air-pumps for surface-condensing engines. The great beam-engine of the "Pilgrim" has a cylinder 110″ by 14′, air-pump 60″ by 6′ stroke of bucket; pump-volume about 25 per cent. of cylinder-volume. The "City of San Francisco" has one 51″ and 88″ by 5′ compound engine and two 24″ by 2′ air-pumps; pump-volume about 5 per cent. of the total cylinder-volume and 6 per cent. of the low-pressure cylinder-volume. The little steam yacht "Adelita," with a keel surface-condenser, has two 7″ by 7″ cylinders and one 5″ by $4\frac{1}{2}''$ air-pump; pump-volume about 16 per cent. of the cylinder-volume. All of these air-pumps are as usual single acting.

It should be borne in mind in considering the opening remarks under this head that the introduction of condensers is only one of a number of factors in the improvement of the economy of marine steam service. There are other influences at work which tend to diminish the relative value of condensers. The higher the steam-pressure carried the less relative work can be done by the $13\frac{1}{2}$ or less pounds per square inch due to the vacuum; but this is not the only consideration. Condensers are peculiarly adapted to help out low grades of expansion as well as low steam. With a great expansion permitted by high steam and light service a condenser might become a worse than useless adjunct. This point has not been reached in marine service, but we can see that the advantages which were very great under 20 or 30 pounds boiler-pressure will have dwindled considerably under 150 pounds boiler-pressure.

BOILERS OF STEAMERS IN FOREIGN TRADE.

Each of the transatlantic steamers of the American Steamship Company has three compound cylindrical return-tubular boilers, double-ended, and fired fore and aft. Each boiler is 12′ 3″ in diameter by 17′ long, and contains six furnaces, three in each end. Each furnace is 2′ 10″ in diameter, grate-bars 5′ 4″ long. Each boiler has three hundred and sixteen 3″ tubes 7′ long.

