vanishingly small when the ions are equal in this respect. Thus with KCl the only potential of significance when a steady state boundary has been achieved is of the kind evaluated above.

The limiting case derived from the Meyer and Sievers theory by Mysels corresponds precisely to the experiment described above, which gave rise to the "perched" potential. The steady state potential between saturated KCl and any exchange material is likely to be much smaller.

Dr. Mysels' letter fulfills a useful purpose by drawing attention to the fact that we must make up our minds what kind of junction we are concerned with in any particular experiment. It seems to the writer that a junction with a representative cross section of the system under investigation is desirable. Conclusions drawn from such measured potentials refer then to the system as a whole. The colloid chemist's task, in general, is the interpretation of such systems.

C. Edmund Marshall

Department of Soils, University of Missouri

References

1. Mysels, K. J. *Science*, **114**, 424 (1951).
2. Jenny, H., *et al. Science*, **112**, 164 (1950).
3. Marshall, C. E. *Soil Sci. Soc. Am., Proc.*, **15**, 110 (1950).
4. Peech, M., and McDevitt, W. F. *Ibid.*, 112.
5. Coleman, N. T., *et al. Ibid.*, 106.

A Practical Laboratory Method for Mass Culturing Bacteria[1]

Bacteriological investigations involving an elucidation of the chemical constituents of bacteria are frequently impeded by lack of suitable facilities for growing sufficient quantities of cells. The method described below requires no unusual laboratory apparatus, and it is mobile, inexpensive to construct, and applicable to mass cultivation of a variety of microorganisms for research purposes. The method has been used here for the past two years for the cultivation of both pathogenic and nonpathogenic bacteria. Good yields have been realized in a minimum of time, without undesirable degenerative changes occurring in the cells, and with no environmental contamination.

The culture container is a 7-gal, cylindrical Pyrex jar resting on a rubber-cushioned sheet-iron base (Fig. 1). Four tierods project from the base through matching holes drilled in the ¼″ aluminum cover. The latter has a collar welded to its under surface around which is fitted a ¼″ rubber gasket. A tight seal around the lid is obtained by tightening the tierod nuts on top of the cover with a wrench.

The cover has holes suitably drilled in it to receive a mercury seal, air and alkali tubes, glass and calomel electrodes, thermoregulator (glass rod type), heating element (300-w Calrod), thermometer (25°–45° C), mercury manometer, and siphon tube, all mounted in rubber stoppers (Fig. 2). A housing consisting of a 2½″ copper pipe nipple with flanges on either end

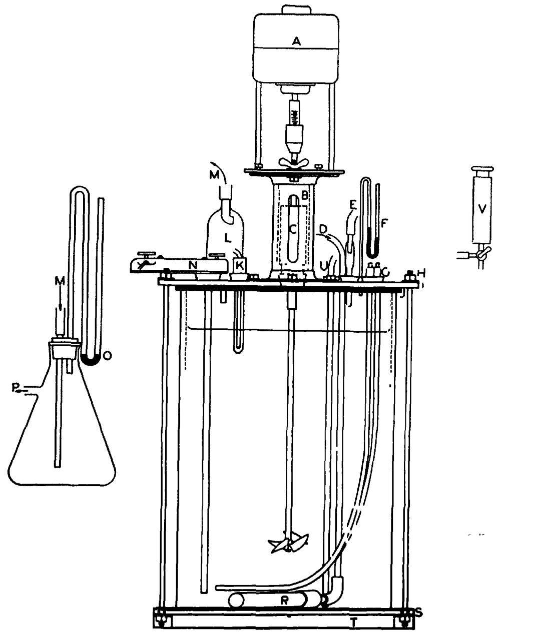

Fig. 1. Schematic representation of culture unit. *A*, motor; *B*, motor support; *C*, mercury seal; *D*, air "in" tube; *E*, to alkali reservoir; *F*, mercury manometer; *G*, heater; *H*, tierod cover nut; *I*, lid; *J*, rubber gasket; *K*, electrode; *L*, froth trap; *M*, exhaust air; *N*, thermoregulator; *O*, relief mercury manometer; *P*, to water pump; *R*, filter candle; *S*, rubber-cushioned base plate; *T*, wooden base; *U*, siphon tube (to sampler, for introduction of medium ingredients, for harvesting); *V*, sampler (30-ml syringe with 2-way Luer stopcock).

is bolted to the center of the cover to support the stirrer motor (1/20 hp, 1400 rpm). The latter is mounted as indicated (Fig. 2) to allow for proper alignment with the stainless steel stirrer through the mercury seal.

