numerous cankers similar to those on the larch. There is no reason to suppose that this locality is the only one where the disease occurs; indeed the reverse is practically sure to be the case, as it is well known that European larch was imported widely and quite generally twenty to fifty years ago. The fact that it can go onto so many different American species, which are important timber trees, makes this discovery of very serious importance to all parts of this country. Further scouting is being done to see if it is widely distributed.

Perley Spaulding,
Paul V. Siggers
Bureau of Plant Industry and
Northeastern Forest Experiment Station

THE DEFICIENCY OF ENGLISH UNITS OF MEASURE AND WEIGHT FOR SCIENTIFIC AND TECHNICAL USES

There are certain deficiencies in the English measures and weights which may be ascribed to historical causes and which have been imperfectly supplied by the use of troy and metric small denomination units. But the troy and metric units are not commensurable with the common or English units. The cause of this deficiency is that the English units were developed for the uses of trade, construction and manufacture, to which purposes they are perfectly adapted. The demand for technical, scientific and precision units is a relatively modern demand.

The English measures have no unit lower than the inch, whereas the metric system has seven such units, *viz.*, centimeters, millimeters, microns, angstroms, millimicrons, milliangstroms and micromicrons, of which the inch contains 2.54 centimeters, 25.4 millimeters, 25,400 microns, 254,000 angstroms, 25,400,000 millimicrons, 254,000,000 milliangstroms and 25,400,000,000 micromicrons.

Likewise the English weights have no unit lower than the ounce, whereas the troy and metric weights have 12 such units, *viz.*, drams, pennyweights, scruples, grams, carats, metric carats, decigrams, grains, centigrams, milligrams and micrograms, of which the ounce contains 7.2916 drams, 18.229 pennyweights, 21.875 scruples, 28.3502 grams, 138.449 carats, 142.045 metric carats, 437.5 grains, 2835.02 centigrams, 28,350.2 milligrams and 28,350,200 micrograms.

To supply the deficiency of our common units in the field of technical and scientific measures and weights, it is proposed that the foot be divided on the decimal scale into 100 lines and 1,000 points and that the ounce be divided into 8 drams, 100 centos and 1,000 moits, the ounce being the cube of the tenth of the foot, the dram the cube of the twentieth of the foot and the moit the cube of the hundredth of the foot of water at the maximum density. The common eight-ounce cup is the cube of two tenths or of one fifth of the foot. This will supply the deficiency of common units lower than the inch and the ounce, made necessary by modern refinements in measuring dimensions, volumes and masses.

For definitive purposes it is proposed that the foot be taken as the length of 473,404 waves of red cadmium light, that the ounce be taken as the weight of 28,316 milligrams and that new material standards or master bars and weights be constructed from these definitive values.

The avoirdupois pound was anciently regarded as equal to 7,002 troy grains. In 1844, however, after the burning of the parliamentary standards, the pound for the sake of certainty was defined by parliament as the weight of 7,000 troy grains, which produces 437.5 grains to the ounce.

The proposal to define ounce as 28,316 milligrams recognizes 28,316 grams as the weight of the cubic foot of water under the definition of the foot as 473,404 red cadmium waves. This takes 34 milligrams off the ounce, which for practical purposes may be regarded as one-half grain of 32.4 milligrams, thus reducing the ounce roughly from 437½ to 437 grains.

It is quite as legitimate to give the ounce a definition in milligrams as it was to give the pound a definition in troy grains, as was done more than eighty years ago. This is the one way to coordinate the ounce with the cubic foot of water and to correlate common volumes and weights.

Samuel Russell
Washington, D. C.

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

The interesting account of the so-called "washboard" or "corduroy" effect due to the travel of automobiles over dirt roads calls to mind an experience which the writer had last summer in the northern part of Minnesota.[1] Professor Dodd's explanation is very much to the point and on the whole I think plausible, but I am not sure that the explanation has gone far enough. In the single instance observed, my motor car was following a "grader" over a newly graveled stretch of road and, since I had myself advanced several theories concerning the cause of this

[1] Dodd, L. E., "'Washboard' or 'Corduroy' Effect Due to the Travel of Automobiles over Dirt Roads," Science 66, 1927, 214–216.

frequent phenomenon, I was very much interested to see that my theories were wrong, especially at the beginning of the causal series. Many of the corrugations that I had noticed were somewhat slanting, and now I saw that the scraping blade of the grading machine was responsible for the original vibration which was left in the road.

