Civil and Mechanical Engineering.

PERFORMANCE OF THE COMPOUND ENGINES OF THE U. S. COAST SURVEY STEAMER "HASSLER."

By CHARLES E. EMERY, Consulting Engineer.

[TO THE EDITOR OF THE JOURNAL OF THE FRANKLIN INSTITUTE:—

DEAR SIR: By permission of Capt. C. P. Patterson, Superintendent of the U. S. Coast Survey, I forward, for publication, the following extracts from a report made to him by myself, as Consulting Engineer U. S. C. S., on the subject above indicated. The facts mentioned are of special interest, as the engine of the Hassler is believed to be the first built in this country to secure special economy for marine purposes, and was designed independently of the English practice and in fact in anticipation somewhat of the revival here of interest in Compound Engines. It will be observed too that special pains were taken to ascertain accurately the facts in regard to the performance. The report is dated November 1st, 1873. C. E. E.]

I transmit herewith an abstract of the Engineer's Journal of the U. S. Coast Survey Steamer "Hassler," with tabulated results founded thereon, showing the performance of the steam machinery, at sea, under conditions substantially uniform, but, on the whole, more unfavorable than in ordinary practice.

The abstract is made from the record of the run from Panama to San Francisco in July and August of last year (1872) that being the first time, after the engineers were furnished with complete blank journals and careful instructions suggested by former experiences, that the vessel was under steam for a sufficient period to furnish reliable information.

The steamer had just come from the Atlantic Coast, consequently some matters were out of repair: for instance a defective stuffing-box caused a poor vacuum, and a leaky tube in the condenser required the use of some salt water; both faults reducing the economy. So also the iron bottom of the vessel was very foul, which reduced the speed.

The steaming for the time included in the abstract, was made at half boiler power, which should have given, with clean bottom, an average speed of $7\frac{1}{2}$ to 8 knots, under the conditions encountered.

Stops were made in various ports and for sounding and dredging purposes during the trip, so the abstract has been divided into five runs, designated by letters, during each of which the conditions were substantially uniform and the steaming continuous, except one stop for dredging in each of the two first; in these the whole watch of four hours, in which the stop was made, has been rejected, to secure the condition of uniform operation. The other columns will be understood from the headings. Following the abstract I give a brief discussion of portions of the same with references to other performances of the vessel. I also append for reference a short description of the vessel and machinery.

The following extracts from the instructions printed in the Engineer's Journal will show the precautions taken to obtain accurately the power developed and its cost in fuel:

"The steam pressures, vacuum, and positions of throttle and cut-off, as recorded, should be the means for the hours, and not simply correct records at the time of the observation. In case that by order or accident, the average conditions are abruptly changed during the hour, interlined entries should be made showing the average for each period, and the exact time of the change be noted in the remarks.

A complete set of indicator-diagrams should be taken at least once every day: for instance, shortly before meridian, at which time the position of the cut-off, throttle, and the steam pressure and other conditions should be regulated so as to represent, as nearly as possible, the average for the steaming done during the previous 24 hours. The diagrams necessary for a complete set should all be taken as nearly as possible at the same time, and the data provided for in the specimen diagram herein be collected and noted without delay. The diagrams and data should show the facts as they exist at the time; the object not being to obtain a maximum result or fair looking diagrams. The original diagram should be slightly secured with mucilage at its upper left hand corner, between the pages of corresponding date in the original journal. When experimenting, diagrams should be taken half hourly, in which case the name of the vessel and the date and time need only be noted thereon, and the other quantities can be obtained from the Journal.

The reading of the engine-counter should be taken exactly at the end of the hour by observing the second hand of the clock in connection with the other hands.

The *net* amount of coal used should always be entered in the log.

