

I. *Department: War**Branch or Bureau: Ordnance Department**Description of activity:*

- A. Moore School of Electrical Engineering, Construction of an electronic digital machine ("EDVAC").
- B. Institute for Advanced Study and RCA Labs., Princeton, N. J. Construction of an electronic digital machine (financed only in part by federal funds).
- C. National Bureau of Standards, Washington, D. C., Long-range component development program.

II. *Department: Navy**Branch or Bureau: Office of Naval Research**Description of Activity:*

- A. National Bureau of Standards, Construction of an electronic digital machine.
- B. Servomechanisms Lab., Mass. Institute of Technology, Construction of an electronic digital machine to be used in a large guided-missile flight simulator.

III. *Department: Navy**Branch or Bureau: Bureau of Ordnance**Description of Activity:*

- A. Harvard Computation Lab., Research and preparation of specifications for an electronic digital machine.
- B. Naval Ordnance Lab., White Oaks, Md., Construction of an electronic digital machine, temporarily abandoned (Dec. 1946).

IV. *Department: Commerce**Branch or Bureau: Bureau of the Census**Description of Activity: National Bureau of Standards, Construction of an electronic digital machine.*

J. H. CURTISS

National Bureau of Standards

EDITORIAL NOTE: Other projected digital machines, unaided in their construction by the U. S. Government, are being built by:

- (i) The Eastman Kodak Co., Rochester, N. Y.
- (ii) The University of California, Berkeley.
- (iii) The National Physical Laboratory, Teddington, England, under the direction of Dr. ALAN M. TURING. The planned Automatic Computing Engine will work at the speed of the ENIAC or possibly somewhat higher, and will take advantage of new technical developments, making possible both a greater memory capacity and a higher degree of complexity in the instructions.

P. G. Scheutz, Publicist, Author, Scientific Mechanician, and Edvard Scheutz, Engineer,—Biography and Bibliography

PEHR GEORG SCHEUTZ (1785–1873), son of a tavern-keeper, after passing examinations in law, practised in different localities before settling in Stockholm in 1812. In 1817 as owner of a printing establishment founded by the well-known writer F. CEDERBORGH, Scheutz devoted himself from that time principally to literary interests. He soon became part owner and co-editor of a newspaper which, with changed name *Argus* (1820–1836), became Sweden's most important political newspaper in the 1820's. During 1826–

1842 he published five other journals and newspapers devoted to manufactures and management; art, sloyd, and kindred sciences; engineering; industry and trade. In the field of literature he worked as a translator of Shakespeare, Werner, Walter Scott, Boccaccio, and others; his editions of *Merchant of Venice* (1820) and of *Julius Caesar* (second ed., 1831), the first translations of Shakespeare into Swedish, are in the Library of Harvard University. (His unpublished translation of *King Lear* was performed at Lindeberg's Theatre). He also published numerous handbooks, and books of instruction. In 1842 he gave up his printing establishment and became one of the regular staff of the *Aftonbladet* (Evening News) Stockholm, with special interest in technical and economic subjects, and continued this interest until a few years before his death (Nos. 24, 25).

But it was neither as a literary man nor as a publicist that Scheutz achieved his greatest commendation, but rather as inventor of a calculating machine. The Difference Engine of CHARLES BABBAGE (1792-1871) had from time to time been cursorily noticed in several periodicals, when a circumstantial and elaborate disquisition on its merits and construction appeared in the *Edinburgh Review* for July 1834. It was from perusal of this article that Scheutz, at that time the editor of a technological journal in Stockholm, derived the first conception of constructing a machine for effecting the same purpose as that of Babbage, namely of calculating and simultaneously printing numerical tables. But after he had satisfied himself of the practicability of the scheme, by constructing various models, composed of wood, pasteboard, and wire, he postponed to a future period the further prosecution of the design (No. 10). Three years afterwards, in the summer of 1837, his son EDVARD (1821-1881), then a student at the Royal Technological Institute, Stockholm, took up the problem of constructing a working model in metal. Working with his father, many improvements in the original conception were introduced, and numerous alterations effected. By 1840 the apparatus was so far completed that it correctly calculated the value of series to 5D and one difference also of five figures. By April 1842 the model was extended so as to calculate similar series with two and three orders of differences. In 1843 the printing apparatus and all other parts of the model were in readiness for the inspection of the Royal Swedish Academy of Sciences. After several trials a certificate of the machine's performance was given in Sept. 1843. Making use of this certificate as a recommendation the inventors sought for orders in various countries; but meeting with no success, the model was shut up in its case during the ensuing seven years (No. 10).

