DISCUSSION ON THE PLACE OF MATERIALS IN AUTOMOBILE ROADS AND RIDES

MR. H. H. MORGAN [1] (*Chairman, A. S. T. M. Committee A-1 on Steel*).—Mr. Kreusser's paper brings out clearly the advancements made in the development of the modern automobile and the place it fills in society today.

As chairman of the Society's Committee A-1 on Steel, I should like to have this meeting recognize the part the automobile takes in the steel field as an indication of the large part the car fills in our industrial activity.

The three largest industrial uses of steel are in automobiles, in buildings and in railroads. From using 9 per cent of the total production of steel in 1922, the percentage used in automobiles has increased to between 20 and 21 per cent in 1933 and 1934, and this percentage is larger than in any other industry. In 1933, the nearest was buildings, using slightly over 12 per cent, and in 1934, the railroads, using not quite 13 per cent.

In the special field of alloy steels, the automotive consumption from 1928 to 1933 averages close to 70 per cent, with the machine tool industry using the next highest percentage, averaging between 5 and 6 per cent. In 1934, the automotive percentage dropped to 53 per cent, not as an indication that they are using less alloy steel, but as an indication that other industries were only then commencing to use more substantial amounts.

In the broad field of activities of Committee A-1, we wish to assure the automotive industry of every cooperation in the development of research, test, and specification procedure that will afford material of more favorable utility-cost ratio. Carbon and alloy steels will very probably still continue to have the highest stress-strain ratio and permit of the highest usable stress values.

While quite generally the supply of steel products to the automotive interests as the largest user can justify special action and a leading attention, at the same time such supply represents but one-fifth of steel consumption with a very definite need of products at the lowest possible cost. It will be of economic importance that such items as hot- and cold-drawn bars, sheets, plates, hot- and cold-rolled strip steel, forgings, castings, wire, etc., be purchased to as near universal standard specifications as possible, thereby shaping industrial production to as near fixed standards as can be consistent with progress and will result in lower production costs and purchase prices.

Under the procedure of the American Society for Testing Materials, all consuming and producing interests are adequately represented and the automotive industry can be assured of every cooperation in their desire to introduce into the construction of the automobile, the most satisfactory product at the lowest prices, or, as Mr. Kreusser expresses it, "the most favorable utility-cost ratio."

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In conclusion, I want to compliment Mr. Kreusser on his live, forceful exposition of the work done and the problems before the car builder, and to assure him and the automotive industry of every cooperation and help from Committee A-1 on Steel.

MR. A. L. CLAYDEN [1] (*Member, A. S. T. M. Committee D-2 on Petroleum Products and Lubricants*).—Committee D-2 is peculiar to some extent in the A. S. T. M. because in developing methods of test for petroleum products, they are developed almost entirely for home consumption; in other words, the oil industry's customer very seldom does any of the testing of the materials he purchases from the oil industry, and the main object in developing improved methods of test for petroleum products has been for the use of the oil industry and has led—probably that is its most useful function today—to a progressive and fairly rapid standardization of, I shall not say qualities but characteristics, of the most generally used petroleum products.

In addition to our standing subcommittees which deal definitely with methods of test, we also have our technical committee organization, and the two leading ones, Committee A on Gasoline and Committee B on Motor Oils, are really forward-looking semi-research organizations, which act to a great extent as steering committees for the whole work of the two groups. They are comparatively new parts of Committee D-2's organization, but in the few short years of their existence they have shown great promise of being extremely beneficial not only to the A. S. T. M. but to the oil industry as a whole and to the automotive industry as a whole. We of course have some problems to deal with in connection with petroleum that are a little more difficult in some respects than those met in the older and more stable materials. Petroleum is not a material of construction, but still lubricating oil is just as essential a part of an automobile as its crankshaft; you cannot operate without a crankshaft and you cannot operate without a lubricant, and the same might be said of fuel.

