60 degrees Fahrenheit temperature, what weight of steam would be condensed per hour by the heat radiation from the 100 square feet of surface under the supposed conditions?

The temperature of steam of 55 pounds absolute pressure per square inch is 287 degrees Fahrenheit, and the latent heat is 912 Fahrenheit units. The difference between the temperatures of the steam and of the air is 227 degrees Fahrenheit. Then, as the constant for the bare cast iron is 2·874757336690, the weight of steam that would be condensed

per hour by the surface is $\left(\frac{2\cdot874757336690 \times 227 \times 100}{912} \right) = 71\cdot55392$

pounds. And the Fahrenheit units of heat that would be radiated per hour from this surface would be $(2\cdot874757336690 \times 227 \times 100) = 65256\cdot99154$.

REPORT OF THE TRIALS OF THE STEAM-MACHINERY OF THE U. S. REVENUE STEAMERS "RUSH," "DEXTER," AND "DALLAS,"*

AT THE U. S. NAVY YARD, BOSTON, MASS., IN THE MONTH OF AUGUST,
1874, BY A JOINT BOARD OF U. S. NAVAL AND U. S.
REVENUE-MARINE ENGINEERS.*

In the early part of the present season there were completed for the U. S. Revenue Marine, three new revenue steamers, named, respectively, in honor of ex-Secretaries of the Treasury, the "Rush," the "Dexter," and the "Dallas." The three vessels are similar as respects the hulls, the screws, and the boilers, but the engines are different each from the other—that of the "Rush" being a compound engine; that of the "Dexter" a high-pressure condensing engine; and that of the "Dallas," a low-pressure condensing engine.

The vessels are each 140 feet long over all, 129½ feet between perpendiculars at water line, 23 feet extreme breadth of beam, and 10 feet depth of hold. The draught of water aft is about 8 feet 10 inches. The hulls are of wood. The vessels represent the smallest type of full-powered screw revenue cutters adapted for cruising pur-

*[Communicated to this JOURNAL by Chas. E. Emery, C. E.—Ed.]

poses. They were all intended to be rigged as schooners, but it having been decided to send the "Rush" to the Pacific Coast, she was rigged as a top-sail schooner. One of the vessels averaged upward of eleven nautical miles per hour for six consecutive hours on her trial trip, and neither of them averaged less than ten knots, the machinery being entirely new in each case.

Each vessel has one boiler, 11 feet wide on base and 9 feet high, with a double segmental shell, each portion being 6 feet 2 inches in diameter. There are three furnaces in each boiler, located between water legs attached to the bottom of the shell. The products of combustion return through tubes within the shell. The boiler of the "Dallas," designed for low-pressure steam, is 13 feet 9 inches long, the front connection being built in and the steam chimney attached to the boiler. The boilers of the two other vessels were designed for high-pressure steam, and are each 12 feet long, independent of front connection, which is a separate structure, bolted on. The steam chimney is also a separate structure, connected to boiler by a large tube. The boiler of the "Dallas" has 160 tubes $3\frac{1}{4}$ inches in diameter and 9 feet 3 inches long. The boilers of the two other vessels have each 158 tubes $3\frac{1}{4}$ inches in diameter and 9 feet 8 inches long.

The "Rush" is propelled by a compound engine, with vertical cylinders and intermediate receiver, arranged fore and aft at the same level, the pistons being separately connected to cranks at right angles. The cylinders are thoroughly steam-jacketed, felted, and lagged, and are, respectively, 24 and 38 inches in diameter, with 27 inches stroke of piston. The steam is distributed to the high-pressure cylinder by a short slide-valve with adjustable cut-off plates sliding on back of same. The distribution of steam to the low-pressure cylinder is effected by means of a double-ported slide-valve with lap proportioned to cut off the steam at about half-stroke. The surface condenser is arranged on the starboard side. It supports two main columns from the cylinders, and contains 900 square feet of condensing surface. The air-pump is operated from the cross-head of the low-pressure engine. The circulating pump is of the centrifugal type operated by a small engine, directly connected. The screw is 8 feet 9 inches in diameter with mean pitch of $14\frac{1}{2}$ feet. The engine was intended to be operated regularly with a steam pressure of 80 pounds, but during the trials, hereafter referred to, it was reduced to corres-

pond to the pressure carried on the trial of the "Dexter." The machinery was designed by Charles E. Emery, consulting engineer, and built by the Atlantic Works, East Boston, Massachusetts, the contractors for the vessel complete.

