FIRST SESSION

THURSDAY, DECEMBER 2, 1926, AT 10:00 A. M.

A N JOHNSON, *Presiding*

Chairman, Executive Committee, Highway Research Board

The meeting was called to order at 10 a m by Dean A N Johnson, the presiding officer The first speaker on the program, Dr. Vernon Kellogg, Permanent Secretary of the National Research Council, welcomed those in attendance in a short address, in which he stated that the National Research Council is proud of the Highway Research Board, of its strong and healthy growth and of the good work it is doing

CHAIRMAN JOHNSON: We shall now have the pleasure of listening to an address by Dr George K. Burgess, Director of the U S Bureau of Standards

ADDRESS ON "THE HIGHWAY AND THE LABORATORY"

GEORGE K. BURGESS

U. S Bureau of Standards, Washington, D C.

The problems of the highway, as we understand them today, are of recent origin and have developed hand in hand with the motor vehicle. Not very long ago the finest type of country highway was constructed of water-bound macadam, while some of our best city streets were paved with a thin sheet of asphalt laid with little or no foundation In those days the problems of the highway were simpler than they are today, and highway engineering as a separate profession scarcely existed A few years ago it was far cheaper and quicker to build a road than to lay a railway track. Today conditions are reversed In those days roads followed the natural contours, and if steep grades were involved the horses simply stopped for a rest at the top and used the water trough at the foot of the incline Now, grades and curves must be reduced and if possible eliminated, dangerous intersections must be avoided and roads banked for high-speed traffic Highways must have long life, because the detouring of a large volume of traffic on a main thoroughfare is a difficult and expensive matter

Naturally, I want to talk to you about things of interest in your profession and I propose to go over very briefly some of the activities of the Bureau of Standards which tie up directly and indirectly

with modern highway problems These problems relate to the materials of highway construction, their testing, definition and improvement, markings and lighting, including methods of measurement and simplification, the characteristics of motor vehicles, including limitations as to performance, as well as the development of specifications for materials, highway accessories, and rules for safety of operation and traffic control.

All of you are interested in Portland cement and in Portland cement concrete, either directly as actual producers or users or indirectly through competitive materials The Bureau tests a great deal of the cement purchased by the Government For this purpose it maintains three branch laboratories—Northampton, Pa, Denver, Colo, and San Francisco, Calif —which are devoted, almost entirely, to the inspection, testing, and shipping of cement on Government purchases in these regions This service is augmented by the cement laboratory of the Bureau in Washington In addition to this inspection service, these laboratories make studies of the proportioning of cement from local materials in connection with preliminary studies of Government construction From this experience data are accumulated which are of value in preparing and revising specifications such as that for Portland cement of the Federal Specifications Board and the American Engineering Standards Committee At this point, I venture to suggest the very great desirability and advantage of maintaining throughout the country a uniform standard of quality of this material, cement, entering so universally as a constituent in road construction Here the laboratory and highway are most closely linked together, and divergence of practice makes for increased costs of construction and difficulty of distribution

The Portland Cement Association, through an associateship at the Bureau established two years ago and now comprising ten men, are studying those very necessary problems What is Portland cement? and What happens when water and solutions of salt are allowed to react with it? Three publications have already been issued by this group The Bureau has maintained since 1910 an experimental cement plant in which a number of studies in connection with these problems have been carried out

Many improvements have been made in recent years in the design of concrete mixtures, with particular reference to the grading of the aggregate and the ratio of water to cement to be used But further work must be done So far an average cement has been used in such investigational work, or an assumption has been made that the results developed with one cement will apply to all others The Bureau has been applying these laws of concrete design and

water-cement ratio to different cements and finds that these laws are not applicable to all

The study of the use of concrete for mine stopping, is of interest to you in view of your concern with impact testing of concrete In cooperation with the Bureau of Mines, there has been constructed a heavily reinforced concrete chamber, one end of which can be closed with differently designed concrete slabs Graded charges of black powder are set off in the chamber developing different impacts which are observed, as well as the strain developed in the slabs The first series of tests is now under way

You have possibly noted in the engineering journals reference to the Bureau's cooperation with Engineering Foundation in the testing of the 60-foot high experimental concrete arch dam at Stevenson Creek, California This, while possibly not of direct interest to you, is illustrative of the type of work which the Bureau does in its concrete investigations Such cooperative work may be further illustrated by that now being carried out with the Common Brick Manufacturers Association of America, the Hollow Building Tile Association, and the National Terra Cotta Society in the studies of the uses of their materials in connection with mortars and concrete