Mr. Kreusser spoke about the close cooperation between the two industries. That is not a very old thing, either; as a matter of fact it was a long time before the automobile industry caught up with the petroleum products which were available, and it is only in the last ten years that they have been asking for specially developed petroleum products. Then again, dealing with the kind of raw materials we deal with and dealing with a processing which must be mainly based upon economics and only secondarily based upon the characteristics of the product, we are always developing new materials. Now there are two ways in which progress occurs; one is the development of the machine which you cannot make because you have not the materials to build it of, and therefore someone has to develop the material for you, but a far more common one nowadays is the discovery of a new material for which there is no use but for which the use is quickly found. One of the things agitating the oil industry most at present is that it can visualize in the very near future an enormous supply of extremely desirable fuel which cannot be burnt in the conventional automobile engine, and nobody knows what is to be done about it.

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MR. N. H. F. OLSEN [1].—I agree with Mr. Kreusser in some of his statements but not necessarily in all. The public of today is demanding more and more from the automobile manufacturer and automotive engineers. Every year something new and better is expected. The main demands, as I see them, are:

1. Greater comfort; which means noise eliminated.
2. More speed with safety.
3. Greater operating economy.
4. Better looking design—more beautiful lines.
5. Better color scheme.

Public demand necessitates a persistent search for a better product, stronger and better material, new and better ways of doing things.

People do not want to hear any noise from the rear axle, transmission or motor, chattering brakes and body rumble or squeaks. They want cars that are absolutely quiet. They want to ride as if sitting in a parlor chair—no noise, no shaking. We are in the noise and ride period of the automobile industry. The body man changes the body lines, but in doing so he may raise the noise level so it will be focused at ear height instead of as before at foot level, and so the body and chassis departments each blames the other for the trouble. As a matter of fact, should we not go back to the metallurgist and find out why we could not get steel or alloy free from rumble having the same price as our present material? Also, get colored steel like colored aluminum. At present we are working top speed toward getting more efficient sound deadener and sound absorbent material.

We must first stop the rumble, for which rubber or similar material is good; second, we need material to absorb the noise after it is within the body, for which any soft upholstering is good. At the present time all manufacturers are spending lots of money for developing anti-drumming and sound absorbing material. As a matter of fact, low-priced cars use up to 16,000 sq. in. of material to stop noise. Let us get some material so that we do not need to put ⅛ to ¼-in. padding between body and frame, for example a ⅜-in. cellotex with a ½-in. jute with carpet on top of the floor, and so forth. I hope Mr. Smith and his tire associates can help us to stop road noise and the whistling sound from tires, which is very noticeable in a little cross wind. Just take different makes of tires, put them on the same car and hit them with a small mallet—you will soon find the best road noise transmitter.

In regard to Mr. Kreusser's statement that independent spring or knee-action has definitely added safety to higher car speed and ride, I do not agree with him. The standard transverse with tapered leaf spring and conventional side spring will give just as good all-around ride as the knee-action with proper design.

It is true we need better lubricants with the ever-increasing speed. As Mr. Smith said, it took about 10 years to make front and rear wheels interchangeable. We have been making the same kind of motors for many

[1] Experimental Engineer, Ford Motor Co., Dearborn, Mich.

years, adding more and more parts, but if taxation continues going up as it is, we might go into the Diesel direction as it is going in Europe. A small two-cycle Diesel car sells for about $300 with automatic transmission or no transmission. Then we might go from Detroit to New York for $2.00. That is possible if we can get strong and light enough material.

MR. H. A. DEPEW [1] (*Chairman, A. S. T. M. Committee D-11 on Rubber Products*).—The extension in the use of rubber in recent times has been nowhere more marked than in the automotive industry and its successful use in this industry is a challenge to other industries to take more complete advantage of the valuable properties of this material.

For the car, the use of rubber is general; a few of the obvious applications are engine mountings, shackles, electrical insulation, and mats.

For use in tires, rubber is essential for giving resiliency to the carcass and abrasion resistance to the tread.