In 1850 another inspection was made by a Committee of the Royal Academy of Sweden, and in 1851 Georg Scheutz made an application to the Government for the means to construct a large and still more improved machine. Such a grant was finally made. The new machine, Difference Engine no. 1, was completed in October 1853, being manufactured by C. W. Bergstrom of Stockholm. From the first it was found to work perfectly. During the latter part of 1854 the inventors visited England and France. The machine aroused considerable interest among a number of men of science. Upon being placed in the Great Exhibition at Paris, in 1855, the jury awarded a gold medal to the inventors. In February 1856 Georg Scheutz was made a member of the Swedish Academy of Sciences and in the same year created a Knight of the Order of Vasa and St. Anna. In 1858 he was also

created a Knight of the Order of the North Star. The Academy voted him an annuity of 1200 riksdollar¹ in 1860; and in 1872 the Academy awarded the Carl John Prize, to "Georg Scheutz, the first who successfully clothed Shakespeare in a Swedish costume, and for whom literature, even though as author, an occupation, comprehensive and pursued to the evening of a long life, has in addition for a long period had a connection which has not been effaced by the fact that the man of letters has also acquired a respected name for himself in a field which lies beyond the boundaries of belles lettres." (No. 25).

Through the interest of the astronomer B. A. GOULD, then Director of the Dudley Observatory at Albany, N. Y., JOHN F. RATHBONE,² a manufacturer of that city, purchased Difference Engine no. 1 for \$5000, and presented it to the Observatory in 1856. There it remained unused until sold in 1924 to the Felt & Tarrant Manufacturing Co., Chicago, Ill., where it may still be seen, in a closed display case at the company's museum at 1735 North Paulina St., Chicago 22.

Scheutz's Difference Engine no. 2, with improvements, was in 1858 constructed for the office of the Register General at Somerset House, by Messrs. Bryan Donkin & Co., from drawings of Edvard Scheutz. It contained some modifications of D. E. no. 1, and was used in the next few years for computations indicated in Nos. 17 and 21 below. In 1914 the machine was presented to the Science Museum, South Kensington where it is still exhibited and occasionally operated for visiting experts.

The descriptions and illustrations in No. 31 are interesting, and the capabilities of the machine are somewhat elaborately set forth in No. 18. Charles Babbage and his son Henry were enthusiastic in their praise of the achievements of the Swedish inventors (Nos. 4, 5, 9). In No. 9 Charles Babbage, who urged upon the Royal Society that their Engine was "highly deserving of a Medal," added

"The principle of Calculation by Differences is common to Mr. Scheutz's engine and to my own, and is so obviously the only principle, at once extensive in its grasp and simple in its mechanical application, that I have little doubt it will be found to have been suggested by more than one antecedent writer.

"Mr. Scheutz's engine consists of two parts,—the Calculating and the Printing; the former being again divided into two,—the Adding and the Carrying parts.

"With respect to the Adding, its structure is entirely different from my own, nor does it even resemble any one of those in my drawings.

"The very ingenious mechanism for carrying the tens is also quite different from my own.

"The Printing part will, on inspection, be pronounced altogether unlike that represented in my drawings; which, it must also be remembered, were entirely unknown to Mr. Scheutz."