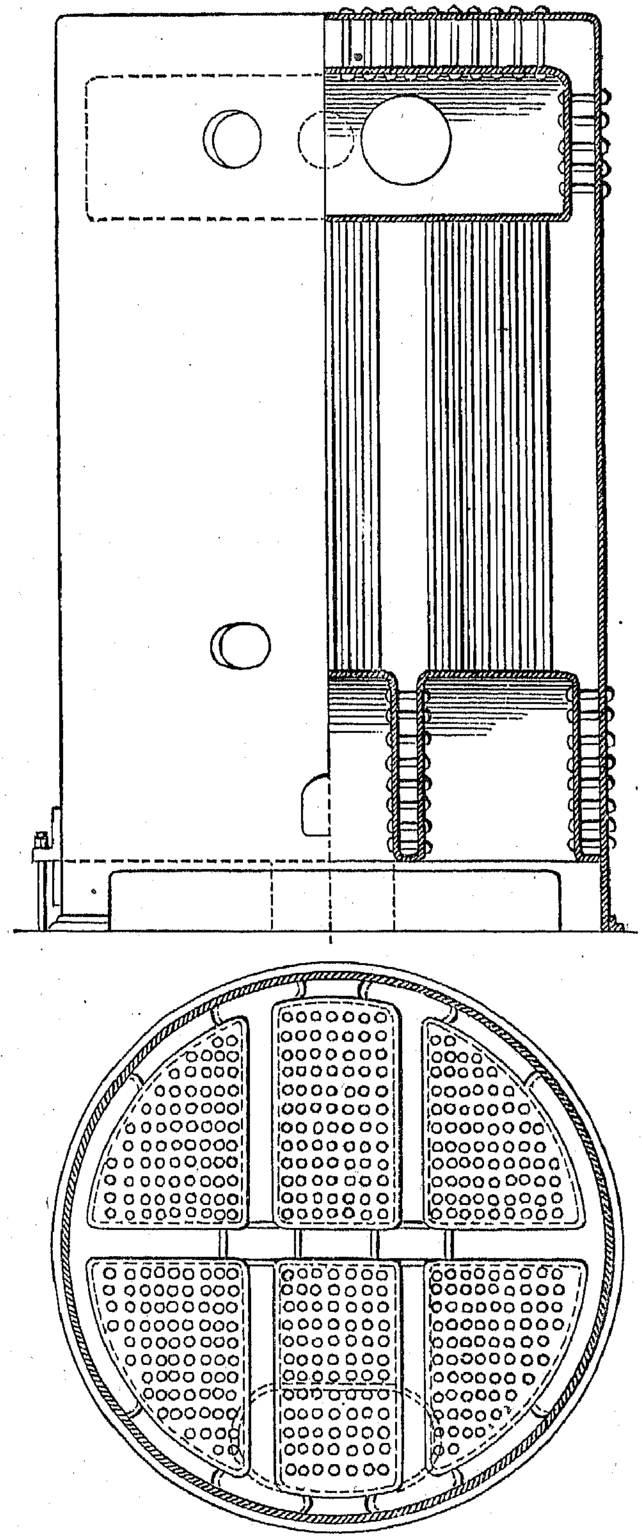


FIG. 18.

Of steamers running to Panama, West Indies, and South America, the following examples of boilers may be cited:

The "United States," 1,180.10 tons, plying from Boston to Havana (and also to Halifax, Nova Scotia) has two rectangular return-tubular boilers 16′ wide and 16½′ long. The "City of Vera Cruz," 1,874.36 tons, of the New York and Havana Mail Steamship Company's line, has vertical boilers, two in number, and each 13′ in diameter by 19′ 10″ high. The employment of such large vertical boilers is unusual in marine service, but their use is said to have been attended with perfect success. Large vertical boilers are not commonly employed even in stationary service (although the Baldwin Locomotive Works have a number of considerable size), but in land service their use is mainly confined to portables and in marine service to small yacht and tug-boat engines. Of one of the boilers of the "Vera Cruz" a plan and an elevation looking forward are given in Fig. 18. Furnace-stays are not shown in the plan. The tubes are 11′ long, 8′ wetted length, and there are 5,290′ heating service for both boilers taken together. The furnaces are full 4′ high, giving ample space for combustion. There are four hundred and seventy-two 2½″ tubes. The temperature at the base of the funnel is about 400° Fahr. These peculiar boilers were designed by Mr. Peck and built by Quintard & Murphy, New York. The "City of Merida," 1,492.45 tons, running to Vera Cruz, has two return-tubular boilers, built by C. H. Delamater & Co. These are each 15′ in diameter by 16′ long, containing two hundred and fifty-four 3½″ tubes.

The "City of Para," 3,532.25 tons, has six return-tubular boilers 13′ 1¼″ diameter, 10½′ long; each boiler has two hundred and four 3¼″ tubes. The steam-pipe is of copper 12″ in diameter. The aggregate safety-valve area is 170 square inches. A donkey boiler is also employed. The "Newport," 2,735.29 tons, has six return-tubular boilers, each 13′ 5″ diameter by 11′ long. Each boiler has three 3½′ flues and two hundred and thirty-one 3¼″ tubes. The aggregate safety-valve area is 197¾ square inches. The "City of Alexandria" has four cylindrical return-tubular boilers, each 14′ 6″ in diameter and 11′ long.

The "Tropic," 379.77 tons, plying from Philadelphia, has one return-tubular boiler 10½′ in diameter by 10½′ long. The "Acadia," 955.58 tons, has two vertical tubular boilers, each 7′ in diameter and 12′ 5″ high.

The "Margaret," 508.05 tons, plying between New Orleans and Havana, has one 8½′ by 20′ cylindrical tubular boiler, and the "E. B. Ward, Jr.," 387.92 tons, has one fire-box and return-tubular boiler 10′ in diameter and 18′ long.

For some of the above-mentioned steamers the gross boiler-volumes are given with the ratios per ton of vessel:

Name.	Boiler-volume.	Per ton of vessel.	Boiler-pressure allowed.	Name.	Boiler-volume.	Per ton of vessel.	Boiler-pressure allowed.
	Cubic feet.		*Pounds.*		*Cubic feet.*		*Pounds.*
Pennsylvania	6,011.61	1.93	64	City of Alexandria	7,216.92	2.93	80
City of Vera Cruz	5,265.08	2.81	70	Tropic	960.21	2.39	35
City of Merida	5,655.36	3.78	40	Acadia	955.58	2.47	40
City of Para	8,491.74	2.42	80	Margaret	1,134.88	2.23	35
Newport	9,199.08	3.36	80	E. B. Ward, Jr	1,413.72	3.64	40

