

**PRACTICE AND
THEORY OF
THE INJECTOR**

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Practice and Theory of the Injector by Strickland L. Kneass

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STRICKLAND L. KNEASS

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OF THE

INJECTOR.

BY

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PRÉFACE.

Although much has been written concerning the theory and the action of the Injector, there have been few books published since the appearance of Giffard's own pamphlet in 1860, which have been based directly upon experimental research.

It has been the object in the following pages to present solutions of some of the more interesting problems, with illustrations drawn from practical tests, and to describe in detail the function of the different parts. To the professional engineer and to the student, theoretical discussion of the Injector is a tempting field, because of the beauty of its underlying principle and by reason of the numerous associated problems of fluid motion; the analysis of this part of the subject, based upon carefully conducted laboratory tests, has been fully treated, and complex formulæ have been avoided in the mathematical discussion.

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THE GIFFARD INJECTOR.

CHAPTER I.

EARLY HISTORY.

TO HENRI JACQUES GIFFARD, an eminent French mathematician and engineer, belongs the honor of having invented the simplest apparatus for feeding boilers that has ever been devised, utilizing in a novel and ingenious way the latent power of a discharging jet of steam.

From the time of his graduation from *L' Ecole Centrale* in 1849, Giffard had directed his energies to the study of aeronautics and had spent much time in developing a light steam motor for propelling balloons; it is, therefore, not strange that he should also have attempted to devise a compact and convenient substitute for the steam pumps then in use. Already a number of patents had been granted him for the application of the steam engine to aerial navigation and for other correlated inventions when, on May 8, 1858, letters patent were issued for *L' Injecteur Automoteur*. His early technical education and wonderful ingenuity well fitted him for breaking away from the old beaten paths and starting out on a new line of discovery; and in view of the originality of his work he fully deserved the unqualified praise accorded him by his contemporaries.

Upon purely theoretical grounds the method by which he proposed to force a continuous stream of water into the boiler appeared to be entirely feasible and would, if practicable, possess many advantages over the intermittent systems. The difficulty seemed to lie in fulfilling the peculiar

conditions required for the condensation of the steam and the subsequent reduction of the velocity of the moving mass. Giffard carefully considered the various phases of the question and made a working drawing embodying his ideas. A model was made by M. Flaud & Cie., of Paris, who found, however, considerable difficulty in forming the tubes in the peculiar shapes required. But in the shape and proportions of the nozzles lay the element of success, and the first instrument constructed entirely fulfilled the expectation of the designer.

There have been few other inventions in which the underlying principles have been so thoroughly worked out by the original inventor. Giffard seems to have made a very complete survey of the possibilities of the Injector prior to placing it before the public, and in his patent specification, describes a number of improvements that have since been made. In 1860 he published a small brochure entitled "A Theoretical and Practical Paper on the Self-acting Injector," in which he says: "Of all the necessary accessories of a Steam Engine, perhaps the most important is the one used for feeding water to the boiler; upon its proper working depends not only the regular running of the engine, but the safety, the very existence of those who approach the boiler; . . . nevertheless, by a kind of fatality, the apparatus employed up to the present time for feeding is, of all others, that which leaves most to be desired." After reviewing the disadvantages of the various methods in use, he continues, "It is important, therefore, to create a new method, free from the imperfection and inconvenience pointed out," and modestly adds, "Such is, it appears to me, the result obtained by the apparatus to which I have given the name of *Injector*, because it produces a veritable continuous injection. Its mode of action, extraordinary in appearance, contrary to that which we are in the habit of seeing or supposing, is explained by the simplest laws of mechanics and has been foreseen and calculated in advance." He describes his invention in detail and explains very fully the best proportions for its various parts, and also the mechanical theory, substantially as advanced

by him in 1850, eight years before the construction of his experimental Injector.

And yet, in common with all new inventions and radical improvements, great difficulty was at first experienced in obtaining a fair trial of its merits, and in many cases the exaggerated claims of its friends interfered as much with its early adoption as the openly expressed criticism of its enemies. The great advantages of the new method were appreciated, however, by the *Academie des Sciences* of France, who awarded Giffard the Grand Mechanical Prize for 1859. This was all the more complimentary as it was entirely unsolicited. Prominent engineers presented before the principal scientific societies analytical demonstrations of the theory of the injector and allayed to a great extent the suspicion in the popular mind that the inventor was encroaching dangerously near the claim for perpetual motion. Combes, Bougere, Reech, Villiers, Zuber and Pochet are among the most prominent scientists who made a special study of the subject, and the demonstration of Pochet is still frequently used in modern text books.

It must not be supposed that Giffard was alone in his efforts to utilize the power of a discharging jet. For exhausting and pumping purposes we have record that a crude ejecting apparatus had been used as early as 1570 by Vitrio and Philebert de Lorme. But the first device that bears any similarity to the principle of the Injector was patented August 15, 1818, by Mannoury de Dectot, who describes "sundry motors or means for employing the power of fire, of steam, of air, etc., to start the movement of machines." He applied his invention for raising water and for propelling boats by utilizing the expansion and condensation of steam in connection with jets of water.

Ravard followed in 1840 with improved forms, but the greatest advance was made by Bourdon, the celebrated inventor of the metallic steam gauge, who approached very near the results obtained by Giffard. Two patents were issued to Bourdon, one in 1848 and one in 1857, but it is to the latter that special reference will be made. This con-