History of the Electric Automobile

Battery-Only Powered Cars

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Published by:
Society of Automotive Engineers, Inc.
400 Commonwealth Drive
Warrendale, PA 15096-0001
U.S.A.
Phone: (412) 776-4841
Fax: (412) 776-5760
Gustave Trouvé,

who in 1881 first assembled an electric vehicle

_Courtesy: H. Munn & Co._
To Ann and John

and

their late mother,

Hilda Gertrude Overholt Wakefield
Those who cannot remember the past are condemned to repeat it.

—George Santayana
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Foreword

The lure of the electric powered vehicle for personalized transportation has been a recurring enigma to automotive engineers for over a century. Like the undulating surge of electrical power itself, the interest in electric vehicles rises and falls with changes in the world’s economic status and concerns about the availability of fossil fuels and environmental health.

Since the late 1800s, more than 300 companies in the United States alone, and many others throughout the world, have espoused the quiet power, ease of control, and cleanliness of electric automobiles for personal and commercial applications.

In the early 1900s, the electric vehicle was the overwhelming favorite to lead America’s transportation revolution. But as the motor vehicle ventured beyond city limits, it soon was apparent that the “silent servant” had an all too severe problem of limited range, weight, and price.

The electric storage battery was its Achilles heel, and despite millions of dollars invested in over a century of research and development, the “miracle” battery is yet undiscovered. However, the promise and excitement of electrically powered personal transportation is as alluring and alive today as it was a century ago.

The past century of electric vehicle development has finally been recorded. It is a story well documented by one of the leading authorities on electric vehicles. Dr. Ernest H. Wakefield has spent a lifetime in the electrical and nuclear engineering fields.

As an electrical engineer, educator, lecturer, author, inventor, and entrepreneur for the past half century, Dr. Wakefield is eminently qualified to chronicle the history of the electric vehicle. In this volume, the development of the electric vehicle throughout the world is recounted.

The early development of the storage battery in France including the efforts of Gaston Planté and Camille Faure in the mid-nineteenth century and the glory days of the electric car in America are highlighted. Included are the pioneering efforts of Riker, Baker, Trouvé, Ayrton, Perry, Baker, and Woods, the evolution of the batteries, the chargers, the controllers, and modern day trials of new alternating-current drive concepts. The developmental history of the electric car is indeed well documented by Dr. Wakefield.

Today, in a world of transportation focused on responding to demands for environmental, economic, and ecological progress and zero emission vehicles, the alluring, elusive, and enduring electric finally stands on the threshold of success after a long, arduous journey.

James A. Wren
Patent Department
American Automobile Manufacturers Association
About the Author

In his teen years Dr. Ernest Henry Wakefield authored a weekly newspaper column. With an enlarging world and education, B.A., M.S. (Fine Arts), and a Ph.D. (Electrical Engineering) from the University of Michigan, by being employed by General Electric Co. and Westinghouse Corp., by teaching electrical engineering at the University of Tennessee, by volunteering into the U.S. Army, by military training at Camp Crowder, Missouri, with stints at MIT in radar and the University of Chicago in physics, and by being assigned to the Physics Division of The Manhattan Project (Atom Bomb) at the University of Chicago, he still writes.

After WWII he founded and operated a world class nuclear instrument company with factories in Skokie, Illinois and Berkeley, California, manufacturing both for the domestic and export markets. Later he employed many persons in the Philippines and Haiti in local fabrication. Then he independently discovered the concept of frequency and pulse-width modulation for changing direct-current to variable frequency three-phase alternating-current, a technique now being widely applied in electric vehicles. To employ this concept he designed and built electric cars. In this period Dr. Wakefield continued his writings on transportation authoring *The Consumer's Electric Car*, 1977.

Travelling in 56 and lecturing in more than 20 foreign countries, participating for more than 40 years as a visitor both in the African and in the Physics Programs at Northwestern University, Dr. Wakefield continues his writing.

Dr. Wakefield has written about the nuclear field, editing and authoring *Nuclear Reactors for Universities and Industry*, 1957; on entrepreneurship and many economic papers on Third World nations: African, Southwest Pacific, as well as the Caribbean.

In history he has recently completed editing fifty booklets bearing text and etchings entitled *Wakefield's American Civil War Series*. Among them are *The Battle of Mobile Bay*, 1988. He has written *The Lighthouse That Wanted To Stay Lit*, 1992, and also on genealogy for writers who have access to a word processor.