The "City of Washington," 2,618.27 tons, plying between New York and Havana, has two vertical tubular boilers 18′ in diameter, and 18′ 6″ high. These have an aggregate boiler-volume of 9,416.50 cubic feet, or more than any other steamer inspected at New York. The boiler capacity is thus ample, and the steamship is one of the swiftest going out of New York. The "Louisiana," of the Cromwell line (New York and New Orleans), the swiftest steamship flying the American flag, has boilers of peculiar design, which will be elsewhere described. The prevailing type of boiler is the return-tubular, sometimes fired fore and aft, as in the steamships of the American line (in which case the boilers are set with their length parallel to that of the vessel), but more generally with the fire-room in the center of the vessel, and the boilers, which are comparatively short, placed in sets of pairs, across, and one on each side of the vessel.

The time has been when the variety of boilers employed in American marine service was so numerous that the exception may almost be said to have been the rule, and there is now much greater uniformity in practice.

The following details are given of a return-tubular boiler of the outside dimensions: Length, 14′ 6″; breadth, 8′ 6″; depth, 9′. Such a boiler might be more fully specified as a compound, rectangular, direct-flue, and return-tubular boiler. A boiler is compound when, as in most large marine boilers, and in most boilers of large diameter in any service, there are several furnaces in each boiler. The boiler in question has two furnaces, and is one of a pair which are set as, is said, right and left, one on each side of the steamship. It has four 11″ and two 18″ flues, 5′ 6″ long, and sixty-four 4½″ tubes, 12′ long. The grate is 3′ 6″ wide, and 6′ long, or nearly half the length of the boiler. The safety-valve is 5½″ in diameter. The grate-surface is 42 square feet; heating-surface, 1,248 square feet; gross volume, 1,109.25 cubic feet. The ratio of heating surface to volume is 1.11; of heating- to grate-surface, 29.71.

The following discussion of the capacities of large marine boilers, and of their capacities relative to the capacities of condensers and compound-engines, will be found of general application, although the data are drawn from foreign sources.

BOILER AND ENGINE CAPACITIES OF OCEAN STEAMERS.

Some exception may be taken to the method of stating boiler capacities by the cubic volume of the boiler-cylinders, which has been the measure of boiler capacity presented by aggregates and averages for the several districts and classes of steamers. The usual measure of capacity for a boiler is the heating-surface below the water-line (neglecting superheating-surface), and in ordinary practice 8 to 16 square feet of heating-surface are calculated for a nominal horse-power. With the great variety of styles and dimensions existing among marine boilers, it has not been practicable to calculate the heating-surface in every case. But the simple measure of capacity given—the boiler-volume—may easily be compared with the heating-surface in a sufficient number of cases to guide the reader to an approximation of the latter quantity in any case.

It must be said, however, that while area of heating-surface is the usual measure of steaming performance, it is by no means an exact measure even for similar construction of boilers. In evidence of this, I may cite Mr. F. C. Marshall's table of the data of long ocean voyages of English steamers. Thirty cases of as many steamships are cited in the order of economy of coal per indicated horse-power of engines, the range being from 1½ to 2¼ pounds coal per horse-power per hour:

COAL.	HEATING-SURFACE OF BOILERS.		COAL.	HEATING-SURFACE OF BOILERS.		COAL.	HEATING-SURFACE OF BOILERS.	
Per indicated horse-power per hour.	Per indicated horse-power.	Per pound coal per hour.	Per indicated horse-power per hour.	Per indicated horse-power.	Per pound coal per hour.	Per indicated horse-power per hour.	Per indicated horse-power.	Per pound coal per hour.
1.50	4.08	3.12	1.76	4.76	2.69	1.90	3.35	1.762
1.60	3.19	1.99	1.76	3.97	2.27	1.90	3.56	1.873
1.63	3.70	2.26	1.763	4.35	2.46	1.90	4.45	2.34
1.66	3.55	2.14	1.80	5.52	3.066	1.90	4.90	2.58
1.67	3.34	2.00	1.83	3.37	1.830	1.93	3.28	1.70
1.67	2.88	1.725	1.84	4.34	2.36	1.945	4.59	2.36
1.69	3.98	2.35	1.85	3.11	1.647	2.00	2.89	1.44
1.70	4.91	2.88	1.85	4.19	2.26	2.125	2.80	1.315
1.70	6.24	3.705	1.87	4.39	2.35	2.25	2.80	1.243
1.72	4.01	2.34	1.89	3.86	2.05	2.25	2.77	1.23

In this connection I present a diagram, comparing some of the relations between the data of ten of these steamers, and if there be any rule of application discoverable from the comparison, it must be of utility in American as well as in English practice.

