Changing Gears:

The Development of the Automotive Transmission

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Dedicated to

Becky and Dave

May you follow your dreams
and work toward their fulfillment,
as did many of those whose work is recognized in this book.

Preface

Every car has a transmission. It is the collection of gears and clutches and/or other devices that connect the engine with the final drive. Above all other vehicle systems, the transmission tames the spinning fury of the engine, born of internal fire, and allows it to be harnessed by the most novice, frail or delicate of drivers. The modern automatic transmission is so transparent that the driver needs to pay little attention to this very complex piece of machinery. Today, most transmissions will survive for the life of the vehicle without maintenance or trouble, and they are taken entirely for granted.

Yet it was not always the case. In the early days, the lack of an acceptably "user friendly" transmission was a major factor in limiting sales and use of the motor car. Once the self-starter was invented, operation of the transmission was the greatest single hurdle to be overcome by would-be drivers. It took great strength, skill and patience to manipulate early gearboxes. The development of an easy-to-use transmission was truly the keystone that made possible the personal freedom and mobility enjoyed today by most every American of legal driving age.

While the basic configuration of the engine was decided upon long before 1930, transmission design continued to evolve. From the '60s through the '70s, the industry settled on a fairly standard design. Innovations and developments focused largely on cost reduction and shift quality. Now, as the industry is faced with pressures for increased fuel economy and cleaner air, there is as much if not more fundamental innovation going on in the design of transmissions today as there is in the engine. In fact, while the basic reciprocating piston and crankshaft layout of the engine continues to be refined, some very novel and unique transmission configurations are being evaluated as this is being written.

This book predominantly focuses on the mechanical configuration of the transmission and its controls. It follows the flow of power from the

engine to the final drive unit. Lubricants, seals, and materials, including friction materials, are very important elements of the transmission, to be sure. To do them proper justice will require their own special piece, however, for the innovations in these fields are no less important and diverse as in the mechanical aspects of the transmission.

The purpose of this book is to provide the reader an overview of What the passenger car transmission was, is, and may be, as well as How and Why it got to be, or rather, is going to be. Equally important, it was written to give due credit to the contributions of so many engineers and innovators who worked with such dedication to their profession and their industry. While many of them go unnamed, recognition of their work, put in the context of their times, would be considered by them to be more than appropriate acknowledgement of their efforts.

While focusing on the transmission, the book also provides an insight into the forces at work behind the scenes. The industry is alive with innovation and ideas. It takes market demand and, in some cases, government regulation to pull those ideas into production. To study the history of a major vehicle component is to study the history of the industry as a whole. By studying those factors which brought transmission innovations from the research bench to the marketplace, the book provides some insight and appeciation for what it takes to commercialize technical innovations.

Many transmissions have been described, and some have been omitted. The transmissions discussed are those which are novel, interesting or instructive, as well as those which have a direct lineage to the modern automatic transmission. To go into full detail on almost any one of them would require a book on each unit equal or greater in size to this volume. If this book whets the appetite of the serious engineering student and also provides an interested reader an appreciation for the mechanical, hydraulic, electric and electronic marvels so often taken for granted, then the scope and content are appropriate. Many references are provided which identify the public sources of information about each transmission. The reader who is interested in greater technical detail is encouraged to pursue these references for further information.

Northborough, Massachusetts June 12, 1990

Acknowledgements

This book is the result of the collective efforts of a great many individuals and companies. It isn't really possible to appropriately thank many of the contributors, nor would they think it necessary. Knowing and unknowing assistance was given by many purely for the love of the subject, the desire to document what has been done in order that future engineers and others are able to learn not only What was done, but How and Why.

A great deal of thanks must be given to the many authors of technical papers and articles in the automotive press and the companies who supported the writing and publication of those documents. Without the rich heritage of technical papers, much of the content of this book would have been impossible to put together. The early authors and transmission pioneers have long since departed our company. Their technical publications are the only direct link we have with much of their work. The surviving examples of the transmissions which made it into production tell us only What was done. Without the written word to help us understand, the How and the Why would be left entirely to our own speculation. Indeed, the production units are only the tip of the iceberg. The many successful designs which were left on the workbench due to lack of funds or poor timing are true testimony to the innovative minds of early engineers. The technical publications are the only evidence we have of those important branches of the automatic transmission's family tree.

