

Lazare and Sadi Carnot: A Scientific and Filial Relationship

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Lazare and Sadi Carnot

A Scientific and Filial Relationship

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Foreword

Les talents écartent l'ennui, chassent le vice, et sèment la vie de fleurs:
puissance, richesse, vous n'offrez point ces avantages!
(Legend of a lithograph depicting the spirit of enlightened industry and belonging to a
great-great granddaughter of Lazare Carnot)

The first part of this compendium consists of slightly revised excerpts from my monograph, *Lazare Carnot Savant*, published in 1971 (Gillispie 1971). The preface to that book, which is based partly on access to the Carnot family archives, explains how it came to be written, and makes the necessary acknowledgments. It contains a short section on the more famous work of Sadi Carnot, whose *Réflexions sur la puissance du feu et sur les machines propres à développer cette puissance* is generally regarded as the origin of the science of thermodynamics (Carnot 1824). It appeared to me that Sadi Carnot's analysis may be read as an application of his father's invention of the science of machines to heat engines.

I have suggested as much in what follows. My colleague and co-author, Raffaele Pisano, has independently devoted much more intensive study to the work of Sadi Carnot and its influence. It seemed to both of us that it would be well to publish, or in my case to republish, our findings. Both father and son were trained as engineers, Sadi at the newly founded *École polytechnique*. They had no idea that their work would develop into the physics of work and energy. So it came about, however, and that is the reason for including an account of it in a series devoted to the role of engineering mechanics.

The major portion of *Lazare Carnot Savant* is here included. We are not reprinting the appendices, which are reproductions of Carnot's unpublished papers discussed in Chapter 3, Parts A and B, nor the essay on the unpublished mathematical theory of the infinite contributed to my book by my late colleague, A.P. Youshkevitch, which has little to do with engineering mechanics. Princeton University Press has generously granted the necessary permission, for which I am extremely grateful.

Princeton, USA

Charles Coulston Gillispie

Preface

This extraordinary book on two outstanding French engineers and scientists has been written by two authors who combined their efforts to that end in a very fruitful way. The result is based on deep historical, epistemological, and methodological insights that shed completely new light on the scientific and filial relationship between the famous politician, mathematician, and engineer Lazare Nicolas Marguerit Carnot (1753–1823) and his son Nicolas Léonard Sadi Carnot (1796–1832) who was also trained as an engineer at the newly founded *École polytechnique de Paris*.

While Lazare Carnot wrote on machines and adapted the science of mechanics to the science of machines, his son elaborated a general, abstract, thermodynamical theory. Insofar the purpose of Gillispie and Pisano is not to recount the history of mechanics, but to identify the points of entry of Lazare Carnot's engineering science into mechanics (p. 100). The authors are well aware that the analogy between fluid flow and heat flow has often been discussed in the research literature in order to characterize the influence of Lazare's work upon Sadi's (p. 18).

Yet, the authors make a much wider claim for the continuity between the works of the two Carnots. They would like to show that Sadi Carnot's *Réflexions sur le puissance motrice du feu* published after his father's death "may properly be read not only as the foundation of thermodynamics, but also as the culmination of a methodologically and conceptually coherent series" of Lazare Carnot's essays on the science of machines (p. 15).

How can such a strong claim be demonstrated? Gillispie and Pisano study and compare the different steps of Lazare Carnot's thinking about mechanics, of his writings, and compare them with Sadi Carnot's *Réflexions* which can be taken for the foundation stone in the science of thermodynamics (p. 77).

To that end they identify those elements of the arguments that were derived from the work of the father. They amply and clearly explain their methods and methodology as well and include even a whole chapter (Chap. 6) that deals with such general issues like historical methodology, interpretation, and scientific theory.

Their key notion is historical epistemology which is based on the use of logical-historical categories. The authors adopt them in order to investigate Sadi Carnot's scientific thought. They are interested in *effective history* that is history relying on

the fundamental choices made by scientists who influenced the interpretation of history by means of crucial choices (p. 156).