The high-alumina cements and the quick-hardening Portland cements are being studied, as well as concrete made from high-alumina cements both by members of the Bureau staff and associates from industry These types of material are mainly of interest in special and repair work May I mention in this respect that the Bureau issued a publication dealing with the high-alumina cements four years before they were on the market Two years before they were on the market it issued its Technologic Paper 197, giving the properties of cements of this type made in its own cement plant

The bituminous and other laboratories of our Chemistry Division have worked on asphalt, and the Federal Specifications Board has issued specifications covering asphalt, road oil, and similar materials

The Division of Simplified Practice of the Bureau is one with which a number of you have been in direct contact and on whose committees I know a number of you have served The first piece of work handled by this Division and its first publication deals with the elimination of excess varieties of paving brick As a result of the first conference, attended by a number of highway engineers, the number of varieties of paving brick was reduced from 66 to 11 A year later these 11 were reduced to 7 The second year later one more variety was eliminated and two years later still another variety was eliminated However, as a result of investigational work done by the Bureau of Public Roads, it would

appear that at the next session of the conference it may be found desirable to replace one or more varieties Other items that have been considered by this Division of interest to you would be the simplification of builders' hardware, steel barrels and drums, steel reinforcing bars, sheet steel, concrete building units, and shovels, spades and scoops

Several years ago the Bureau developed a new type of strain gauge in which the displacement is indicated by changing the pressure on a pile of carbon disks whose electrical resistance is thereby altered This arrangement makes it possible to construct instruments which will follow accurately very rapid changes in stress The apparatus has the further advantage that reading may either be read from an electrical instrument or be recorded photographically at any convenient location For example, it is entirely practicable to mount the gauges on relatively inaccessible members of a bridge structure, and place the reading or recording apparatus on the ground at any distance desired These gauges have found use in a great variety of problems including the study of live stresses on bridges both for highway and railway use and street railway joints

A set of the gauges was prepared in 1923 for the Iowa State Highway Commission and has been used very successfully in an investigation carried out by the Commission in cooperation with the Iowa State College These gauges may also be used simultaneously as resistance thermometers and they are being so used, as well as to measure strains in the Stevenson Creek dam

Our investigations of the strength of structural steel for bridges have yielded many valuable results Take, for example, the work on the columns of the Delaware River bridge Here a new type of construction was involved and there was some question as to the safe loads which certain members could stand and as to the way in which failure would take place Specimens of the construction were tested to destruction in the 10,000,000 pound testing machine at the Bureau As a result of the work, a large saving in steel was made possible

Our work in cooperation with the American Electric Railway Association and other national organizations on the most durable joints for street railway tracks is of importance to the highway engineer, because when track work must be done on a street car line it means tearing up the roadway Every type of welded joint in common use is being investigated For a part of this work we are employing a special impact machine A heavy hammer is dropped several times a minute on the joint The specimen rests on a spring supported anvil, and the number of blows which the joint

can stand is an indication of the excellence of the weld Supplementary tests of the material are also made

Turning now to the motor vehicle, one of the problems that concerns all of us is the life efficiency of tires With a view to aiding in the formulation of tire specifications for the Government, the Bureau has carried out a long series of tests, still under way, on the abrasion of tires and the relative power losses of various types of tires As a result the Government purchases are now on a much more satisfactory basis than formerly

One of the most serious problems which confronts the highway engineer today is that of caring for the ever-increasing use of our roads by motor trucks We are carrying loads that would have been unbelievable a few years ago at high speeds over ordinary highways The wear and tear on the road are tremendous In this connection it is important to make sure that trucks are not overloaded The necessity for enforcing regulations against overloaded trucks has created a demand for portable wheel-load weighers Several such scales are now on the market The Bureau has investigated the problem and has prepared specifications governing the construction and use of these portable weighing machines

Our automotive section has also cooperated with several States in working out satisfactory rules for rating motor trucks for purposes of taxation

Among the foremost problems of highway control is that of safe and adequate braking control of vehicles Some years ago the Bureau designed and put in service a type of recording accelerometer intended to record the performance of motor vehicle brakes in operation on the road An extended study of methods of conveniently and accurately measuring this quantity was made Later a simple and convenient indicating acceleromoter was designed, and with these instruments the braking ability of several hundred typical motor vehicles of all classes selected at random from traffic have been measured Something like a thousand instruments are now in use by State and municipal authorities and others interested in brake performance, for the control of brake conditions in the interest of public safety, or for more extended study of conditions in regard to this phase of vehicle operation

Among instruments applicable to the vehicle is another, or rather a combination of instruments, designed to make a complete and permanent record of the essential elements in the road performance of a vehicle This equipment has a group of sixteen recording pens, each drawing an independent record on a single roll of paper These various records include ground speed, wind speed, wind direction,

manifold pressure, oil, water, and rear axle temperature, rate of gasoline flow, acceleration, etc From such a record taken over a comparatively short course, an analysis may be made of all the more important characteristics of the vehicle as regards its performance on the road

The Bureau of Standards several years ago undertook a comprehensive study of the effect of motor fuel characteristics on the overall consumption of fuels in motor vehicles The initial question propounded was, "What grade of gasoline as regards volatility will assure the maximum number of car miles per barrel of crude oil consumed in its production?"