Among Edvard Scheutz's own inventions was a rotary steam engine which was used on some steamboats. In 1860 the Swedish Academy awarded him a prize for this. (Nos. 24, 30; see also *Poggendorff's Biographisch-Literarisches Handwörterbuch*, v. 3₂, Leipzig, 1898.)

¹ A riksdollar is worth a little more than an American dollar.

² There is a brief biography of JOHN FINLEY RATHBONE in *Appleton's Cyclopædia of American Biography*, New York, v. 5, 1888.

BIBLIOGRAPHY

1. Acad. d. Sci., Paris, *C.R.*, v. 7, 1838, p. 1056.

[Statement based on a communication of Georg Scheutz, concerning his calculating machine, announced as being more simple, and consequently less costly than that of Babbage.]

2. *Biographiskt Lexikon . . .*, v. 14, Upsala, 1847, p. 54–66. Supplemented in *Svenskt Biografiskt Lexikon*, v. 9, Stockholm, 1883, p. 495–496. On p. 63–64 of *B.L.* is reprinted a statement about the Scheutz machine in Svenska Vetenskapsakad., Minutes, 1843, Sept. 18.

3. GREAT BRITAIN, *Specifications of Inventions*, v. 83, no. 2216. 11 p. + 2 large sheets (Plates, v. 30) of specifications dated 17 Oct., 1854 (20½ × 28 ins.) London, 1855.

[Copy in the Boston Public Library; possibly the volume numbers given above are those assigned by the Library in binding. "Letters Patent to Georg Scheutz of Salisbury Street, in the County of Middlesex, Gentleman, and Edward Scheutz, of the same place, Civil Engineer, for the Invention of 'Improvements in Machinery or Apparatus for Calculating, and Printing the Results of Such Calculations.'" The sworn statement of the Scheutzes is concluded on p. 11 and dated 9 March, 1855.]

4. CHARLES BABBAGE, "Note sur la machine Suédoise de MM. Schutz [*sic*] pour calculer les tables mathématiques, par la méthode des différences, et en imprimer les résultats sur des planches stéréotypes," Académie d. Sci., Paris, *C.R.*, v. 41, 1855, p. 557–560, 591.

[A lecture based on charts prepared by his son HENRY PREVOST BABBAGE.]

5. HENRY P. BABBAGE, "On mechanical notation as exemplified in the Swedish calculating machine of Messrs. Scheutz," B.A.A.S., *Report 1855*, "Notices and Abstracts," p. 203–205. Reprinted as a pamphlet (4 p.) with slightly changed title: *Mechanical Notation, exemplified on the Swedish Calculating Machine of Messrs. Scheütz. . . . A paper read at the British Assoc. held at Glasgow, Sept. 1855.* 11 × 17.2 cm.

[There is a copy of this pamphlet in the library of the Harvard School of Business Administration; it is also listed in the catalogue of the Staatsbibliothek, Berlin.]

°6. *Machine à Calculer, qui présente les résultats en les imprimant elle-même. Inventée par Georges Scheutz et Edouard Scheutz.* Stockholm, 1855, 4to. 4 p.

7. "New calculating machine," *Illustrated London News*, v. 26, 30 June, 1855, p. 661.

[There are two illustrations of the machine, and two samples of tables as printed by it. It is noted that the machine was inspected by Prince Albert, at the Royal Society's rooms.]

8. CHARLES MANBY, "Scheutz' Difference Engine and Babbage's Mechanical Notation," Institution of Civil Engineers, *Minutes of Proc.*, v. 15, 1856, p. 497–514; reprinted as a pamphlet, 8A. London, 1856, 8vo, 20 p. [Copy in the British Museum; listed in No. 25.] In *Minutes of Proc.*, v. 16, 1857, p. 224, there is a note of 11 lines telling of the exhibition and sale of the machine.

9. CHARLES BABBAGE, *Observations addressed, at the last anniversary, to the President and Fellows of the Royal Society after the Delivery of the Medals.* London, John Murray, 1856. 12 p.

