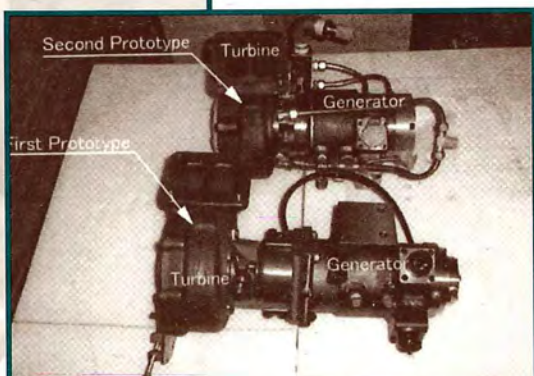
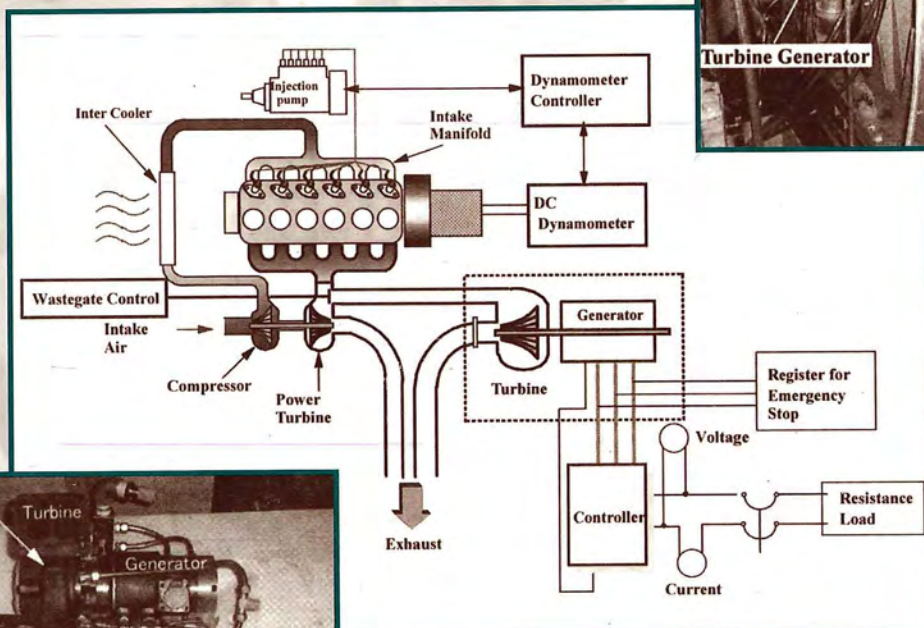
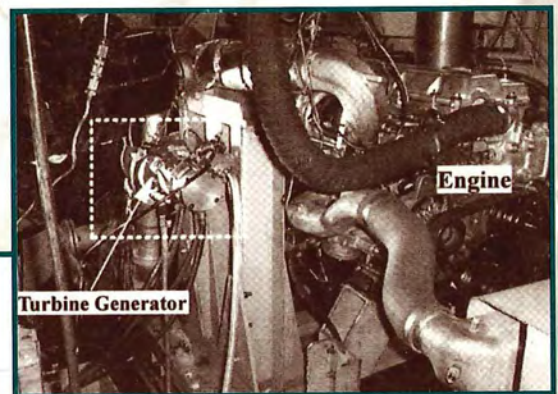


# Technology for Electric and Hybrid Vehicles



... SAE SP-1331 ...

# Technology for Electric and Hybrid Vehicles

SP-1331



**GLOBAL MOBILITY** DATABASE

*All SAE papers, standards, and selected books are abstracted and indexed in the Global Mobility Database*

Published by:  
Society of Automotive Engineers, Inc.  
400 Commonwealth Drive  
Warrendale, PA 15096-0001  
USA

Permission to photocopy for internal or personal use of specific clients, is granted by SAE for libraries and other users registered with the Copyright Clearance Center (CCC), provided that the base fee of \$7.00 per article is paid directly to CCC, 222 Rosewood Drive, Danvers, MA 01923. Special requests should be addressed to the SAE Publications Group. 0-7680-0151-X/98\$7.00.

Any part of this publication authored solely by one or more U.S. Government employees in the course of their employment is considered to be in the public domain, and is not subject to this copyright.

No part of this publication may be reproduced in any form, in an electronic retrieval system or otherwise, without the prior written permission of the publisher.

ISBN 0-7680-0151-X

SAE/SP-98/1331

Library of Congress Catalog Card Number: 97-81283

Copyright © 1998 Society of Automotive Engineers, Inc.

Positions and opinions advanced in this paper are those of the author(s) and not necessarily those of SAE. The author is solely responsible for the content of the paper. A process is available by which the discussions will be printed with the paper if it is published in SAE Transactions. For permission to publish this paper in full or in part, contact the SAE Publications Group.

