become acclimatized to the United States and to the English language. I had occasion to meet him many years later when he came to lecture to a colloquium at Purdue, and I recalled to him our first meeting many years earlier. I was pleased that he had been so successful at Berkeley and was sad to read about his death in 1983 after a long and brilliant career.

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Comments on Minutes of Patent Conference at Moore School

Here are three of many possible comments on the "Minutes of 1947 Patent Conference" at the Moore School, which appeared in the April 1985 issue of the *Annals* (Vol. 7, No. 2) with an introduction by Nancy Stern.

1. It is evident from the "Minutes," but it won't hurt to repeat, that the "Minutes" were not reported by an experienced reporter. There are many places where the "Minutes" should be considered strictly tentative or even questionable. In a literal sense the "Minutes" are not minutes. They were never reviewed or proofread by a knowledgeable person, and were never signed by such a person.

2. I give an example of how impressions can be distorted from the "Minutes." At one point Dean Pender asked Eckert, "By what authority [did you send out letters to our research engineers (virtually asking for disclaimers from them)]? . . . Did you get permission from the supervisor?" Eckert is quoted as replying, "I gave Dr. Brainerd a copy of the letters."

It is true that he gave me a copy of the letters, but it was *after* I received complaints about them from other engineers on the project, and asked Eckert to talk with me. At that time I expressed my extreme dissatisfaction and immediately thereafter sent letters to all concerned stating that the Eckert letter (already circulated) was not approved and should be disregarded.

3. For those who are interested in the general question of the ENIAC and its potential for a patent, let me point out that the earliest history of the patent situation at the Moore School has never been published.

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Reviews

HENRY S. TROPP, EDITOR

The Reviews department features reviews of selected publications. Most reviews are solicited, but colleagues are invited (and indeed encouraged) to participate in this reviewing activity by indicating their wish to review a work, by suggesting titles to the Reviews editor, or by submitting a manuscript. In the latter instance please consult with the editor to avoid duplication. Books, monographs, journal articles, films, videotapes, and other publications relating to the history of computing will be described briefly in the Capsule Reviews section. Comments on books, articles, or reviews are welcome. NB: Reviews without bylines are by the editor.

REVIEWS

☐ Eckert, W. J. **Punched Card Methods in Scientific Computation.** Charles Babbage Institute Reprint Series, Volume 5, Cambridge, MIT Press, 1984, 136 pp., $25.00.

Three roads led to the fantastic world of the computer. Two of them are familiar not only to professionals but also to interested bystanders: component innovation and systems development.

The first was memorialized by the "generation" label. There was the nonautomatic, which began with the Babylonians and the Greeks and reached its apogee with the giant key-driven bookkeeping machines of the thirties. There was the automatic electromechanical, which began with Hollerith and blossomed until the fifties. There were the vacuum tube, transistor, integrated circuit, and microchip generations—and electro-optics is in sight.

The second was pioneered by The Father Of Us All, Charles Babbage. We have to put Hollerith here also, but the next name that we all think of is Aiken, and then the great Johnnie (although in my view von Neumann machines should properly be called Babbage machines). Then came the explosion: stack architecture, array processors, LISP machines. And the future is limitless; the slowness of signal propagation and the difficulty of heat dissipation must limit the component people, but systems can be almost as intricate as the human mind.

I began fifty years ago, as a very young undergraduate, to tread the third road—the road of the user. Although there will always be far more members of the user community than of the component or systems communities, the history of that road to the computer is only beginning to be appreciated. The names of the great pioneers like Wallace Eckert are hardly known; we tend to begin with Hopper and Backus, forgetting that a small but vitally important world of users existed before the days of software.

This book, reprinted by the MIT Press and Tomash Publishers, was the second signpost I encountered on the computer road. I still have the copy I ordered through my college bookstore in 1940, after seeing a publication notice in one of the astronomy journals (there were no computing publications, of course; even MTAC was not yet born). Some years later, when I was working for Eckert at the Watson Scientific Computing Laboratory, which he had established at Columbia under the difficult benevolence of Watson Senior, we laughed together over the fact that I had paid for my copy. Wallace thought I might be the only American individual to do so; with IBM support he had sent free copies to all the astronomers and all the computers he knew of (computers were people then—people who did computing). Many libraries paid for copies, of course, and even in the late forties the Watson Lab was sending some out from the dwindling stock I kept in a third-floor closet. But I laid out actual cash for mine—four dollars, as I remember. Ah, the snows of yesterday!

Before I describe the book itself, and the important added foreword by John McPherson, I must mention Signpost Number One, which was the precursor to Eckert's book and Eckert's entire career. There was a giant—a man who in my view ranks with Babbage and von Neumann and the solid-state boys—named Leslie John Comrie. Like Babbage, what he did was all his own, self-generated. In the thirties he was head of His Majesty's Nautical Almanac Office at Greenwich, a position he had obtained as the result of his preeminence as a mathematical table maker, and in spite of his New Zealand origin and lowly astronomical standing. He revolutionized the art of table-making, first by introducing mechanical calculators (Brunsvigas, mostly), then by using multiregister bookkeeping machines, and then by renting punched card equipment (for a year or two; he could not afford to keep it) and applying it to an enormous one-shot calculation of the positions of the Moon for the decades ahead.

