# UNPUBLISHED MATHEMATICAL TABLES

**181[E].**—NATIONAL BUREAU OF STANDARDS, *Tables of* sinh $x$ *and* cosh $x$. Available on IBM cards at NBSCL.

A table of sinh $x$, cosh $x$ for $x = 2(.001)10$ to 9S has been prepared on SEAC. This is an extension of the material available in National Bureau of Standards Applied Math. Ser. No. 36. Among those who contributed to the preparation of this table were W. F. CAHILL and S. B. PRUSCH.

J. T.

**182[E].**—NATIONAL BUREAU OF STANDARDS, *Table of* $\exp(-x)$. Available on IBM cards at NBSCL.

A table of $\exp(-x)$, $x = 2.5(.001)10$, to 20D has been prepared on SEAC. This is an extension of the material in NBS Applied Math. Ser. No. 14 which gives $\exp(-x)$ for $x = -2.5(.0001)2.5(.001)5(.01)10$ to at least 12D.

Among those who contributed to the preparation of this table were R. M. DAVIS, E. C. MARDEN, M. PAULSEN and S. B. PRUSCH.

J. T.

**183[F].**—A. GLODEN, *Factorization of* $2N^4 + 1$, $N \leq 1000$. 17 typewritten pages deposited in the UMT FILE.

Factorizations are complete up to $N = 100$ except for $N = 73$. They are mostly incomplete beyond $N = 500$.

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**184[F].**—F. GRUENBERGER, *Table of residue-indices of* 2 *for prime moduli between* 100000 *and* 110000. One sheet tabulated from punched cards deposited in the UMT FILE. Other copies available from the author.

This table is the beginning of a recalculation of an unreliable table of KRAITCHIK[1] for $p < 300000$. It gives for each $p$ between the limits indicated the integer $\nu = (p - 1)/x$ where $x$ is the "exponent" of 2, that is, the least positive integer $n$ for which $2^n - 1$ is divisible by $p$. New errors uncovered in Kraitchik's table by collation with the present table are given in MTE **237** in this issue.

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[1] M. KRAITCHIK, *Recherches sur la Théorie des Nombres*, v. 1, Paris, 1924, p. 131–191.

**185[F].**—R. J. PORTER, *Additional Tables of Irregular Negative Determinants of Exponent* $3n$. Typewritten manuscript on deposit in the UMT FILE.

This is an extension of UMT **155** [*MTAC*, v. 7, p. 34] to determinants $-D$ with $50000 \leq D < 80000$.

In this range there are three $D$'s with exponent of irregularity equal to 6, namely

$$D = 55555, 67899, 70244.$$

As in the earlier table, there are many more $D$'s with exponent 9 in fact the following 11.

52731, 54675, 56403, 58563, 60075, 64395, 70227, 70956, 75411, 76059, 77571.

All 1169 other $D$'s have exponent 3.

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**186[L].**—C.-E. FRÖBERG & P. RABINOWITZ, *Tables of Coulomb Wave Functions* NBS Report, 12 January 1954. Deposited in the UMT FILE.

The first volume of a table of *Coulomb Wave Functions* was issued in the NBS Applied Math. Ser. in 1952 (see RMT **1091**); it is devoted to the regular solution and enables values to about 7 figures to be obtained in the range $L = 0(1)21$, $-6 \leq \eta < 6$, $0 \leq \rho \leq 5$. A second volume will be issued in the same series; it will be concerned with the regular and irregular solution for $L = 0$ and in the range $0 \leq \eta \leq 10$, $0 \leq \rho \leq 10$. This report, of which a limited number of copies are available, is concerned with a skeleton table for both the regular and irregular solutions. From this table it is possible to obtain both the functions to about 6–7 figures in the range $L = 0(1)21$, $1 \leq \eta \leq 10$, $1 \leq \rho \leq 10$, using standard techniques of interpolation and the recurrence relations for the functions.

Although this table itself will be of considerable use to physicists who are prepared to do a fairly heavy interpolation job, it is best to regard it as the result of proving in a SEAC code for the whole range $L = 0(1)25$, $0 \leq \eta \leq 100$, $\frac{1}{2} \leq \rho \leq 100$. From this code, by insertion of suitable parameters, it is possible to obtain a detailed table of the functions in any part of the range mentioned. This is prepared, in the first place on magnetic wire, and from this IBM cards can be punched, or a Flexowriter manuscript obtained. At present it is not thought likely that more detailed tables will be printed, but consideration can be given to the preparation of decks or manuscripts to satisfy individual or organizational needs.

A preliminary report on the method of computation, including some new integral representations of the functions, was given as Paper No. 9, at the NBS Tables Conference on May 15, 1952.

J. T.

**187[L].**—NATIONAL BUREAU OF STANDARDS, *Table of the Sievert Integral.*

The Sievert integral is defined by

$$y(\theta, x) = \int_0^\theta \exp(-x \sec t)dt$$

(see **Q.19**, *MTAC*, v. 2, p. 196). For $\theta = \frac{1}{2}\pi$, $y(\theta, x)$ coincides with $Ki_1(x)$ which has been tabulated by BICKLEY & NAYLER[1].

This function has been tabulated using SEAC, the computations being planned by H. E. SALZER. Among those who contributed to the preparation were R. B. JASPER, P. J. O'HARA, M. PAULSEN, and W. R. SODERQUIST. The quadratures were checked by comparison with the Bickley-Nayler table. There is now available, on IBM cards, values to 9S of $y(\theta, x)$ for

$$\theta = 0(1°)90°, \quad x = 0(.01)2(.02)5(.05)10.$$

A table to about 5S for $x = 0(.5)10$ and the same values of $\theta$ by SIDNEY JOHNSTON is referred to in UMT **103**, *MTAC* v. 4, p. 163.

J. T.

[1] W. G. BICKLEY & J. NAYLER, *Phil. Mag.*, s. 7, v. 20, 1935, p. 343–347.

# AUTOMATIC COMPUTING MACHINERY

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## TECHNICAL DEVELOPMENTS

## THE DEVELOPMENT OF A.P.E.(X).C.

**1. Historical.**—It is the purpose of this paper to give a technical description of the all purpose electronic digital computer developed at the Birkbeck College computation laboratory. Before embarking on this, however, it seems appropriate to mention certain historical details which put the present machine into perspective.

In 1946 the present author was engaged in the development of a special purpose relay digital calculator for the automatic evaluation of three dimensional Fourier sums[1] of the type:

$$\rho(x, y, z) = \sum_{-H}^{+H} \sum_{-K}^{+K} \sum_{-L}^{+L} |F_{hkl}| \cos\left\{ 2\pi\left(\frac{hx}{a} + \frac{ky}{b} + \frac{lz}{c}\right) - \alpha_{hkl} \right\}$$

where the $F$ and $\alpha$ are given in digital form and are available from a punched tape.

The complete design for this machine involved a magnetic *disc* store for 256 words of 16 bits, and also a matrix function table (one-many, many-one) for producing the cosine function.

Although this machine was to be relatively compact (600 relays and 100 vacuum tubes) it did not satisfy aesthetically since the input had to be in binary form and output resulted in a like manner.

Fortunately, at this point, the author was invited to address the American Society for X-ray and Electron Diffraction, and in the course of this visit to the U.S.A. was able to make contact with the pioneer work which was being carried out at several centres.

Through the generosity of the Rockefeller Foundation a period of study at the Institute for Advanced Study followed, during which plans were completed for an all purpose relay computer using roughly the same equipment as was already available for the earlier project.