# THE RELATIVE PROPORTIONS OF THE STEAM-ENGINE: BEING A RATIONAL AND PRACTICAL DISCUSSION OF THE DIMENSIONS OF EVERY DETAIL OF THE STEAM-ENGINE

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A RATIONAL AND PRACTICAL DISCUSSION OF THE DIMENSIONS OF EVERY DETAIL OF THE STEAM-ENGINE.

BY

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*WITH NUMEROUS DIAGRAMS.*

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1884

# PREFACE.

It is a source of regret to the author of these Lectures that none of the distinguished writers upon Mechanics or the Steam-engine have undertaken to give, in a simple and practical form, rules and formulæ for the determination of the relative proportions of the component parts of the steam-engine.

The authors of the few works as yet published in the English language either entirely ignore the proportions of the steam-engine or content themselves with scanty and general rules—Rankine excepted, who in the attempt to be brief is sometimes obscure, leaving many gaps in the immense field which he has attempted to cover. This deficiency in the literature of the steam-engine is remarkable, because the problem which the mechanical engineer is most frequently called upon to solve is the determination of the dimensions of its various parts.

From time to time hand-books of the steam-engine have been published giving practical (?) rules, the result of observation of successful construction; and with these rules the practising engineer, who has little time for original investigation, has had to content himself. It is of course reasonable to limit the correctness of these rules to cases in which all

the conditions are the same, as in the case or cases from which these rules have been derived, thus placing a serious obstruction in the way of improvement or alteration of design, and rendering the rules worse than useless—even dangerous in many cases.

"The usual resource of the merely practical man is precedent, but the true way of benefiting by the experience of others is not by blindly following their practice, but by avoiding their errors, as well as extending and improving what time and experience have proved successful. If one were asked, What is the difference between an engineer and a mere craftsman? he would well reply that the one merely executes mechanically the designs of others, or copies something which has been done before, without introducing any new application of scientific principles, while the other moulds matter into new forms suited for the special object to be attained, and lets his experience be guided and aided by theoretic knowledge, so as to arrange and proportion the various parts to the exact duty they are intended to fulfil.

"'For this is art's true indication,
When skill is minister to thought,
When types that are the mind's creation
The hand to perfect form hath wrought.'"

STONEY'S *Theory of Strains.*

Zeuner, in his elegant *Treatise on Valve Gears*, translated by M. Müller, has laid the foundation for the treatment of slide-valve motions for all time, and in his *Mechanische Wärmetheorie* has carried the application of the mechan-

ical theory of heat to the steam-engine as far as the present state of the science of Thermo-dynamics will permit.

Poncelet, in his *Mécanique appliquée aux Machines*, has most thoroughly treated some members of the steam-engine, neglecting others of as great practical importance.

Hirn, in his *Théorie mécanique de la Chaleur*, gives us, besides a very able treatise on the science of Thermo-dynamics, a valuable series of experiments upon the steam-engine itself, confirming Joule's results.

A translation of *Der Constructeur*, by F. Reuleaux, would, if made, add much to our knowledge of the proper proportions of the steam-engine, as well as of other machines.

A rational and practical method of determining the proper relative proportions of the steam-engine seems as yet to be a desideratum in the English literature of the steam-engine; and these Lectures have been written with that feeling, purposely omitting the consideration of such topics as have already in many cases been over-written, and considering only those which have not received the attention which their importance demands.

In the choice of a factor of safety—a matter wherein opinions widely differ—the author, guided by considerations set forth in Weyrauch's *Structures of Iron and Steel*, translated by DuBois, has fixed upon *10* as being the most correct value. If any of our readers should prefer a different factor, the formulæ deduced will be correct if the actual steam-pressure per square inch is divided by *10* and multi-

plied by the preferred factor of safety, and the result used in the place of the actual steam-pressure.

In reducing all the required dimensions of parts of the steam-engine to functions of the boiler-pressure or mean steam-pressure in the cylinder per square inch, of the diameter of the steam-cylinder, length of stroke, number of strokes per minute, and horse-power, he trusts that he has put the formulæ in the simplest possible form for immediate use.

It is indeed in this transformation of the formulæ for the strength of materials that the usefulness of the book lies; for the practitioner, once satisfied of their correctness, has but to insert quantities fixed at the commencement of his design, and derive from the formulæ the required dimensions, being relieved of many formulæ and details connected with the applications of statics to the strength and elasticity of materials.

The constant references to the fourth section of Weisbach's *Mechanics of Engineering* are necessary, as it is no part of the author's plan to discuss the strength and elasticity of materials any further than it is necessary to do so in their application to the steam-engine. Those unacquainted with this branch of mechanical engineering will nowhere find it treated with greater simplicity and thoroughness. Other references have been made for the purpose of directing the reader to such sources as have been drawn upon in the consideration of topics discussed in this work.

"We who write at this late day are all too much indebted to our predecessors, whether we know it or not, to complain of those who borrow from us;" and each of us is only able to make his relay, taking up his work where others have left it.

The lack of accurate experimental data has, in many cases, forced the writer to make, perhaps, bold assumptions which may not prove entirely correct; however, as in all cases the method of reasoning is given, the reader, where he is in possession of more accurate data, can modify by substitution.

The accidental loss of all of the original manuscript and drawings of these Lectures, and the necessity of rapidly rewriting them for use in daily instruction, have caused the work to be more abbreviated than was originally intended.

Deeply sensible of the many unavoidable deficiencies of this little work, even in the limited field covered, its author still hopes that it will aid in the diffusion and advancement of real knowledge, upon whose progress the prosperity of our civilization depends.

W. D. M.

UNIVERSITY OF PENNSYLVANIA,
Philadelphia, 1878.