In fiction Dr. Wakefield wrote *The Treasure of Fisherman's Reef*, 1953. Using his forty-year experience in nuclear energy, he has also chronicled the chance of nuclear winter, and has written a three volume love story.
Preface

This book is the story about electric automobiles. In anticipation of oil shortages and increasing air pollution in American cities the U.S. Congress passed over a Presidential veto the *Electric and Hybrid Vehicle Research, Development and Demonstration Act* of 1976. By nomenclature the Congress differentiated between battery-powered electric vehicles and those vehicles which might have both battery-power as well as other means of propulsion. This particular book is devoted to the history of the battery-only powered electric vehicle and its components. A second volume is being written that covers the development of the many multi-powered electrics including battery-powered plus: a spring, an internal combustion engine, a flywheel, solar cell powered, and fuel cell vehicles and their unique constituents. As batteries, controllers, and electric motors are common to both classes of vehicles, their development is in this volume only.

While probably no person has exact knowledge, qualitatively speaking possibly equal time has been spent on each of these two paths of personal transportation. Presently intense work is proceeding on battery-only powered vehicles with possibly less emphasis on multi-powered electric cars. Both approaches have a rich background; however, no one knows which system will be followed in the near and distant future.

To many the romance and nostalgia of electric cars and electric carriages have an almost mystical interest. Furthermore, with electricity being such a clean and versatile fuel that is so widely used, a perennial question is asked: why not employ it for personal transportation? Because no book chronicles the history of electric vehicles, the author collected this information and placed it in book form for its preservation. Fortunately, the author has been, for more than a third of a century, an integral part of the emerging electric vehicle industry in conception, design, construction, marketing, financing, and interpretation. This book, in treating the past of this long nascent industry, is an attempt to bring clean air to metropolitan cities worldwide. Hopefully objective and correct, the authorship has been a labor of love.

Electric cars have resulted from a happy arrangement of mechanical, electrical, magnetic, and chemical laws which, operating in perfect order, yield personal transportation. This book describes and illustrates the application of these natural laws to vehicles, to battery chargers, to batteries or other sources of energy, to controllers, to motors, to transmissions, to wheels, and identifies some pioneers who were responsible for their applications. Considering the range of physical principles embodied in an electric vehicle, no one can be an expert on all phases of their
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elements. The present volume can only touch on much of the technology. However, the serious student should be able to secure an introductory grasp on the principles of electric vehicles from this book and its Notes, Appendices, and Further Readings list.

*History of the Electric Vehicle: Battery-Only Powered Cars* is structured into five sections. There is a brief introduction indicating how the knowledge for electric vehicles was gained through earlier centuries, particularly the period beginning with the quantitative experimentation with electrical phenomena. These innovations were finally assembled as an electric vehicle system in 1881. Then the first two electrical vehicles, which were developed in France and England, are explored first, followed by early electric vehicle development in America. With this introduction, a critical comparison of gasoline, steam, and electric powered systems is undertaken. Then turning to the vehicles themselves, the development of the electric battery charger, the motive power batteries, the controller, and direct-current electric motors are briefly discussed. In design, the motorcars of this period were wagons or carriages which closely copied horse-drawn vehicles. Small wonder they were called horseless carriages.

The second section demonstrates improvements in electric vehicles from 1900 to 1935. Beginning in 1902 the automobile adopted its present conformation, engine forward. Personal cars also gained a closed-in body during the early years of this time span, serving to protect passengers from the weather. The era was a period which saw the flowering and demise of the commercially produced over-the-road electric car. Yet the decade from 1902 to 1912 was one of the most productive and fruitful in design of personal cars and industrial trucks. And it was also an era of high mortality of companies. One could succeed, and one could fail.

Steel-tired, wood-fabricated wheels yielded to solid rubber-tired, then pneumatic-tired, wire-spoked wheels which in turn became pressed all-steel design as well as cast aluminum. From the component with the greatest single problem—punctures, tires became a paragon of reliability. The chassis was transformed from a wagon to a well-engineered assembly. The body metamorphosed from a horseless carriage to its present configuration. Wick lamps became acetylene, then filament, now gaseous-discharge. Brakes proceeded from wheel rim-friction to an axle-based contracting cylinder, then finally to disc-type. Drive power-transfer passed from linked chain to the concept of the earlier conceived differential. Smooth friction surfaces adopted roller-bearings. Lubrication changed to high-technology, petroleum greases and liquid. All these improvements, and many more, transpired to place the Western World on wheels. As if to match, many nations began major road-building programs that continue today.

