Second Edition

HYBRID, ELECTRIC, & FUEL-CELL VEHICLES

JACK ERJAVEC

Hybrid, Electric & Fuel-Cell Vehicles

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Preface

The U.S. government has set new standards that require new cars and light trucks to average the equivalent of 54.5 mpg in 2025 while reducing greenhouse gas emissions to 163 grams per mile. To achieve this, auto manufacturers are investing great amounts of time and money looking for practical ways to meet the new standards. Much of the research has been focused on battery-operated electric vehicles, hybrid electric vehicles, and fuel cell electric vehicles. These are the main subjects of this book.

Although refinements to internal combustion engines have made them more efficient, they will never be developed to the point where they emit zero emissions. Nor can an internal combustion engine ever be 100 percent energy efficient. To meet the new government standards, the industry cannot rely on refinements to an engine. Attention must also be spent on designing special-purpose all-electric vehicles and combinations of engine and electric. Although the total elimination of the internal combustion engine would meet the new standards, this is not yet practical.

Many different alternative fuels have been tested and used in conventional engines to reduce our dependency on fossil fuels and to reduce emission levels. All of these show promise and are briefly discussed in this book. However, the only technology that promises to drastically reduce emissions and provide excellent fuel economy is the electric drive vehicle.

A few manufacturers are currently offering all-electric, battery-operated vehicles. These will be discussed, as will a brief history of electric vehicles. Much of what was discovered in the past about electric vehicles is being used today in hybrid vehicles and will also be used in fuel cell vehicles.

Electric drive vehicles are powered by high-voltage systems. With the high voltages also come serious safety issues. The voltages of electric drive vehicles are high enough to kill anyone who does not respect them and does not carefully adhere to the precautions given by the manufacturers of these vehicles. If this book has one dominant theme, it is "respect the voltage!" Throughout this book, regardless of the topic, **CAUTIONS, NOTES,** and **WARNINGS** are given to remind everyone who reads this book to be very careful while doing anything on an electric drive vehicle.

Many assume that because some of the vehicle's systems are just like what has been used for years in conventional vehicles, they can just maintain and service electric drive vehicles unimpeded. This is not true. To prevent great personal injury and/or damage to the vehicle, you must do what you can to work safely on these vehicles.

Too often, technicians and others take some risks to complete a job quickly. On electric drive vehicles, moving too quickly or proceeding without checking a few things can end a career or a life quickly. These messages are not meant to scare anyone away from working on electric vehicles; rather they are intended to make one aware of the dangers. Knowing the dangers, I hope that everyone will enjoy the technology and the thrill of working with it.

Electric drive technologies are advancing very quickly. So much has changed between the time I started writing this and the time I thought I was finished. In fact, when I thought it was completed, and I reviewed what I had written, I saw some vehicles I did not write about that were running on the roads. Unfortunately, this will be the case for quite some time, so I decided to stop. If I waited to stop until the technology cooled down a bit, this book would not have been available for another 10 years or so. But I did try to cover the basics to allow you to understand those systems that cannot be covered in this book.

The topics are presented in a progression, from yesterday's technology to tomorrow's. The first chapter focuses on the basics. The various types of electric drive vehicles are defined and described. There is also a discussion of various alternative fuels that can be used in an internal combustion engine. This discussion may seem out of place for a book about electric vehicles, but these fuels can be used in hybrid vehicles and as sources of hydrogen for fuel cell vehicles. There is also a quick look at the history of electric drive vehicles.

Chapters 2 through **4** provide the basics for the rest of the book. Basic electricity, as it applies to these

vehicles, is covered from a theoretical and practical standpoint. The basics of electric motors and batteries are also covered, in separate chapters. Regardless of the type of electric drive vehicle being considered, the two most important items are the motor and battery. Many different designs of both are covered in these chapters because many designs have been and can be used in electric vehicles.

Chapter 5 covers pure electric vehicles. These battery-operated vehicles are currently available from different manufacturers, and more will be available in the future.

Since hybrid vehicles are quite popular today, there are five chapters, **Chapters 6** through **10,** dedicated to the subject. All hybrid vehicles available at the time of this writing are described and discussed. These are grouped by system and operational commonalities. **Chapter 10** addresses general service to these vehicles. That chapter does not go into extreme detail because the manufacturers do not want technicians going deeply into their systems without special training. However, because of the high voltages found in these vehicles, many common nonhybrid service procedures need to be modified to work safely. Many of these new procedures are presented in the chapter.

Chapter 11 is a look into the future. It contains a look at fuel cell vehicles and other potential technologies that may affect the operation of an automobile in the future. Manufacturers have built and tested many fuel cell vehicles, and this chapter looks at what worked and what did not in many of these vehicles.

I sincerely hope the information in this book opens doors of thought and rewards for you. The electric drive technology is different, rewarding, and exciting.

Jack Erjavec

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