This diagram is explained as follows: The ten vertical dotted lines are representative of ten English ocean steamships of which the data were published in the London *Engineering*. They are arranged in order of economy of coal consumption from left to right. The line A, taken as a base line, represents the data charted for the most economical engine, with which the others are compared. The cross-lines B, C, and D represent the areas of grate-, condensing-, and heating-surface per indicated horse-power cited by Mr. Marshall as embodying the best practice.

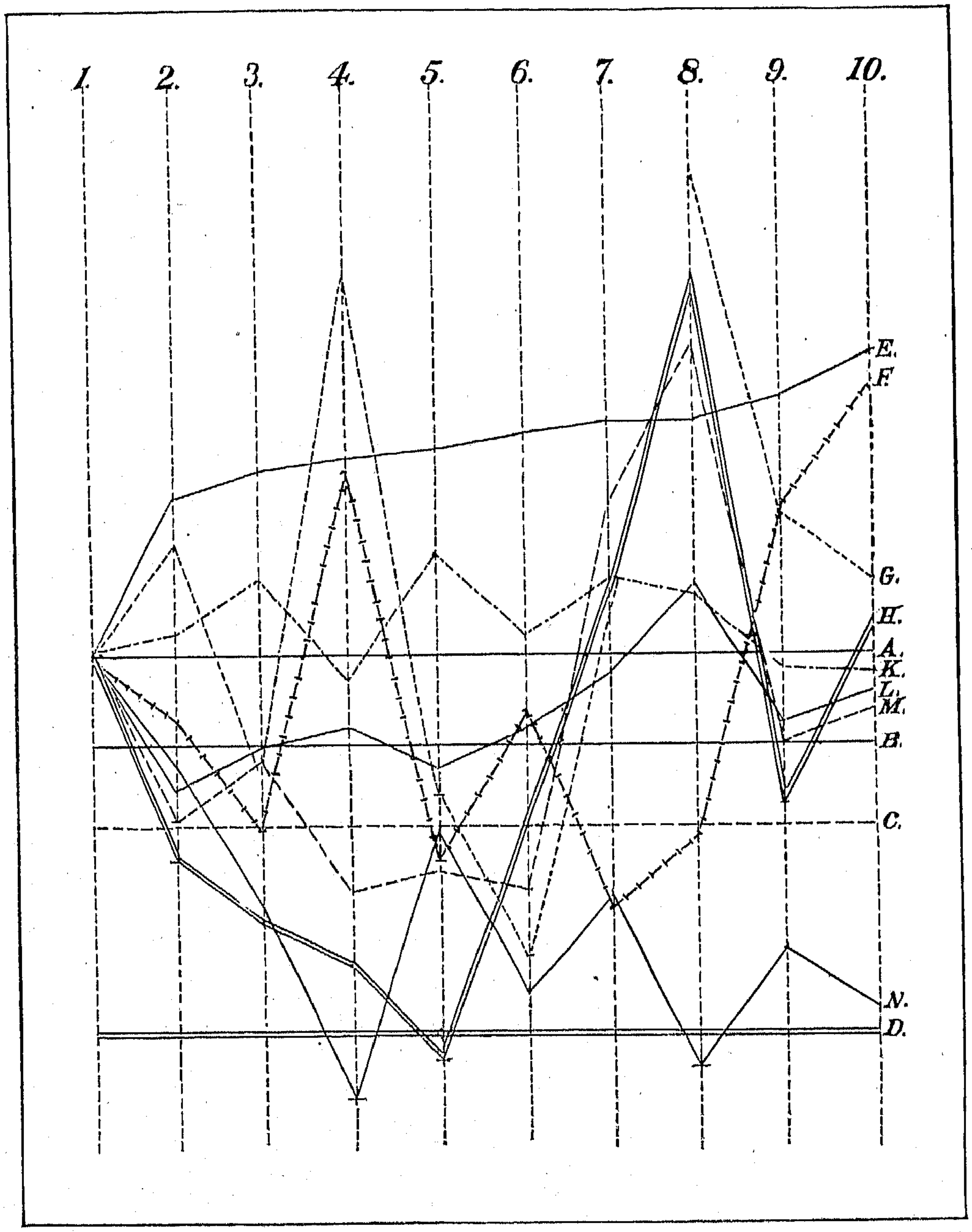


FIG. 19.

