L-70

PROC. I.R.E. - April 1950

is more stable and less subject to aging than the American transistor and this is attributed principally to the composition of the germanium. A four-transistron telephone repeater is pictured having a gain of 45 db for a pass band from 40 to 10,000 cps, which indicates somewhat lower gain per stage than for the average transistor. This may contribute to its greater stability. Other applications included a miniature 2-transistron amplifier with passive components printed on plexiglass, a similar amplifier inserted in a 4-wire telephone line, a 6-transistron radio receiver, and a miniature transmitter for 300-meter wavelengths.

(330) E. Aisberg, "Transistron = Transistor + ?" *Toute la Radio*, vol. 16, pp. 218–220; July and August, 1949.

A transistor using a thin filament of germanium (about 0.01×0.01 cm in cross section) having an ohmic base contact at one end, an ohmic collector at the other end, and a point contact emitter on the filament very close to the emitter was described. For *n*-type material, these electrodes are biased in a manner similar to that for the 2-point contact transistor. It was pointed out that the gain of this device results from the modulation of the high body resistance of the filament between the emitter and collector in contrast to the situation in the 2-point contact transistor where it is the high reverse impedance of the collector barrier that is modulated by hole injection from the emitter. Power gains of 15 decibels up to frequencies of the order of a megacycle were reported and noise measurements were made indicating an improvement of 10 to 15 decibels over the average 2-point contact transistor.

(331) W. Shockley, G. L. Pearson, and J. R. Haynes, "Hole injection in germanium—quantitive studies and filamentary transistors," *Bell Sys. Tech. Jour.*, vol. 28, pp. 344–366; July, 1949.
(332) W. Shockley, G. L. Pearson, M. Sparks, and W. H. Brattain, "Modulation of the resistance of a germanium filament by hole injection," *Phys. Rev.*, vol. 76, p. 459; August, 1949.

Electronic Computers

Digital Computers

Four large-scale digital computers were completed and put into operation during 1949. These represent a substantial addition to the previously completed machines.

The Mark III Calculator was completed at Harvard and the event was celebrated by an excellent four-day symposium in September on large-scale digital calculating machinery and its application. This calculator stores on magnetic drums, 200 numbers and 150 constants with an access time of 4.3 milliseconds and 4,000 numbers with longer access. Sixteen-digit decimal numbers are used in a serial, quasi-fixed-point, arithmetic unit which multiplies in 12.9 milliseconds. Another drum contains 4,000 3-address instructions. Input and output are on magnetic tape.

The Bell Computer—Model VI is a general purpose digital relay computer with an electronically or tape controlled program. The electronic program arrangement has access to combinations of several hundred semipermanent built-in standard formulas. The solution of any standard problem requires that the problem tape simply furnish the formula number and the input data of the problem. Nonstandard problems are programmed by individually coded instructions on the problem tape.

International Business Machines Corporation delivered card-programmed calculators which combine an accounting machine with an electronic calculating punch. Instructions and data are introduced on punched cards to make possible iterations and optional subroutines for involved engineering, scientific and actuarial calculations. Results appear on printed forms or punched cards.

The BINAC, completed by the Eckert-Mauchly Computer Corporation, has twin memory, arithmetic control, and checking circuits operating in complete synchronism. Each memory stores 512 30-binary-digit words in a 16-channel delay line. Multiplication time is about one millisecond. An octonary keyboard, octonary printer, and magnetic tape input and output are provided.

(333) "Mark III," *Digital Computer Newsletter*,* vol. 1, p. 4; April, 1949.
(334) E. G. Andrews, "The Bell computer, Model VI," *Elec. Eng.*, vol. 68, pp. 751–756; September, 1949.
(335) "IBM card-programmed electronic calculator," Digital Computer Newsletter,* vol. 1, p. 3; September, 1949.
(336) "Card-Programmed Electronic Calculator, Preliminary Manual of Information," International Business Machines Corp., New York, N. Y., 1949; p. 37.
(337) J. P. Eckert, Jr., J. W. Mauchly, and J. R. Weiner, "An octal system automatic computer," *Elec. Eng.*, vol. 68, p. 335; April, 1949.
(338) "The BINAC," *Digital Computer Newsletter*,* vol. 1, p. 3; April, 1949.
(339) "The BINAC," *Digital Computer Newsletter*,* vol. 1, p. 4; September, 1949.

