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TABLE OF CONTENTS

Papers 720447-720743

| | | |
|--------|---|------|
| 720447 | An Investigation of Thermal Conditions Leading to Surface Rupture of Cast Iron Rotors—Rudolf Limpert | 1507 |
| 720450 | Radioisotope Reveals Behavior of Lubricants in Two-Stroke Cycle Engines—Takashi Kohayakawa, Yoshimi Hirai, Tsugio Ogawa, and Eizi Suzuki | 1521 |
| 720451 | A Screening Tool for Outboard Motor Fuels and Lubricants—W. R. Pyle | 1530 |
| 720454 | Transient Engine Testing by Computer Control—J. F. Cassidy, Jr., and J. H. Rillings | 1550 |
| 720455 | A Comparison of Dynamic Exhaust Emissions Tests: Chassis Dynamometer versus Engine Dynamometer—J. F. Cassidy, Jr. | 1562 |
| 720462 | Professional Ethics and Environmental Technology—M. R. J. Wyllie | 1569 |
| 720466 | Improvements of the Rotary Engine with a Charge Cooled Rotor—Kojiro Yamaoka and Hiroshi Tado | 1575 |
| 720469 | Specialized Road Surfaces for Traction Test Purposes—C. V. Allen and F. D. Smithson | 1594 |
| 720471 | Testing and Analysis of Tire Hydroplaning—R. W. Yeager and J. L. Tuttle | 1601 |
| 720473 | A New Laboratory Facility for Measuring Vehicle Parameters Affecting Understeer and Brake Steer—A. L. Nedley and W. J. Wilson | 1612 |
| 720479 | Status Report on HC/CO Oxidation Catalysts for Exhaust Emission Control—P. W. Snyder, W. A. Stover, and H. G. Lassen | 1631 |
| 720480 | NO _x Reduction Catalysts for Vehicle Emission Control—G. H. Meguerian, F. W. Rakowsky, E. H. Hirschberg, C. R. Lang, and D. N. Schock | 1642 |
| 720481 | Methods for Fast Catalytic System Warm-Up During Vehicle Cold Starts—W. E. Bernhardt and E. Hoffman | 1654 |
| 720484 | Economical Matching of the Thermal Reactor to Small Engine-Low Emission Concept Vehicles—H. Kuroda, Y. Nakajima, Y. Hayashi, and K. Sugihara | 1668 |
| 720490 | Metal Foams as Energy Absorbers for Automobile Bumpers—L. M. Niebylski and R. J. Fanning | 1676 |
| 720494 | Development and Analysis of Door Side-Impact Reinforcements—John S. Haynes | 1683 |
| 720496 | Crash Data Analysis—G. G. Lim | 1690 |
| 720501 | Automotive Lamp Outage Detection—F. J. Scharf | 1698 |
| 720503 | Interior Window Fogging—An Analysis of the Parameters Involved—Alexander R. Peters | 1720 |
| 720510 | A Systems Approach to Vehicle Emission Control—E. N. Cantwell, R. A. Hoffman, I. T. Rosenlund, and S. W. Ross | 1732 |
| 720511 | Field Test of an Exhaust Gas Recirculation System for the Control of Automotive Oxides of Nitrogen—John C. Chipman, John Y. Chao, Ray M. Ingels, Roy G. Jewell, and Wendell F. Deeter | 1751 |
| 720514 | Designing Clad Metals for Corrosion Control—Robert Baboian | 1763 |
| 720515 | Aluminum Striped Stainless Trim for Prevention of Auto Body Galvanic Corrosion—Jack M. Beigay and Donald R. Zaremski | 1772 |
| 720520 | Analytical Evaluation of a Catalytic Converter System—John L. Harned | 1781 |
| 720531 | Air Freight Pays Off in Profits—L. D. Richardson | 1816 |
| 720532 | The Day's News Goes to Market on Night Flights—Edward F. McDougal | 1824 |
| 720533 | Handling Intermodal and Interline Containers—Gregory V. Schultz | 1827 |
| 720537 | Removing Roadblocks from International Customs Clearance—John B. O'Loughlin | 1836 |
| 720553 | The Development of Personal Rapid Transit—Albert J. Sobey | 1841 |