The "Dexter" was also built under contract with the Atlantic Works of East Boston, Massachusetts. The engine of this vessel was built from designs of that establishment, and is of the inverted type, with a single cylinder 26 inches in diameter and 36 inches stroke of piston. The cylinder is not jacketed, but is carefully felted and lagged. Steam is distributed by a short slide-valve, with adjustable cut-off plates sliding on back of same. The condenser is located outside the frame, but it and the air and circulating pumps are exact duplicates of those in the "Rush." The engine and boiler are designed to be operated with a maximum steam pressure of 70 pounds.

The "Dallas" was built under contract with the Portland Machine Works, of Portland, Maine. The engine was designed in that establishment, and is of the inverted type, with a single cylinder 36 inches in diameter, with 30 inches stroke of piston. The cylinder is not steam-jacketed, but is carefully covered with non-conducting composition and lagged. Steam is distributed by a short slide valve, with adjustable cut-off plates sliding on back of same. The surface condenser is located under starboard frames and has the same condensing surface as those in the other vessels. The air and circulating pumps are also substantially the same. The engine and boiler are designed to be operated with a maximum steam pressure of 40 pounds.

The opportunity presented of testing, in these vessels, the relative merits of the three kinds of engines attracted considerable attention. Several manufacturers and engineers expressed a desire that competitive trials be made. A correspondence on the subject was opened between the Navy and Treasury Departments, which resulted in an agreement for a trial under the direction of persons representing both services, and the undersigned, Chief Engineer Chas. H. Loring, U. S. N., and Chas. E. Emery, consulting engineer, were selected in behalf of the Navy and Treasury Departments, respectively, to make preparations for and take general charge of the trials.

When the preparations were complete, the following officers were detailed to conduct the experiments, viz.: Chief Engineer Edward Farmer, U. S. N.; Chief Engineer Geo. D. Emmons, U. S. N.; Chief

Engineer F. H. Pulsifer, U. S. R. M.; and Chief Engineer F. A. D. Bremon, U. S. R. M. As assistants to these gentlemen there were detailed Past Assistant Engineers Harvey and Cook, U. S. N.; Assistant Engineer Tobin, U. S. N., and Mr. E. Hugentobler. The care of the machinery was entrusted to the engineers of the respective vessels. The chief engineers detailed for the experiments stood regular watches with an assistant while the experiments were in progress, and at the close certified duplicate copies of the logs, which are deposited in the Navy and Treasury Departments, respectively. They also computed the principal results for their own satisfaction, and returned to their regular duties, but two of the assistants were retained to assist the undersigned in making out a statement in detail, which is presented in the annexed table.

MANNER OF MAKING THE EXPERIMENTS.

The experiments were made with the vessel secured to the wharf.

The coal, which was anthracite of fair quality, was broken on the wharf to proper size (the vessel's bunkers having been closed and sealed) and filled into bags to a certain weight.

The bags were sent on board when ordered by the senior engineer on watch, he making record on the log of the number of bags and the time of receipt; a similar record being made by one of the men on the wharf. At the end of the hour the number of bags of coal actually put on the fire was reported from the fire-room and entered in the appropriate column. The several records agreed with each other, and the total amount expended corresponded with the total number of bags filled on the wharf. The ashes were measured into buckets of which the mean weight was ascertained and tallied as they were hoisted out. They were afterwards weighed in gross on the wharf, and the two accounts found to agree substantially.