He published his account of this latter, almost incredible achievement in the *Monthly Notices of the Royal Astronomical Society* in 1932, and Eckert, who was then studying at Yale under the man whose lunar tables Comrie had mechanized, saw the possibilities. Six or seven years later I read the story, my first signpost on the computer road, and was also told about Comrie and his other achievements by my thesis adviser. I too had the dream—but Wallace Eckert had it first!

John C. McPherson, himself very much a giant in our curious profession, retired a decade ago as vice-president (and before that, director of engineering) of IBM. More than any other person, he knows the story of IBM's early support and all-consuming entry and current eminence in computers. He publishes little, and says even less—a great pity. His coauthorship of the SSEC paper that appeared after a *thirty-four year* delay in these *Annals* [Vol. 4, No. 4, October 1982] is a notable exception. He has written an informative but flawed introduction to this fine reprint. I will return to the flaws later.

McPherson tells the story of Wallace Eckert's career, as a young astronomer, at Columbia (where with the help of a trustee named Thomas J. Watson he established his first computing shop), at the U.S. Naval Observatory (where he built up the world's first rent-paying permanent scientific punched card installation), and in his long service (1945–1967) as Director of Pure Science in IBM. Both McPherson in his introduction and Eckert in the book itself glide rather rapidly past Comrie, which is one reason for the length of my earlier remarks. But, as McPherson makes clear, it was Eckert alone who introduced the idea of automatic computation to American astronomy, and who first persuaded Watson and IBM that the scientific community needed heavy computing power. The later adventures at Los Alamos and Douglas and across the world owe much to his foresight.

The original book, republished without its bright orange cover (alas!), describes the punched card machinery of the thirties, gives some detail about modifications made at Eckert's suggestion that increased the minuscule sequencing capabilities of major equipment, and in an appendix lays out the management arrangements of the Thomas J. Watson Astronomical Computing Bureau. A now-forgotten computer/astronomer known to Eckert was named James Craig Watson, and I was intrigued to be told recently that the "Thomas J." in the bureau name was to avoid possible confusion.

In front material Eckert introduces us to other players in the tiny thirties drama, notably to Lillian Feinstein (later Mrs. Hausman), who ran the bureau after Eckert was called away to Washington, and who gave me my first lesson in plugboard wiring in 1945, when I was helping Eckert set up the new Watson Lab.

Wallace J. Eckert

The rest of the text is divided into two parts, the first of which gives general methodology ("Machine Methods"): for table-making and interpolation therein, for harmonic analysis, for the solution of systems of differential equations (the central problem of celestial mechanics), and the like. The second part, "Astronomical Applications," describes Eckert's seminal work, beyond Comrie for instance, in computing the perturbations of planet, satellite, and asteroid orbits by painful extensions of punched card technique . . . in excruciating detail! The lunar table calculations are mentioned, but because Comrie had finished that off as far as Hollerith machines were concerned, it is a short chapter. We can see from a later perspective, however, what Eckert and the SSEC crew would do to put the original expressions, from which the Yale tables were computed, onto the second giant IBM calculator in 1948.

A few earlier books and papers are referenced in footnotes, but all are already familiar to history buffs. The statistical work at Columbia, also supported by IBM and also mentioned in the McPherson foreword, is briefly described. And there is grateful but not groveling acknowledgment to Watson. A great book, and well worthy of the reprint series.

Now, about those flaws. I will try to avoid the nit-picking—the "I was there" syndrome—except in two cases. First, Figure 1 following the McPherson introduction is a picture of the attic of the Pupin Laboratory at Columbia, and shows the Thomas J. Watson Astronomical Computing Bureau, not the Watson Scientific Computing Laboratory. The Watson Lab, shown in its midlife effulgence in the last [unnumbered] figure, was indeed housed in Pupin for a few months in 1945, but on a lower floor; the Astronomical Bureau was still in the attic, doing war work for General Electric. And, second nit-pick, the official name of the Watson Lab, as for instance given on the covers of our Columbia brochures and course catalogues, did not include the "IBM": it was The Watson Scientific Computing Laboratory.

I am unhappy that McPherson did not see fit to give the long list of great astronomical papers that Wallace published, usually with his lifelong associates Gerald Clemence (who succeeded him at the Naval Observatory) and Dirk Brouwer, chairman for many years of the Yale astronomy department. These papers, always done with the help of powerful IBM computers, are landmarks in celestial mechanics; they would have qualified the three men for Nobel honors if such were awarded in astronomy. They, not the book under review and not the SSEC, were Eckert's chosen monument.

That would be a nice place to stop, but there is one more flaw—a very serious one for the history of our wonderful trade. John McPherson, much as I admire him—and admired him when I worked under him in the forties—has perpetuated an old IBM ugliness, one that makes it extremely hard to tell the early IBM story, to allot credit to the terrific people who put that company in the very forefront of information technology, and—although IBM management never seemed to realize it—to give full credit to the company for its support of science and technology before such support was popular, and for its tremendous contributions to componentry and systems, as well as to the user community.