To check errors, the bunkers should be carefully measured when empty and drawn to scale, and after every fifteen days steaming, and just before coal is received, the coal in the bunkers should be trimmed to regular slopes, the amount measured and calculated, and the coal account corrected by an additional entry under the daily balance, as follows: 'Remaining as per measurement this day ——— pounds.' The plan of adding a percentage to each day's expenditure, or of charging for ship's use extraordinarily large amounts, is disapproved. The log should in all respects show facts as accurately as they can be ascertained; hence every deficiency or surplus should be recorded as soon as it is discovered, and the account adjusted at once."

During a previous voyage, the Commander of the vessel, to satisfy himself as to the accuracy of the coal account, had issued an order that the bunker doors be locked and opened only once in the watch in the presence of the engineer, when the coal for a watch was to be measured out. This system was productive of such good results that it was continued in connection with periodical measurements of the bunkers. Such measurement was made August 6th and again August 21st, and a deficiency in the coal account found amounting to 6·008 per cent., which could be easily accounted for by the few lumps that fell on the floor in measuring the buckets. This percentage was in later trials much reduced; but, not to overstate results, the amounts in column marked "Coal per hour by Journal" have been increased six per cent., and the augmented or actual amounts, recorded in the next column, have been used in the final determination of the cost of the power.

The above shows that, even with a comparatively small compound engine of good construction, each indicated horse power can be obtained, on regular duty at sea, for $1\frac{7}{8}$ pounds of coal per hour, or less than half that required with ordinary marine machinery of the old type, and hardly two-thirds that used, according to best testimony available, in the better class of large, direct-exhausting marine engines, using high pressure steam.

This cannot be called an experimental result. In fact the unfavorable conditions mentioned prevented it from being the maximum for regular sea duty. There is every reason to believe that, with careful attention, and both boilers in use, a result could have been obtained of $1\frac{1}{2}$ pounds of coal per horse power per hour. In fact some previous runs show this performance, but as they were made before the coal account was checked regularly by the bunker measurement, the

results are not given in detail. There is, however, no reason to doubt their accuracy.

The vessel, on her trial trip, using Schuylkill coal and both boilers, developed 125 horse power with 250 pounds of coal per hour, a performance of two pounds of coal per horse power per hour, when the boiler and engines were not felted and the weather quite cold. The firemen, too, were not accustomed to the slow combustion obtained by using two boilers, and much watchfulness was required to ensure regulation by the dampers instead of by opening furnace doors. This difficulty caused a very great waste of fuel, afterward, when it was attempted to run moderately with both boilers on regular duty at sea, and finally it was actually found, in practice, that unless an engineer was kept constantly in the fire-room, it was far more economical to *force the fires* under one boiler at slow speeds than to use slow combustion in two boilers.*

Only one boiler was in use during the runs set forth in the foregoing abstract.

The following extracts, from the official report of Commander P. C. Johnson, U. S. N., commanding the Hassler, to yourself, may, I think, be considered in place in this report:

"It gives me pleasure to request your notice of the consumption of coal while engaged in such work as the Hassler was designed for. At San Diego, before starting the fires, the ship had in her bunkers 101·09 tons.

Today on hand	68·30	"
Deduct for distilling water, galley, stoves, etc., . .	3·60	"
Showing a consumption in 35 days of . . .	29·19	"
Averaging per day	0·83	"

The ship has been under steam every moment since leaving San Diego. Excepting Sundays she has been underway during the day, and banked fires at night, having steamed 1069 miles, and made 704,026 revolutions. The bunker doors are closed and locked at all times, (except when in the act of getting out coal) and the key always in possession of the engineer. Besides weighing, the bunkers are frequently examined and their contents measured."

In a subsequent letter, Commander Johnson writes: "We have been 58 days under steam, running from daylight till dark, generally. Banked fires at night and Sundays, and have consumed in the fur-

* An attempt is being made, however, to secure the economy due to increased heat-absorbing surface by using both boilers and reducing the grate surface with fire brick. So far it has been found that the steam can be carried more steadily, but no accurate determination can yet be given in regard to the question of economy.

naces only 1891·4 lbs of coal per 24 hours —0·844 tons per day.

