able hydrogens will then all be exchanged for deuterium.

Different conditions with respect to temperature, time, presence of suitable surface catalysts, etc., will be needed in different cases, but the principle is evidently of very general application. An example would be the bubbling of NH_3 gas through a train of bubble-tubes containing deuterium water and with suitable provision for drying the gas between tubes. From the end of such a train, deuterammonia, $NH^2{}_3$, would be evolved.

Similarly, if benzoic acid be shaken with successive portions of pure deuterium water it will probably be quantitatively converted into the corresponding deuterium acid, probably benzodeuteric acid, $C_6H^1{}_5COOH^2$. To prepare deuterobenzoic acid, $C_6H^2{}_5COOH^2$, would probably require a higher temperature and a suitable catalyst. This acid, if shaken with successive portions of pure protium water, $(H^1{}_2O)$ would probably yield deuterobenzoprotic acid, $C_6H^2{}_5COOH^1$.

The comparative ease with which many new compounds can be prepared in this way gives further emphasis to the great need of provision for the large-scale production of heavy water. To equip a small plant having a capacity of 6 to 10 gallons of 95 per cent. deuterium water per year would cost something like $25,000. Labor costs would be about $5,000 per year, and power costs (40 KW) would depend upon location. Such a plant would be much more economical than the small-scale laboratory outfits now in use at a number of universities and would produce sufficient heavy water to allow many chemical and biological investigations to be carried out.

In contrast with the hundreds of millions which are being spent in new projects by the Federal Government and by private industry, the amount of money involved is almost infinitesimal. Yet probably in no other way could the expenditure of an equal amount of money be productive of greater advances in chemistry and possibly biology and medicine, not to mention physics, which requires only relatively small amounts of the heavy water.

EDWARD W. WASHBURN

BUREAU OF STANDARDS

ALFALFA YELLOWS

FOLLOWING the publication of the abbreviated discussion on "alfalfa yellows" (SCIENCE, October 27, 1933) we have been informed by Professor E. M. Searls, of the Department of Economic Entomology of the University of Wisconsin, that he had secured data from the entomological view-point, which lead essentially to the same conclusions with reference to leafhopper populations and time of cutting alfalfa, as expressed by us. This lends much emphasis to the validity of the findings, and because Professor Searls has not yet published his results we take this opportunity to provide for a simultaneity of recognition for his contribution.

L. F. GRABER
V. G. SPRAGUE

UNIVERSITY OF WISCONSIN

SCIENTIFIC APPARATUS AND LABORATORY METHODS

A PORTABLE VACUUM TUBE VOLTMETER FOR MEASUREMENT OF GLASS ELECTRODE POTENTIALS WITH EXAMPLES OF pH ESTIMATIONS[1]

SIMPLICITY of design, small cost, accuracy and stability of the zero point are factors which justify a brief description of an equipment which has been found extremely useful in measuring the pH of biological fluids, food products and the like. Any laboratory possessing a suitable potentiometer and galvanometer may be provided with equipment for measurements with a glass electrode for a sum not exceeding ten dollars. The necessary parts are: One R. C. A. tube No. 232, thirteen flashlight cells, four No. 6 dry cells, two single-pole single-throw switches, twenty-five feet of rubber insulated wire No. 16 B. and S. gauge, and a wide mouth bottle, with tight-fitting rubber stopper.

The vacuum-tube is kept in a dry atmosphere by mounting in the wide mouth bottle in the following manner: An eighteen-inch length of insulated wire is soldered to each of the four base prongs, and a twelve-inch length to the cap of the tube. The wires attached to the prongs are bent so that when the tube is in a vertical position the five wires may be passed through small holes in the rubber stopper, in which they should fit snugly. A dry atmosphere is maintained either by a thin layer of phosphorus pentoxide in the bottom of the bottle, or by means of phosphorus pentoxide contained in a side arm connecting through the rubber stopper.

The wiring diagram is shown in Fig. 1. The tube filament is supplied with 1.5 volts, four No. 6 dry cells connected in parallel to give sufficient capacity for the maintenance of a constant filament temperature. Seven flashlight cells, connected in series to the filament battery, furnish twelve volts to the screen or space charge grid. Four flashlight cells in series furnish six volts to the plate, acting through a galvanometer which has a sensitivity of 0.025 microamperes

[1] Food Research Division Contribution No. 176.