The completion of these instruments probably means that 1949 will mark the end of the first phase of postwar computer development in which there has been much discussion of the remarkable accomplishments which are anticipated and few reports on actual achievements. However, the completed machines are still outnumbered by the projected ones.

Other major development projects now being carried out are listed in references (340) to (354).

(340) "Institute for Advanced Study Computer," *Digital Computer Newsletter*,* vol. 1, p. 2, April, 1949.
(341) "Institute for Advanced Study Computer," *Digital Computer Newsletter*,* vol. 1, p. 2; September, 1949.
(342) "Whirlwind I," *Digital Computer Newsletter*,* vol. 1, p. 4; April, 1949.
(343) "Whirlwind I," *Digital Computer Newsletter*,* vol. 1, p. 3, September, 1949.
(344) "ORDVAC," *Digital Computer Newsletter*,* vol. 1, p. 2; April, 1949.
(345) "Institute for Numerical Analysis computer," *Digital Computer Newsletter*,* vol. 1, p. 3; April, 1949.
(346) "Institute for Numerical Analysis computer," *Digital Computer Newsletter*,* vol. 1, p. 1; September, 1949.
(347) R. M. Bloch, R. V. D. Campbell, and M. Ellis, "The logical design of the Raytheon computer," and "General design considerations for the Raytheon computer," *Math. Tables and Other Aids to Computation*, vol. 3, pp. 286–295, 317–332; October, 1948.
(348) C. F. West and J. E. DeTurk, "A digital computer for scientific application," PROC. I.R.E., vol. 36, pp. 1452–1460; December, 1948. Also, minor correction, vol. 37, p. 861; August, 1949.
(349) "Raytheon computer," *Digital Computer Newsletter*,* vol. 1, p. 3; April, 1949.

* Office of Naval Research, Code 434.

1 of 3

(350) R. L. Snyder, "EDVAC test instrumentation," *Elec. Eng.*, vol. 68, p. 335; April, 1949.
(351) F. Koons and S. Lubkin, "Conversion of numbers from decimal to binary form in the EDVAC," *Math. Tables and Other Aids to Computation*, vol. 3, pp. 427–431; April, 1949.
(352) "EDVAC," *Digital Computer Newsletter*,* vol. 1, p. 1; April, 1949.
(353) "EDVAC," *Digital Computer Newsletter*,* vol. 1, p. 2; September, 1949.
(354) "CALDIC," *Digital Computer Newsletter*,* vol. 1, p. 3; September, 1949.

There is also considerable activity in other countries.

(355) D. R. Hartree, "Modern calculating machines," *Endeavour*, vol. 8, pp. 65–69; April, 1949.
(356) F. C. Williams and T. Kilburn, "Electronic digital computers," *Nature* (London), p. 487; September 25, 1948.
(357) M. V. Wilkes, "Programme design for a high-speed automatic calculating machine," *Jour. Sci. Instr.*, vol. 26, pp. 217–220; June, 1949.
(358) D. R. Hartree, M. H. A. Newman, M. V. Wilkes, F. C. Williams, J. H. Wilkinson, and A. D. Booth, "A discussion on computing machines," *Proc. Roy. Soc. A.*, vol. 195, pp. 265–287; December 22, 1948.

Many general surveys have been made and other descriptive material written.

(359) W. H. Bliss, "Electronic digital counters," *Elec. Eng.*, vol. 68, pp. 309–314; April, 1949.
(360) W. J. Eckert, "Electrons and computation," *Sci. Mon.*, vol. 67, pp. 315–323; November, 1948.
(361) R. Davis and A. Berry, "Electromechanical and electronic calculating devices," *Trans. S. Afr. Inst. Elec. Eng.*, vol. 40, part 3, pp. 55–73; March, 1949.
(362) L. N. Ridenour, "Mechanical brains," *Fortune*, vol. 39, pp. 109–118; May, 1949.
(363) "ENIAC," *Digital Computer Newsletter*,* vol. 1, p. 1; April, 1949.
(364) D. R. Hartree, "Calculating Instruments and Machines," University of Illinois Press, Urbana, Ill.; pp. 138; 1949.
(365) R. D. Richtmyer and N. C. Metropolis, "Modern computing," *Physics Today*, vol. 2, pp. 8–15; October, 1949.