I am referring to the complete and intentional omission of names throughout McPherson's foreword. Wallace himself was a generous man, and also was accustomed to scholarly attribution of credit. He would have wanted the names of the people he worked with to appear in notes about his career. I have mentioned Clemence and Brouwer; there were Belzer and Hollander and many others at the Naval Observatory, myself and Seeber and Thomas and Lentz and Havens (the father of NORC, the first supercomputer), and Lillian Hausman when she ran the Aberdeen relay machines, and youngsters like Severy and Krawitz and Hankam—all at the Watson Lab. There were even more such people down at the SSEC, *and their names are missing from the Annals article also.* It was conscious IBM policy. All good things flowed from Mr. Watson, and Mr. Watson only. It distressed me in the forties; it distresses me now.

But it was great to be with Comrie and Eckert again—yes, and John McPherson too. A golden time!

H. R. J. Grosch
Mies, Switzerland

Comment on Review

Having been with IBM for fifty-five years, may I remark with some credibility that the company's growth was founded on respect for the individual. Its policy was and is to service three equal constituencies: our customers, our stockholders, and our employees. Individual contributions are widely known throughout the company through *Business Machines*, *Think*, and many other similar in-company news publications; suggestion awards; 100% Club meetings for salesmen; recognition dinners for scientists and engineers; IBM fellowships; Invention Awards.

Grosch's comments regarding Watson and IBM are so completely at variance with reality in both the July issue of the *Annals* and in his review of *Punched Card Methods in Scientific Computation* that it is fair to liken his stance to that of Don Quixote tilting at windmills. Those comments are not relevant to the book under review, written five years or more before there was a Watson Scientific Computing Laboratory, or to its author, or to the history of computing. I regret his insistence on including them in what otherwise would have been an informative and constructive review.

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Editor's Note

John McPherson's new introduction to the reprint edition of Wallace Eckert's volume, reviewed on the previous pages by Herb Grosch, contains a brief bibliography of related material. Quite by accident, in another publication, I saw a reference to a paper by McPherson that was published in 1942 and was not mentioned in the bibliography. I asked McPherson for a copy of the paper. He was surprised by my request and said that he didn't remember the paper. I gave him the citation and within a few days he sent me a copy, saying that he wished he had remembered that paper before writing the Eckert introduction because it would have been helpful. I read the paper and agreed with him that it was relevant; hence we are reprinting it here, without editing or correcting, in conjunction with the review of Eckert.

The punched card has become obsolete so recently that most of us can vividly recall its central role in the computational and record-keeping environment. What we have all probably forgotten is the central role of punched-card equipment in engineering, mathematics, statistics, surveying, etc., between 1930 and 1950, thanks to the pioneering work of individuals like L. J. Comrie and Wallace Eckert. As Ed Berkeley once pointed out (*Giant Brains*, Science Editions, Inc., 1949, p. 64), "Over 30 scientific and engineering laboratories in the United States are doing computation by punch cards. Over a billion punch cards, in fact, are used annually in this country."

Mathematical Operations with Punched Cards*

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In the past fifty years we have seen a very significant change in the extent and complexity of computations required to apply mathematical formulae to concrete situations. The early laws of physics, mechanics and chemistry were expressed very frequently by mathematical expressions for which the computations were fairly simple, and well within the range of the mechanical devices, including tables, then available.

More recently we have been faced, as higher branches of mathematics have been called into use in solving other phenomena, with an immense increase in the amount of labor required to compute results under the mathematical expressions developed for this work. As an example, we might mention boundary value problems and the use of determinants in analyzing statistical correlations and for solving electrical networks. While the mathematical expressions are simple, the actual labor of carrying out the computations indicated can be a matter of weeks of work.

There thus arises a further course for mathematical study, the development of mathematical expressions or expansions whose computation can be effected by the means at our disposal. This involves determining the relative simplicity *in use* of various mathematical forms and the establishment of additional information regarding the accuracy and limits of error of various processes which can be carried out by the devices which we now have and can project.

It is my purpose in this paper to describe briefly one of the more powerful but little used tools for extensive mathematical computation in order to point out its general function and its present application to computing problems.

Punched-card tabulating machines, because they require no further manual work than the original entry of the problem on punched cards which afterwards actuate automatic machines, form the most powerful tool yet devised for

* A paper presented at the 103rd Annual Meeting of the American Statistical Association in joint session with the Institute of Mathematical Statistics, New York, December 28, 1941. Published in the *Journal of the American Statistical Association*, Vol. 37, June 1942, pp. 275–281.

the performance of mathematical computations. As yet the full capabilities of the automatic punched-card method have not been achieved in scientific fields, except in isolated instances in widely separated fields of activity. In bringing before you the results of the use of machines in the various fields of science, it is hoped that many additional uses for machines will be developed and that thinking in machine terms will be greatly stimulated.