For use in road construction, costs have been a restricting factor, but experimental rubber roads have been built. If the cost were lower, rubber roadways would be ideal, and they may yet assume a deserved importance where minimizing of vibration and noise elimination is a factor.

Since the successful use of rubber in widely different applications depends on a knowledge of the engineering properties of this material, Committee D-11 has devoted an important part of its activities to research. The obtaining and disseminating of information regarding the engineering needs that can be met with rubber will increase its use greatly. In my opinion, the use of rubber around the automobile engine was retarded because it was believed that rubber would soften unduly, yield, and disintegrate due to the oil, high temperatures, and stresses involved. When the rubber was properly made, these difficulties did not exist. It is evident that engineers should have tables of engineering properties of rubber compounds to guide them in their designs.

Once a proper rubber part has been compounded and designed, it is essential to have suitable testing methods so that the consumer will be certain to receive uniform products and so that the producer will not be faced with the rejection of suitable goods based on poor testing methods. In the development of testing methods, Committee D-11 is working most effectively. In addition to the conventional strength tests, it is necessary to use performance tests to evaluate in part at least the behavior of rubber products in service.

Subcommittee XIV on Abrasion Tests for Rubber Products has correlated and standardized many of the existing abrasion methods. Subcommittee XVIII on Dynamic Fatigue Testing for Rubber Products has prepared methods for measuring the flexing of rubber and of rubber-cotton fabrications. Subcommittee XVII on Rubber Products for Absorbing Vibration has investigated the yielding of rubber under stress and has developed methods for measuring the "set" of the rubber compounds. This committee has developed recently a method for testing the hardness of rubber that is far superior to those previously in existence. No matter what properties a

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rubber product may have as manufactured, it is essential to know how the product will behave on storage. Methods have been developed that are very helpful in this regard, and they have been tentatively standardized by Subcommittee XV on Life Tests for Rubber Products.

The measurement of the adhesion of rubber to other materials is a matter of great importance and many methods have been worked out to improve the adhesion. Subcommittee XX on Adhesion Tests has proposed a new method for measuring the adhesion. This method deserves serious consideration.

The recent developments of artificial rubbers with specialized properties superior to natural rubber have greatly widened the field where rubber-like materials can be used. Among the superior properties given by some of these materials are resistance to heat, resistance to oxidation, and inertness in liquids that cause natural rubber to swell. The latter property makes it possible to build "rubber" gasoline hose, to connect the carburetor with the gasoline line as an example. To evaluate this property, Subcommittee XIX on Tests for Properties of Rubber and Rubber-like Materials in Liquids is pressing an extensive research investigation.

Subcommittee IX on Insulating Tape, Subcommittee VI on Packings, Gaskets and Pump Valves, Subcommittee V on Insulated Wire and Cable, and Subcommittee I on Mechanical Rubber Hose have written product specifications that may be helpful in the choice of rubber parts used in the automobile.

Subcommittee X on Physical Testing of Rubber Products has standardized the formal strength tests and the chemical methods of Subcommittee XI on Chemical Analysis of Rubber Products are accepted internationally.

The various testing methods are being summarized and will be published shortly as a testing manual. This manual should be of value to all technologists and engineers interested in rubber products and processes.

Committee D-11 will be glad to accept Mr. Smith's challenge to develop performance tire tests and will be glad to cooperate with other groups such as the Rubber Manufacturers' Association and the Society of Automotive Engineers as interest develops. Speaking as chairman of Committee D-11, I wish to express the interest of our group in this program and to thank the speakers for the thoughts that they have given us.

MR. MARTIN CASTRICUM [1] (*Member, A. S. T. M. Committee D-13 on Textile Materials*).—Since its organization in 1915, Committee D-13's activities have been closely allied with textiles used in automobile tires. Today, out of 29 standards sponsored by this committee, 6 relate directly to materials used exclusively in tires. Numerous others bear strong marks of the influence of work done on tire fabrics.

Some Committee D-13 standards deal with test methods, some deal with testing machines, while others are actual purchase specifications for materials.