The relation between digital calculators and the brain has been the subject of considerable discussion.

(366) W. S. McCulloch, "The brain as a computing machine," *Elec. Eng.*, vol. 68, pp. 492–497; June, 1949.
(367) W. R. Ashby, "Design for a brain," *Electronic Eng.* (London), vol. 20, pp. 379–383; December, 1948.
(368) N. Wiener, "Cybernetics or Control and Communication in the Animal and Machine," John Wiley and Sons, Inc., New York, N. Y.; 1948.

The most difficult problem in the construction of a large-scale digital computers continues to be the question of how to build a memory, and the few papers written do not reflect the greatness of the effort which is being exerted.

(369) J. P. Eckert, Jr., H. Lukoff, and G. Smoliar, "A dynamically regenerated memory tube," Proc. I.R.E., vol. 37, p. 165; February, 1949. Abstract of oral paper.
(370) L. Pensak, "The graphecon—a picture storage tube," *RCA Rev.*, vol. 10, pp. 59–73; March, 1949.
(371) A. V. Haeff, "The memory tube and its application to electronic computation," *Math. Tables and Other Aids to Computation*, vol. 3, pp. 281–286; October, 1948.
(372) F. C. Williams and T. Kilburn, "A storage system for use with binary-digital machines," *Proc. IEE* (London), vol. 96, part 3, pp. 183–200; March, 1949.
(373) M. V. Wilkes and W. Renwick, "An ultrasonic memory for the EDSAC," *Electronic Eng.* (London), vol. 20, pp. 208–213; July, 1948.
(374) A. D. Booth, "A magnetic digital storage system," *Electronic Eng.* (London), vol. 21, pp. 234–238; July, 1949.
(375) F. A. Metz, Jr. and W. M. A. Andersen, "Improved ultrasonic delay lines," *Electronics*, vol. 22, pp. 96–100; July, 1949.
(376) H. Alfvén, L. Lindberg, K. G. Malmfors, T. Wallmark, and E. Åström, "Theory and application of trochotrons," *Kungl. Tekn. Hogsk., Handl.* (Stockholm), No. 22, pp. 106; 1948 (In English).
(377) I. L. Auerbach, J. P. Eckert, Jr., R. F. Shaw, and C. B. Sheppard, "Mercury delay line using a pulse rate of several megacycles," Proc. I.R.E., vol. 37, pp. 855–861; August, 1949.

The development of circuits, usually of an electronic nature, continued at a great pace. A few papers have appeared describing some of this work.

(378) K. H. Barney, "The binary quantizer," *Elec. Eng.*, vol. 68, pp. 962–967; November, 1949.
(379) R. D. O'Neal and A. W. Tyler, "Progress Report No. 1, photographic digital recorder," *Math. Tables and Other Aids to Computation*, vol. 3, pp. 444–445; April, 1949. Review of a Progress Report of Eastman Kodak Co., dated June 7, 1948.
(380) F. R. Martens, "Differential counting with reversible decade counting circuits," *Rev. Sci. Instr.*, vol. 20, pp. 424–425; June, 1949.
(381) H. J. Reich, and R. L. Ungvary, "A transistor trigger circuit," *Rev. Sci. Instr.*, vol. 20, pp. 586–588; August, 1949.
(382) D. R. Brown and N. Rochester, "Rectifier networks for multiposition switching," Proc. I.R.E., vol. 37, pp. 139–147; February, 1949.
(383) B. R. Gossick, "Predetermined electronic counter," Proc. I.R.E., vol. 37, p. 813; July, 1949.
(384) S. H. Washburn, "Relay 'trees' and symmetric circuits," *Elec. Eng.*, vol. 68, p. 958; November, 1949.
(385) A. E. Ritchie, "Sequential aspects of relay circuits," *Elec. Eng.*, vol. 68, p. 974; November, 1949.
(386) G. R. Frost, "Counting with relays," *Elec. Eng.*, vol. 68, p. 975; November, 1949.
(387) W. Keister, "Logic of relay circuits," *Elec. Eng.*, vol. 68, p. 980; November, 1949.
(388) "University of Illinois component research," *Digital Computer Newsletter*,* vol. 1, p. 4; September, 1949.
(389) E. C. Berkeley, "Giant Brains," John Wiley & Sons, Inc., New York, N. Y.; 1949.