Electrical punched-card accounting machines were developed primarily as a result of the analytical demands of the census and their great growth has been due to their usefulness in handling statistical and accounting procedures. This has led to the development of a specific series of machines actuated by the punched cards on a functional basis, i.e., each machine designed to perform a specific function and record its results in form for further automatic machine handling if desired.

The basic feature of tabulating equipment is its ability to read punched holes and perform the computations indicated by the holes, recording the results in printed or punched-hole form for subsequent processing. These machines read a line at a time and with automatic reading of the cards goes a high speed of computing and handling of individual problems. Each machine has the ability to handle tabulating cards regardless of arrangement of data.

There are some six punched-card machines whose usefulness in handling mathematical work has been demonstrated. For computing work, the automatic Multiplier is perhaps the most useful. This machine reads multiplication problems, performs the computations, and punches the answer back in the card on which the problem is stated. The Multiplier can also make cross additions or subtractions while multiplying, thus performing in a single step such operations as linear interpolation. Its operation is completely automatic and at a speed several times that of a clerk with a computing machine. On such work as 8 by 8 multiplications, machine speed is 750 multiplications per hour and on smaller problems speeds up to 1,500 are obtained.

Of next importance is the machine termed the Reproducer. This machine can transfer all or part of the punched information on one card or set of cards to another set of cards at the fixed speed of 100 cards per minute. It is used, for example, in making copies of punched-card tables or parts of tables; for combining intermediate results computed on different sets of cards onto a single card for further processing; and for transferring data from one set of cards to another. The Reproducer is unique in its ability to copy information from one document to another. At 6,000 cards per hour we are able to reproduce, rearrange, or extract information from punched-card records.

An automatic Sorting Machine is available for rapidly rearranging a set of cards into another sequence or for bringing together all cards carrying a similar punched-card designation. It operates at 400 cards per minute.

Another card arranging machine is the Collator, which can interleave two separate files of cards into a single file; or select cards from the one file matching cards in the other file; or select all cards greater than a certain value, or less than a certain value, or falling between specified limits. This machine is used to select cards from a table file, and to refile the selected cards after use.

The principal punched-card machine is called the Electric Accounting Machine. It is a giant printing adding machine actuated by the passage of the cards through a card feed at speeds as high as 150 cards a minute. It has the ability to add, subtract, or eliminate amounts punched in one or several fields of the cards passing through it. It automatically adds all cards having a common designation; and at the end of the group, which it determines automatically, it prints the total and punches a new card with the group designation and the group total on an automatic punch electrically connected to the accounting machine. The machine has a maximum adding capacity of 80 digits. These adding wheels may be grouped at will into counters of varying size and several factors may be added simultaneously. This machine is the commercial version of Babbage's "Differential Engine" capable of operation over any number of orders of differences, and a counter large enough to handle figures of practically any required size.

There are several kinds of punches available for originally recording data on the punched cards, and they are designed for rapid operation. There are also Verifiers for checking punching by a second recording of the data and Interpreters for printing on the cards the information punched in the card.

The use of the punched-card method for mathematical computation involves the use of one or more of the machines briefly described above. Some of the techniques require only the use of the Punches, Sorter and the Electric Accounting Machine, while other operations will call for the use at some point of all of the machines described above.

Tables

An extremely important use for the punched-card equipment is the preparation of tables. The equipment is so powerful in this respect that it has been said that every computational problem should be examined to see to what extent special tables prepared by machine can be used in its solution. This statement applies not only to processes conducted entirely by the machine method, but also to extensive problems where the special tables can be prepared by the machine and then used by computers in their further work. Even in so simple a thing as making a linear table, in one instance the first thousand multiples of each of four 20-figure numbers were produced in 4 hours, i.e., in about one-tenth of the time in which they could have been copied by hand.

The Electric Accounting Machine and Summary Punch are used in the preparation of tables using the method of differences. The process is covered in detail in a recent paper "On the Mechanical Tabulation of Polynomials," appearing in the September, 1941, issue of the *Annals of Mathematical Statistics*.

Interpolation of tables is frequently performed by aid of punched-card techniques. On systematic interpolation, a paper by L. J. Comrie in 1928 on "Construction of Tables

by Interpolation" explains the preparation of subdivided tables by computing the last digit of each interpolated value exactly by the aid of a set of prepunched cards. These figures are then differenced until they are smooth and the entire value of the differences inferred. From these differences, the Electric Accounting Machine will then automatically construct the subdivided values of the function.

Interpolation by use of the Lagrangian formulas can be readily accomplished with the Multiplier and Electric Accounting Machine. The details of the machine process are fully described in Dr. Eckert's book *Punched Card Methods in Scientific Computation.*

The Electric Accounting Machine can be used to difference a punched-card table, directly computing and printing both first and second differences in a single, high-speed operation—2,400 per hour.

One use of punched-card tables is for the automatic application of values of functions to problem cards. This is done by sorting the problem cards in order according to the argument of the table and then automatically selecting the proper table cards with the Collator. The Reproducer then punches the data from the table onto the problem cards. If interpolation is required it is done by the Multiplier.