These areas are 0.11 square foot of grate-, 2 square feet of condensing-, and 3 square feet of heating-surface per indicated horse-power. They are shown in comparison not with each other but to different scales, being compared with like data of the most efficient engine cited, viz, 0.15 square foot of grate-, 2.73 square feet of condensing-, and 4.68 square feet of heating-surface. The data charted for the other engines are compared with those of the first in like manner, and the points determined on the vertical lines are connected by joining lines, with the idea of exhibiting progressive series of the several data attendant upon a requirement of fuel progressing from $1\frac{1}{2}$ to $1\frac{3}{4}$ pounds coal per indicated horse-power per hour. The line E indicates the coal consumption per indicated horse-power per hour, viz, 1.50 pounds (the base line), 1.63 pounds, 1.66 pounds, 1.67 pounds, 1.67 pounds, 1.69 pounds, 1.7 pounds, 1.7 pounds, 1.72 pounds, and 1.76 pounds, respectively. The line F indicates the inches diameter of screw per indicated horse-power, viz, 0.20 (the base line), 0.17, 0.10, 0.31, 0.08, 0.17, 0.09, 0.12, 0.26, 0.32, respectively. Too large a screw is sometimes said to "lock up" an engine, or to reduce its power. Thus an 18′ 10½″ screw may be said to "lock up" a 3,000 horse-power engine to 2,000 horse-power, or, in other words, to prevent the engine from being speeded up to the higher power, precisely as speed is limited in driving paddle-wheels or in doing any work against resistances. To be sure the engine may perhaps be run economically at a low speed, but if speed be permanently reduced there remain unnecessarily large areas of the heating and other essential surfaces so that the steam machinery is much heavier and more costly than necessary. The line H indicates the heating-surface per indicated horse-power, viz, 4.68 (the base line), 3.70, 3.55, 3.34, 2.88, 3.98, 4.91, 6.29, 4.01, and 4.76 square feet, respectively. The line G indicates the product of boiler-volume into pressure per indicated horse-power, viz, 262 (the base line), 288, 238, 344, 232, 196, 272, 367, 292, and 279. The line K indicates the absolute indicated horse-powers, viz, 900 (the base line), 1,200, 2,200, 420, 2,677, 1,200, 2,207, 1,801, 650, and 500 indicated horse-power, respectively. The line L indicates the grate-surface per indicated horse-power, viz, 0.15 of a square foot (the base line), 0.09, 0.11, 0.12, 0.10, 0.12, 0.14, 0.18, 0.11, and 0.13 of a square foot respectively. The line M indicates the condensing-surface per indicated horse-power, viz, 2.73 square feet (the base line), 2, 2.27, 1.67, 1.81, 1.66, 3.36, 4.12, 2.33, and 2.50 square feet, respectively. Lastly, the line N represents the ratio of tube-surface to furnace-surface in the whole heating-surface, viz, 6.98 (the base line), 6.09, 4.65, 3.10, 5.48, 4.01, 4.84, 3.35, 4.34, and 3.87. It may be noted that the areas of grate-, condensing-, and heating-surface stated as embodying the best practice are nearly minima of the examples cited, from which it may be said that the most effective areas may be considerably increased without seriously affecting the efficiency of the engine, and, above these effective areas, it will be seen from the diagram that widely varying ratios of proportionment between these areas may exist without reference to the efficiency. Liberal proportions may effect a saving by wider adaptability to varying conditions, as, for example, when the fires are forced. But beyond a certain ill-defined point the influences of loss due to cylinder condensation and radiation of heat, the wastefulness of too light loads, and redundant heating-surfaces begin to show themselves in the coal-bunkers. In first cost per horse-power the difference between the engines cited is very great, the excessively large engines costing about twice as much per horse-power as those more closely proportioned to the demands put upon them. To provide for variations of draught and speed, for differences in fuel, stoking, heat of fire, boiler encrustation, and other contingencies, it may not be advisable to skimp proportions very closely, much less to seek for any commercial economy beyond the best engineering economy; but to put in 20 tons of engines and boilers where 10 tons would do as good duty is certainly a foolish though not altogether an unexampled waste of capital.