There is, of course, a necessary mutual adjustment between the characteristics of the average fuel and those of the average vehicle and such an adjustment takes place more or less automatically, as a result of supply and demand There is much to be gained in general efficiency if the adjustment can be arrived at which yields the maximum amount of transportation per dollar of cost

The definite answer found to the initial question stated above was that the least volatile or heaviest fuel which could be succesfully used gives most miles per gallon of crude consumed and presumably per dollar of cost

Other questions were raised therefore as to what factors place limits on the use of heavier and cheaper fuels The more important of these are dilution of oil and difficulty of starting the engine Both these problems have been investigated and most of the outstanding technical questions regarding them have been answered Other phases of the broad problem of mutual adaptation of fuel and engine are also being investigated

In the important field of highway safety, the Bureau of Standards has accomplished several results which may be of interest Several years ago there was begun an investigation of brake-lining materials primarily for the benefit of the Government as a purchaser of these materials The work thus begun led to cooperation with manufacturers and in some three years resulted in an increase of about 300 per cent in the useful life of the average brake lining This study of materials led to a study of the behavior of brake linings and of brake mechanisms in service, the latter resulting in the collection of data from which a national brake safety code has been drafted by a committee under the procedure of the American Engineering Standards Committee The general interest aroused during the preliminary work on this code and the development of the accelerometer mentioned above have led to general adoption of more effective means of controlling the condition of motor-car brakes

While brakes are one element in determining what speed a vehicle may safely maintain under any particular condition of traffic, there are other factors equally important, such as condition of the highway surface, as well as traffic conditions themselves The Bureau of Standards has made a study of these factors and incorporated the findings into a single statement, "Safe speed is that from which a vehicle can always be stopped within the clear course ahead" where clear course is defined as that portion of the highway which the driver can know is unobstructed and cannot become obstructed by any person or other vehicle within the ordinary right-of-way rules, in such a way as to interfere with his progress

It has been suggested that this general principle can be made the basis for more effective legislation than now exists regarding vehicle speeds

A brief study has been made of the theoretical safe traffic capacity of highways as affected by brake ability and average speed of traffic The results of some of these calculations have been published and others are available for such use as may arise

Closely related to brake performance is that of the car under application of the brakes The dangerous action of a vehicle, sometimes known as pivoting under action of the brakes on slippery roads, has long been something of a mechanical mystery Some time ago an analysis was made of the causes of this behavior by the use of models, and it was found that there is a simple mechanical explanation for the phenomenon It was shown that, contrary to previous generally accepted belief, when, on a slippery surface, the rear wheels of a vehicle are locked, is must necessarily reverse its direction unless the tendency to do so is skillfully controlled by proper steering Locking of the front wheels on the contrary, while it prevents steering of the vehicle, does not have this effect, but under these conditions a vehicle will proceed straight ahead A knowledge of these facts appears to be of utmost importance in the design and adjustment of two and four wheel brakes and it may perhaps influence other matters of highway and traffic control

Automotive headlighting and its relation to highway illumination has been a subject of much recent discussion While many of the States have fairly adequate laws for the licensing of headlighting equipments and for their proper adjustment and use, there are only a few localities were anything like satisfactory headlighting conditions exist This fact raises the question whether existing laws are adequate in themselves or whether the fault is in enforcement alone Recently the Bureau of Standards, in cooperation with the Illuminating Engineering Society and the Society of Automotive Engineers,

has been making a study of the safety and effectiveness of different headlight illumination patterns For this purpose two special adjustable headlight sets, each consisting of four lamps, are available for use on different cars Some work has already been done in an attempt to determine independently what type of lighting is safest for the driver when no other cars are approaching, and what type is safest for both when cars are approaching With modern depressible lighting systems, it is conceivable that both these conditions of maximum safety can be realized To make this possible it is necessary to know first what beam patterns will afford maximum safety under each of the above conditions, rather than what is the best simple compromise between them

The Bureau has been cooperating with manufacturers of headlamp and headlighting devices and with the commissioners of motor vehicle administrators of a number of States, particularly on the Pacific coast, and with the States comprising the Eastern Conference of Motor Vehicle Administrators Tests on some forty devices have been made for the State of Oregon, and numerous tests have also been carried out for the Director of Traffic of the District of Columbia