The feed-water was measured, after its delivery from the surface-condenser and before its return to the boiler, for which purpose a tank of boiler-plate was especially constructed, having a plate dividing it vertically into two equal parts.* In the upper edge of the plate was cut a rectangular notch eight inches long, by which the height to which each half of the tank could be filled was determined. The mean of the weight of water which the half tanks contained was $1129\frac{1}{2}$

* [A description of this tank appears among the Editorial Items.—Ed.]

' AND "DALLAS," MADE AT THE U. S. NAVY YARD, BOSTON, MASS., AUGUST 1874, BY A
 ORING, U. S. N., SENIOR MEMBER REPRESENTING U. S. NAVY DEPARTMENT, AND CHARLES

T E R . "				" D A L L A S . "				
CONDENSING.				LOW PRESSURE, CONDENSING.				
y 2 537				36 30 33 by 23% .0802				
85 74 58 37				57 1689.24 7.84 49.63 7.27				
	7 G.	8 F.	9 E.	10 L.	11 K.	12 Long run Dallas.	13 J.	14 H.
17.	Aug. 17.	Aug. 17.	Aug. 17.	Aug. 23.	Aug. 23	Aug. 20-21.	Aug. 23.	Aug. 23.
350	1.3166	1.200	0.9166	1.5166	1.550	31.	1.60	1.5333
12	40.625	39.9	41.875	35.40	35.286	31.96	33.7	27.40
3331	.262	.38114	.4518	.13296	.19723	.30445	.28774	.38585
7239	3.3377	2.4232	2.0845	5.0674	3.8936	3.1341	2.9368	2.3176
310	26.10	26.00	25.541	26.08	26.00	25.20	25.363	24.790
195	30.195	30.195	30.195	30.080	30.080	29.997	30.080	30.080
821	14.821	14.821	14.821	14.765	14.765	14.7245	14.765	14.765
285	66.33	67.00	67.00	69.75	72.00	74.35	72.66	69.833
128	86.00	86.00	85.66	75.25	76.80	88.20	76.83	73.166
359	67.66	66.66	67.00	67.75	68.00	68.75	66.00	67.666
14	99.66	95.66	99.00	103.50	100.00	98.93	103.50	108.66
28	107.33	108.66	117.33	122.00	122.00	128.41	128.66	134.00
						122.76		
23	4017.00	3978.	3338.	4430.	5294.	114426.	6190.	5839.
3205	3050.88	3315.00	3641.45	2920.88	3415.48	3691.16	3868.75	3808.04
	50.8481	55.25	60.6909	48.6813	56.9248	61.5193	64.4791	63.4674
155	37.50	36.55	38.812	32.14	32.275	31.8587	31.095	24.666
176	52.321	51.371	53.633	46.905	47.040	46.5832	45.860	39.431
333	13.134	15.771	19.008	9.475	11.869	12.6810	14.008	14.7783
321	6.258	8.771	9.196	5.065	5.194	6.1595	5.875	6.182
	Full.....	Full.....	Full.....	Full.....	Full.....	Full.....	Full.....	Full.....
2710	3.1570	3.6347	4.3137	2.9730	3.3678	3.9073	4.1101	4.0911
2285	25.5826	30.6649	33.8385	18.5215	21.4471	23.5255	24.6107	24.1264
2995	28.7396	34.2996	38.1522	21.4945	24.8149	27.4328	28.7308	28.2175
00	3.00	3.00	3.00	2.5	2.5	2.5	2.5	2.5
370	124.267	161.848	196.187	137.962	186.805	221.447	242.807	234.295
501	109.694	146.015	178.794	119.340	165.030	197.915	218.137	210.017
138	139.602	181.032	221.197	160.107	216.139	258.228	283.357	274.024