There is no mistake about it. There has been no stealing of coal. The bunker doors were locked except when serving out, and the measurement shows the proper amount on hand now."

I submit that the above facts are sufficient to show conclusively the great economy which may be obtained by the use of the compound engine.

For convenience of reference, a general description of the Hassler is hereto annexed.

General Description of the U. S. Coast Survey Steamer Hassler.

The Hassler is an iron screw propeller of 350 tons burthen O. M. She was built at Philadelphia, in the year 1871, and is 151 feet long on load line, and has 24½ feet breadth of beam, and 10 feet depth of hold. Her rig is that of a three masted schooner, with lower masts of moderate length and tall top masts. The officers' quarters are on deck and are very commodious.

The vessel is propelled by a compound engine of 200 horse power. The cylinders are 18·1 and 28 inches in diameter, by 26 inches stroke, and are arranged one above the other, in the same line, with both pistons on the same rod, and operating the crank through a single connecting rod. The steam chests extend beyond the ends of the cylinders to reduce the length of the cylinder ports; but for simplicity of construction, the valve face of the upper cylinder is brought out in line with the other, and the valves of both cylinders are operated by the same rods. The upper cylinder is supported from the framing by four wrought-iron columns, and the two cylinders are sufficiently separated to allow the cover of the lower cylinder to be raised to obtain access to the piston. The bed plate is made of sufficient length to receive three bearings, in addition to which an independent thrust-bearing is connected to the same. The surface condenser is arranged under one side of the frames, and slants inward at the same angle as the latter. The circulation is performed by a centrifugal pump driven directly by a small engine. The air and feed pumps are vertical, and receive motion from the main crosshead through beams in the usual way. The necessary valves are provided, so that live steam can be excluded from the upper cylinder, and supplied direct to the larger one if desired. Ordinarily the steam passes to the upper cylinder, in which it is cut off at such point as to give the power desired, or usually

at less than half stroke. The steam then passes to a large reservoir, placed under the main deck, through which it traverses slowly, thus permitting the water due to condensation for the work done, to become separated. From this reservoir the steam passes to the lower cylinder, but the supply is suppressed therein at such point as to keep the pressure in the reservoir substantially uniform. The lower cylinder communicates with the condenser in the usual way. The large cylinder and its bottom and head are steam jacketed. Drip vessels with glass gauges are provided to assist in blowing the condensed water from the jacket and reservoir. The propeller is a true screw, 8 feet 6 inches in diameter, with 13 feet pitch. At the hub the blades are rounded on both sides to reduce the resistance where the metal is thickest. The flat propelling surface gradually widens from the hub outward to 4 feet diameter, and the outer portions of the blades are of the ordinary construction.

Steam is supplied by two flue and return tubular boilers, each 6 feet in diameter and 12 feet long, and provided with a steam chimney. The total grate surface is 42 square feet, and the total heating surface 1400 square feet.

The shells are $\frac{3}{8}$ inch thick, with double riveted longitudinal seams. All flat surfaces are stayed 6 inches between centres. The boilers are considered of sufficient strength to carry regularly 80 pounds pressure for a series of years.

The maximum speed of the vessel, under steam alone, is $9\frac{1}{2}$ knots. Under steam and sail, she has made easily 10 and 11 knots. The ordinary speed at sea, under steam alone, is restricted by order to 8 knots, which can be obtained with one boiler under favorable circumstances.*

* It will be of interest to add, in this connection, that the first reports as to the performance of the "Hassler" were unsatisfactory, owing to very bad management in the Engineer Department. The vessel left the Atlantic Coast in the fall of 1871, and as her commander found it necessary to take coal much sooner than was expected from results obtained on the trial trip, he instituted an investigation which had the effect, eventually, to make the performance all that could be desired, and to interest all on board in the matter, so that in fact a number of naval officers, then attached to the vessel, but who have recently returned to the East, have expressed a desire that the actual facts, as to the vessel's later performances, should be made public.