Checking out welds between the barrels are, from left, John F. Nixon, Engineer of Research, Texas Highway Department; T. J. Hirsch, Research Engineer, Texas Transportation Institute; and Eugene L. Marquis, Assistant Research Engineer, Texas Transportation Institute. The three men co-authored the paper given at the 53rd Annual Meeting of HRB.

Walter C. Jones, District Equipment Supervisor for District 17 of the Texas Highway Department, explains the trailer's five-point hitch system to District Engineer Joe Hanover (right) and Assistant District Engineer Carrol Zigler.

- Protection of maintenance workers and motorists at detour locations, where the crash cushion trailer could be stationed beyond the detour sign on a temporary basis;
- Protection of workers performing routine maintenance on traffic lanes or shoulders--as in mowing, guardrail repair, chuckhole filling, or trash collection; and
- Protection during maintenance operations in traffic, as for lane-striping, placement of pavement "buttons," etc.

The authors note that a crash trailer for local street operations can be much smaller than that needed on highways where greater vehicle speeds prevail.

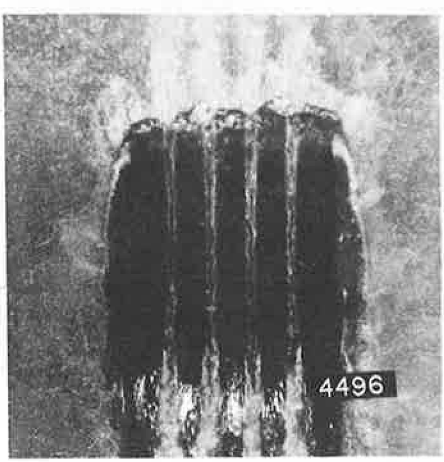
Symposium on Tire-Pavement Interaction Explores Skid Resistance, Tread Design

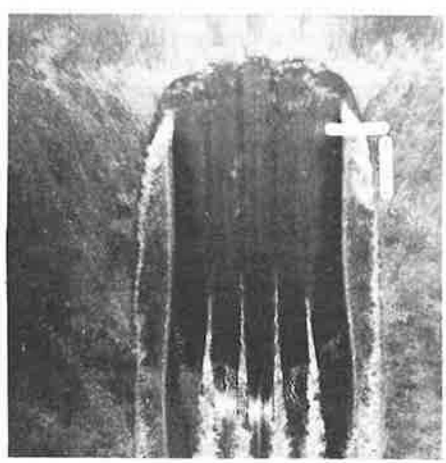
The 17th General Motors Research Symposium, the Physics of Tire Traction: Theory and Experiment, was held at the GM Research Laboratories in Warren, Michigan, October 8-9, 1973. Adrian G. Clary, Lawrence F. Spaine, and Harry R. Smith of the HRB staff were among the 172 people from 13 countries invited to attend and participate in the meeting. A total of 15 formal papers plus several panel discussions reviewed the role of the tire, the role of the pavement, and the complex nature of their interaction with other factors, such as contaminants and weather, to affect tire-pavement traction.

An overall impression from the meeting is that the tire-pavement traction problem is far from being resolved. Much research effort has gone into studies on the fundamental aspects of rubber friction, and information was presented during the meeting on the more practical influence of tread rubber compounds and tread design on tire performance under a variety of climatic and pavement surface conditions. Although tire construction and tire wear also influence performance, research and experience have shown that braking performance can be reasonably predicted from currently available types of tire and pavement data. However, the tire-pavement cornering problem is much more difficult, and both fundamental and empirical information is needed to optimize tire-pavement traction systems from the standpoint of improved performance and safety at least cost to the general public. For a large percentage of the paved mileage of highways in the United States, the passing maneuver, involving combinations of cornering and acceleration, results in the greatest demand on tire-pavement traction. If substantial reduction of wet-weather skidding accidents is a high-priority national goal, changes in tread rubber composition and minimum tread depth requirements might be a more practical and less costly approach than the resurfacing of highways to improve their skid resistance.

The first session of the symposium focused on a general description of the tire traction phenomenon, including requirements for good performance in operating environments such as dry, wet, or snow-covered pavements. The first two papers of the session dealt with wet-pavement traction and hydroplaning. They presented data emphasizing the influence of water depth, speed, and pavement texture on tire performance. Due to the interaction of these and other factors, the nature of the problem of rating or ranking tire performance is very complex. Operational severity and ultimate performance rating concepts were described as tools to provide a qualitative evaluation of the roles that the many factors play in tire traction, leading to an average ranking of a tire under a variety of wet-traction conditions.

An extensive study by a U.S. tire manufacturer was reviewed in a paper on tire hydroplaning. The water film action between the surface and tire was photographed from below by driving and/or pulling a locked tire over a glass plate.





