THE MANUAL OF THE HYDROMETER

Published @ 2017 Trieste Publishing Pty Ltd

ISBN 9780649336432

The manual of the hydrometer by Lionel Swift

Edited by Trieste Publishing Pty Ltd.
Cover @ 2017

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Trieste

THE MANUAL

OF THE

HYDROMETER;

CONTAINING

ITS HISTORY; PHILOSOPHY, MODE OF GRADUATING SCALE. APPLICATION TO TECHNICAL AND GENERAL PURPOSES; WITH RULES, WORKED EXAMPLES, AND COMPLETE TABLES.

CHAPTERS ON THE

EFFECTS OF SURFACE CONDENSERS;

THE CAUSE OF

OXYDATION AND DEPOSITIONS IN MARINE BOILERS,

ITS PREVENTION AND CURE:

PRIMING; MANAGEMENT OF BOILERS

AND SUPERHEATERS.

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SECOND EDITION.

REVISED AND ENLARGED.

PORTSMOUTH:

GRIFFIN & Co., 2, THE HARD.

PUBLISHERS TO H. R. H. THE DUKE OF EDINBURGH.

LONDON:

SIMPKIN, MARSHALL & Co.;

E. & F. N. SPON, CHARING CROSS; IMRAY & SON, MINORIES;

PHILIP & SON, LIVERPOOL.

1870.

PREFACE.

SOME apology is due to our readers for the delay that has occurred in the appearance of this second edition so long after the announcement of its being in preparation. To those familiar with the duties of fitting out a large and somewhat new type of ship, most probably the explanation will suggest itself: the nature of these public duties allow but narrow intervals unclogged with professional anxieties and special inconveniences: and the faculty of self-abstraction and command of thought is not easy to untrained and new authors. However, there being a continued demand for the old work, which had for some time been out of print, I was induced to prepare a second edition. Feeling that I had something to say about the cognate matters referred to in the supplementary chapters of this volume, and having a desire to curtail, re-arrange, and otherwise alter and amend the old and former part, I willingly undertook the responsibility of appearing again before the public, on whose kind forbearance I rely, that the same indulgence will be extended both to the views put forth, and the obvious deficiencies of authorship, which is so generously and usually accorded to merely practical, though earnest workers.

It is some source of congratulation that nearly all the suggestions prominently made in the first edition, although then but in very limited use and adoption, are now become matters of established and orthodox practice.

I would particularly mention the high importance and economy of surface condensers, the value of "*scum collectors*," and the views, I believe for the first time then propounded, of the *modus* of calcareous depositions in Marine Boilers. These two last features become of the highest interest in face of the practical inconveniences found to occur, and more particularly referred to, in the additional chapters of this edition.

PRINTED AT THE OFFICE OF THE PUBLISHERS.

INTRODUCTION.

EXPERIMENTAL science has demonstrated that in very many instances of chemical combinations there is an attendant change of a physical character totally unaccountable, and frequently of a nature apparently paradoxical. Thus, some combinations exhibit a considerable decrease in bulk, whilst others increase in volume by mixing. There are other extraordinary changes resulting from some combinations, such as the alterations of temperature, the relative hardness, the color, the freezing point, and other changes dependent on the ratio of the peculiar ingredients; but it is more particularly the change of the resultant volume in combinations, that we propose remarking upon. Dr. Ure gives the following list of ingredients in alloys of metal that respectively increase or decrease in volume by mixing, viz.:—

That INCREASE in Volume.	That DECREASE in Volume.
Gold and Silver	Gold and Zinc
,, ,, Lead	,, ,, Tin
,, ,, Iron	,, ,, Bismuth
,, ,, Copper	,, ,, Antimony
,, ,, Iridium	,, ,, Cobalt
Silver ,, Copper	Silver ,, Zinc
Iron ,, Bismuth	,, ,, Tin
,, ,, Antimony	,, ,, Bismuth
,, ,, Lead	,, ,, Antimony
Tin ,, Lead	Copper ,, Zinc
,, ,, Palladium	,, ,, Tin
Zinc ,, Antimony	,, ,, Palladium
And several other combinations.	