Analogue Computers

Rapid progress has been made in analogue computers, (distinguished from digital computers in that the variables are represented as analogous voltages, shaft rotations, etc., rather than by discrete digits). The mathematical operations are performed through analogous physical relations such as addition of voltages in an electric circuit by a series connection or integration as with a planimeter. Because of the continuous character of the analogue, such computers are also referred to as the continuous-variable type.

Alternating-current networks calculators for power system problems have undergone important improvements in equipment and techniques and a number of new calculators are under construction.

The Anacom (at Westinghouse), the Northwestern University computer (Bureau of Aeronautics, Armament Division), and the California Institute of Technology analog computer are large-scale general purpose electric computers of the direct-analogue type. The Westinghouse and California Institute of Technology units were jointly developed, the former being used principally for solving transient problems involved in the electrical and mechanical design of machinery and power systems. The California Institute of Technology unit is used for a wide variety of problems, including many aircraft structural and servo problems. The Northwestern computer is composed of the basic-circuit-elements section of the Anacom, together with special electronic sections developed by the Aerial Measurements Laboratory at Northwestern University. It has been used chiefly on armament problems.

(390) W. A. Morgan, F. S. Rothe, and J. J. Winsness, "An improved ac network analyzer," paper 49-164, presented, AIEE Summer General Meeting, Swampscott, Mass., June 20–24, 1949.

* Office of Naval Research, Code 434.

(391) P. O. Bobo, "Technique of handling power system problems on a modern ac calculator," presented, AIEE Winter General Meeting, New York, N. Y., January 31, 1950.
(392) E. L. Harder and J. T. Carleton, "New techniques on the Anacom" paper 50-85, presented, AIEE Winter General Meeting, New York, N. Y., January 31, 1950.
(393) J. P. Corbett, "Summary of transformation useful in constructing analogs of linear vibration problems," AIEE paper 49-166, presented, AIEE Summer General Meeting, Swampscott, Mass., June 20–24, 1949.
(394) G. D. McCann, C. H. Wilts, and B. N. Locanthi, "Electronic techniques applied to analogue methods of computation," Proc. I.R.E., vol. 37, p. 954; August, 1949.
(395) G. D. McCann, C. H. Wilts, and B. N. Locanthi, "Application of the Cal Tech electric analog computer to nonlinear mechanics and servomechanisms," Paper 49-165, presented, AIEE Summer General Meeting, Swampscott, Mass., June 20–24, 1949.

Differential Analyzer. The earliest of the differential analyzers have been in service for a considerable number of years. The latest machine at Massachusetts Institute of Technology is electrically connected and operated through servos and a cross-bar switching system. Setups and much of the problem data are fed in through punched tapes. The usefulness of differential analyzers has been extended recently by the Michel techniques.

Meteor (Massachusetts Institute of Technology) is a large-scale, combined electric-analogue computer and flight simulator. In flight simulation a flight table is positioned at normal speed, the computer solving the aerodynamic equation of flight, i.e., simulating the action of the plane. An auto pilot can thus be tested on the flight table just as though it were in the plane under the specified flight conditions.

In straight computing, the time base is arbitrary and the computer functions as an electronic differential analyzer. Integrating amplifiers provide integration with respect to time. Multipliers are of the carrier-strain-gauge type.

Development has also continued on electronic-differential-analyzer-type computers by Reeves, Philbrick, Goodyear, and others. Over thirty of the Reeves computers are now in use, principally by the Air Force and its contractors.

