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### The Steam Engine

Thomas Tredgold (1788–1829) has been described as 'the most influential technical author of his generation and possibly of the nineteenth century'. His writings contributed greatly to the wider understanding of engineering, and it is his definition of civil engineering that the Institution of Civil Engineers wrote into their charter of 1828. Published in 1827, this work provides a historical survey and explanation of 'a masterpiece of human contrivance'. Tredgold breaks his subject down into ten sections, each covering areas such as the properties of steam, the differing means of harnessing its power, the history of the steam engine's invention and improvement, and the various applications of steam power. Containing many tables, formulae and line drawings, this thorough work complements Charles Frederick Partington's *Historical and Descriptive Account of the Steam Engine* (1822), which is also reissued in this series.

# The Steam Engine

*Comprising an Account of its Invention and Progressive Improvement*

THOMAS TREDGOLD

CAMBRIDGE UNIVERSITY PRESS

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# THE STEAM ENGINE,

COMPRISING

AN ACCOUNT OF ITS INVENTION AND PROGRESSIVE IMPROVEMENT;

WITH AN

INVESTIGATION OF ITS PRINCIPLES,

AND THE

PROPORTIONS OF ITS PARTS FOR EFFICIENCY AND STRENGTH:

DETAILING ALSO ITS APPLICATION TO

NAVIGATION, MINING, IMPELLING MACHINES, &c.

AND THE RESULTS COLLECTED IN

NUMEROUS TABLES FOR PRACTICAL USE.

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*ILLUSTRATED BY TWENTY PLATES, AND NUMEROUS WOOD CUTS.*

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BY THOMAS TREDGOLD,
CIVIL ENGINEER;

MEMBER OF THE INSTITUTION OF CIVIL ENGINEERS; AUTHOR OF ELEMENTARY PRINCIPLES OF CARPENTRY; A PRACTICAL TREATISE ON THE STRENGTH OF IRON, &c.

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"It is certain, that of all powers in nature, heat is the chief."—BACON.
"The errors are not in the art, but in the artificers."—NEWTON.

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TO

# THOMAS HOBLYN, ESQ.

FELLOW OF THE ROYAL SOCIETY,

VICE PRESIDENT OF THE SOCIETY

FOR

THE ENCOURAGEMENT OF ARTS, MANUFACTURES, AND COMMERCE, &c. &c. &c

THE AUTHOR

INSCRIBES

THIS WORK

DESCRIPTIVE OF

THE PRINCIPLES AND CONSTRUCTION OF THE

# STEAM ENGINE;

WHICH, INVENTED AND PERFECTED BY THE ARTISTS OF BRITAIN, HAS RENDERED HEAT AN INEXHAUSTIBLE SOURCE

OF

WEALTH AND PROSPERITY

TO THE

BRITISH EMPIRE.

# PREFACE.

OF the various books published on that important and national subject the Steam Engine, there is not one in our own or any foreign language, which I consider as a fully satisfactory illustration of its principles; it is therefore only requisite for me to state this fact to render any apology unnecessary for the work I now offer to the notice of the Public. I have frequently and successfully claimed attention as an author; and in this case I hope to meet with equal success, and to shew by the labour and attention I have bestowed on this important subject, how highly I value the ostensible character I have acquired, and the extensive encouragement I have received.

It has been too common of late for mathematicians to complain of want of patronage, and to censure official authorities for not encouraging science, forgetting that research will always be estimated by its intermediate utility; and while they continue to confine their attention to abstract knowledge, while they do not devote a greater part of their time to its application to the wants and the welfare of society, they must be contented with a small share of those advantages which result from combining with practical skill, the power afforded by abstract reasoning. They should recollect that a Watt could have earned no fame, in an age nor in a country where the value of mecha-

nical power was unknown. In following the application of science to art, I have not, however, I hope been unsuccessful in adding also to the stores of pure science; and, so far from being insensible to the value of abstract research, I wish it to be pursued with redoubled vigour by those who have spirit to break through the prejudices of existing systems, and study from nature: but it should be cultivated with a desire to promote the great end of human research, that is, the improvement of the condition of man; otherwise the fantasies of the Greek philosophers might with equal force claim the student's regard.

I hope these remarks will tend to encourage those who pursue knowledge, whether with the energy of youth or the more steady enthusiasm of riper years; and as all nature, so all art, must ever be the result of those immutable proportions and laws of action which it has pleased our Creator to impress on matter, its objects are truly boundless. Our imperfection consists generally in not being able to foresee all the circumstances which have an influence on the effects of causes; but in proportion as we proceed in knowledge, we also acquire greater powers of perception: that which was at first difficult becomes easy, and the mind is often roused by the bright gleam of truth, breaking as it were accidentally upon a mass of obscure ideas, and rendering the true solution of the difficulty at once obvious; and as my gifted countryman Emerson has remarked, "the labour and fatigue of seeking after it instantly vanishes."

I proceed now to give some idea of this work. It appears to be large for its object; but, though confined to a single source of power,

that power is gigantic, and involves so many new and important doctrines in mechanical science and practice, that it was impossible in justice to comprise it in less space. The work is in Ten Sections.

In the *First*, the history of the progressive improvement of the steam engine is traced, from the period of its first suggestion by the Marquis of Worcester, to its present state of high perfection.