The table-making process is useful in statistics for converting raw scores. After the mean and standard deviation have been determined a linear equation of the form $Y = AX + B$ can be established and a punched-card table made for this function. The punched-card table is then sorted ahead of the raw score cards and the converted score gang punched into all cards.

Harmonic Functions

Several of the most important uses of the machines have been in connection with the synthesis and analysis of harmonic functions. A technical paper on the use of Hollerith machines for synthesis of harmonic series appeared in 1932. This paper, appearing in the *Monthly Notices of the Royal Astronomical Society*, presented by Mr. L. J. Comrie, described the method by which the many coefficients in Brown's tables of the moon were combined into an orbit for the moon carried out to the year 2,000. This was the most difficult case of harmonic synthesis where the periods of the various components were not commensurable. This paper explains the method by which punched-card tables were prepared which took this fact into account and permitted the synthesis to proceed on a mechanical basis.

The use of cards for harmonic synthesis is indicated by the recurrent use of the same component values in different arrangements as the periods repeat. The preliminary card preparation consists in determining the interval of the desired synthesis and then computing the values of each term throughout its period for values of the argument at the desired interval. These values can be computed initially with the aid of a punched-card table and the multiplying punch.

The cards for each term are then placed in stacks on a table and the top card of each stack picked up and totaled in the Electric Accounting Machine. Checks on the proper selection of cards can be secured by adding card numbers as well as the coefficients. This addition can be performed automatically by placing a special card ahead of each group of cards for a distinct argument.

After tabulation, the cards for the various terms are separated by a run through the Sorter and replaced behind the unused cards for each respective term.

For repeated synthesis of Fourier Series, prepunched decks which can be combined to produce any amplitude of each frequency are used. Such a deck has been used extensively at California Institute of Technology and computes points at intervals of $1/500$ of a circle and goes up to a frequency of 30.

In the analysis of harmonic series as distinct from synthesis, the Multiplier and Tabulator combine to give a most effective method in reducing the manual effort involved. These analyses are made with the aid of a set of prepunched cards. These cards are prepunched with the value of the trigonometric function and a pattern showing in successive columns whether the product formed on that card is to be added, subtracted or eliminated in computing the successive amplitude coefficients.

One interesting possibility in the use of cards for harmonic synthesis which was suggested by Comrie is that a whole series of harmonic syntheses involving the same periods but varying amplitudes can be tabulated from a double set of cards. By combining the original and duplicate sets of cards out of phase sufficiently, any desired amplitude from zero to twice the amplitude of the set may be produced.

Progressive Digiting

Tabulating machines have been recognized quite widely as an efficient means of computing the sums of products needed in computation of multiple correlations and least square trend lines and other statistical and computational problems. This work can be performed with a sorter and the Electric Accounting Machine. The process is such that a number of cross products may be handled simultaneously in separate counter groups of the Electric Accounting Machine.

All the factors which are to be multiplied together are punched on cards, each card carrying the related data of a single case. The sums of the squares and of the cross products are obtained by a method of multiplication by addition. This process handles one multiplier digit at a time and is extremely rapid. Comrie states that "on one occasion 25,000 products of three-figure numbers were formed and added in about three hours." This method of multiplication is probably the fastest known today. Multiplication takes place at the same speed as addition and many products may be accumulated at one time.

A development of this method of multiplying by addition is now in use where the multiplication is done without sorting. In this process an analyzing device on the Electric Accounting Machine analyzes the digits of the multiplier column, adding or subtracting the multiplicand into one or more of three counters assigned values of 1, 3 and 5. For example, the digit 4 adds into counters 1 and 3, the digit 6

into counters 1 and 5, and digit 7 adds into counters 3 and 5 and is subtracted in counter 1, etc. These totals are summary punched and the 5 counter multiplied by 5; 3 counter by 3, and sum of 5, 3, 1 cross footed on multiplier.*

Evaluation of Determinants

The solution of determinants, particularly of the higher orders, is one which is particularly burdensome when done manually. It is a problem to which the punched-card method has been applied for elimination of the manual labor. The method involves the use of the Multiplier, the Reproducer, and Sorter, and parallels the short method of single division usually followed under manual methods.

A card is punched for each element of the determinant identified by its row and column. The reciprocal of the element a_{11} is punched in card a_{11} and used as a group multiplier for all the cards in row 1. The cards for the remaining rows are offset gang punched transferring the value of the element of column 1 to the remaining cards for each row. The cards for row 1 are then sorted as group multiplier cards ahead of the remaining cards by column. The cards are then group multiplied for the reduction $a - b \times c$. This routine has reduced the determinant by one order and is repeated until the determinant can be evaluated at sight.

This method is entirely general, very rapid, and involves a limited number of simple machine operations. The identical process can be used for the solution of simultaneous equations.