I have no doubt that the wheels of cars which travel on newly graded roads very much deepen these ridges when they resonate in tune to the original vibration of the scraping blade of steel which has left its marks in the ridges on the road. It must not be forgotten, too, that rain falling on the road will then also tend to drain off along these ridges and deepen them by erosion. I am wondering, too, when the road is of a certain elastic consistency, with a slight amount of moisture in the top layer, whether it will not then act much in the same fashion as the black asphalt pavements do when they are corrugated by impact, especially on down grades.

Naturally, this was only a single instance that came under my observation, but I made sure that there were no corrugations in front of the grader and that there were characteristically slanting and partially formed ones behind, and I am offering this bit of discussion in the hope that the matter may be verified or contradicted by observations of others. In general, this additional cause does not contradict the excellent explanation of Professor Dodd, but goes simply one step farther in certain cases.

CHRISTIAN A. RUCKMICK
THE UNIVERSITY OF IOWA

THE SEARCH FOR ELEMENTS ESSENTIAL IN ONLY SMALL AMOUNTS FOR PLANT GROWTH

FOR many years the essential nature of certain elements for normal plant growth remained undiscovered because they are needed in such small amounts that they were supplied as undetected impurities in the media in which the plants were grown. Between the years 1910 and 1919 Mazé,[1] by careful technique, showed boron, zinc and manganese to be essential to the growth of maize. Possibly because most of his papers were published in a journal devoted chiefly to bacteriological literature, they were overlooked by most plant physiologists. It was not until 1922 that the work of McHargue[2] emphasized the essential nature of manganese.

Boron was the next of these elements to receive attention. Warrington[3] in 1923, showed it to be essential for broad beans (*Vicia Faba*) and probably for runner beans, crimson clover (*Trifolium incarnatum*) and *Trifolium multiflorus*, but reported inconclusive results for white clover (*Trifolium repens*) and peas and negative results for barley and rye. The writer[4] in experiments with silicon and aluminum in which purified salts were used, confirmed the results with broad beans. The "mason" jars in which the solution culture experiments were being carried out were coated with "Valspar," a resistant varnish, to prevent contamination by solution of the glass, and sufficient boron for apparently normal growth of wheat, peas, millet and *Penisitum vilosum* was furnished by the varnish. Broad beans, however, made very little growth and showed the symptoms described by Warrington. They made remarkable recovery and normal growth when .5 mg. per liter of boron as boric acid was added to the solution. Later on when using uncoated jars in an experiment to determine whether or not chlorine is essential to plant growth, buckwheat failed to develop beyond the cotyledon stage when purified salts were used but developed normally when the ordinary "C.P." analyzed salts were employed. Because of the experience with broad beans, absence of boron was suspected of being the limiting factor. Investigation showed this to be the case. This and the effect of boron on the growth of sunflowers led the writer to study the effect of the absence of boron on a number of plants. Part of this work[5] with that continued at the University of California and later at the University of Minnesota, showed boron to be essential to corn, peas, sunflowers, vetch, barley, buckwheat, dahlias, lettuce, potatoes, millet, castor beans, sugar beets, kafir, sorghum, flax, mustard and pumpkins. Plants differed in the time, and to some extent in the way, in which the effect first appeared but none of the plants reached the flowering stage. Dicotyledonous plants in general responded more quickly than did monocotyledonous plants. In the case of sunflowers, cotton and buckwheat, the tops did not develop beyond the cotyledon stage and the roots grew very little. Other dicotyledonous plants showed the lack of boron by suppressed roots with enlarged apices within a few days but, depending on the type of plant, produced from

[1] Mazé, P. *Ann. Inst. Pasteur.* 1914, 28, 21–68; 1919, 33, 139–173. *Comp. Rend. Acad. Sci.* 1915, 160, 211–214.

[2] McHargue, J. S. *Jour. Amer. Chem. Soc.* 1922, 44, 1592–1598.

[3] Warrington, Katherine. *Ann. Bot.* 1923, 37, 629–672.

[4] Sommer, A. L. *Agri. Sci. Series,* Univ. California. 1926.

[5] Sommer, A. L. and Lipman, C. B. *Plant Phys.* 1926, 1, 231–249.