The third section of the volume covers the dead period for electric vehicles (1935 to 1955) and prepares the reader for the transition and rebirth. This section critiques why the manufacture of electric cars ceased and presents reasons for the dominance of the internal combustion engine-powered vehicle.

The fourth section describes the innovative, modern electric drive systems that were devised internationally in the early 1960s. Employed is solid-state electronics, 3-phase A-C power, and more exotic batteries. The period demonstrated new electric drive systems. This segment also shows advances, which continue at this writing, to vehicles that reach road-testing.

The fifth section of *History of the Electric Automobile: Battery-Only Powered Cars* contains ten appendices, a glossary, and an index. Finally, for more than a century, from 1881 through the present, nearly all seers who have predicted the role of electric vehicles in personal transportation have been wrong. This book records what actually happened in America and throughout the world.
Acknowledgements

In writing this book the author owes a debt of gratitude to the late Claud Erickson, formerly Manager of the Lansing, Michigan Electric Power Board, for originally interesting me in the history of electric vehicles. I also owe an obligation to Janet Ayers, Engineering and Science Librarian; Mary Roy, Mary McCreadie, Renée McHenry, Dorothy Ramm, Librarians, Transportation Center; Marjorie Carpenter, Interlibrary Loan Librarian; and Maude M. Kelso, Periodical Supervisor; and to all of Northwestern University. Also, I wish to thank the staff of the University of Illinois Library, Champaign-Urbana, for their many courtesies.

For help in the technical phase, I thank my good friend Dr. Gordon J. Murphy, Professor of Electrical Engineering and Computer Sciences, Northwestern University; and my peers who were instrumental in the revival of the electric vehicle industry in the 1960s and 1970s: Dr. Paul D. Agarwal of General Motors; Robert R. Aronson of Electric Fuel Propulsion; Robert F. Beaumont of Sebring-Vanguard Company; Wayne E. Goldman of Electromotion, Inc.; Paul R. Hafer of Battronics, Inc.; Robert S. McKee of McKee Engineering Corporation; Mark J. Obert of the American Motors Corporation; Wally E. Rippel of California Institute of Technology; Dr. Lewis E. Unnewehr of the Ford Motor Company; and Dr. Victor Wouk of Petro-Motors, Inc. And surely there were others.

Thanks is also extended to those who have patiently reviewed elements of the book (Dr. John B. Ketterson, Professor of Physics, Northwestern University; and Dr. Paul A. Nelson, Deputy-Director of the Electrochemical Division, Argonne National Laboratory, who contributed to Chapter 11 on batteries and fuel cells) and those who reviewed the entire manuscript (Mary Irwin, Editor of the University of Michigan Press; Dr. Alan L. Kistler, Professor of Mechanical Engineering at Northwestern University; Ralph A. Ocon, science writer of Sarasota, Florida; William H. Shafer, spokesman for Commonwealth Edison Company on electric vehicles (ret.); Dr. Gene E. Smith, Professor of Mechanical Engineering of the University of Michigan; James Wren, Manager of the Patent Department, Motor Vehicle Manufactures Association; and others). All of these people helped improve the work.

In preparing the electrical and multi-powered vehicle glossary, I received help from the late John Bardeen, Nobel Laureate, University of Illinois, Urbana; the late Lewis Erwin, Professor, Mechanical Engineering, Northwestern University; Douglas A. Fraser, Thayer School of Engineering, Dartmouth College; and William B. Rever III, Product Manager, Crystalline
Acknowledgements


For technical aid in preparing the book, I wish to salute Dr. Peter Roll, Vice President for Information Services, the University Microcomputer Support Group; Joel D. Meyers, Assistant Dean, Robert R. McCormick School of Engineering and Applied Science; Robert T. Schreiber and Ms. Mildred Wiesser, both of the Center for Manufacturing Engineering; and Frances Glass-Newmann of the Program of Master of Management in Manufacturing; and all of Northwestern University, Evanston, Illinois. All have been most helpful. In addition, I wish to thank Ruth L. Barrash for placing onto computer disks all that is read below and for much more. Likewise, I would compliment Apple Computer, Inc. for aid in additional computer service.

I wish to thank the many industrial and utility companies who, in their early funding when dollars were hard to come by, encouraged my own continued interest in designing and building electric vehicles in this emerging industry. These organizations are listed in Chapter 24.