another letter to Ingenhousz, dated February 11, 1788, in which he said:

I lament with you the Prospect of a horrid War, which is likely to engage So great a Part of Mankind. There is little Good gain'd, and so much mischief done generally, by Wars, that I wish the Imprudence of undertaking them was more evident to Princes; in which case I think they would be less frequent.[3]

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"ROGER BACON WAS MISTAKEN"

IN SCIENCE of March 29, I find an article entitled "Roger Bacon Was Mistaken," in which the author attributes to Roger Bacon the statement that "hot water would freeze more quickly than cold water."

The present writer is not an authority on the writings of Roger Bacon, though he has given some attention to them, and he has no recollection of seeing any discussion of temperature changes in Roger Bacon's writings; but he is aware that some four hundred years later Francis Bacon devoted a considerable portion of his "Novum Organum" to a discussion of "The Form of Heat." In this discussion he says:

The preparation of bodies, also, for the reception of cold should not be omitted, such as that water a little warmed is much more easily frozen than that which is quite cold, and the like.

In his "Table of the Degree or Comparative Instances of Heat" he says in example 39:

A brick or stone or hot iron, plunged in a basin of cold water and kept there for a quarter of an hour or thereabouts, retains such a heat as not to admit of being touched.

Evidently, Lord Bacon in this case must have performed his critical experiment in the same manner as did the author of the article on Roger Bacon's mistake. In this latter instance it would be very interesting to know why the pint of water from mother's tea-kettle continued to cool faster than the pint from the kitchen faucet after they had both reached the same temperature.

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PROFESSOR JOSEPH O. THOMPSON's comments on the freezing of hot water sooner than cold water appealed to me rather keenly. When I was a schoolboy some of my elders said that the hot water pipes always froze first and that hot water, put in a vessel and exposed to the atmosphere, would freeze more quickly than cold water placed in a similar vessel. The idea appeared so preposterous to me that I performed exactly the experiment performed by Bacon. I got two deep pans of the same shape and size. One I filled with cold water and the other with hot water, placed them on a cold porch one evening and watched the rapidity with which each froze. I was pleased to note that the one containing cold water froze very much sooner than the one containing hot water, much to the disgust of my elders.

If Professor Thompson's volume of water which had been heated becomes rapidly less in volume than the cold water, the experiment does not seem to be carried out along strictly scientific lines.

The belief that hot water does freeze more quickly seems to be firmly ingrained in the public mind so that many persons believe if hot water is placed in the ice-cube compartment of an electric refrigerator it will freeze faster than if cold water is placed therein. Perhaps it will if a large portion of it is lost through evaporation.

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BEING mildly intrigued by Dr. J. O. Thompson's recent note: "Roger Bacon Was Mistaken,"[1] I repeated the experiment at Caribou, Colo. (elevation, 10,600 feet) on an evening during which the temperature fell from $-14°$ C. to $-17°$ C.

Four 500 cc glass cylinders and four ordinary pie-tins were used in the experiment. These were placed on the wooden floor of the cabin-porch. The volume of water used in each case was very nearly 250 cc. Twin-samples of water at various temperatures were placed in cylinders and pie-tins—and the times recorded for the first appearance of ice crystals. The results are given in the table:

Type of receptacle	Original temperature of water	Time of cooling to freezing point
Cylinder	93.3° C.	54 min.
Pie-tin	93.3° C.	31 "
Cylinder	30° C.	42 "
Pie-tin	30° C.	33 "
Cylinder	20° C.	39 "
Pie-tin	20° C.	31 "
Cylinder	10° C.	37 "
Pie-tin	10° C.	29 "

Perhaps it should be noted that at an altitude of 10,600 feet brook-water boils at 93.3° C. Slightly different results might have been obtained with distilled water at sea-level.

Only in one case did the originally boiling water freeze, (in a receptacle of the same type), more quickly than cold water, and even in this case the "cold" water was nearly lukewarm. It seems clear that the shape and heat-capacity of the receptacle are critical. Various other factors may be involved.

[3] *Ibidem*, Letter 1715, p. 633.