Thus far we have discussed basic principles of punched-card methods for performing mathematical computations. In addition to the specific purposes of these basic principles there is a wide variety of problems which can be solved by combinations or repeated application of the basic punched-card steps. I will but briefly point out a few such problems which have been successfully attacked and solved in this manner.

One of the outstanding applications of the punched-card method is its application to the solution of differential equations which was developed by Dr. W. J. Eckert at Columbia. This machine procedure is extremely effective and we expect to see its application carried into many fields. Of particular significance in connection with this use of machines as compared with other methods is the degree of accuracy which can be established.

A simple but useful application of the Electric Accounting Machine is the preparation of scatter diagrams. The punched-card technique for factor analysis has been worked and successfully applied in Chicago.

Other major machine applications have been in the evaluation of formulae, for instance, the transformation of spherical coordinates into rectangular coordinates.

Another very extensive computation now being performed is a bivariate linear interpolation where a series of multiplier operations determines the weight to be given each of the four surrounding known values of the function and performs the final evaluation.

It should be clear that punched-card methods may be applied to many computational problems extensive enough to warrant mechanization. The three fundamental mathematical operations into which almost all computational problems can be transformed, namely, evaluation of determinants, evaluation of harmonic series, and evaluation of polynomials can be performed by these methods. Much of the preliminary work in applying punched-card methods to scientific computation has already been done by pioneers in this field. The task now before us is to exploit intensively the new methods and more efficient tools they have tested for us.

* *Editor's Note:* McPherson (in August 1985) notes: "This is an early instance of electrical stored-program control anticipating all the later claims and counterclaims over the origin of stored-program control in the early electronic computers. The pattern for selecting the counters in which the multiplicand was to add (or subtract) was punched in every card, and positions of the control unit used to match each column of the pattern against the multiplier column. IBM decided this was unpatentable as an adaption of existing hardware, and it was published at the time in a "Pointer" to Electric Accounting Machine users."

☐ Albers, Donald J., and G. L. Alexanderson (eds.). **Mathematical People: Profiles and Interviews.** Boston, Birkhauser, 1985, 372 pp. + xvi, $24.95.

This volume contains twenty-three interviews conducted by the editors and other individuals and two biographical essays. A number of the interviews were originally published in the *Two-Year College Mathematics Journal* during Don Albers's term as its editor. Others, like the interview with Mina Rees by Peter Hilton and *Annals* managing editor Rosamond W. Dana, and Olga Taussky-Todd's autobiographical essay, appear for the first time. (The Donald Knuth interview was reprinted in the *Annals*, Vol. 4, No. 3, July 1982, pp. 257–274.)

Philip J. Davis wrote an excellent introductory essay, "Reflections on Writing the History of Mathematics." Davis's thoughtful and incisive exposition should be read in its entirety, particularly by historians of contemporary events (such as computing). In terms of the contents of the book, I completely agree with Davis: "It is inevitable that having turned the last leaf of the last profile one finds oneself in a historical mood."

Of particular interest to *Annals* readers is the interview with Mina Rees mentioned earlier. (Peter Hilton is also the subject of an interview conducted by Lynn A. Steen and G. L. Alexanderson.)

Rees relates her experience during and after World War II in the Office of Scientific Research and Development (OSRD) and the Office of Naval Research

(ONR), but typically does not describe the extent of the impact her work had on mathematics. Richard Bellman's recently published autobiography (*Eye of the Hurricane*, World Scientific, 1984, p. 277) sums it up:

> On one visit to New York, we ran across Mina Rees at the airport. She was head of the mathematics branch of ONR. . . . Hitler provided the tremendous spurt in the level of American mathematics and science by driving so many refugees to these shores. Mina Rees provided the money for support of many of these and for the support for many students that they trained. Many people, like myself, got their Ph.D.'s through an ONR grant. Mina Rees is too modest to speak of the great role that she played in raising American mathematics to the level that it is now.

Rees discusses the small number of prominent women in mathematics and her experiences in what was predominantly male territory. She recounts the following exchange with Cathleen Morawetz:

> I said, "I hope that young girls will see that it is possible to be a serious mathematician—to be what a mathematician calls a mathematician."
>
> Cathleen said, "Mina, I don't think girls are prepared to give the kind of single-minded devotion that you need if you are going to be a great mathematician."

Whether this brief exchange reflects social, parental, or other influences, one can use it as a basis for viewing Olga Taussky-Todd's autobiographical essay illustrating that a woman can give mathematics the necessary dedication and devotion.

Subjects of other interviews in *Mathematical People* are: Garrett Birkhoff, David Blackwell, Shiing-Shen Chern, John Horton Conway, H. S. M. Coxeter, Persi Diaconis, Paul Erdös, Martin Gardner, Ronald L. Graham, Paul R. Halmos, John Kemeny, Morris Kline, Benoit Mandelbrot, Henry O. Pollak, George Pólya, Constance Reid, Herbert Robbins, Raymond Smullyan, Albert W. Tucker, and Stanislaw M. Ulam. Albert Tucker has written "Reminiscences of Solomon Lefshetz."