But perhaps the most extraordinary instance of change in volume occurs in mixing iron with platina.

If ten cubic inches of iron be mixed with one and a quarter cubic inches of platina, the bulk of the compound is only nine and three quarter cubic inches, or $10+1{\cdot}25=9{\cdot}75$, exhibiting a concentration in volume equal to more than thirteen per cent. Again, in the mixing of two parts of brass and one part of tin, whose respective specific gravities are 8·006 and 7·363, the sp. gr. of the mixture becomes 8·917, whereas, if each had retained its former bulk, the sp. gr. would have been 7·7916. A mixture of equal parts of the above ingredients should have the sp. gr. 7·684, but it is really 8·441. It is also remarkable in this instance, that mixing brass with this lighter metal has made a composition harder than is due to the relative hardness of the metals, and *more* dense and heavier than the original brass could be made by any ordinary hammering or compression.

A further instance is afforded in mixing 16½ ounces of alcohol with 20 ounces of water, when the condensation is equal to about $\frac{1}{16}$ of the whole bulk of the ingredients. So that a pint of proof spirit would not realise a quart of mixture.

So also, 100 ounces of water, mixed with 34 ounces of common salt; the condensation in volume is equal to four per cent. of the sum of their respective volumes.

And in the case of turbith-mineral, if some is added to a narrow-necked bottle filled with water, the water, instead of rising in the neck of the bottle, sinks considerably, and the two ingredients occupy less space than the water did alone.

Enough has been shown in these instances to satisfy us that the usual mode of determining the relative amount of ingredients cannot be deduced from the specific gravities of the constituents in the compound, and the specific gravity of the compound itself; and that Archimedes must rather have overstepped the practical fact in his assumption that he had discovered the means of detecting the extent of dishonesty practised in the manufacture of the famous crown of King Hiero. The desirability of a mathematical solution of these physical laws suggest an ample field for investigation and research. Some combinations have been made the subject of most elaborate and complete experiment, more especially, perhaps, the experiment with varied mixtures of alcohol and water, prosecuted for the guidance and information of the Board of Excise; but hitherto these,

and indeed all experiments on this subject, have only resulted in the application of particular empirical formulæ, adapted each to its respective case. In applying ourselves to the consideration and bearing of sea-water brines, to the practice of Naval Engineering, our object will be to examine first, the different forms of Hydrometers, their principles as applied to determine specific gravities, and the mode and philosophy of their graduations, more especially for testing the brines of sea-water; and secondly, to examine the change in volume in brines, under different proportions in the amount of contained salt, and with variations of temperature; and further to deduce some practical formulæ applicable to the working of marine boilers.

"HYDROMETERS."

THE HYDROMETER was known and used by the ancients, having been originally invented by Hypatia, the accomplished daughter of Theon, a mathematician of Alexandria.

The form of Hydrometer first used was one with an uniformly graduated stem, a pear-shaped form of ball, and a weighted ball underneath.

The Hydrometer is based on the principle, that the weight of a floating body is equal to the weight of the quantity of liquid which it displaces. Therefore, the weights required to sink an Hydrometer equally far in different liquids, will be directly as the densities of the liquids; and the Hydrometer will sink in different liquids in an inverse proportion to the density of the liquids. Hence these two facts have given rise to different kinds of Hydrometers:—*The first*, with a graduated scale on the stem, and the volume of immersion varying; *the second*, with a fixed point of floatation, and brought to that point by adjusting weights to the stem; and the *third*, a combination of weights and graduated scale on stem.

For anything like an extended range of specific gravities, and great delicacy in observing, the last-mentioned one alone is to be depended upon.

We do not, however, intend to refer to all the various Hydrometers that special requirements may have brought into use, but only such as may be of practical service to the Engineer, and have met with general approval and adoption. First of which is—