The development of standard test methods required a study of those

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physical characteristics which needed evaluation, a determination of test sample conditioning which would best allow reproduction of results and the establishment of correction factors applicable to instances of deviation from established standard conditions. Some of the physical characteristics considered critical in their bearing on performance of textiles used in tires are strength, elongation, degree of twist, thickness, weight and texture. Practically all of these are materially affected by moisture content of specimens. Committee D-13 specifications give due consideration to this effect and establish standard conditions with standard correction factors.

Requirements for testing machines have been written which are sufficiently specific in nature to insure reproduction of results. The attainment of this condition involved the standardization of means for gripping samples, specimen rates of load and certain additional requirements for clarification of stress-strain relationships.

Purchase specifications are written in sufficiently specific form to allow their use with complete understanding between seller and purchaser.

The foregoing applies to manufactured textiles. Recent work of Committee D-13 has been directed toward evaluating the physical characteristics of raw cotton. As a result of this work tentative specifications have been prepared which with growing use should add materially to the knowledge on this extremely important material.

Committee D-13's work to date has not actually entered the field of service test specifications. However, in establishing standard methods of test and material specifications, it has made a major contribution to the development of the present highly efficient automobile tire. It has given tire technologists accurate means of measurement of physical characteristics of tire textiles. With these means available, modifications in physical characteristics are correctly labeled and being so labeled can be evaluated in terms of tire life.

Committee D-13 specifications are available in the Books of A. S. T. M. Standards and Tentative Standards and in the form of an annually published booklet entitled "A. S. T. M. Standards on Textile Materials."

MR. S. M. CADWELL.[1]—Mr. Smith's paper presents a good general survey of the development of the automobile tire and of its functions. The subject is necessarily broad, so detailed treatment of the different phases cannot be expected.

From the point of view of materials, Mr. Smith has indicated the limitations now encountered in applying available materials to the increasingly severe conditions of service. As speeds have been increased, the internal temperature of tires has steadily risen until we are close to the maximum which materials of vegetable origin can stand. The rate of deterioration of cotton increases very rapidly as the temperature is raised. We must either find new materials which will permit an extension of the present temperature range or we must find methods of reducing tire temperatures, if still higher speeds are to be obtained. One solution of the problem is to reduce the load on the tires, or to increase tire sizes for present loads. Tire sizes

[1] Director of Tire Development, U. S. Rubber Products, Inc., Detroit, Mich.

have been determined in the past on the basis of loads. Speed now appears to be an additional factor of great importance which should be considered in the determination of tire size.

This meeting seems an appropriate place for discussion of another item of tire performance which Mr. Smith has mentioned. The problem of skidding is an extremely serious one. It contributes, directly or indirectly, to about 25 per cent of all accidents, and accounts for nearly 40 per cent of the accidents during winter months. Tires have been blamed for many accidents of this type for which they were not wholly responsible. There are four important variables in every skidding problem:

1. The road surface,
2. The tire surface,
3. The lubricating film, and
4. The vehicle speed.

There is a very much larger variation in road surfaces than in tires. The work at Iowa State College and at Ohio State University which Mr. Smith mentioned, has shown that roads which are superficially similar may have very different coefficients of friction against a tire tread. The materials and methods of construction used for roads need much more careful control in respect to skid resistance than they have so far received.

We are in full agreement with Mr. Smith's statement that differences in tread design have only a slight influence on the coefficient of friction. Smooth tires are always poor on lubricated surfaces, but with tires having antiskid elements the difference between different types of tread designs is small. Many advertising claims for superior skid resistance are contrary to facts.

Changes in skid resistance due to the road surface and the lubricating film are so much greater than any changes due to tire design, that there is a much better chance of reducing skidding accidents through study of the road than through further changes in tread design.