(396) A. C. Cook and F. J. Maginniss, "More differential analyzer application," *Gen. Elec. Rev.*, August, 1949.
(397) G. L. Michel, "Extensions in differential analyzer technique," *Jour. Sci. Instr.*, p. 357; 1948.
(398) V. Paschkis, "Comparison of long time and short time analog computers," Paper 49-13, presented, AIEE Summer General Meeting, Swampscott, Mass., June 20–24, 1949.
(399) A. C. Hall, "A generalized analog computer for flight simulation," paper 50-48, presented, AIEE Winter General Meeting, New York, N. Y., January 31, 1950.
(400) H. S. Kirschbaum and C. E. Warren, "A method for designing pulse transformers," paper 49-198, presented, AIEE Summer General Meeting, Swampscott, Mass., June 20–24, 1949.

Facsimile

An analysis of facsimile as viewed by the armed services was presented. Facsimile applications to commercial telegraph systems have been expanded. A new recording medium utilizing selenium coatings for fine-grain reproduction has been described.

(401) "Facsimile and its place in telegraphy," *Western Union Tech. Rev.*, vol. 3, pp. 1–5; January, 1949.
(402) "The xerographic process," *Western Union Tech. Rev.*, vol. 3, pp. 43–44; January, 1949.
(403) H. F. Burkhard, "Considerations on facsimile transmission speed," AIEE Technical Paper 49-108; December, 1948.

There was developed by the Philips Research Laboratories in Holland, a very high-speed facsimile communication system employing a continuous belt scanning unit for transmission and a continuous photographic method for reception, described in five articles:

(404) "Experimental transmitting and receiving equipment for high-speed facsimile transmission,"
(a) H. Rinia, D. Kleis, and M. van Tol, "General," *Philips Tech. Rev.*, vol. 10, pp. 189–220; January, 1949.
(b) D. Kleis, F. C. W. Sloof, and J. M. Unk, "Details of the transmitter," *Philips Tech. Rev.*, vol. 10, pp. 257–264; March, 1949.
(c) F. C. W. Sloof, M. van Tol, and J. M. Unk, "Details of the receiver," *Philips Tech. Rev.*, vol. 10, pp. 265–272; March 1949.
(d) D. Kleis and M. van Tol, "Transmission of the signals," *Philips Tech. Rev.*, vol. 10, pp. 289–298; April, 1949.
(e) D. Kleis and M. van Tol, "Synchronization of transmitter and receiver," *Philips Tech. Rev.*, vol. 10, pp. 325–333; May, 1949.

Applications of FM broadcast facsimile equipment in educational fields, particularly journalism, increased throughout the year.

(405) D. Z. Shefrin, "Talking newspaper," *The Quill*, vol. 37, p. 8010; March, 1949.

Descriptive material for broadcast engineers appeared as a brief treatment of systems operation.

(406) "Facsimile," Engineering Handbook, National Association of Broadcasters, fourth edition, section 2, article 6; 1949.

A book related the experiences of two newspapermen in installing and operating a multi-edition broadcast facsimile publication in Florida over a three-year period.

(407) Lee Hills and T. J. Sullivan, "Facsimile," McGraw-Hill Book Co., New York, N. Y.; 1949.

Another book, contained data on circuit analysis and equipment as designed and fabricated in the United States.

(408) C. R. Jones, "Facsimile," Murray Hill Books, Inc., New York, N. Y.; 1949.

The further interest of government agencies in weather map distribution by facsimile was followed by continued development and production of improved equipments.

(409) "New facsimile recorder," *Tel. and Tel. Age*, vol. 67, pp. 10, 12; January, 1949.

One development of significance was the introduction of a high-speed system for the transmission of graphic material.

(410) "Ultrafax," *Electronics*, vol. 22, pp. 77–79; January, 1949.
(411) D. S. Bond and V. J. Duke, "Ultrafax," *RCA Rev.*, vol. 10, pp. 99–115; March, 1949.

Industrial Electronics

The applications of electronics to the solution of industrial problems have grown at an accelerated rate in 1949. A conference held in April in Buffalo, N. Y., focused attention on problems of greater reliability. Papers were presented on the application of electron tubes to motor control, electronic regulators, ac power control, life tests of vacuum tubes and maintenance problems of tubes in industry, and regulation of supply voltage needs. The inadequacies of tube ratings, needed improvements in tube characteristics and ratings and use of capacitors in electronic circuits, etc., were also dis-