A comparison of the heating-surfaces and boiler-volumes of the 10 marine engines cited is as follows:

PER INDICATED HORSE-POWER.		Ratio, surface to volume.	PER INDICATED HORSE-POWER.		Ratio, surface to volume.
Heating-surface.	Boiler-volume.		Heating-surface.	Boiler-volume.	
Square feet.	*Cubic feet.*		*Square feet.*	*Cubic feet.*	
4.68	3.75	1.25	3.98	2.19	1.81
3.70	3.20	1.16	4.01	3.03	1.35
3.55	2.97	1.19	6.29	4.45	1.41
3.34	3.44	0.97	4.01	3.65	1.10
2.88	3.23	0.89	4.76	3.55	1.34

The volumes exhibit less variation per horse-power than do the surfaces, the extreme variation being 103 per cent. for the former to 118 per cent. for the latter, and the extreme variation from the average being 1.22 in the former against 2.08 in the latter.

The data of the ten engines are here given as an illustration of the best English practice. Whatever we may say of rule-of-thumb methods while we consider the variations in proportion of the essential areas, we must admit that the results, ranging from 1½ to 1¾ pounds coal per horse-power per hour, are of the very best:

1. Cylinders, 34″ and 61″ by 45″ stroke; 450′ piston speed per minute; 2,466 square feet condensing-surface; 15′ 3″ diameter screw; 70 pounds boiler-pressure; two boilers 12′ shell by 15′ long, with eight furnaces, each 3′ 6″ in diameter; eight hundred 3″ tubes 6′ long; grate-surface, 140 square feet; heating-surface, tubes 3,688 square feet, furnace and boxes 528 square feet, total 4,216 square feet; coal in twenty-four hours, 14.5 gross tons (32,400 pounds); heating-surface per pound coal per hour, 3.12 square feet.

2. Cylinders, 35″ and 70″ by 48″ stroke; 400′ piston speed; 2,400 square feet condensing-surface; 17′ diameter screw; 90 pounds boiler-pressure; two boilers 11′ 6″ shell by 18′ 6″ long, with eight furnaces, each 3′ 6″ in diameter, six hundred and forty 3½″ tubes 6′ 10″ long; grate-surface, 160 square feet; heating-surface, tubes 3,814, furnace and boxes 626, total 4,440 square feet; coal in twenty-four hours, 21 tons (gross); heating-surface per pound coal per hour, 2.26 square feet.

3. Cylinders, 46″ and 87″ by 57″ stroke; 484′ piston speed; 5,000 square feet condensing-surface; 19′ diameter screw; 80 pounds boiler-pressure; three boilers 12′ 3″ shell by 18′ 6″ long, with twelve furnaces, each 3′ 9″ in diameter, one thousand one hundred and sixty-four 3¼″ tubes 6′ 7″ long; grate-surface, 250 square feet; heating-surface, tubes 6,420, furnace and boxes 1,383, total 7,803 square feet; coal in twenty-four hours, 40 tons; heating-surface per pound coal per hour, 2.14 square feet.

4. Cylinders, 22″ and 44″ by 30″ stroke; 360′ piston speed; 705 square feet condensing-surface; 11′ diameter screw; 100 pounds boiler-pressure; one boiler 12′ 8″ shell by 11′ 6″ long, with three furnaces, each 3′ in diameter, one hundred and seventy-two 3¼″ tubes 7′ 3″ long; grate-surface, 49½ square feet; heating-surface, tubes 1,060, furnace and boxes 342, total 1,402 square feet; coal in twenty-four hours, 7½ tons; heating-surface per pound coal per hour, 2 square feet.

5. Cylinders, 50″ and 86″ by 54″ stroke; 540′ piston speed; 4,865 square feet condensing-surface; 17′ 6″ diameter screw; 72 pounds boiler-pressure; four boilers, each 13′ 4½″ wide, 16′ ¾″ high, 10′ ¾″ long, with twelve furnaces, each 3′ 6″ in diameter, one thousand and twenty-four 3½″ tubes 7′ long; grate-surface, 273 square feet; heating-surface, tubes 6,530, furnace and boxes 1,192, total 7,722 square feet; 48 tons coal in twenty-four hours.

