Relationship of Vehicle Dynamics to Skidding

Report of Subcommittee on Relationship of Vehicle Dynamics to Skidding to the First International Skid Prevention Conference, September 8-12, 1958

● THIS PORTION of the program consisted of the following papers:

"The Fundamentals of Braking—Heat Capacity and Control," J. George Oetzel, Vice President—Engineering Research, Warner Electric Brake and Clutch Company.

"Traction and Braking Characteristics of Vehicles," W. A. McConnell, Executive Technical Assistant—Vehicles Testing, Ford Motor Company—Engineering Staff.

"Vehicle Road Stability as Related to Suspension Geometry," R. T. Jarman, Project Engineer, Suspension Laboratory, Chrysler Corporation.

"The Dynamics of Vehicle Skid Deviation as Caused by Road Conditions," Dr. William Zuk, Highway Research Engineer, Virginia Council of Highway Investigation and Research and Associate Professor of Civil Engineering, University of Virginia.

"Experiments with a Device to Prevent Wheel Locking During Braking," R. D. Lister and R. N. Kemp, Vehicle Section, Traffic and Safety Division, British Road Research Laboratory.

INVENTORY OF WHAT WE KNOW

Brake Development

The fundamentals of brake systems are treated comprehensively and clearly in the paper "Fundamentals of Braking—Heat Capacity and Control," by J. George Oetzel. This paper lists the primary problems confronting the brake development engineer, and the paper and the appendices cover a great deal of engineering data on the braking problem and braking systems.

Included as a part of this report is an extensive bibliography on the general subject of vehicle braking which has been prepared by the subcommittee.

The student of the literature is well aware of the numerous problems which still confront the brake engineer in spite of the vast research over more than 50 years. While many problems still remain, it is to be noted that with proper maintenance the performance of modern braking systems on automotive vehicles is reliable and predictable.

Theory of Car Control and Stability

During the past five years, an extensive research project at the Cornell Aeronautical Laboratories [1] has resulted in a partial understanding, at least, of control and stability problems of the automobile. In essence, in the earliest stages, this work adapted the analysis of aircraft stability and control to the automotive problems, developed a tentative theory, and evaluated this theory by careful experimentation. Mr. Jarman summarized a part of this work in his paper. Progress is still continuing in this area.

Dr. Zuk contributed an application of dynamic theory to the treatment of certain perturbations.

Tire-Brake Behavior

Many of the problems of vehicle dynamics related to the skidding problem are associated with tire-brake behavior. For this reason, many aspects of tire behavior related to the dynamics of the tire-road system are studied by automotive engineers

[1] "Research in Automobile Stability and Control and in Tire Performance." Five papers by W. F. Milliken and D. W. Whitcomb; Leonard Segel; W. Close and C. L. Muzzey; A. G. Fonda; D. W. Whitcomb and W. F. Milliken. Presented at a General Meeting of the Automobile Division, the Institution of Mechanical Engineers, in London, November 13, 1956.

so that the dynamics of the vehicle may be understood better. The paper by Mr. McConnell presented at this Conference, "Traction and Braking Characteristics of Vehicles," includes such data; significant is the demonstration that the static friction between the tires and the road surface is never reestablished on a rolling tire. From this, he concludes that the maximum benefit which can be derived from an anti-skid device is to regain most of the frictional reaction which is lost at high skidding speeds. Lister and Kemp, in their paper also presented at this Conference, "Experiments with a Device to Prevent Wheel Locking During Braking," give a very interesting study of experiments with such a device. The bibliographies of these papers, particularly McConnell's, include the significant references in this field.

GAPS IN OUR KNOWLEDGE

Tire Efficiencies

Tire efficiencies are reasonably well established under normal conditions in the transmission of braking, driving, and steering forces and combinations thereof, but little is known about efficiencies under extreme conditions of steering and braking. Since these are the conditions of particular interest to this Conference, the deficiency in knowledge must be regarded as a gap.

Effect of Unbalanced Braking on Skidding

There are data on the effect of unbalanced braking, front and rear, on skidding of a vehicle, but little data have been shown on the effect of unbalance in braking on the right and left sides.

Dynamic Behavior of Suspension Systems on Brake Balance

Little is known about the dynamic behavior of suspension systems with regard to changes in brake balance, and the resulting influence on skidding.

Differential Design

Little data are available on the influence of differential design on skidding. As an example, there are few quantitative measurements on record of the effect of the general class of locked differentials and on the variations of locking design.

METHODS OF FILLING THE GAP

Research

It is almost redundant to say that the only method of obtaining data which we do not now possess is through continued research.

1. The bibliographies associated with the papers presented on this program and prepared by the subcommittee are testimonial of the duration, scope, and depth of the research in this area. A reference to these bibliographies makes it clear that there are thousands of engineers and scientists engaged currently in such research, principally because of the pressures of industrial competition.

This research has been under way for some years. It is continuing with increasing emphasis, and it is inevitable that valuable results will be derived.

2. The Winter Driving Hazards Committee of the National Safety Council has a history of more than 20 years of significant achievement in evaluating and describing the hazards of operation on roads made slippery by snow and ice. During this period, they have made critical evaluations of innumerable traction devices with respect to standard equipment, and it is suggested that this unbiased group might make immediate studies to measure the effect of unbalanced right and left braking and of differential design on skidding.

Exchange of Information

It is recognized everywhere that the exchange of information through technical societies and through such conferences as the International Skid Prevention Conference add to the rate at which new knowledge is developed. We are confident that a most effective method of filling the gaps in our knowledge of this problem will be the interchange of information in scientific conferences. Here each of a group may add one of a series of related facts, so that when many of the pieces are in place, the remainder may be inferred.

Continued Development of Anti-Skid Devices

This Conference has seen some interesting results with anti-skid devices, and at least the elements of a discussion of their limitations.

We are led to believe, from the data presented by McConnell, that the ultimate in an anti-skid device would be to restore a reaction between the tire and the road, equivalent, for example, to a 5-mph sliding speed. It has been shown many times that the coefficient of friction decreases with sliding speed; according to this presentation, we might hope to reestablish as the ultimate the sliding coefficient prevailing at 5 mph sliding speed to the case of a vehicle going an actual speed of 60 mph, for example. It is also implied that of the total reaction between the tire and the road, part can be used for stopping and part for steering. In the experiment described by Lister and Kemp, we are given some quantitative measurements of relative stopping ability of a vehicle with an anti-skid device, and a demonstration, but not quantitative measurements, of the degree of steering control available simultaneously; it seems evident that continued development of these devices is essential to determine the practical maximum capabilities in simultaneous stopping and steering.

Control Systems

Vehicle control systems have developed through the years on a practical basis, and it is believed that they have evolved to the point where they are generally satisfactory to the majority of people. However, the effectiveness of control systems is determined currently by popular vote rather than by scientific evaluation. It is our hope that the application of the methods of experimental psychology will promote the development of control systems more effective with regard to both precision and driver response.

For the Subcommittee
by K. A. Stonex, Chairman

Appendix

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