[Not printed in R. S. London, *Proc.* In the Boston Public Library is a copy with title on a paper cover *On the Swedish Tabulating Machine of Mr. George Scheutz*. On p. 11 are advertisements of Babbage publications.]

10. [GEORGE & EDWARD SCHEUTZ], *Specimens of Tables, Calculated, Stereomoulded, and Printed by Machinery*. London, Longman, . . ., 1856. xviii, 50 p. + frontispiece plate + paper cover.

[This pamphlet was dedicated to CHARLES BABBAGE "by his sincere admirers, George and Edward Scheutz." The Swedish name "Edvard" is herè transformed to Edward. On p. 11-42 is the first of the "specimens of tables," $\log N$, $N = [1000(1)10000; 5D]$, calculated, stereomoulded and printed by machinery. On p. 45-50 are 14 short specimens of other tables which might have been similarly elaborated; nos. 2-3 values of polynomials for successive integral values of the variable; nos. 4-5 $\log N$ to $7D$, with characteristics, for series of successive integers; no. 6 $\log \tan A$, $A = [27^{\circ}0' (1'')27^{\circ}0'50''; 7D]$, and similarly, to $7D$, nps. 7-8 for $\log \sin A$, for $A = 1^{\circ}$, and 45° . No. 9 $\sin A = .230(.001).270$, A is given in degrees, minutes, and to the nearest tenth of a second. Nos. 10-11 are a few values of ranges of shot with various charges and \log value of male life in London. The last four, p. 49-50, are astronomical, for example, no. 12 is the \log radius vector of Venus, and no. 13 the Sun's longitude for every twenty-four hours.

In the Boston Public Library is a copy of the *Specimens* with "Presented to Bowditch Library by Edward Scheutz, 15 Park St., Westminster, May 11th, 1857," on the cover in the handwriting of the donor. In this copy also is a printed slip of paper headed, just before the preface: *Note at the foot of page 7*. The Note is as follows: "In the next machine this rate of working may easily be increased tenfold, so that twenty pages might be quietly *calculated* and *stereomoulded* whilst a compositor was merely '*setting up*' a single page. The addition of fifth and sixth, or indeed of any number of differences, would not occasion any diminution in the rate of working.

"These facts are sufficient to show how vain it would now be to attempt reprints of the existing tables (even if uncertainty and error be disregarded) in any other way than by machinery.

"The object of the Messrs. Scheutz in the present machine was not great speed; and if they had attempted to do more than they actually have done, the reader of the foregoing little history will readily see, they, from mere want of means, would probably have produced no *working* machine at all."

Specimens was reviewed in (i) Institution of Civil Engineers, *Minutes of Proc.*, v. 16, 1857, p. 422; (ii) *The Athenaeum*, no. 1545, 6 June 1857, p. 720-721; [Possibly written by A. DEMORGAN; quotation: "the tables before us were *stereoglyphed*. We cannot accept such a hybrid as *stereomoulded*."]; °(iii) *The Practical Mechanics Jn.*, v. 10, 1857, p. 78; °(iv) *Daily News*, London, no. 4324, Mar. 22, 1857. Nos. (iii) and (iv) are listed in No. 25.

It was the recent acquisition of a copy of No. 10 by the Library of Brown University, coupled with the observation of various misstatements of fact about the Difference Engine, which led to the compilation of the present article, with a rather complete Bibliography, by means of which the interested reader may still further enlarge his knowledge in this regard.]

11. *Specimen de Tables calculées, stéréotypées et imprimées au moyen d'une Machine*. Paris, 1858. 8 vo. 68 p. + 1 plate.

[Also dedicated to CHARLES BABBAGE. Reviewed in °(i) *Propriété Industrielle*, Paris, 1858, no. 34; °(ii) *Siècle*, Paris, 1858, no. 8533; °(iii) *Le Pays*, Paris, Sept. 24, 1858. (i)-(iii) are listed in No. 25.]