U. S. REVENUE STEAMERS. — CONCLUDED.

U. S. N.			"DALLAS."					
CONDENSING.			LOW PRESSURE, CONDENSING.					
	7 G.	8 F.	9 E.	10 L.	11 K.	12 Long run Dallas.	13 J.	14 H.
8	4660.93 3973.00 1.3022 3579.15 2341.96	5605.7 3968.00 1.1969 4683.19 3019.52	5745.52 3855.00 .9213 6235.93 3988.28	5592.79 4437. 1.5191 3681.74 2648.88	7829.9 5310. 1.5547 5086.83 3871.18	183893. 113759. 30.8192 5966.83 4442.12	11166.02 6156. 1.59121 7017.30 5148.68	11149.6 5847. 1.5 7261.5 5336.1
5	.6543	.6448	.6396	.7195	.7687	.7445	.7337	.7
						23523.75 758.831 13.313 20.503 603.247		
1	28.802	28.9356	31.7864	26.6866	26.9603	26.9447	28.9007	30.96
0	18.8462	18.6564	20.3290	19.2000	20.7230	20.0595	21.2048	22.77
0	32.6284	32.0734	34.6786	30.8508	30.5176	30.1484	32.1693	34.57
7	25.6383	25.8694	28.1924	22.9955	23.3014	23.1069	24.7649	26.46
						3.4267 3.8341 2.9386		
						2.7241 3.0480 2.3361		
						7.8632		
						8.458		
						8.7625		
						9.8912		
						9.8693		
						11.0225		
						2.994		
						2.694		
	40.625 3.3877	39.9 2.4232	41.875 2.0845	35.40 5.0674	35.286 3.8936	31.96 3.1341	33.7 2.9358	27.40 2.517
						1.4156		
	1.5667	1.5789	1.7291	1.4516	1.4665	1.4657	1.5721	1.686
	1.2048	1.2104	1.3297	1.1164	1.1278	1.1272	1.2090	1.296
	1.3073	1.2129	1.3324	1.1186	1.1301	1.1294	1.2114	1.299
	1.0689	1.0739	1.1797	.9904	1.0006	1.	1.0726	1.150
	1.3086	1.3096	1.4387	1.2078	1.2202	1.2196	1.3081	1.402
	1.0793	1.0843	1.1911	1.	1.0102	1.0097	1.0805	1.161
	1.	1.0046	1.1037	.9265	.9360	.9355	1.0034	1.076

CHARLES H. LORING, CHIEF ENGINEER U. S. N.,
CHARLES E. EMERY, CONSULTING ENGINEER U. S. R. M.

pounds, at a temperature of 72 degrees Fahrenheit. In the computations for each experiment, the weight of water is reduced to correspond with mean temperature.

One of the feed-pumps was disconnected from the check-feed valve, and its discharge pipe led to a small receiving tank placed over the two halves of the measuring tank, into which this pump forced the condensed water from the hot well. The receiving tank had on its bottom two cocks, one over each half-tank, so that either could be filled from it at will.

The other feed pump had its suction pipe detached from the hot well and connected with the bottoms of the two half-tanks, through a cock on each, so that the contents of either could be drawn out and discharged with the boiler.

The method of measuring the water and recording it was as follows: One side having been filled, the cock over it on the receiving tank was closed and the other over the empty half opened. When the water in the full one had settled to the height of the edge of the notch, its cock in the feed-pipe was opened and the contents pumped into the boiler (care being taken to empty one in less time than it required to fill the other); when empty, its feed cock was closed. When the water in the tank, being filled, reached within a few inches of the notch, a gong in the engine-room was sounded to call attention, and when it reached the notch the gong was struck twice; at this instant the assistant engineer in the engine-room noted the reading of the counter, and an attendant in the fire-room noted and reported the height of water in the glass gauge on the boiler, as shown by a scale of inches secured to it. The attendant at the tank also noted the time of filling, and the temperature when the tank was half emptied. After entering the number of the counter in the log, the assistant engineer ascertained the numerical difference between that and the preceding entry, and if it was far from the average its cause was sought for.

By this system of checks all errors of record could be detected, and it was possible to preserve and utilize any continuous run which came to an end through derangement of the engine. All parts of the tanks, pipes and cocks were plainly visible to the eye, and had any leaks occurred therein they must have been detected. That the condensers were tight was evident from the fact that the water remained quite fresh in the boilers.