Persons wishing to submit papers to be considered for presentation or publication through SAE should send the manuscript or a 300 word abstract to: Secretary, Engineering Meetings Board, SAE.

Printed in USA

## PREFACE

This Special Publication, Technology for Electric and Hybrid Vehicles (SP-1331), is a collection of papers from the "Electric Vehicle Technology" and "Engines and Fuel Technology for Hybrid Vehicles" sessions of the 1998 SAE International Congress and Exposition.

Hybrid vehicles are now a reality in Japan, and they could soon be coming to the United States. The heart of the Toyota Prius hybrid vehicle is its fuel-efficient engine and unique transmission, coupled with a limited-range battery. The hybrid vehicle's advantage is its ability to run the engine at its "sweet spot" to minimize emissions of criteria pollutants or minimize energy consumption and CO2 production, depending on the control strategy. The key technical measure of success for a hybrid vehicle is a well designed engine--electrical-battery system that is matched to the load demand.

The papers from the "Engines and Fuel Technology for Hybrid Vehicles" session focus on leading-edge engine design, engine management, and fuel strategies for low emission, high mileage hybrid cars and commercial vehicles.

The papers from the "Electric Vehicle Technology" session focus on hybrid vehicle control technology, energy storage, and management for hybrid vehicles and simulation development.

**Bradford Bates**  
Ford Research Laboratory

**Frank Stodolsky**  
Argonne National Laboratory

Session Organizers

# TABLE OF CONTENTS

980890	<b>An Algorithm of Optimum Torque Control for Hybrid Vehicle .....</b> 1 Yoshishige Ohyama Hitachi Car Engineering Co., Ltd.
980891	<b>Energy Regeneration of Heavy Duty Diesel Powered Vehicles .....</b> 11 Matsuo Odaka and Noriyuki Koike Ministry of Transport, Japan Yoshito Hijikata and Toshihide Miyajima Hino Motors, Ltd.
981122	<b>Development of the Hybrid/Battery ECU for the Toyota Hybrid System.....</b> 19 Akira Nagasaka, Mitsuhiro Nada, Hidetsugu Hamada, Shu Hiramatsu, and Yoshiaki Kikuchi Toyota Motor Corporation Hidetoshi Kato Denso Corporation
981124	<b>Hybrid Power Unit Development for FIAT MULTIPLA Vehicle .....</b> 29 Caraceni and G. Cipolla ELASIS ScPA – Motori R. Barbiero FIAT AUTO –VAMIA
981125	<b>The Development of a Simulation Software Tool for Evaluating Advanced Powertrain Solutions and New Technology Vehicles.....</b> 37 Jaimie Swann and Andy Green Motor Industry Research Association (MIRA)
981126	<b>Styling for a Small Electric City Car.....</b> 43 T. G. Chondros, S. D. Panteliou, S. Pipano, and D. Vergos, P. A. Dimarogonas and D. V. Spanos University of Patras, Greece A.D. Dimarogonas Washington University in St. Louis, Mo.
981127	<b>Patents and Alternatively Powered Vehicles .....</b> 53 Rob Adams Derwent Information
981128	<b>An Electric Vehicle with Racing Speeds .....</b> 59 Edward Heil, Colin Jordan, Karim J. Nasr and Keith M. Plagens, Massoud Tavakoli, Mark Thompson and Jeffrey T. Wolak GMI Engineering & Management Institute

# Explore Litigation Insights

Docket Alarm provides insights to develop a more informed litigation strategy and the peace of mind of knowing you're on top of things.

## Real-Time Litigation Alerts



Keep your litigation team up-to-date with **real-time alerts** and advanced team management tools built for the enterprise, all while greatly reducing PACER spend.

Our comprehensive service means we can handle Federal, State, and Administrative courts across the country.

## Advanced Docket Research



With over 230 million records, Docket Alarm's cloud-native docket research platform finds what other services can't. Coverage includes Federal, State, plus PTAB, TTAB, ITC and NLRB decisions, all in one place.

Identify arguments that have been successful in the past with full text, pinpoint searching. Link to case law cited within any court document via Fastcase.

## Analytics At Your Fingertips



Learn what happened the last time a particular judge, opposing counsel or company faced cases similar to yours.

Advanced out-of-the-box PTAB and TTAB analytics are always at your fingertips.

## API

Docket Alarm offers a powerful API (application programming interface) to developers that want to integrate case filings into their apps.

## LAW FIRMS

Build custom dashboards for your attorneys and clients with live data direct from the court.

Automate many repetitive legal tasks like conflict checks, document management, and marketing.

## FINANCIAL INSTITUTIONS

Litigation and bankruptcy checks for companies and debtors.

## E-DISCOVERY AND LEGAL VENDORS

Sync your system to PACER to automate legal marketing.