12. A. RIVIÈRE, "Machine à calculer," *L'Illustration, Journal Universel*, Paris, v. 32, 28 Aug. 1858, p. 143, illustrated by a picture of the machine.

13. F. N. M. MOIGNO, *Cosmos*, v. 13, 1858, p. 78-84.

[An account, with a full-page illustration, of the Scheutz machine, and reports, with comments, of discussions by Babinet, Leverrier, and others, at a meeting of the Académie des Sciences, Paris, 12 July 1858.]

°14. Three articles in *Aftonbladet* [Evening News], 1859, nos. 14, 17, 253. [Listed in No. 25.]

°15. *Report on the Calculating Machine recently constructed by Mr. Donkin.* London, 1859. 4to. 4 p. [Listed in No. 25. An account of Difference Engine no. 2.]

16. G. SCHEUTZ, "Scheutz's Räkmemaskin," Svenska Vetenskapsakad., Stockholm, *Öfversigt af . . . Förhandlingar*, v. 16, 1859, p. 391.

°17. *Mountain Barometer Tables: Calculated and Stereoglyphed* by Messrs. Scheutz's Calculating Machine no. 2, and printed by machinery, London, 1859. 19 p.

[A small booklet, $2 \times 6\frac{1}{4}$ ins., "for private circulation," printed for WM. GRAVATT F.R.S., foreign member of the Royal Academy of Sweden—the first publication of results from Difference Engine no. 2. There has been a copy in the Science Museum, South Kensington, since 1914. Listed in Nos. 25 (with date 1859) and 31 (with date 1862). The title here seems to have been influenced by the criticism in No. 10 (ii).]

18. H. MEIDLINGER, "Die Scheutz'sche Rechenmaschine," *Dinglers Polytechnisches Jn.*, Stuttgart and Augsburg, s. 4, v. 6, 1860, p. 241–256, 321–336.

19. A. DEMORGAN, "Table," *English Cyclopaedia, Arts and Science Section*, London, v. 7, 1861, col. 1007, 9 lines.

[The date of publication of No. 17 is here given as 1859.]

20. CHARLES BABBAGE, *Passages from the Life of a Philosopher*, London, 1864, p. 47–48.

21. *English Life Tables. Tables of Lifetimes, Annuities, and Premiums. With an Introduction by William Farr, M.D., F.R.S., D.C.L. Published by Authority of the Registrar General of Births, Deaths, and Marriages in England.* London, printed for Her Majesty's Stationery Office, 1864. clvi, 606 p. "English Life Table no. 3" p. 6–605.

[Appendix, "Scheutz's calculating machine and its use in the construction of the English Life Table no. 3," p. cxxxix–cxliv. "This volume is the result; and thus—if I may use the expression—the soul of the machine is exhibited in a series of Tables which are submitted to the criticism of the consummate judges of this kind of work in England and in the world," p. cxl. The tables calculated and printed by Difference Engine no. 2 are on p. 6–11, 42–47, 76–81, 114–115, 129–133, 142–145, 175–245 (mostly), 355–425 (mostly), 481–551 (mostly). There are copies of these tables at Harvard University, and in the South Kensington Museum.]

22. "The Swedish tabulating machine of G. & E. Scheutz," *Annals of the Dudley Observatory*, v. 1, Albany, 1866, p. 116–126 + large folding plate of the machine on a stand.

23. J. W. L. GLAISHER, "Report of the Committee on mathematical tables," reprint from B.A.A.S., *Report 1873*, p. 59, 159. 6 lines about No. 10.

24. HERMAN HOFBERG, *Svensk Biografiskt Handlexicon*, Stockholm, v. 2, 1876, p. 242–243.

[Sketches of P. G. and E. Scheutz. Copy at Library of Congress.]

New edition, Stockholm, v. 2, 1906, p. 428–429:

[Biographical sketches, with portraits, of Per Georg Scheutz and Edvard Scheutz. Copy at Harvard University. This, No. 25, No. 2, and No. 10, were the main bases for the compilation of our sketch.]