Hydroplaning action is graphically illustrated in two photographs used by R. W. Yeager, Goodyear Tire and Rubber Company. In the left photograph, the tread pattern on a tire traveling at moderate speeds allows the water on the pavement to flow freely among the grooves, while the tire on the right is locked in a skidding configuration at high speed, squeezing the treads together and preventing the water from draining properly.

The results were correlated with vehicle stopping performance on specially developed surfaces with controlled water depth. Data from these studies offer insight into the tire hydroplaning phenomenon. The photographs clearly reveal the action of the tread elements during expelling of water from the interface and should provide useful information to improve the tread design. A paper on the subject of tire traction on snow-covered pavements addressed itself to the lack of reliable test data and a basic understanding of the problem. A general theory of snow traction was presented based on conjectures about the mechanism involved, and snow-traction research needs were discussed. The work described in the paper will be quite helpful during the conduct of NCHRP Project 1-16, "Evaluation of Winter-Driving Traction Aids," which as a first step will select methods and develop criteria for effectively evaluating traction aids with regard to vehicle performance and pavement surface conditions.

Fundamental aspects of rubber friction were reviewed in the second session, with considerable differences of opinion on the matter of the relative importance of adhesion and hysteresis in explaining tire traction. From a practical standpoint, there appears to be a substantial gap between the academic understanding of rubber-solid interaction and the ability to predict tire traction on pavement surfaces.

The third session focused on the contribution of the tire to the traction phenomenon. The wet skid resistance of a tread compound is determined primarily by its hardness and hysteresis. Improvements in skid resistance are usually made with a concurrent loss in wear resistance. One participant presented information indicating that wet-pavement traction is influenced by tire tread compound by a factor of less than two to one from best to worst, whereas such factors as speed, water depth, pavement surface characteristics, and tire tread influence wet-pavement traction by as much as a factor of 10.

Another important aspect of tire-pavement traction is the tire tread pattern. From comparison of wet traction tests for performance conditions such as 60 mph during moderate rain, it is apparent that many commonly used tread patterns are quite ineffective in spite of their complex appearance. The multiplicity of tread designs indicates a lack of agreement on the best approach to attainment of good wet-pavement traction. Several approaches to effective tread design were offered during the meeting. It is hoped that they are the beginning of a concerted effort in this field.

Although not the subject of a formal paper, the proliferation in tire sizes and types of construction is being questioned, and measures aimed at standardization are likely to occur. It is important that the influence of size and type of construction on tire-pavement traction, particularly during the cornering mode, be explored so that the most desirable choices will be made.

The role of the pavement surface in tire-pavement traction was the subject of the final symposium session. A pavement surface texture classification method based on the concept of a geometric structure consisting of six parameters—height, width, angularity, distribution, harshness of particles, and harshness of binder—was reviewed. Photo-interpretation of pavement surface texture, using the six parameters, is used to predict skid resistance. This method, developed and used successfully in Canada, is helpful in the design as well as surveillance of pavement surfaces.

A theoretical approach to optimizing tire-pavement traction, noise generation, and tire wear, developed and undergoing field testing in England, could be a significant influence on pavement design and construction in the future. The macro-texture of pavements is required to dissipate bulk water with minimum spray but also contributes to noise generation and tire wear. Pavement micro-texture is essential for the large area of contact with the tread rubber that contributes to traction when the surface is dry and at low speeds when wet.

Participating in the third session on "Tire Traction: The Role of the Tire" are, from left: H. B. Pacejka, Delft University of Technology; S. K. Clark, University of Michigan; R. N. Kienle, Uniroyal, Inc.; and R. F. Peterson, Uniroyal, Inc.

Symposium co-chairman Dr. A. L. Browne, General Motors Research Laboratories, speaks on "Tire Traction on Snow-Covered Pavements."

The concept of micro-texture and macro-texture optimization has been applied to a new wearing course mix design being field-tested in England.

The papers and discussions at the symposium indicate that theoretical and experimental research has provided sufficient insight into wet pavement-tire traction to provide a basis for altering traction-speed curves by modifications in the pavement and tire parameters. Unfortunately, modifications that increase traction performance under conditions of high operational severity may result in a decrease in traction at low operational severity as well as increased tire noise and wear. The critical need at this point seems to be for overall system optimization.

This article was prepared by H. A. Smith, Projects Engineer, NCHRP, from materials presented during the symposium, including a summary by Dr. A. L. Browne of the G. M. Research Laboratories. The symposium proceedings are being prepared by the G. M. staff and will be available July 1 by contacting Plenum Press, 227 West 17th Street, New York, N.Y. 10011.