The *Second Section* presents an analysis of the nature of steam and of other species of vapour; the laws of their combination with heat, and of their elastic force, density, and comparative power; with the principles of calculating their velocity when in motion, loss of force by cooling, &c. In this section it is shewn that water is of all other known fluids that best adapted for producing steam.

The *Third Section* treats of the laws of combustion, and of the effect of different species of fuel in producing steam; the proportions of fire places and chimneys of boilers, and the precautions necessary for their security and effect: the nature and application of safety apparatus is fully discussed. The section closes with a developement of the principles of condensing steam.

In the *Fourth Section*, the power afforded by a given quantity of steam, and all the methods of developing it, are illustrated both in a popular and scientific manner; and the theoretical defect of the rotary action of steam is investigated. The various modes of applying the power of steam are shewn, with a classification of engines; and the velocity and proportions which give a maximum of effect in engines, as well as the nature and office, and the power lost in working the air pumps of engines, are investigated.

The *Fifth Section* treats of the construction of the essentially different varieties of noncondensing steam engines; these engines are all of the high pressure kind, and the causes of loss of power, and means of employing steam to the best advantage, and the mode of calculating the power and proportion of the parts, are given in detail for each species.

The *Sixth Section* treats, in like manner, of the construction, proportions, power, and economy of condensing engines: in these sections, for the first time, those minute causes which affect the action of steam are not only stated, but are reduced to measure; and I trust in such a manner as to be most useful, both to those who wish to apply, and to those who wish to improve, the steam engine.

In the *Seventh Section*, the proportions and construction of the parts of steam engines are considered, as of cocks, valves, slides, pistons, stuffing boxes, &c.; also the modes of opening and closing valves, and the like, followed by a description of the different kinds of piston-rod guides, and an investigation of crank motions, and of the combinations for producing parallel motion. Also practical rules for the strength of the various parts of steam engines are added, and especially for boilers of different kinds.

The *Eighth Section* treats, First, of the modes of equalizing the action of the steam engine, as by fly wheels or counter weights. Secondly, of regulating the power of engines, as by valves, governors, regulators, &c. Thirdly, the method of ascertaining the state and intensity of the forces in engines, and the means of measuring their effective power. And, Fourthly, of the mode of working a steam engine.

The *Ninth Section* illustrates the application of steam power, to raising water, to the drainage and business of mining, to impelling machinery for manufacturing and for agricultural purposes, and its application to land carriage by means of railways.

The *Tenth Section* is on steam navigation; and the stability of vessels, their resistance to motion in fluids, the means of propelling them, and the modes of proportioning the power to the effect, are investigations altogether new; and of necessity so, for the theory of the resistance of fluids hitherto taught in schools, is erroneous and cannot be applied. I have therefore endeavoured to explain the methods of my own researches in popular rather than strictly scientific discussions, reserving for a separate work the full developement of my views on this important branch of science.

The tables will be useful in practice, and the plates are accompanied by descriptions, so as to render them of easy reference, and also to enable me to refer to the parts of the work which they tend to illustrate.

I am indebted to the friendly assistance of some of my professional brethren for access to information, which otherwise I could not have obtained: in a few instances, their favours arrived too late, except for my own satisfaction in finding that they conformed to the principles laid down in this treatise; of Mr. Bevan's interesting experiments on the resistance of boats I have given only part, because the others were evidently affected by the limited section of the canal. One of the plates (XIII.) was furnished by Mr. White, Engineer, and a few of the others are selected from the very accurate plates drawn by Clement,

and published in Partington's History of the Steam Engine; the rest are engraved from my own drawings, and are aided by a great number of wood engravings on the pages.

My great object has been to lead the reader to study the principles of the steam engine, and to furnish him not only with materials for study, but also with methods of reasoning, and in sufficient variety to enable him to examine any new case likely to occur; and in proportion to the care and pains he bestows on the inquiry, he will feel the advantage of the few steps I have taken in this interesting and important subject.

I shall conclude in the language of Sir Isaac Newton, on a greater occasion, "I heartily beg that what I have here done may be read with candour, and that the defects I have been guilty of upon this difficult subject may not be so much reprehended as kindly supplied, and investigated by new endeavours of my readers."

THOMAS TREDGOLD.

16 GROVE PLACE,
LISSON GROVE, LONDON.
August 13, 1827

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## Sect. VI.—Of the Construction of Condensing Engines.



## Sect. VII.—Of the Proportions, and the Construction of the Parts of Steam Engines.

## Sect. VIII.—Of Equalizing the Action, Regulating the Power, Measuring the Useful Effect, and Managing the Steam Engine.

## MEASURES, WEIGHTS, &c. USED IN THIS WORK.

Temperature is measured by degrees of Fahrenheit's scale, of which the freezing point is 32°, and the boiling point 212°.

Heat is measured by the degrees the same quantity of heat would increase the temperature of a given quantity of water at 60°, with the barometer at 30 inches.

Mechanical power is measured by the elementary horse power, as settled by Mr. Watt. A horse power is = 33,000 lbs. raised one foot high per minute, or = 550 lbs. raised one foot high per second; and a day's work of a horse is this power acting eight hours.

This horse power is, in French measures, 4661 kilogrammes raised one metre high per minute.

The pound is the avoirdupois pound, = 7000 troy grains, = ·4535 French kilogrammes.

The foot is = ·3048 French metres.

An atmosphere is 30 inches of mercury = ·762 French metres.