computations are available in this office. Since the volume was at first set up at the Government Printing Office, it was thought impossible to insert all the corrections on the original plates without their resulting mutilation. To replate the volume would have cost $15,000 or more. Funds available did not justify this additional expenditure. It was thought that by correcting all altitudes that were in error by more than .3′ and all azimuths in error by more than .4° the tables would be serviceable and that the remaining smaller errors, which were numerous, would result in no ill effects to the practical navigator. Errors of greater magnitude now appearing in the volume, if such exist, were apparently overlooked by the person in comparing the original printing with the later computed manuscript. Thus, the entire set of tables, excluding v. 4, are considered accurate and to contain fewer errors than most such tables, involving a multiplicity of computations and resulting figures. V. 4 is believed to be sufficiently accurate for general use.

"All latitudes were computed in duplicate by the W.P.A. project excepting latitude 20°, which had been computed and largely checked on machines in what was then the Division of Research of the Hydrographic Office. As you perhaps know the project was organized to spread work and hence the use of calculating machines was practically forbidden. The computations were made by two separate groups, the results compared, and where differences occurred the computation was redone. This explains the high degree of accuracy to be expected throughout the other 8 volumes."

In the light of this new information, it is clear that a more accurate statement would be that the Errata mentioned earlier may be considered as typical of v. 4 rather than as typical of all 9 volumes of H.O. 214.

CHARLES H. SMILEY

Brown University

UNPUBLISHED MATHEMATICAL TABLES

72[F].—H. E. SALZER, *Representation Table for Squares as Sums of Four Tetrahedral Numbers.* MS in possession of the author, NBSCL.

This table shows for each square, $m^2 \leq 10^6$, a set of four tetrahedral numbers, i.e. numbers of the form $n(n+1)(n+2)/6$ whose sum is m^2. The author conjectures that every square is the sum of four such numbers. See *MTAC*, v. 1, p. 95, UMT **8**.

73[K].—WILFRED JOSEPH DIXON (1915–), *Table of Normal Probabilities for Various Intervals.* Completed in 1945 at Princeton University. Manuscripts in possession of the author, University of Oregon, and of the Library at Brown University. 4 sheets of text 19.5 × 26.7 cm. 10 sheets of tables, 36 × 26.2 cm.

Prof. Dixon writes: "The table is useful for the investigation of many of the problems in order statistics. A discussion of order statistics is given in Amer. Math. Soc., *Bull.*, Jan. 1948, by S. S. WILKS. Several of the distribution functions he gives there are such that it is necessary to evaluate them numerically."

Let for $l > 0$

$$g(x, l) = (2\pi)^{-\frac{1}{2}} \int_{x-\frac{1}{2}l}^{x+\frac{1}{2}l} e^{-\frac{1}{2}t^2} dt.$$

The present tables give values to 6D of $g(x, l)$ for $x = [0(.1)5]$ and $l = [0(.1)10]$. The rows of the double-entry table correspond to fixed values of x, the columns to l. There are 49 rows and 10 columns per sheet. Let

$$\phi(x) = (2\pi)^{-\frac{1}{2}} \int_{-\infty}^{x} e^{-\frac{1}{2}t^2} dt.$$

Then $g(x, l) = \phi(x + \frac{1}{2}l) - \phi(x - \frac{1}{2}l)$. The present table was computed in this way from the tables of $\phi(x)$ given by L. R. SALVOSA (*Annals Math. Statistics*, v. 1, 1930, p. 191 f.). Since the latter is only to 6D it is clear that the last digit of the present tables is not reliable.

More accurate values could be obtained from NBSCL, *Tables of Probability Functions*, v. 2, 1942. In applications one usually requires differences $\phi(b) - \phi(a)$ rather than values of $\phi(x)$. Such differences can now be obtained by a single reading, putting $x = \frac{1}{2}(b + a)$ and $l = b - a$.

W. FELLER

74[L].—HERBERT E. SALZER, *Table of* $\Gamma(n + \frac{1}{2})$, ms. in possession of the author, NBSCL, 150 Nassau St., New York City.

This is a manuscript of $\Gamma(n + \frac{1}{2})$, n = [0(1)1000;8S, guaranteed to 7S]. The table can also be used to obtain $\Gamma(-n + \frac{1}{2})$ by a single division, from the relation $\Gamma(-n + \frac{1}{2}) = (-1)^n\pi/\Gamma(n + \frac{1}{2})$.

H. E. SALZER

AUTOMATIC COMPUTING MACHINERY

Edited by the Staff of the Machine Development Laboratory of the National Bureau of Standards. Correspondence regarding the Section should be directed to Dr. E. W. CANNON, 418 South Building, National Bureau of Standards, Washington 25, D. C.

TECHNICAL DEVELOPMENTS

Our current contributions under this heading appear in the earlier part of this issue. They are "The memory tube and its application to electronic computation," by ANDREW V. HAEFF, and "The logical design of the Raytheon Computer," by R. M. BLOCH, R. V. D. CAMPBELL & M. ELLIS.

DISCUSSIONS

General Design Considerations for the Raytheon Computer

The basic logical units of a general-purpose automatic digital computer are: first, a memory for storing numbers and coded instructions; second, an arithmetic unit for performing addition, subtraction, multiplication, division, and other required operations; third, a central controlling facility for directing the machine in accordance with the coded instructions; and fourth, auxiliary devices required for transforming the input data into a form suitable for the machine, and for recording final results.

In most machines, there are two types of memory provided: a unit of relatively low storage capacity in which any selected item in the unit may be obtained quickly; and another unit, having a much larger capacity, but from which items can be obtained quickly only if they are used in a preassigned order.

In the design of computers, there are a number of basic decisions which together largely characterize the machine. These decisions relate to the manner of representing numbers and instructions inside the machine, the basic or built-in operations provided in the arithmetic unit, and the framework within which machine operations are scheduled.

Representation of Numbers.—In digital machines, the radices 2 and 10 are almost universally used for number representation. Normally the digits used are non-negative, except possibly during the performance of certain operations such as multiplication and division.

The use of the radix 10 has the advantages that numbers and arithmetic processes are in a familiar form. The normal form of the digits of the decimal representation is not necessarily preserved, however, since in many machines it is necessary to use a coded decimal notation. Thus, if bi-valued storage elements are used for number representation, a set of at least four such elements must be used to obtain 10 distinct configurations. The binary system makes for simpler arithmetic processes than does the decimal or coded decimal and frequently requires less equipment for the storage of numbers.

If a digital computer is used as part of a control device, it may receive its numerical input data from instrument readings. Such readings, if in continuous form, must be con-