The book is attractively bound, with appropriate photographs and biographical data included for each subject. It is highly recommended, not only for its excellent contents, but as an example that can be of great value to individuals interested in the history of information processing. A volume of comparable discussions with some of our key figures and reflective essays on those who are no longer alive would be an important addition to the existing literature.

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CAPSULE REVIEWS

☐ **The History of Computers.** *Cobblestone Magazine: The History Magazine for Young People* (Cobblestone Publishing, 28 Main Street, Peterborough, NH 03458), June 1984.

This slim magazine, obviously intended for junior high school children, has done quite a nice job in describing the history and current status of computers. This is perhaps not very surprising when you note that the articles are written by people like Alice Burks, that the editors had the assistance of the staff of MIT and the Computer Museum, and that two of the consulting editors are Bernie Galler and Nancy Stern.

In only 40 pages the magazine presents 14 well-written and well-illustrated (considering the intended audience) articles dealing with topics that range from Stonehenge and the abacus to computerphobia and how computers will affect future society. Interspersed between the articles are practical projects to keep younger folks both busy and amused. Included are instructions on how to make and use an abacus (Chinese version), word-finding games, comic strips, and an interesting maze puzzle in which you have to find your way through the wires of a printed circuit board.

A joy to inspect and, I suspect, a joy for kids to have. Ahh, to be 30 years younger again!

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☐ **The Computer Museum Report.** The Computer Museum, 300 Congress Street, Boston, MA 02210, Winter 1982–1983 through Fall 1984.

For those who do not live in the northeastern U.S., and thus cannot take advantage of the free admission to the Computer Museum that comes with membership, the *Report* provides the one main reason for joining. It is usually both informative and entertaining with high-quality illustrations of new museum acquisitions, capsule reports on machines, people, and ideas, and offers of unusual items from the Museum Store.

The Winter 1982–1983 issue contains a series of short reports on a number of the very early computing machines. While not profound, the quick coverage of 14 different machines (from the Bell Telephone Laboratories Model 1, through the ABC, Harvard Mark I, Colossus, ENIAC, and early stored-program computers to the Whirlwind project) provides a nice illustrated

overview of the early days. The issue concludes with a two-page chart that compares 10 different attributes for each of these machines.

The highlights of the Winter 1983–1984 issue are the article discussing the general capabilities of the first-generation computers and the detailed photo-essay of how ferrite core memories were constructed by the Lincoln Labs in 1952.

One of the nice things about the *Report* is that it provides the opportunity to receive the details of some of the special invited lectures that the Computer Museum hosts, even if you can't actually attend these gala affairs. The Summer 1984 issue, for example, contains two articles based on the lectures given by Bernard Gordon ("Computer Engineering Attitudes From Eckert-Mauchly to Analogic") and Bob O. Evans ("IBM System/360").

The Fall 1984 issue not only brings us up to date on some of the more interesting acquisitions (including the first object ever produced using a CAD/CAM system—an ashtray), but also gives us a photo-essay on the preview party held to celebrate the museum's move to its new location on Boston's waterfront.

M. R. Williams

☐ Bolhm, Hans. **Pebbles to Bytes.** *Equinox* (Equinox Publishing, 7 Queen Victoria Road, Camden East, Ontario, K0K 1J0, Canada), Vol. 21, May–June 1985, pp. 42–51.

This photographic essay sketches the development of calculation from the abacus, through Pascal's machine and other mechanical devices, to the integrated circuit. Along the way it includes the only photograph I have seen of "Dirty Gerty," the first transistorized computer built in Canada. The photographs are spectacular, but the text is inaccurate in several places.

According to the text, the photographs are part of a collection being put together for display at Expo 86—the world's fair to be held in Vancouver, Canada. If this is an example of the illustrations for that display, then I, for one, am going to the fair!

M. R. Williams

☐ David, H. A., and H. T. David (eds.). **Statistics: An Appraisal.** Proceedings of a Conference Marking the 50th Anniversary of the Statistical Laboratory, Iowa State University, June 13–15, 1983. Ames, The Iowa State University Press, 1984, 664 pp., $31.25.

Although this book has little that will interest most readers of the *Annals*, it does provide a few brief glimpses of the development of computing in both the Statistical Laboratory and Iowa State University. The first three papers, by H. A. David, T. A. Bancroft, and Oscar Kempthorne in a section entitled "Historical Setting," are especially useful here. The functions of the laboratory were first described in the 1934–1935 college catalog as being "research, statistical counsel, teaching, computational service and calculating machines." The laboratory continued to provide a campuswide general computing service until a Computation Center was established in 1962. The first computing equipment was installed a few years before the founding of the laboratory and consisted, of course, of punched-card tabulating equipment. An IBM 650 was installed in 1957 and was followed a few years later by the Cyclone Computer, a copy of the ILLIAC, built in the Department of Electrical Engineering.

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☐ Andrew, Christopher, and David Dilks (eds.). **The Missing Dimension: Governments and Intelligence Communities in the Twentieth Century.** London, Macmillan, 1984, 300 pp., £16.95.