Probably the most effective way to reduce skidding accidents would be to educate the public as to the facts. The only real answer that we can see to skidding is to reduce speed to match the reduction in the coefficient of friction under bad conditions. The following data on this point are presented:

Surface	Coefficient of Friction	Stopping Distance in Feet From 40 M.P.H.
Dry concrete	0.8	67
Wet concrete	0.5	106
Snow or mud	0.2	268
Sleet or ice	0.1	535

	Equivalent Safe Speeds, M.P.H.		
Stopping distance in feet	*38*	*106*	*204*
Dry concrete	30	50	70
Wet concrete	24	40	55
Snow or mud	15	25	35
Sleet or ice	11	18	25

The coefficients are approximate and for average roads. Different concretes vary a good deal, so only an average value can be given. But if we assume the coefficients to be those given, the great range in stopping distance from 40 m.p.h. is rather startling.

The second portion of the table expresses the essential data in a slightly different form. The same road surfaces are used and equivalent speeds have been calculated. The speeds are those which will give the same stopping distance on the different surfaces. In other words, 25 m.p.h. on an icy road is no safer than 70 m.p.h. when the same road is dry.

MR. TORE FRANZEN.[1]—On the story of "Roads" as treated by Mr. Worley, there is but little to add other than the fact that better roads and more of them all over the world must precede the generalization of the automobile as a transportation unit—all of which is so ably discussed in Mr. Kreusser's story on the application of the automobile in general.

In the story of the "Tire" as given by Mr. Smith, there is little mention of tire relationship to suspension and in view of the fact that Mr. Kreusser only touches upon it, the following might be in place. At the time when tires were pumped up to a pressure of over 60 lb. per sq. in., relatively stiff springs were called for. In other words, there was no use for an extremely supple spring and no inducement to improve the materials or treatment for them. With the advent of the balloon tire, now over ten years ago, there arose a demand for softer springs. With the coming of these softer springs, the carbon steel used quite extensively up to that time practically passed out and alloys of several kinds were the order of the day.

When the super-balloon tire made its appearance approximately four years ago, the suspension was not ready for it. This situation among other factors precipitated the introduction of the independent suspension, particularly the one used with coil springs, which made it possible to take full advantage of the low pressure tire as we know it today.

The conventional leaf spring has in the meantime caught up with the demand for a softer ride with increased spring deflection and it is now possible to get most excellent results with the conventional type of suspension.

A molybdenum alloy steel, termed "Amola" steel, is now being used at the rate of over 200 tons a day by the Chrysler Corporation in leaf springs that have a static stress in the neighborhood of 100,000 lb. per sq. in. and a stress range of over 80,000 lb. per sq. in. The metallurgical development of this steel and the new heat treating facilities developed for it have resulted in a material which, heat treated, has an elastic limit of over 220,000 lb. per sq. in., but which nevertheless can now be purchased for the same price as silico-manganese steel previously used as spring material. This development is, of course, not exclusively metallurgical because the leaf spring has changed in appearance as well due to entirely new design features. This type of spring represents a happy example of coordinating an advanced design with the use of a new material.

MR. MAURICE OLLEY.[2]—The thing that strikes me most in this symposium is Mr. Worley's statement that pavement surfaces should approach a perfect plane. Obviously the sort of "flatness" that roads should have

[1] Experimental Engineer, Chrysler Corp., Detroit, Mich.

[2] Special Problems Engineer, General Motors Corp., Detroit, Mich.

needs definition. The rungs of a ladder might be counted as flat for most speeds. Even railroad ties and gravel washboard surfaces are "flat" for speeds above 40 m.p.h.

In other words, we are vitally concerned with frequency and therefore with wave length. The frequencies of a motor car are two:

1. Frequency of unsprung masses, of the order of 540 per min. or 9 per sec.

2. Frequency of sprung masses, covering a range from 1 to 2 cycles per sec.

If one now accepts two typical speeds, 45 ft. per sec. for cities and 90 ft. per sec. for the open road, (1 resonance of the unsprung masses will occur in cities at a wave length of 5 ft. and on the open road at a wave length of 10 ft.; and (2) resonance of the sprung masses will occur in cities at wave lengths between 22½ and 45 ft. and on the open road at wave lengths between 45 and 90 ft.