Their leading questions read: What is the theoretical organization in the two Carnots? On what principles is it based? In order to answer to these two questions they study the history of science by means of a logical investigation (p. 191). Thus they are able to demonstrate that Sadi Carnot's reasonings with double negative sentences (DNS) are based on non-classical logic. The authors' list in the appendix comprehends 65 such sentences. Their sequence may synthetically express the entire development of Sadi Carnot's scientific thought (p. 205).

Gillispie and Pisano convincingly conclude that Sadi Carnot's "theory has to be qualified as a logical theory because the double negative sentences illustrate for the first time a very detailed structure of Sadi Carnot's arguments, adequately representing Carnot's original scientific thought" (p. 211). But the two authors go even further by explaining that the origin of the idea of the cycle was the analogy with the electric circuit in Alessandro Volta's battery. Hence Lazare Carnot, not Sadi, first had the idea of the cycle of heat machines (p. 234).

The fruitfulness of Gillispie's and Pisano's approach becomes again obvious when they apply the method of historical epistemology to the mathematical footnote in Sadi Carnot's *Réflexions* which combines epistemological and historical approaches to identify significant historical hypotheses (p. 257). The authors claim that Lazare Carnot's synthetic method is present in Sadi Carnot's theory paying particular attention to Sadi Carnot's reasoning process (p. 279). Their hope is certainly justified that their approach can contribute to clarify the birth and development of Sadi Carnot's theory and the historical knowledge of thermodynamics.

Comparing Lazare and Sadi Carnot's theories of the efficiency of a machine, they conclude that "neither theory is based on axioms, but on the program of scientifically resolving a crucial problem that in the minds of the lay people of the time coincided with metaphysics" (p. 370).

Gillispie and Pisano have written a really remarkable book that reveals an impressing knowledge of the huge amount of original and modern publications regarding history and philosophy of science. They always help the reader not to lose track of things by adding summaries, illustrations, and by compiling their arguments or those of their heroes in long lists. In spite of all similarities they have proved between father and son they do not overlook a crucial difference between them. Sadi Carnot's work was deep in a way that his father's was not: It founded the science of thermodynamics (p. 86).

Berlin, Germany

Eberhard Knobloch

Acknowledgments

The genesis of such a difficult and lengthy book has deep roots, and the final result has been a long time in the making. When the research and production of a work of this nature is carried out over a significant period of time, many friends and scholars become contributors to both the research and the writing process. I owe gratitude to many such people and will never manage to thank them all appropriately.

My own early research on Lazare and Sadi Carnot began with a lengthy dissertation on Sadi Carnot's logic and mathematics which I wrote while on the faculty of physics at the University of Naples "Federico II", in my native city. Since appearance of this specialized historical and scientific work, many additional papers have been written by me and by others, on Sadi Carnot alone and on the two Carnots jointly, often in collaboration with my adviser Antonino Drago, the first Italian historian since the 1980s–1990s to recognize the importance of studying the two Carnots jointly as a unique program of scientific research in Italy. Therefore, my first acknowledgments are to him.

Of course, this crucial first book to include both of the Carnots would not have been possible, first without Charles Gillispie's approval and vast, indispensable works on Lazare Carnot, and second without all of Robert Fox's historical details and profound research on Sadi Carnot. These are two definitive, worldwide recognized, masters of the history of science and, as well, friends and colleagues of mine. I feel very privileged to have known and to have worked with them.

A special acknowledgment goes out to my friend and historian, Eberhard Knobloch, President of the *International Academy of the History of Science* who generously accepted to write his insightful and very much appreciated *Preface*. I also thank him for his cultural and persuasive and constant, encouragement. A particular acknowledgement and appreciation goes to the *European Society for the History of Science's* congresses for promoting the history of science in its broadest sense and contacts between scholars and institutions across Europe, and all the world. It gave me the possibility to know and exchange several elements of interest of history of science, mechanics and thermodynamics. Thus I have naturally incurred many debts.

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