I am no less indebted to the many individuals who broke into their busy schedules to help. Some, like General Motors' George R. Smith (now retired), spent almost their entire careers with the automatic transmission and worked long and hard to assist me. The history and lore resident within their memories can never be completely captured, yet the industry is indebted to them for both their technical prowess as well as their enthusiasm to humbly share what they know so that others may know What, How, Why and Who. Many others spent considerable time to help me piece together the stories behind the development of the transmission. Berthold Martin at Chrysler has been researching and preserving the history of the transmission long before this book was ever conceived, and

I am thankful to him for his willingness to share information with me. The hours spent by Hydra-matic staff providing reviews of the drafts are no less important and appreciated.

Beyond the confines of the manufacturers, the transmission community remains rich with innovators. Some have been supportive within the sphere of their own developments. Others have opened their offices to me in order to add strength, depth and breadth to this document. Of those individuals I would particularly like to express my appreciation to Yves Kemper for his willingness to share his historical industry-wide files on transmissions in general.

At the risk of forgetting others who offered freely of their time, I would like to acknowledge, in no particular order, the assistance provided by Jason P. March, Michael Shaw, Wayne Higashi, Bruce Stapleton, Evan Jones, George Hanley, Martin Gabriel, James Wood, Theodore Craver, Paul Lewis, Edward Clary, Lyle Cummins, Leo Steinl, Keith Wickes, Roy Ellis, James Gathercole, Darrel Sand, Christopher Nowak, Carl Shellman, James Wagner, Jim Savoyard, Jr., Richard Smirl, and Irving Hallberg.

The idea for this book dates back to approximately 1975. Ralph Colello, then a Contract Technical Monitor for the Transportation Systems Center, was faced with providing Congress technically realistic fuel economy performance figures on which to base Corporate Average Fuel Economy (CAFE) regulations. He and his associates recognized the important role a transmission could make in reducing the fuel consumption of a passenger car. They contracted with Arthur D. Little, Inc. to demonstrate the sort of fuel economy benefits which might be obtainable through the use of readily available alternative transmission technology. In addition, Colello wanted to know Why then-current transmissions were designed as they were, and How they came to be. As part of that contract, he requested a documentation of a History of the Automatic Transmission. Focused as it was on the then-current automatic, that history followed a more or less direct line from the early attempts to those transmissions produced in the U.S. during the 1970s. That effort forms the backbone of this book, although the amount of information contained in the following pages more than trebles that of the first work. I was one of the authors of that prior attempt, and wish to acknowledge the contributions of the other authors: Carl Gottesman and Michael Martin.

Donald Hurter, Manager of the Automotive Technology Unit at A. D. Little, was project manager of that activity.

This project could not have been accomplished with so little pain without the support of the staff at SAE. They worked long and hard to wring out all of the technical papers dating back to 1905. The archives yielded many invaluable documents from all eras. These would not have been uncovered without their help. Neither would the publication of this manuscript be possible without their facilities, untiring efforts and support. Thank you, one and all.

And finally, I wish to thank my wife, Joanna, for her help and understanding. Her support of this project made this book possible. Without her patient assistance and guidance in the manipulation of the Macintosh, I would not have been able to accomplish any of this so easily.

Northborough, Massachusetts Philip Gott

Table of Contents

Chapter 1

Introduction

In the years before World War I, all the power-carrying mechanism between the engine and the wheels was included in the term "transmission." It was all of this mechanism, after all, that *transmitted* power from the engine to the wheels. Gradually, the change-gear and final drive mechanisms became separate, distinct entities. Indeed, many of them were produced by different manufacturers. The term transmission became limited to the ratio-changing mechanism. The clutch and final drive systems were considered separate components. It is the more modern, limited definition of transmission which is used throughout this book.

Why is a Transmission Needed?

It was recognized early in the development of the motor car that, unlike the steam or electric power plants of the day, a gasoline engine of reasonable size and weight, directly coupled to the driven wheels, could not deliver the range of speed and power required of the passenger car. Starting from a rest position, a car has an infinite range of speed and torque requirements. Most internal combustion engines of the day had practical and usable speed ranges of only two or three to one and could not simultaneously start both themselves and the car into motion from rest. In addition, early engineers recognized that the vehicle usually demanded the greatest torque at the driving wheels when starting from rest (zero wheel speed). The engine, on the other hand, produced its maximum torque at relatively high speeds. In addition, a very large engine capable of delivering the starting torque without a transmission