25. C. F. BERGSTEDT, "Georg Scheutz," Svenska Vetenskapsakad., *Lefnadsteckningar*, v. 2, part 1, Stockholm, 1878, p. 155–179.

[The most extensive biography of Scheutz, with a complete bibliography of his publications.]

26. MAURICE D'OCAGNE, *Le Calcul Simplifié par les Procédés Mécaniques et Graphiques*, Paris, 1894, p. 37-38.

Second ed., Paris, 1905, p. 83-86, 213-218.

Third ed., Paris, 1928, p. 74-77, 182-187 ("Note sur la machine à différences Scheutz" by Colonel BERTRAND).

[In the third edition, there is a picture of the machine on p. 75. On p. 76 it is incorrectly stated that after Difference Engine no. 1 was at Albany it was utilized for the calculation of tables of logarithms, sines, and logarithmic sines (see No. 9). The statement concerning Difference Engine no. 2, "Cette machine a calculé et imprimé 605 tables (grand in-4°) qui constituent le fondement du calcul des rentes viagères servies par les caisses d'épargne postale anglaises" is also highly inaccurate and misleading; see No. 21.]

27. V. G. VON BOOL, *Pribory i mashiny dliã mekhanicheskago Proizvodstva arifmeticheskikh Deĭstviĭ* [Apparatuses and machines for mechanical execution of arithmetical operations]. Moscow, 1896, p. 184-189.

[There is a copy of this work in Library of Congress, by VLADIMIR GEORGIËVICH VON BOOL (1835-1889). A picture of the Scheutz Difference Engine no. 1 fills p. 189].

28. R. MEHMKE & M. D'OCAGNE, "Calculs numériques," *Encycl. d. Sci. Math.*, I, 4. 2. Paris, 1908, p. 268-269.

[Mostly accurate and with good bibliography; there are a number of errors in the reference to no. 27.]

29. L. JACOB, *Le Calcul Mécanique*, Paris, 1911, p. 115-117. [Seems to be an abridgment of No. 26, second ed.]

30. *Kungl. Svenska Vetenskapsak.*, *Personforteckningar, 1739-1915*, ed. E. W. DAHLGREN, Stockholm, 1915.

31. D. BAXANDALL, *Mathematics. I. Calculating Machines and Instruments (Catalogue of the Collections in The Science Museum, South Kensington with Descriptive and Historical Notes and Illustrations.)* London, 1926, p. 32, 34-36 plate IX (i. Scheutz's Difference Engine no. 2; ii. Details of wheelwork; iii. Portion of a calculated and printed table).

[The entries of the *Catalogue* are: no. 86, portrait of Edvard Scheutz during his student days at the Royal Technological Institute, Stockholm. No. 87, no. 7. No. 88, photograph of the Scheutz Difference Engine no. 1 at the Dudley Observatory. No. 89, No. 10. No. 90, Scheutz Difference Engine no. 2, presented by the General Register Office, Somerset House, 1914. No. 91, No. 17, but with date 1862. No. 92, No. 21. No. 93, moulds and stereotypes produced by the Scheutz Difference Engine no. 2. No. 94, Stereotype block from a matrix produced by the Scheutz Difference Engine no. 2. No. 95, Lead mould, papier-mâché moulds (3) and stereotype produced by the Scheutz Difference Engine no. 2.]

32. *Svensk Uppslagsbok*, v. 24, Malmö, 1937.

[Sketch and portrait of P. G. Scheutz, col. 119].

33. H. H. AIKEN, etc., *A Manual of Operations for the Automatic Sequence Controlled Calculator (Annals of the Computation Laboratory of Harvard University, v. 1)*. Cambridge, Mass., 1946, p. 6-7.

