IT is announced in *Nature* that the British Secretary of State for the Colonies has appointed a committee "to formulate practical proposals for submission to the Colonial Governments to give effect to the resolution for the Colonial Office Conference on the subject of Colonial Agricultural Scientific and Research Services." These proposals are to "include a scheme, based on contributions to a common pool, for the creation of a Colonial Agricultural Scientific and Research Service available for the requirements of the whole Colonial Empire for the support of institutions needed for that purpose, and for the increase of research and study facilities in connection with specialist services of the Colonies generally." The committee is thus constituted: Lord Lovat, Parliamentary Under-Secretary of State for Dominion Affairs (chairman), Mr. W. Ormsby-Gore, Parliamentary Under-Secretary of State for the Colonies; Sir Graeme Thomson, Governor of Nigeria; Mr. A. S. Jelf, Colonial Secretary, Jamaica; Mr. O. G. R. Williams, Assistant Secretary, Colonial Office; Major R. D. Furse, Private Secretary (Appointments) to the Secretary of State for the Colonies; Sir J. B. Farmer, Dr. A. W. Hill, Mr. F. L. Engledow, and Dr. A. T. Stanton, Chief Medical Adviser to the Secretary of State for the Colonies.

THE *British Royal Geographical Journal* reports that the Italian National Committee for Geography has decided to promote the creation of a fund for studies in Palestine, which will be devoted mainly to geographical research, whereas the scope of similar institutions which have existed for many years in other countries has been mainly historical and archeological. In accordance with this purpose, the first work to be undertaken by the Italian fund will be an expedition to chart the Dead Sea on a fairly large scale and to map the adjoining portion of the depression in which it lies and of the Jordan trough. In addition to the hydrography and mapping a geological survey and various limnological researches will be carried out. It is also planned to establish a station on the Dead Sea shores for protracted observation of variations in the sea-level and of the meteorological conditions of the basin.

UNIVERSITY AND EDUCATIONAL NOTES

THE will of Elbert H. Gary, chairman of the board of the United States Steel Corporation, includes bequests for scholarship funds of $50,000 each to McKendree College, the University of Pittsburgh, Lafayette College, Trinity College, Lincoln Memorial University, Syracuse University, Northwestern University and New York University.

THE campaign to raise $1,000,000 for the Medical School of Howard University, Washington, has been brought to a successful conclusion. Negroes contributed $150,259 to the campaign. A tablet bearing the names of fifty-one Negroes whose donations ranged from $1,000 to $10,000 will be placed in the new medical school building.

AT a meeting of the board of trustees of Ohio State University, on August 4, Dr. John H. J. Upham, Columbus, was appointed acting dean of the Ohio State University College of Medicine. Dr. Eugene F. McCampbell, who was formerly dean, retired on July 1.

DR. ALBERT WARREN STEARNS has been appointed dean of Tufts College Medical School, Boston, and will take up his new work on September 1, succeeding Dr. Stephen Rushmore.

DR. F. M. BALDWIN, who for the past ten years has been in charge of physiology at Iowa State College at Ames, has resigned his professorship to take charge of the department of physiology and become director of experimental marine biology in the University of Southern California at Los Angeles.

M. N. SHORT, of the U. S. Geological Survey, has been appointed lecturer in mining geology at Harvard University during the absence of Professor Graton on his sabbatical year.

DR. O. H. ELMER, assistant plant pathologist at the Iowa Agricultural Experiment Station, has been appointed to succeed Dr. R. P. White as assistant professor of botany and assistant plant pathologist at the Kansas College and Experiment Station.

D. S. MASTERS, of Ohio State University, has been appointed instructor in chemistry and chemical engineering at Washington University, St. Louis, Mo.

DR. J. H. ASHWORTH, of the University of Edinburgh, has been transferred from the chair of zoology to the chair of natural history.

DISCUSSION AND CORRESPONDENCE

THE "WASHBOARD" OR "CORDUROY" EFFECT DUE TO TRAVEL OF AUTOMOBILES OVER DIRT ROADS

THE writer returned recently from a somewhat extended trip by motor car in the Mojave desert, where much of the mileage was over unpaved roads. Of these, two types were noted, first, primitive desert road, which winds among sage and cactus over the long gently sloping alluvial washes characteristic of this desert, apparently following the trail of the first wagon or automobile to mark the way, and second, the worked dirt roads mainly traveled.