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|--|------|
| 720579 Flexible Wings for Transportation—Francis M. Rogallo, Harned | 1781 |
| 720531 Air Freight Pays Off in Profits—L. D. Richardson | 1816 |
| 720532 The Day's News Goes to Market on Night Flights—Edward F. McDougal | 1824 |
| 720533 Handling Intermodal and Interline Containers—Gregory V. Schultz | 1827 |
| 720537 Removing Roadblocks from International Customs Clearance—John B. O'Loughlin | 1836 |
| 720553 The Development of Personal Rapid Transit—Albert J. Sobey | 1841 |
| 720579 Flexible Wings for Transportation—Francis M. Rogallo, Delwin R. Croom, and William C. Sleeman, Jr. | 1874 |
| 720581 Civil Applications of the Air Cushion Landing System—David H. Grupe | 1885 |
| 720598 The Development of Propulsion Systems for Air Transport—Harry Pearson | 1891 |
| 720610 The Impact of Aircraft Emissions Upon Air Quality—Melvin Platt and E. Karl Bastress | 1902 |
| 720611 Monitoring and Modeling of Airport Air Pollution—D. M. Rote, I. T. Wang, L. Wangen, J. Pratapas, Lois Leffler, and Glen Cato | 1912 |
| 720621 Aircraft Noise and the Airlines—William B. Becker | 1936 |
| 720627 Consideration of Environmental Noise Effects in Transportation Planning by Governmental Entities—Louis H. Mayo | 1941 |
| 720630 Ecologic Ramifications of Air Pollution—Harvey Babich and Guenther Stotzky | 1955 |
| 720636 Origins of Diesel Truck Noise and Its Control—P. E. Waters and T. Priede | 1972 |
| 720669 Selection Models—Small Truck Fleets—J. C. Selby | 1993 |
| 720670 The Boston Reformed Fuel Car—Marc S. Newkirk and James L. Abel | 2006 |
| 720677 Guidance of Vehicles by Telecommand in Order to Simulate Accidents—Harald J. Schimkat, Erich W. Unterreiner, and Rüdiger W. Will | 2015 |
| 720686 Interactions Among Oil Additive and Engine Operating Parameters Affecting Engine Deposits and Wear—Loren G. Pless | 2025 |
| 720689 Unleaded Gasoline—Lubricant Requirements and Fuel Additive Performance—D. S. Orrin, W. R. Miner, and K. L. Kipp | 2040 |
| 720691 New Choice in Excavating with a Hydraulic Digger—Charles L. Fleming and Alan S. McClimon | 2056 |
| 720692 Engine Performance and Exhaust Emissions: Methanol versus Isooctane—G. D. Ebersole and F. S. Manning | 2076 |
| 720693 Exhaust Emissions from a Methanol-Fueled Automobile—H. G. Adelman, D. G. Andrews, and R. S. Devoto | 2096 |
| 720707 On the Noise Reduction of a Rectangular Box with Application to Tractor Cabs—M. G. Milsted and E. L. Wegs- cheid | 2112 |
| 720708 Torque Sensing Variable Speed V-Belt Drive—Larry R. Oliver and Dewey D. Henderson | 2130 |
| 720710 Driveline Torque Coupling for Tractor Draft Control—C. E. McKeon | 2138 |
| 720719 Sound Level Tests of Agricultural Tractors—W. E. Splinter, M. L. Mumgaard, G. W. Steinbruegge, and L. F. Larsen | 2147 |
| 720724 Characteristics of Multiple Range Hydromechanical Transmissions—Eli Orshansky and William E. Weseloh | 2153 |
| 720728 Approaches to Design of Low-Emission Gas Turbine Combustion Chambers—Donald M. Dix and E. Karl Bastress .. | 2166 |
| 720731 Determining Critical Whirl Speeds for Outboard Motor Crankshaft Flywheel Assembly—Robert T. Larsen and Arthur Sorenson, Jr. | 2186 |
| 720739 New Bearing Concepts for Gas Turbines—Elie B. Arwas, John M. McGrew, and Leo W. Winn | 2203 |
| 720740 Low-Cost Fluid Film Bearings for Gas Turbine Engines—J. M. Ross | 2222 |
| 720743 Traction and Flotation Characteristics of Earthmover Tires on Soft Soil—Masatoshi Satake and Tsuneo Mukai | 2242 |

Methods for Fast Catalytic System Warm-Up During Vehicle Cold Starts

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TO ACHIEVE the emission targets prescribed by law for 1975-1976 a number of emission concepts with conventional internal combustion engines and emission control systems have been examined by the automotive industry. Catalytic converters, thermal reactors, and a combination of these two have been considered as emission control systems (1)*. Low emission values have been attained with these concepts when the engine is under warm working condition. However, the difficulties lie mainly in the warmup phase during cold vehicle startup.

To improve the overall effectiveness of catalytic systems at vehicle startup, extensive experimental tests were carried out during the warmup phase on various afterburning systems by the Research Department of the Volkswagenwerk AG. The intent of this paper is to illustrate the utility of improving the

*Numbers in parentheses designate References at end of paper.

warmup characteristic of catalytic emission-control systems for achieving very low emission levels.

WARMUP METHODS FOR CATALYTIC SYSTEMS

Catalytic emission-control systems described in this paper operate mainly with the dual-bed catalytic process. The first bed contains the reduction catalyst which reduces the oxides of nitrogen (NO_x) by carbon monoxide (CO), hydrogen (H_2), and hydrocarbons (HC) which are present in the exhaust gases. The reaction between NO_x and CO will only take place providing that the amount of oxygen (O_2) present in the exhaust gas is strictly limited to low concentrations. This oxygen limitation is met by adjusting rich fuel/air-mixtures.

The second catalyst bed contains the oxidation catalyst which burns the CO and HC after introducing secondary air between the first and second beds. The quantity of second-

ABSTRACT

Catalytic exhaust-control systems must be designed to operate at high efficiency almost from the moment of engine startup. Catalysts must reach their operating temperature as quickly as possible. Therefore, the utility of different methods for improving the warmup characteristics of catalytic systems is illustrated.

A very elegant method to speed the warmup is the use of the engine itself as a "preheater" for the catalytic converters. High exhaust gas enthalpy to raise exhaust system mass up to its operating temperature is obtained by the use of extreme spark retard, stoichiometric mixtures, and fully opened

throttle. Intensive studies to investigate the effects of concurrent changes of spark timing and air/fuel mixtures on exhaust gas temperature, enthalpy, NO_x and HC emissions are discussed.

Finally, NO_x catalyst characteristics are dealt with, because the NO_x catalyst is the first in a dual-bed catalytic system. The NO_x catalyst should have high activity, low-ignition temperature, and good warmup performance. If the NO_x catalyst has a fast warmup rate, this would result even in a significant improvement in the warmup characteristic of the HC/CO bed.

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