Three new papers in this collection of historical essays are of interest. The palm must go to Jean Stengers for his stylish "Enigma: the French, the Poles and the British, 1931–1940" in which he deftly draws various threads together, revealing some new details. Curiously, he does not refer to the problems inherent in suggesting that it was the receipt of key lists for October and November 1931 that enabled Marian Rejewski to reconstruct Enigma's wiring in January 1933. He cites a 1941–1942 report by Rejewski, but in the *Annals* (Vol. 3, No. 3, at p. 221), Rejewski stated that his task was eased because the lists were for months in different quarters.

"Radio Intelligence and the Battle of the Atlantic" by Jürgen Rohwer, the distinguished German naval historian, is also excellent, if all too short. He suggests that the most important factor in determining its outcome was the deciphering of U-boat Enigma messages (to which American versions of the electromechanical bombes used as key-finding aids made a considerable contribution—see F. H. Hinsley et al., *British Intelligence in the Second World War*, Vol. 2, p. 752). Rohwer observes that knowledge of the successful work done by the British Admiralty's Room 40, the preeminent codebreaking agency in World War I, influenced the building up of the German navy's highly efficient cryptanalytical unit in the Funkbeobachtungs-Dienst (B-Dienst). Ironically, therefore,

Room 40 affected both sides in the conflict. Cambridge dons who had been members of Room 40 acted as talent scouts in the 1930s for the Government Code and Cypher School, the British codebreaking department in World War II, spotting such key figures as Alan Turing for its emergency list.

Christopher Andrew's "Codebreakers and Foreign Offices: the French, British and American Experience" deserves an honorable mention for his coverage of the French agencies before 1914, but contains nothing new on the American front.

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☐ Kaye, Glynnis Thompson (ed.). **A Revolution in Progress . . . A History of Intel to Date.** Santa Clara, Intel Corporation, 1984, 51 pp.

This glossy, picture-packed monograph is a survey of the sixteen-year history of the technological accomplishments of one of Silicon Valley's most dramatic firms. Beginning with the announcement of its founding (*Palo Alto Times*, August 2, 1968) by Robert N. Noyce and Gordon E. Moore, newly resigned from Fairchild Semiconductor, and soon joined by Andrew S. Grove, the monograph chronicles the technical milestones in the short life of the Intel Corporation: the 1101, the 1103, the 8080, Busicom and the birth of the microprocessor, the computer on a chip, EPROM, CAD. In the process, one gets a feel for corporate attitudes and traditions as well as market difficulties and technical detours. A foldout chronological map and an accompanying chart give a concise portrait of the Intel Product Family Tree.

☐ Johnson, David S. **The Genealogy of Theoretical Computer Science: A Preliminary Report.** *SIGACT NEWS,* Vol. 16, No. 2, Summer 1984, pp. 36–49.

This paper attempts to trace the intellectual genealogy of current researchers in theoretical computer science. According to the author, the study arose from the need to devise an example to illustrate a talk on recreational databases. The author chose the popular parent-child relation, but instead of the tired "Kings of England" example, he chose to use subjects taken from the world of current research in theoretical computer science, using the Ph.D. advisor-advisee relation instead of parent-child.

Since the original talk in 1981, the database has been regularly updated so that it now includes the genesis of well over 500 current researchers and their

supervisors. The paper includes several genealogical trees, typically four generations deep, of major schools (e.g., the "Floyd tree," the "Harvard tree," and so on).

The database is far from exhaustive, the author having pruned the list of students supplied to him "to keep the size of the database within reasonable limits." Nonetheless, this paper would make a good starting point for anyone researching the origins of contemporary theoretical computer science. It is also an interesting example of using the computer for historical investigation; an object often stated to be worthwhile, but all too rarely attempted.

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☐ Augarten, Stan. **Bit by Bit: An Illustrated History of Computers.** New York, Ticknor & Fields, 1984, 324 pp. + x, $29.95 cloth; $17.95 paper.

This lavishly illustrated volume is more than a decorative coffee-table book; it is well written and gives evidence of some solid research. Augarten traces the history of computers from the first mechanical calculators to the Wozniak-Jobs story and the Apple II. After a nice account of the Schickard calculator, he has a chapter on Babbage, followed by the work of Hollerith, early analog devices, and Zuse's machines. These are followed by the early electromechanical devices developed by Aiken and Stibitz. Augarten then covers the evolution of the electronic computer emanating from the work of Eckert and Mauchly and the contributions of Atanasoff, von Neumann, and others. The remaining chapters include the history of IBM, Project Whirlwind, integrated circuits, and the personal computer.

Augarten focuses primarily on people and ideas and makes good use of illustrations and diagrams to illuminate technical subjects. Many of the photographs are new to me. Perhaps the most exciting item is an appended summary of the FBI dossier on John Mauchly, whose security clearance problems in the BINAC era have often been mentioned, but, to my knowledge, these files have not been published before.

The volume is not as flawed by errors as it is by omission. Its subtitle should end with "in the United States" because foreign contributions such as Wilkes and EDSAC are rarely mentioned.