The first type, particularly serving as feeders for ranches lying some miles off the highway, consists mostly of the two ruts of the wheels, usually sandy and gravelly, underlain by more compact, or solid material. In this type of unpaved road the "washboard" effect to be described was not observed to a very appreciable extent. It is surprising how rapidly automobiles can be driven on such roads by drivers accustomed to them, with the many turns, which in places are quite abrupt, and with the necessity of keeping in the ruts. As much as a fifty-mile rate has been averaged on such a road, according to reliable information. With the continued twisting of the road the driver must continually watch details of the steering, so as not to let the wheels cut into the sand and gravel of the walls of the ruts. The driver unaccustomed to this type of road tends to turn his steering-wheel too soon in approaching a turn, causing departure from the ruts, whereas the trick is to let the wheels ride the ruts clear to their turning, and to turn with them. Of course much of the success of rapid driving under these conditions is in knowing from experience the details of the road, such as the curvature of each turn, its total angle, and where the straighter stretches are located that will permit speeding.

On the other type of dirt road, graded and occasionally dragged, the "washboard" phenomenon was found frequently. It may be familiar to drivers on dirt roads everywhere. A stretch of road well illustrating it at intervals is that between Daggett and Needles on the much-traveled National Old Trails Highway (Santa Fé Route). The usual road surface on this stretch is a rather thin layer of loose sand and gravel, or small fragments of broken rock, lying on more compact material as base. The phenomenon consists in the heaping up, by the tires of the automobiles themselves, of this loose material into parallel ridges, an inch or so in height, crossing the road at right angles, often with a slight sinuosity. The ridges have a quite uniform spacing of one and one half feet, very roughly, and are found in groups of six or eight, or more. A remarkable fact about them is that while as a group they appear to have grown in the direction of the road, as though they were the effect of sheets of water flowing along on the road, their growth has been essentially across the road, and is the result of the passing of many machines in both directions.

A reasonable explanation of the "washboard" roads ("corduroy," they are sometimes called, from a similarity to the old time roads where logs were laid transversely to make a safe passage for vehicles on soft ground) would seem to be as follows: Given, a somewhat shallow and uniform layer of loose sand and gravel on a fairly flat, hard surface, and a local inequality, say a fair-sized rock, or a chuck-hole in the solid base, which imparts a sudden upward impulse to one or both of the front wheels of the first automobile to encounter it. Consider one of the front wheels as experiencing this bounce. The physical quantities involved are (1) the elasticity both of the tire and of the spring, and (2) the inertia of the wheel system as distinct from that of the much heavier body. The necessary conditions are thus present for vibrations. If the automobile is supposed to be traveling at a speed of 35 or 40 miles per hour, the body of the car, on account of its far greater inertia, may be assumed to undergo at the time of the bounce a vertical displacement which is relatively negligible. With a given elasticity in the system the particular wheel mentioned will have a definite period of vertical vibration relative to the approximately non-displaced body. Thus it will vibrate for an appreciable time after the initial shock, and each time it moves away from the body of the car it will squeeze out before and behind it on the road some of the loose material, and in this way leave a series of equally spaced low ridges and shallow depressions. It is conceivable that a sympathetic effect would at the same time be transmitted to the other front wheel, which also would then tend to produce a similar effect on the loose material over which it passes. There must follow similar action on the part of the rear wheels. The question arises as to how the natural frequency of the front wheels, with respect to the body of the car, compares with that of the rear wheels. The two periods must be comparable, otherwise the rear wheels would tend to undo the work of the front ones, with the result that the well-defined washboard effect would not perpetuate itself.

