INTRODUCTION

How did it happen that an age which proclaimed itself "enlightened," but had developed no electrical industry, ended up with an invention that would make of electric lighting an everyday marvel? The age in question historians call the Enlightenment,[1] and the invention was the electric or voltaic battery, the earliest examples of which were built toward the end of 1799. The present book revolves around wide-ranging questions like the one just raised, and it seeks the answers in a detailed study of the cultures of science and technology in late-eighteenth- and early-nineteenth-century Europe.

Many of the threads linking the Enlightenment tradition to the science of electricity are already well known. "The Enlightenment liked to play with electricity," it has been noted by a leading historian in the field,[2] and a figure like Benjamin Franklin was represented already by his contemporaries as embodying an alliance between the science of electricity and "enlightened" political endeavors.[3] The present book focuses on the specific threads linking the battery to Enlightenment culture on one hand, and to later industrial societies on the other. The book argues that a key factor in the process that led to the battery was the cultural, technological, and social ferment that, around 1800, inspired a mixed population of natural philosophers, physicists, physicians, instrument makers, and amateurs interested in electricity, belonging to different cultural traditions and scattered over several European countries. The book further argues that the role of the inventor in that process was, to an important extent, one of interpreting and mediating between the different agendas pursued within that mixed population.

By emphasizing the diversity of the cultures involved in the process that led to the battery—and the unintended consequences attached to diversity—the book outlines a picture of late Enlightenment science and technology that goes beyond the interpretive framework provided by the traditional conflicting views held by the supporters or critics of the Enlightenment and their present-day descendants.[4] The book argues that the diversity of the cultures and goals involved in the pursuit of science and technology around 1800 was just as important as the discipline propounded by some of the followers of the Enlightenment as a key factor in the scientific enterprise. The book also argues that the unintended consequences of diversity (and thus the difficulty of orienting and predicting scientific and technological change) character-

ized the earlier, no less than the later, stages of the age of electricity. As in other fields of comparatively free human endeavor, too in scientific and technological pursuits both diversity and unintended consequences seem to be at work, in spite of the efforts of the advocates of a normative view of science, rationality, and social order, or the understandable denunciations leveled by those critics of the Enlightenment tradition who fear the power of elites won over to the notion of useful knowledge.

The book's narrative follows three main lines. The first is biographical: it is the story of Alessandro Volta, a leading figure in the history of the science of electricity during the late Enlightenment, and the inventor of the battery. His personal, scientific, and social endeavors are dealt with, offering a glimpse of what it meant to be a "natural philosopher" (the old phrase for scientist) and an inventor of electrical instruments (mostly useless, by our early-twenty-first-century standards) in late-eighteenth-century Europe.

Insofar as it is a biography, this is a biography in context. Volta's work and instruments are appraised both as products of specialist endeavor and in connection with the reforms of the educational system and the public administration then under way in several European countries. Volta, whom historiography has singled out as a key figure in the transition of the science of electricity from amateur to professional enterprise, was also a well-known figure in the Republic of Letters, to which enlightened "philosophers" felt they belonged. We thus explore Volta's network of acquaintances and his frequent travels, during which he felt as much at home in London, Paris, Geneva, Berlin, Göttingen, or Vienna, where he would perform his electrical experiments, as in Milan, Pavia, or Como, in Lombardy (then part of the Austrian empire), where he was born.

The second line the book follows is an inquiry into some long-term features of the culture of science and technology as they developed in the early age of electricity. This entails a reassessment of the legacies of the Enlightenment based on a field of historical evidence—placed at the intersection between cultures, natural philosophies, and machines—that has received comparatively little attention by the interpreters of the Enlightenment tradition so far. Seen from a long-term perspective, the case of Volta and the battery can be regarded as a paradigmatic episode in the economy of invention enforced by Enlightenment ideas and practices: a case study of some of the consequences brought about by Enlightenment values and notions, which resulted in the introduction of the nineteenth-century figure of the "scientist" and the partial eclipse of the "natural philosopher."

The third line of inquiry to be pursued is epistemological and anthropological. It is an investigation into the material culture of science and technology exemplified in Volta's machines. It describes their early, "private" development, as well as their public career, using the rich documentation offered by Volta's laboratory notes and by the negotiations he undertook to obtain recognition via a varied network of expert and amateur electricians, patrons, and reward-dispensing colleagues scattered in several countries. As an epistemological and anthropological study, an approach has been adopted that goes beyond the opposition between realism and constructivism that has nurtured protracted scholarly controversies over the past decade.[5] Throughout the book it will be assumed that scientific and technological objects are both real *and* historical: real in the sense of pragmatic realism;[6] historical in the sense that scientific and technological knowledge and practices are in any case embedded in human culture, as constructivists emphasize.[7]

Moving to a review of the detailed contents of the book, chapter 1 examines what was distinctive in Volta's personal, social, and cultural endeavors. His career from amateur to expert, to professor and public servant, is outlined, as are some of the features of his emotional life, his attitude toward religion, and his scientific work. Chapter 2 is a study of the Italian scientific community from 1770–1795, based on a survey of seventy-four natural philosophers active south of the Alps. The aims of the institutional reforms being carried out in the Italian peninsula in the second half of the eighteenth century, and their constraints, are assessed through the testimony of insiders and foreigners. Chapters 3 and 4 review Volta's contributions to the science of electricity in the 1770s and 1780s. His day-to-day work is reconstructed from a wealth of surviving manuscript notes. His qualities as an investigator are presented as stemming from an adjustment between his ambition to be regarded as a natural philosopher and the more modest role of inventor that some of his colleagues were inclined to assign him. In chapter 4 a detailed discussion of Volta's techniques, and his reactions to Coulomb's celebrated memoirs on electricity, is used to outline both the peculiar traits of the "quantifying spirit" Volta subscribed to and the plurality of the strategies that late-eighteenth-century physicists adopted in their pursuit of a quantitative science of electricity.