[Quotation: "In 1834 George Scheutz, a printer in Stockholm, built a less ambitious difference engine with the aid of a grant from the Swedish government. This machine was completed in 1853 and used for the computation and printing of tables of logarithms, sines, and logarithms of sines." In view of the details given above the first sentence clearly conveys more than one erroneous impression. The latter sentence is equally misleading since only

the tables described in No. 10 are in question. Because the reviewer in *MTAC*, v. 2, p. 186, followed the *Harvard Annals* v. 1, he listed "SCHEUTZ (1834)", rather than SCHEUTZ (1853).]

R. C. A.

A New Approximation to π

A. EDITORIAL NOTES: In *MTAC*, v. 2, p. 143-145 we noted various formulae which had been used for calculating π to many places of decimals. These included that of MACHIN (1706)

$$(1) \quad \frac{\pi}{4} = 4 \tan^{-1} \frac{1}{5} - \tan^{-1} \frac{1}{239},$$

which was used by WILLIAM SHANKS (1812-1882) to compute π to 707D. The accuracy of this computation to 500D was verified by an independent calculation completed and published in 1854. No one appears to have checked the later figures until 1945, when Mr. D. F. FERGUSON, now connected with the Department of Mathematics of the University of Manchester, undertook the task. As we have already noted he used the formula

$$(2) \quad \frac{\pi}{4} = 3 \tan^{-1} \frac{1}{4} + \tan^{-1} \frac{1}{50} + \tan^{-1} \frac{1}{1985},$$

given in LONEY'S *Plane Trigonometry* (1893). We published his new computation for π from the 526th through the 620th decimal place (p. 145). Mr. Ferguson gave an account of his work in *Mathematical Gazette*, v. 30, May 1946, p. 89-90, and recorded there his figures for π from the 521st to the 540th decimal place. Mr. Ferguson found that Shanks' approximation to π was incorrect beyond 527D. By November 1946 he had carried on his calculations of the value of π to 700D, and by January 1947 to 710D.

In December 1945 we suggested to Dr. JOHN W. WRENCH, JR. that he might take up the wholly independent computation of π by means of Machin's formula (1). In April 1946 he reported that he was in communication with Mr. LEVI B. SMITH of Talbotton, Georgia, who began his work on computing $\tan^{-1} \frac{1}{239}$ in November 1940 and had by February 1944 completed the work to 820D, through the term $[173 \cdot 239^{173}]^{-1}$. Then Dr. W. took up actively the computation of $\tan^{-1} \frac{1}{5}$ so that his results might be combined with those of Mr. S. as in Machin's formula. He found the errors in work of Shanks, earlier pointed out by Mr. F., and others described below.

Early in January 1947 Dr. W. sent to us his new approximation to π to 808D given below, as a companion to the value of e to 808D (*MTAC*, v. 2, April 1946, p. 69). The value found by Mr. F. to 710D agrees with this.

$\pi =$	3.14159	26535	89793	23846	26433	83279	50288	41971	69399	37510
	58209	74944	59230	78164	06286	20899	86280	34825	34211	70679
	82148	08651	32823	06647	09384	46095	50582	23172	53594	08128
	48111	74502	84102	70193	85211	05559	64462	29489	54930	38196
	44288	10975	66593	34461	28475	64823	37867	83165	27120	19091
	45648	56692	34603	48610	45432	66482	13393	60726	02491	41273
	72458	70066	06315	58817	48815	20920	96282	92540	91715	36436
	78925	90360	01133	05305	48820	46652	13841	46951	94151	16094
	33057	27036	57595	91953	09218	61173	81932	61179	31051	18548
	07446	23799	62749	56735	18857	52724	89122	79381	83011	94912
	98336	73362	44065	66430	86021	39494	63952	24737	19070	21798
	60943	70277	05392	17176	29317	67523	84674	81846	76694	05132
	00056	81271	45263	56082	77857	71342	75778	96091	73637	17872
	14684	40901	22495	34301	46549	58537	10507	92279	68925	89235
	42019	95611	21290	21960	86355	44191	19716	02977	46113	09960
	51870	72113	49999	99837	29780	49951	05973	17328	16096	31867
	50244	594(55)								