In operation, the thermometer and electrodes are sterilized separately in a quaternary ammonium salt and maintained in tubes of sterile broth. Cotton plugs are placed in the cover holes occupied by these, the motor removed, and the otherwise assembled apparatus is placed on its side in an ordinary autoclave and sterilized. After sterilization, the thermometer and electrodes are aseptically inserted into the cover, the motor attached, and the proper amounts (about 24

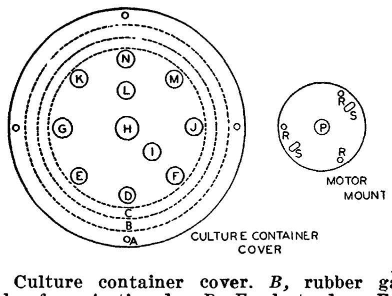

Fig. 2. Culture container cover. *B*, rubber gasket; *C*, collar; holes for: *A*, tierods; *D*, *E*, electrodes; *F*, air out; *E*, air in; *G*, heater; *H*, mercury seal; *J*, manometer; *K*, siphon; *L*, alkali; *N*, thermometer; *M*, thermoregulator. Motor mount: *R*, taped holes for leveling screws; *S*, slots for motor mount bolts; *P*, drilled holes for stirrer shaft.

[1] This investigation was supported in part by a contract (No. 9-ONR-87,200) between the Office of Naval Research and the University of New Mexico.

liters) of distilled water previously sterilized and stored in 5-gal carboys, along with sterilized concentrates of the medium ingredients, are aseptically siphoned into the container.

The pH of the medium is initially adjusted and maintained during the growth of the culture by connecting the electrodes to an a-c pH meter and, with constant stirring, by manually adjusting the rate of addition of alkali. The incubation temperature is held to within ± 0.1° C with the thermoregulator indicated, without the necessity of interposing a relay system.

Aeration is obtained by forcing compressed air through a filter candle while the exhaust air is aspirated from the container with a water pump at the same time. The rates of the air flow are balanced to maintain a slight negative pressure within the apparatus, obviating any chance of environmental contamination. A relief mercury manometer adjusts for fluctuation in water flow and compressed air pressure, as shown. The addition of an antifoam reagent such as *n*-butyl phosphate prevents undue foaming. At the termination of incubation, the culture may be easily harvested by siphoning it directly into a masked Sharples Supercentrifuge.

With this apparatus, we obtain yields of 55 g, dry weight, of *Shigella sonnei* organisms in 7½ hr, using a simple culture medium containing 1% dextrose as fermentable sugar. About 470 ml of 5 *N* NaOH solution is required to maintain neutrality during the incubation period.

RICHARD B. JOHNSON[2]

Department of Biology
University of New Mexico

[2] The technical assistance given by Philip G. Crook is gratefully acknowledged.

Book Reviews

Combustion, Flames and Explosions of Gases. Bernard Lewis and Guenther von Elbe. New York: Academic Press, 1951. 795 pp. $13.50.

In recent years, the original book entitled *Combustion, Flames and Explosions of Gases,* issued by Cambridge University Press in 1938, achieved ultimate literary distinction by disappearing from library shelves—the copies apparently going into bookcases of prospective purchasers who were unable to obtain them by other means.

The publication of this second book by Lewis and von Elbe has been anticipated with interest by workers in combustion research. The authors, who are associated with the Explosives and Physical Sciences Division, U. S. Bureau of Mines, are eminently qualified by years of work on combustion to write a comprehensive text on the subject.

Although the authors borrowed the title of their first treatise, the tremendous increase in the scope and volume of combustion research in the past decade required that they write essentially a new book. It is intended to provide the investigator, whether he be research scientist, industrial engineer, or student, with the fundamental observations and theories concerning combustion.

This book, like its predecessor, is in four parts. The first discusses the chemistry and kinetics of combustion reactions. New material on reactions of oxygen with hydrogen, carbon monoxide, and hydrocarbons is given. The second part, covering flame propagation, shows the greatest expansion of knowledge. Chapters on flame photography and pressure recording, combustion in nonturbulent and turbulent gases, fuel jets, burners, detonation waves, and flames in electric fields are included.

Part III concerns experimental and theoretical investigations of adiabatic explosions for several systems. It is essentially unchanged from the corresponding section in the first book. Part IV covers technical combustion processes. New material on gas turbines and turbojets is included. The appendices list selected thermodynamic data, limits of inflammability, and flame temperatures.

The presence of this book on the desk of the combustion investigator is justified alone by its extensive reference list of more than 800 authors, its abundant descriptions of experimental techniques, and its compilations of data. In addition the authors give detailed expositions of many current theories.

The only adverse criticism this reviewer is disposed to make is that the research of several workers has been omitted. Some of the omitted work may have been published after the literature survey was completed. This criticism, then, only indicates the fate of a book in an ever-expanding field. Undoubtedly 13 years hence we shall look to the authors for a third volume in their series.

MARJORIE W. EVANS
Armour Research Foundation, Chicago, Illinois

Igneous and Metamorphic Petrology. Francis J. Turner and Jean Verhoogen. New York: McGraw-Hill, 1951. 602 pp. $9.00.

Seldom has there been a book published that can be recommended so highly as this impressive volume. Although it is intended for the use of advanced students, research workers, and teachers in the field of geology, it is essential collateral reading for serious students in all branches of the natural and physical sciences who have an interest in the earth and in the physical and chemical principles that underlie rock genesis. It provides factual information on the classi-