On this subject of headlights, the Bureau has issued a circular entitled, "Motor Vehicle Headlighting," Circular No 276, and a chart "Adjust Your Headlights," Miscellaneous Publication No 68, which are widely used

As to signal lights, a sectional committee, working under the auspices of the American Engineering Standards Committee and sponsored by the American Association of State Highway Officials the National Safety Council and the Bureau of Standards, has agreed upon specifications for the use of colors, and this has already resulted in pretty general adoption of uniform practice in the use of red, green, and yellow luminous signals for traffic control

A series of tests has been made on the visibility of red, yellow green, and blue traffic signal glasses under daylight conditions It was found that color traffic signals under daylight conditions, with the sun shining on the signals, are clearly distinguishable by the average observer at a distance of 1,200 feet from the signal if there is behind the signal a light having a beam candlepower of approximately the following values for the four colors

Red	1,400
Green	2,600
Yellow	3,800
Blue	9,300

It was found that a 15-watt lamp in a 4 or 5 inch parabolic reflector will be satisfactory to use as a source of light for such signal glasses and that with a lamp of that intensity the colors will be clearly distinguishable at a distance of 1,200 feet, even though the sun is shining directly on the signals

Experiments have been conducted on the visibility of the letters and figures on automobile license plates It is found that there is, of course, great difference in the intensity of illumination on rear license plates as produced by tail lamps ordinarily supplied on automobiles There is also considerable difficulty due to the fact that the design of the letters and figures themselves as used on the license plates of a number of States is not the best in many instances Certain figures are difficult to distinguish, even under daylight conditions It is found in general, however, that dark letters and figures on a light background are more readily visible and legible than are light-colored letters and figures on a dark background In other words, letters and figures in black, dark green, or maroon, on yellow, white or buff backgrounds are more easily distinguished than white, yellow or buff figures on black, green, dark blue, or dark red backgrounds It would appear desirable to suggest to commissioners of motor vehicles in the various States that this fact be kept in mind in selecting the combinations of colors for the annual issue of license plates These principles apply also to highway markings

An investigation carried out at the request of the Director of Traffic of the District of Columbia on a small number of rear signal lamps commonly called "stop signals" shows a rather confused state of supply for these devices More work should be done in a study of the design of the reflectors and glasses used for such rear signal devices

In conclusion, I would like to refer again to the importance of the work of national organizations engaged in promulgating standards, such as the American Engineering Standards Committee and the Federal Specification Board, which last is doing so much to unify requirements for Government purchases If the service to be rendered is the same, there is no reason why the requirements for road materials and other equipment in one State should differ from those in another Uniformity in purchase requirements does much to insure the best material at the lowest price In this movement, I believe the Bureau has played an important part, because it has oftentimes assisted in determining what the best material really is for a given purpose

In what precedes, I trust I have left with you the impression that the laboratory is essential to the highway as an aid in working out

many of the highly complex problems confronting its operation and maintenance The real test, however, of the adequacy of the laboratory investigation is service in or on the highway of the material, machine, or practice recommended by the laboratory If, in this paper, you find I have unduly emphasized the rôle of the Bureau of Standards, you will appreciate that I have limited my remarks to that laboratory and those problems with which I am best acquainted

Finally, I would call your attention to the fact that the Bureau of Standards in celebrating its 25th anniversary on December 4, and I extend to you, one and all, a most cordial invitation to visit the Bureau on that day and see for yourselves what we are doing of interest to highway engineers

CHAIRMAN JOHNSON We shall now hear the report of the Director of the Highway Research Board, Mr Charles M Upham

REPORT OF DIRECTOR

CHARLES M UPHAM
Highway Research Board, Washington, D C

The year now closing has been a very active one for the Highway Research Board Through its publications and the work of its research committees as well as of its special investigators, the contacts of the Highway Research Board have been greatly broadened, and it has become evident that the Board is occupying a place in the highway engineering field that cannot be filled as well by any other organization.

During the past year the number of State contact men has been increased from 44 to 48, thereby making 100 per cent representation from the State highway departments

The great demand for the publications of the Board continues These publications are unique in that they represent the combined research thought of all the State highway departments and all the universities of the country engaged in highway research

The finances of the Board have been sufficient to meet the immediate needs of the organization, but it has been felt that it might be desirable to receive contributions in the form of a membership fee or service fee from the State highway departments who are directly the recipients of the benefits arising from the work of the Highway Research Board These funds would enable the Board to continue the work it has already begun and to enlarge its field of service. No definite amount of contribution has been decided upon nor has the manner of payment been definitely determined. This matter