Washboard gravel roads have a wave length of about three feet and it is a common observation that riding of cars on these roads at ordinary "open road" speeds is better than on concrete roads of any but the very best quality.

One cannot escape the conclusion that the methods adopted for laying our concrete roads are defective in neglecting this very important question of wave length and in producing inadvertently very slight waves which have an average length somewhere in the range of 50 to 100 ft.

What subsequently occurs may be proved very readily by observation or mathematics, namely, that the passage of cars over such roads tends to increase the amplitude of the waves, beating down the low spots and missing the crests. My observation is that this "long wave" is a typical fault of American roads, not found to anything like the same extent in Europe. The severe temperature changes of our climate may also account for it, also defective subgrades in many districts. It accounts to a large extent for the very soft springing adopted on American cars which is generally criticized abroad, but is absolutely necessary for comfortable riding on American roads. Perhaps this point is worthy of consideration by the Society.

MR. R. R. LITEHISER [1] (*Secretary, A. S. T. M. Committee C-9 on Concrete and Concrete Aggregates*).—Being a member of the Society's Committee C-9 and also an engineer in a state highway department, I am in position to know from experience what Committee C-9 has done to foster the development of one type of road, concrete, which has a definite place in fulfilling the requirements of modern automobile transportation, so ably outlined in Mr. Worley's paper.

Committee C-9 began its work in 1915, under the leadership of Sanford E. Thompson, when concrete highways were in their infancy. Within the scope of its work are the assembling and study of data pertaining to the properties of Portland-cement concrete and concrete aggregates, and the preparation of definitions, specifications and test methods relative to the

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constituents, manufacture, handling and testing of concrete and concrete aggregates.

A continuous effort is made to maintain a committee personnel which is recognized not only for what it has contributed in the past but for its understanding of the concrete problems of the present.

Committee C-9 has made its contribution to the development of the concrete highway through its annual reports, with appended technical papers, and in the preparation and publication of specifications and methods of test for concrete and concrete aggregates. It should be mentioned too that subcommittee work involves extensive laboratory and field investigation.

While it would be tedious to enumerate all of the specifications and methods of testing which the committee has developed, yet it is fitting to mention that they include specifications for aggregate for concrete, for methods of curing concrete, for ready-mixed concrete, and methods of testing for aggregates to determine their fitness for concrete, for determining the cement content of hardened concrete, and for making and testing concrete specimens. Without these specifications and methods of test the highway engineer, and any engineer using concrete as well, would be seriously handicapped.

Committee C-9 has long been interested in durability of concrete, a characteristic upon which its continued use depends. Cement and methods of making concrete are quite well standardized, but aggregates are by no means standard. The committee has already done much in this field and will continue to work actively.

The committee recognizes with Mr. Worley that there is still much to be done in the field of highway research and so far as concrete and concrete aggregates are concerned, will spare no effort in extending its knowledge and making this knowledge available through the *Proceedings* of the Society.

MR. F. C. LANG[1] (*Member, A. S. T. M. Committee D-4 on Road and Paving Materials*).—A highway transportation system cannot be considered as satisfactory until we have roads to take care adequately of the flow of traffic on all classes of highways, from the farm to market road to the densest traveled arterial highway. To be able to do this at a cost which would not be prohibitive is going to tax the mental resources of all the engineers interested in the development of highways.

There has been a tremendous development in the vehicles which use the highways, but, as Mr. Worley states, "They are, as a rule, required to operate over highways which have not kept pace with the improvement in the vehicle."

There are, no doubt, good reasons for this condition as the demand for and the resultant financing of highways must necessarily follow the development and widespread use of the vehicle which uses them. Also, there have been many road problems to solve as this comparatively new highway vehicle has been so rapidly developed. Highway engineers have no reason to apologize for the progress in road building, particularly since the World War.

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