Chapter 5 describes the cosmopolitan network of contacts that Volta developed in his dual role of expert in search of recognition and public servant involved in the imitation-competition game that several governments of Enlightenment Europe played in their well-advertised support of fashionable science. The chapter shows how closely Volta's assessment of scientific merit, and his choice of foreign experts and

scientific institutions from which to expect reward, linked up with his perception of their broad cultural and political leanings.

Chapter 6 is a fine-grained study of Volta's path to the battery. It begins with a detailed discussion of Volta's reactions to Galvani's experimental results and interpretations of "animal electricity" in the 1790s. It continues with a description of the sophisticated measuring techniques that Volta developed while engaged in the hunt for "weak" electricity generated by the controversy over galvanism. The chapter concludes with a circumstantial reconstruction, based on Volta's laboratory notes, of the cognitive and manipulative steps, and expert negotiations, that led Volta to conceive and build the battery in 1799, and announce it to the Royal Society of London in the spring of 1800. This took only a few months once Volta had read a paper by William Nicholson suggesting a method for "imitating the electric fish" (the torpedo) by means of an electrical and mechanical apparatus based on one of Volta's own earlier machines. The circumstance that the battery (later depicted as a momentous turning point in the history of physics) was the outcome of a program that included the goal of "imitating the electric fish" is used as a cautionary tale against the sort of history of science that prevailed when the disciplinary boundaries imposed by twentieth-century developments oriented the work of historians.

A comparative study of the early reception of the voltaic battery in five European countries is developed in chapter 7. It is an essay on how scientific instruments and their interpretations travel across cultural frontiers. It shows how easily simple machines like the voltaic battery could be replicated, and how—easy replication notwithstanding—they could be adopted within widely different research programs, occasionally far removed from the interests and goals pursued by the inventor. The easy replication of the voltaic battery, and its appropriation within different cultural contexts, are discussed as evidence that a revision is needed in the way historians and sociologists have dealt with the issue of replication in scientific practice, and with the role of local cultures and expert knowledge in the production and diffusion of scientific instruments. The revision recommended combines the realist notion that the voltaic batteries built throughout Europe in the early nineteenth century were basically the same apparatus, with the constructivist notion that indeed any expert electrician in Europe could bend the battery to his or her own particular intellectual and social needs.

The early reception of the voltaic battery shows that consensus on how the battery worked, and on its implications for natural philosophy, was conspicuously lacking in both expert and amateur circles around Europe in the first few years after the introduction of the new

instrument. Despite this, experts, amateurs, and even heads of state like general Bonaparte—often informed of Volta's achievement merely through the daily press—showed themselves able and willing to celebrate the merits of Volta's contribution to expert knowledge before Europe's cultivated elites.

The mechanisms that regulate the assessment and celebration of scientific and technological achievement among lay audiences are the subject of chapter 8. It explores the ways in which, in nineteenth- and twentieth-century Italy, Volta became a sort of national hero. The chapter shows that some long-established rituals, used to celebrate achievement in general, were easily—and superficially—adapted during the "age of progress" to celebrate scientists and the new technologies. The chapter also shows how, within these celebrating mechanisms, the cultural, social, and political needs of the celebrating people were often imposed on the celebrated hero.

The conclusions (chapter 9) offer an overview of the economy of invention emerging from the present study, and its implications for an assessment of the legacies of the Enlightenment. The chapter provides an analysis of the system of values and utilitarian concerns that prepared the shift from the classical and Enlightenment figure of the natural philosopher to the nineteenth-century (and present-day) figure of the scientist. It also shows that, within the broad framework provided by Enlightenment notions like "useful knowledge" and "the quantifying spirit," several different cultural and research traditions shaped the endeavors of physicists like Volta.

Accordingly, the conclusions advocate an interpretation of the history of science and technology that reintroduces those elements of diversity and contingency that the critics of the Enlightenment, and some of its supporters, have removed from their narratives in response to their respective agendas. The supporters of the Enlightenment tradition (to be found more often among scientists, engineers, and philosophers of science) have often been led to remove diversity, and contingency because they wanted to impose a normative conception of science and technology, and their proclaimed rationality. The critics of the Enlightenment (to be found more often among historians and sociologists), on the other hand, have claimed that that same normative view was typical of the Enlightenment in order to expose more easily what they regard as the cynical use, by interested elites, of the prestige of science and technology to enforce an authoritarian view of science, rationality, and social order.

The present book argues that neither party has done proper justice to the wealth, diversity, and unpredictability of the intellectual, technological, and social ferment that, under the banner of the vague but compelling Enlightenment notions of useful knowledge and the quantifying spirit, led to the age of electricity, and to our industrial societies.