[1] SCIENCE, 91: 2361, 315, March 29, 1940.

Roger Bacon and the "ancients" were probably both right in so far as they reported the results of individual experiments. They were both wrong in generalizing from insufficient experimental data. I do not presume to say what Dr. Thompson was.

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SCIENTIFIC BOOKS

THE THEORY OF NUMBERS

Modern Elementary Theory of Numbers. By LEONARD EUGENE DICKSON. vii + 309 pp. Chicago: The University of Chicago Press. 1939.

THIS book provides an account of the essentials of the classical theory of numbers, and of such special topics as Diophantine equations of the second degree, the representation of integers by quadratic forms in three or more variables (with integer coefficients and variables), Waring's problem for cubes and fourth powers, and other problems of representation by quadratic, cubic or quartic polynomials, in so far as these questions can be handled by elementary (*i.e.*, non-analytical) methods.

The word "modern" in the title is justified by the inclusion of new or recent results and methods, due in the main to the author and his pupils. Thus the theorem that every positive integer can be expressed as a sum of nine non-negative integral cubes (the classical solution by Wieferich and Kempner of the "universal" Waring's problem for cubes) is treated as a particular case of representation by $\sum_{i=1}^{9} h_i x_i^3$ (where the h_i are assigned positive integers and the variables x_i are restricted to non-negative integer values), and the author gives an extensive list of cases in which this form is "universal," *i.e.*, represents all positive integers. As another extension of Waring's problem for cubes the representation of positive integers by $\sum_{i=1}^{9} \varphi(x_i)$ is discussed for various integer-valued cubic polynomials $\varphi(x)$. Wieferich's theorem that every positive integer can be expressed as a sum of 37 positive or zero fourth powers (the nearest approach by elementary methods to the 19 which is believed to be the "correct" number) is proved by a method which shows in addition that 20 of the 37 fourth powers can be taken equal in pairs.

The sections on quadratic forms include a discussion of "universal" forms (*i.e.*, positive definite or indefinite forms which represent all positive integers or all integers respectfully), and of "zero forms" (*i.e.*, indefinite forms which represent the number zero with integer values of the variables not all zero).

An appendix is devoted to Dirichlet's theorem on primes in an arithmetical progression, a result frequently required though not "elementary" in the strictest sense.

It may perhaps be felt that the scope of the book hardly justifies so comprehensive a title, for the elementary theory of numbers has made important advances in other directions in recent years. A notable example is the additive theory of the "density" of sequences of integers, created in the last decade. Within its own limits, however, the book is a storehouse of information on a variety of topics not easily accessible hitherto, and the author has made the proofs about as simple as can be expected from the nature of the problems. This is not to say that the book will be found easy reading by anyone who sets out to work conscientiously through its 309 compactly written pages of text and examples (some of which are quoted in the text), for many of the discussions necessarily involve much intricate detail and lengthy enumeration of cases. The reader interested in a particular topic can, however, read selectively; and the reader desiring to pursue any subject further will find the essential references scattered through the text.

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A MATHEMATICAL CLASSIC

Topological Groups. By L. PONTRJAGIN (translated by Emma Lehmer). ix + 299 pp. Princeton, 1939.

PROFESSOR PONTRJAGIN'S book on "Topological Groups" is more than distinguished; it is a mathematical classic. The subject of topological algebra, occurring as it does at the junction of two great streams of thought, has been one of the most fascinating mathematical developments of the past fifteen years. The present volume by the brilliant blind Russian scientist is likely to remain far and away the most important work on this subject for many years to come.

The main theme of the book is the "analyticity" and representability by ordinary matrices of compact and (locally compact) commutative topological groups. One's enjoyment of the beautifully clear exposition of this theme is enhanced by the realization that many of the principal ideas are due directly to the author. The discussion is also rounded off at the end by an appropriate selection of related special topics from the theory of Lie groups.

Although the book generalizes a theory which has proved of great importance in quantum mechanics, it is probably too abstract and technical for the non-mathematician. But it should be an ideal text for graduate courses in mathematics, both because of the value of the contents and as an introduction to modern mathematical ideas.

GARRETT BIRKHOFF