DISCUSSION OF REPORT OF COMMITTEE ON ECONOMIC THEORY OF HIGHWAY IMPROVEMENT

Opened by W L HOLT AND P L WORMELEY

U S Bureau of Standards, Washington, D C

The Wear Investigation, State College of Washington—1 In reading the paper it does not seem to be clear in all cases whether the author refers to the wear of the tread or the deterioration of the tire as a whole—two quite distinct points

2 The Bureau has no information as to the effect of temperature on the abrasive resistance of tread rubbers, but the fact that high temperatures have a deteriorating action is well established, which temperatures affect the tire internally as much or more than externally Based on the Bureau's work and observations the increase in tire costs during the summer months to which the author refers, is probably due largely to the deterioration of the tire as a whole rather than to a decrease in the abrasive resistance of the tread rubber This deterioration of the tire as a whole is illustrated by the fact that when tires are run at high temperatures the inner tubes (which are not subject to abrasive wear) deteriorate rapidly These temperature effects are problems of the tire manufacturer and considerable progress has been made in the last few years in the construction of tires which will not reach as high temperatures and which will resist the effects of heat to a greater extent than formerly

3 The author refers to the low tire mileage obtained by a certain bus line, which during its course descended a long steep grade It would appear from the conditions stated that this might be due to high abrasive wear caused by the tangential shear on the tread rubber rather than to the heat generated at the brake drum

4 The failures of tires in hot desert regions, on the other hand, are probably due to deterioration internally from high temperatures

5 For different sizes of tires properly designed and operated the author concludes that as an average the wear per ton mile is about the same This conclusion is in line with the Bureau's tests, which showed that the rolling resistances of different sizes of tires per ton load are about the same It is logical to expect, however, that overloaded tires will have a comparatively shorter life due to deterioration, both internally and externally Also a tire run in an overloaded condition would be more susceptible to injury

6 Tires are naturally designed to withstand severe road service, and on smooth roads where the carcass is punished to a less extent than on rough roads the tread will naturally wear through before the carcass fails With the increase in good roads, this feature of tread abrasion being the limiting factor in tire life comes more into prominence

7 In bringing to the attention of the public the value of good roads in decreasing the cost of automobile operation the use of the increase in fuel consumption due to poor roads would probably be a simple method It does not seem, however, from the composite cost figures which the author gives that it would be the most logical, inasmuch as gasoline cost appears as only about 16 per cent of the total cost

Progress Report on Tire Wear Investigation, University of Kansas —1 The conclusion that balloon tires wear less on a sand clay road than on a hard paved road seems logical, as with balloon tires considerable abrasive wear is caused on the hard surfaced roads by the tread creeping back and forth on each side of the center line. On softer roads the loose surface probably lessens the actual tread slip because of the fact that it conforms more nearly to the shape of the tire

2 Before drawing two definite conclusions on the wear of balloon tires as a class it would be well to give consideration to the fact that there is quite a wide variation in the manner in which the tread wears in different sizes and types of balloon tires For instance, it is not uncommon for balloon tires run under certain conditions to wear on the sides of the tread rather than in the center, as would be expected

3 The Bureau has no data on the abrasive resistance of rubber compounds at different temperatures, but the temperature corrections which the author makes seem surprisingly large It would be interesting to know the basis for these temperature corrections

The North Carolina Road Test Truck —1 The figures for the mechanical efficiency of the drive are not what would be expected and a further explanation would seem desirable

2 This general question is brought to the author's attention Is displacement resistance constant for all speeds to a sufficient degree, and is the formula for air resistance sufficiently accurate to justify computing the impact resistance from them?

3 More descriptive matter would be desirable showing how the different curves were obtained, and also an explanation as to why the impact resistance of translation varies as the square of the speed

4 Based on the Bureau's investigation of the rolling resistance of tires, it would be expected that the displacement resistance for smooth roads per ton load would be between 16 and 40 pounds, with an average of about 25 pounds This agrees with the author's determinations

5 The formula used for air resistance is questioned (See comments in discussion by Dr H L Dryden on the method by which this formula was obtained)

H L DRYDEN, U S Bureau of Standards, Washington, D C

Investigations of Air Resistance of Automobiles—There are certain matters in connection with the air resistance of automobiles which should be discussed more fully In the first place an average resistance curve is of doubtful utility, since deviations of as much as 20 per cent from the average are not uncommon In most cases the resistance of a particular automobile is desired under certain specified conditions of car speed, wind speed, and wind direction This is most readily found by wind tunnel experiments on a model, since full scale conditions are not easily controlled

The use of an exponential formula is not only a needless refinement but is probably wrong There is much experimental evidence on the forces and air flow for all kinds of bodies to indicate that for bodies with fairly sharp corners the air resistance varies exactly as the square of the air speed and the square of a linear dimension Deviations are due either to experimental error or to departures from the desired condition of a very large air stream of uniform and steady velocity The difference between the exponential formula $P=0\ 00149\ V^{2\ 14}$ and the square law formula $P=0\ 0025\ V^2$ corresponds to a shift of the exponential curve by about 1 mile per hour at its lower end

The matter of determining the area to be multiplied by the mean pressure seems to be misunderstood Many engineers still have the erroneous belief that there is a certain pressure corresponding to a given wind speed and that the force on a body of any shape can be obtained by multiplying this pressure by the proper area Actually there is a very complicated distribution of pressure and suction around an automobile which gives rise to a certain definite force at any wind speed We may choose any convenient area, as for example the area of projection on a plane normal to the direction of air flow when driving on a straight road in still air Dividing the force by this area we obtain a certain value of the mean pressure This value may be applied to geometrically similar automobiles but not to those of another shape There is no way of specifying the area which will give rise to the same mean pressure for all shapes of cars

A serious source of error in full scale tests is the effect of wind direction Wind tunnel experiments on a model of a typical automobile indicate that when the air strikes the car at an angle of 5°, the head resistance is increased about 20 to 25 per cent and there is a lateral force tending to skid the car equal to about 50 per cent of the head resistance at 0° An angle of 5° requires a side wind of a speed equal to only 11 per cent of the automobile speed One of the speakers has stated that the effect of the wind was eliminated by running over the course in both directions Unfortunately natural winds vary in speed and direction so rapidly that the compensation would hardly be perfect Testing on selected quiet days at moderate speeds offers the best means of minimizing the effects of the variable natural wind

In the tests made by means of mounting a full scale automobile on a flat car, the effect of the air flow around the flat car introduces a source of uncertainty The air sweeps up over the front of the flat car in a manner different from the ordinary flow near the ground The effect is, however, probably not a serious one

It is gratifying to note that the full scale tests give results in line with wind tunnel values, although this result would be expected by wind tunnel investigators for this type of body In general it is felt that full scale tests are subject to greater errors because of lack of control of the experimental conditions and that the air force on an automobile of a particular shape under specified conditions of air speed and direction can be found more conveniently, quickly, and accurately by wind tunnel tests on a model