A SHORT TREATISE ON THE COMPOUND STEAM ENGINE, WITH A NEW METHOD OF FINDING THE RELATIVE AREAS OF THE TWO CYLINDERS

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JOHN TURNBULL

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TWO CYLINDERS.

ILLUSTRATED WITH DIAGRAMS, TABLES, ETC.

BY

JOHN TURNBULL, Jr.

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THE COMPOUND ENGINE.

The compound engine—whatever diversity of opinion may be held by engineers and others as to its merits as an economical expansive engine—has attracted towards itself a very considerable share of attention, from the superior results that have been obtained by it in many instances; and it is reasonable to suppose that, when a certain degree of perfection has once been attained in the manufacture of any machine, or economy secured by any new arrangement of its parts, similar machines can be so constructed as to give out the same results, if proper care is taken that the same arrangement and construction is faithfully carried out as in that of the more perfect machine. And when that degree of economy has not been obtained from a compound engine which had reasonably been expected, it would, no doubt, be found, if proper inquiry were made, that the fault lay, not in the principle that had been adopted, but that sufficient skill had not been exercised in properly proportioning the different parts through which the steam had to pass or come in contact on its way from the boiler to the condenser, and that sufficient means had not been employed to prevent or replace any waste of heat from condensation and other causes.

As the compound engine is being now so universally adopted in the Mercantile Marine Service, and a knowledge of its principles absolutely necessary by those engaged in attending it, we will, in the following remarks, explain these principles in as simple a manner as possible, and institute a comparison between the respective merits of the single-cylinder expansive condensing engine and the compound engine:

The compound engine is a high and low-pressure condensing engine, having two ordinary steam cylinders, the smaller or high-pressure cylinder communicating direct with the boiler, the larger or low-pressure condensing cylinder direct with the condenser, and both with each other. The steam is admitted freely from the boiler into the high-pressure cylinder until the piston has been moved through a certain distance where the valve is so regulated that the communication with the boiler is entirely shut off, and the remainder of the space to be passed through by the piston is performed by the expansion of the steam now shut up in the cylinder, and which, after doing its work in this cylinder, passes on to the condensing cylinder, where it does an equal or proportionate quantity of work, and then passes into the condenser.

It has been found from modern practice that when the length of stroke of both cylinders is the same, it is necessary that the condensing cylinder be about three times greater in area than the high-pressure one, and this proportion is best suited when the steam employed is from 45 to 50 lbs pressure above the atmosphere, and cutting off the steam after being admitted during $\frac{1}{3}$ of the stroke in the high-pressure cylinder. When the steam to be employed is of a less pressure, but the point of cut-off the same, then the relative proportions of the cylinders must be nearer to each other, and the reverse when steam of a greater pressure is to be used.

To get the maximum of economy out of any class of expansive condensing engine, the pressure of steam and point of cut-off must be so regulated that the steam passes into the condenser at the end of the stroke at a pressure not exceeding 5 lbs. above a perfect vacuum, and with steam at 45 lbs. pressure above the atmosphere, which is equal to 60 lbs. pressure above a perfect vacuum (the pressure of the atmosphere being considered as equal to 15 lbs. on the square inch), and a terminal pressure of 5 lbs., we get 12 expansions, because the pressure at the end of the stroke is 12 times less than what it was at the point off cut-off, and is expressed by the formula—

$$\frac{P}{t} = R.$$

Where $P =$ pressure at point of cut-off, $t =$ terminal pressure, and $R =$ ratio or number of expansions, and as the pressure of steam, according to Marriotte's law, varies inversely as the space it occupies, the steam will now fill 12 times the space it originally occupied at a pressure equal to $\frac{1}{12}$th of the original pressure, that is, supposing there had been no loss of heat during the process of expansion, and this we must suppose to simplify this inquiry.

On reference to the annexed table of average pressures, it will be seen that steam admitted at 60 lbs. pressure, and cut-off at $\frac{1}{12}$th part of the stroke, exerts an average pressure = 17.32 lbs. per sq. in. on the piston throughout the whole stroke, and, although this is $3\frac{1}{2}$ times less work than would have been done had the steam been used at the full pressure of 60 lbs. throughout the whole length of the stroke, still only a 12th part of the cylinder's contents had been filled from the boiler, and the power required is thus got by working the steam expansively, at a saving equal to about $3\frac{1}{2}$ to 1. (See Table A.)