6. Cylinders, 35″ and 70″ by 48″; 424′ piston speed; 2,000 square feet condensing-surface; 17 feet diameter screw; 90 pounds boiler-pressure; two boilers 9′ 6″ shell by 18′ 6″ long, with eight furnaces, each 3′ 6″ in diameter, six hundred and eight 3½″ tubes 6′ 10⅜″ long; grate-surface, 150 square feet; heating-surface, tubes 3,822, furnace and boxes 952, total 4,774 square feet; 21½ tons coal in twenty-four hours.

7. Cylinders, 54″ and 94″ by 60″ stroke; 530′ piston speed; 7,420 square feet condensing-surface; 18′ 3½″ diameter screw; 75 pounds boiler-pressure; six boilers 12′ 9″ shell by 10′ 6″ long, with eighteen furnaces, each 3′ 2″ in diameter, one thousand three hundred and eight 3½″ tubes 7′ 6″ long; grate-surface, 313 square feet; heating-surface, tubes 8,983, furnace and boxes 1,856, total 10,839 square feet; 40.3 tons coal in twenty-four hours.

8. Cylinders, 54″ and 94″ by 60″ stroke; 486′ piston speed; 7,422 square feet condensing-surface; 18′ diameter screw; 82½ pounds boiler-pressure; six boilers 12′ 9″ shell by 10′ 6″ long, with eighteen furnaces, each 3′ 2″ in diameter, one thousand two hundred and sixty-six 3½″ tubes 7′ 6″ long; grate-surface, 324 square feet; heating-surface, tubes 8,735, furnace and boxes 2,605, total 11,340 square feet; 32.8 tons coal in twenty-four hours.

9. Cylinders, 30″ and 58″ by 39″ stroke; 400′ piston speed; 1,518 square feet condensing-surface; 14′ 2″ diameter screw; 80 pounds boiler-pressure; two boilers 12′ shell by 10′ 6″ diameter, with four furnaces, each 3′ 2″ in diameter, three hundred and forty-four 3¼″ tubes 7′ 3″ long; grate-surface, 69.64 square feet; heating-surface, tubes 2,120, furnace and boxes 488, total 2,608 square feet; 12 tons coal in twenty-four hours.

10. Cylinders, 29″ and 56″ by 33″ stroke; 350′ piston speed; 1,250 square feet condensing-surface; 13′ 3″ diameter screw; 70 pounds boiler-pressure; two boilers 11′ shell 10′ 6″ long, with four furnaces, each 3′ in diameter, three hundred and sixteen 3¼″ tubes 7′ ½″ long; grate-surface, 66 square feet; heating-surface, tubes 1,891, furnace and boxes 488, total 2,379 square feet; 9½ tons coal in twenty-four hours.

BOILERS OF NEW ENGLAND STEAMERS.

Of 85 boilers in vessels of class I, 82 are return-tubular, and 3 return-flue, though many of the boilers have direct flues. Ten are rectangular and 75 cylindrical. The boilers are invariably of large diameter, being in several cases deeper than the hold of the boat itself. In only one boat is a boiler-pressure of over 40 pounds allowed. In this 80 pounds per square inch is allowed, the boiler being 11 feet in diameter, with a shell 0″.692 thick. For the low-pressure boilers the most usual thickness of shell is ⅜″. The smallest diameter of boiler is 8′ 9″, and diameters above 13 feet are exceptional. The average pressure allowed is about 32 pounds. There is is one set of 6 boilers, two of 4, four of 3, and twenty-three of 2 boilers per vessel, the rest being used singly. The "Decatur H. Miller," plying between Baltimore and Boston, has four return-tubular boilers, each 11′ in diameter by 11′ long.

Of the pressures allowed in the boilers of smaller vessels, the following table will exhibit the range. The extreme high pressures are allowed for coil-boilers, but one horizontal tubular boiler, 2½ feet diameter by 4 feet long, and two vertical tubular steel boilers are allowed a pressure of 150 pounds.

[Pressure allowed in pounds per square inch.]

	CLASS II.			CLASS III.			CLASS IV.			CLASS V.			CLASS VI.		
	Highest.	Average.	Lowest.	Highest.	Average	Lowest.	Highest.	Average.	Lowest.	Highest.	Average.	Lowest.	Highest.	Average.	Lowest.
Portland	33	31	30	100	55	30	90	76	40	100	78	60	150	97	70
Boston	40	34	23	100	58	25	90	80	50	124	80	60	150	94	70
New London	45	38	30	100	53	25	170	79	40	173	84	40	160	100	65