The water lost from ordinary causes in the circulation to and from the engine and boiler was replaced by running hydrant water into the tank that was being filled. The additional water was therefore measured and charged in the cost.

The loss of water was not sufficient to affect the result materially in either case. It was greatest in the "Dexter," which had been on service. The safety-valve of this vessel leaked slightly, and there was probably some other trifling leak that could not be detected. The number of inches that the water fell in the boiler between the periods of supply being shown in the logs, were added together, and from the same and known dimensions of boiler the volume and weight lost were ascertained quite accurately. The reduction in the number of revolutions per tank, when the water was being received from the hydrant, furnished another and perhaps still more accurate means of ascertaining the proportionate amount lost and returned. The two methods closely agreed in fixing the loss in the case of the "Dexter" at 4.96 per cent. of the total amount of water used.

A number of indicators were tested with steam before the trials, and a pair selected for use which proved correct by a standard gauge at varying pressures. Indicator diagrams were taken every twenty minutes throughout the trials, and the data for the usual columns of the log, except the coal and ashes, every half hour.

It was ascertained that the pistons of the "Dexter" and "Dallas" were tight by removing the cylinder covers and letting on full steam pressure.

During the first and principal experiments with each vessel the boilers were worked at their maximum power with natural draft at the dock, the fires being cleaned regularly as at sea, and the cut-off being adjusted to carry a steam pressure of about 70 pounds during trial of the "Rush" and "Dexter," and about 35 pounds during that of the "Dallas."

At the conclusion of the principal experiments on each vessel shorter experiments, designated in the table by letters, were made to determine the effect of varying the degree of expansion at the approximate steam pressures of 70 and 40 pounds. In the case of the "Dexter" the cut-off was shortened for one experiment as much as the gear provided would permit, and for this vessel, as well as for the "Dallas," the cut-off was gradually lengthened, during other experiments, as far as the boiler would supply steam at the pressure desired

The long runs having demonstrated the evaporative qualities of the boilers, record was made during the short runs of the amount of water used only; from this quantity of coal necessary to evaporate it can easily be obtained. It would have been impossible to distribute properly the coal consumed during the short runs which followed each other immediately. While these runs were in progress an officer was stationed at the tanks and one in the fire-room, in addition to the usual number on watch, to avoid the possibility of error.

In the annexed table we have endeavored to show accurately, in condensed form, the results of the trials of the particular machinery described under the particular conditions named.

The actual performances will be found in lines 53 to 68, inclusive, of the table, the previous lines showing the several observed and computed quantities from which the performances were calculated.

As previously stated the boiler during the principal experiments on each vessel was operated at maximum power, and the results show that the evaporation was fully equal to that obtained in ordinary practice, but inasmuch as on land, and occasionally in steamers where space will permit, it is the practice to use a slower rate of combustion in comparatively larger boilers, thereby increasing the evaporative effect, there has been added to the table, for comparison under such circumstances, lines 69 and 70, showing the performances compared on the basis of the water actually used, but with boilers of such proportions or using such variety of coal that the evaporation will equal nine and ten pounds, respectively, per pound of coal.

The relative performances shown decimally in lines 73 to 80, inclusive, with different experiments as unity, will be found convenient for comparison.

It is believed that the other portions of the table will be fully understood without discussion or further explanation on our part.

Annexed will be found specimens of the Indicator Diagrams taken during the principal runs.

CHAS. H. LORING,
Chief Engineer, U. S. N.

CHAS. E. EMERY,
Consulting Engineer, U. S. R. M.

October 10, 1874.

INDICATOR DIAGRAMS.

U. S. REVENUE-STEAMER, "RUSH."

High-Pressure Cylinder.

Scale of indicator, 40 pounds per inch.

Low-Pressure Cylinder.

Scale of indicator, 13 pounds per inch.

U. S. REVENUE-STEAMER, "DEXTER."

Scale of indicator, 40 pounds per inch.

U. S. REVENUE-STEAMER, "DALLAS."

Scale of indicator, 24 pounds per inch.