An explanation offered by a driver living in the desert, of the phenomenon, was that the wheel, at the first bounce, because of lowered resistance between tire and road resulting from the diminished pressure between them, actually "spins," and in doing so kicks some of the loose material backward, repeating this action a number of times as the bouncing, that is, the vibration, continues. This explanation would require, at any rate after the group of ridges is once established, that the diminished pressure occur when the wheel is nearest the more compact sub-surface of the road, if the ridges are to perpetuate themselves in positions approximately fixed, so that the pressure should then be greater on the ridge than in the depression. This greater pressure on the loose material of the ridge would then be expected to show a tendency toward flattening it out, undoing the effect of the wheel while "spinning" in the depression. However, if the wheel slips periodically at the depressions but not at the ridges, then for a constant speed of the car body forward over the road, and thus presumably of the axle also (neglecting any vibration lengthwise of the road, of the wheels relative to the body) a constant rate of rotation of the wheels would be consistent with this explanation. For in ascending and descending the ridges the periphery of the tire at the point of contact would be moving at an angle with the direction of the forward motion of the axle, and if there were no slipping anywhere, would have to be moving circumferentially around the axle at a rate greater than that necessary in the depressions. But by the same argument there would be a tendency to spin on the peaks of the ridges also, which would tend to wear them down. This explanation by slippage uses, to be sure, the natural rate of vibration of the wheels relative to the approximately stationary body of the automobile. But on its face it does not appear so acceptable as that attributing the ridges entirely, or almost so, to the simple, periodic bumping of the road by the wheels, with negligible periodic slip.

The problem more generally, and in its simplest form, is that of a vibrating system of two masses, one much greater than the other, connected by an elastic spring, and affected by an elastic push corresponding to that of the rubber tire, and by gravity.

As to the transverse growth of the ridges, whose individual identity as they lie across the road, can be recognized often over a length of ten or twelve feet, possibly more, suppose a second car, similar to the first, follows it and strikes the first humps formed, which will be necessarily short transversely to the road. The chances are that the wheel of the second car will not strike the humps squarely if at all, but at one end of them or the other. But this is sufficient to give an initial bounce, and the result is a slight lengthening, transverse to the road, of the initial humps. It is rather remarkable that the two series of humps, one at either side of the first car to pass, should eventually join up into continuous ridges across the road, but this is the actual effect from the passing of many cars. Perhaps this joining up is the result mainly of a sympathetic action, mentioned above, of the wheel on the opposite side of the machine.

Alternate grooves and ridges, roughly parallel, can be formed by water flowing across the road, but this type is likely to lie obliquely rather than perpendicularly with respect to the road, and at any rate will hardly be so uniformly spaced over a considerable distance. The opinion may be ventured that where ridges of the particular washboard type are found on solid road surface devoid of loose material, they were formed by the vibration process at a time when the ground, due probably to moisture, was in a more pliable condition.

The frequency of vibration of the wheels of a car relative to a stationary body is a quantity much greater than the frequency of the heavier body relative to stationary wheels. Assuming one and one half feet as the approximately uniform interval between the ridges of the "washboard," and further assuming 30 miles per hour as the speed of the "average" car, the average vibration rate of the wheels relative to the body of the car, comes out about 30 v.p.s. ($v = \lambda$. The value of one and one half feet as the distance between ridges in a group makes the vibration rate about 2 per cent. less than the speed of the automobile in miles per hour.) A certain driver, who has driven much on these desert roads, mentioned 25 miles as an average value for all machines, which would give approximately 25 v.p.s. for an average value.

The question might be raised whether the "average" car, or a particular class of cars, heavy or light, is in the main responsible for the ridges. Also, is the vibration chiefly that of the balloon tires? Heavier cars with balloon tires were observed to travel in the straight stretches at 40 miles and better. Riders in the heavier machines traveling at the higher speeds are probably little disturbed by these corrugations on the road. The bumping effect in a lighter car at a speed of 12 or 15 miles would become at times monotonous, to say the least. A certain other driver living in the desert stated he found the bumping effect least at a speed of about 35 miles. This should vary with the type of automobile, but theoretically for each car there is one best speed for maximum comfort of riding, and that is the speed at which the wheels "resonate" with the ridges.

The writer has taken no actual measurements on these ridges. Moreover, it would be interesting to check the vibration rates of automobile wheels in the laboratory, with the values calculated on the basis of the physical explanation offered. Such matters are properly subjects for consideration in the fields of road and automobile engineering.

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THE REVERSIBLE MIXING OF SUBSTANCES IN THE CONDENSED STATE AT THE ABSOLUTE ZERO OF TEMPERATURE

THE thermodynamical results established in a previous paper[1] and extended in a subsequent paper[2]

[1] Read at the Philadelphia meeting of the American Association; SCIENCE, Feb. 25.