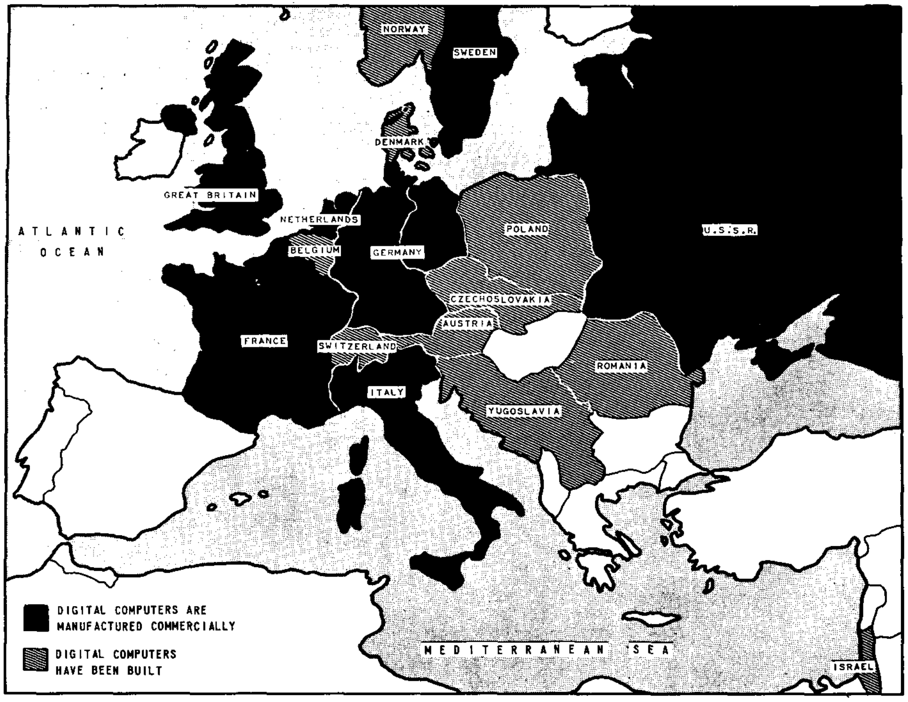

This report indicates the level of computer development and application in each of the thirty countries of Europe, most of which were recently visited by the author

The State Of Digital Computer Technology In Europe

By Nelson M. Blachman

Digital computers are now in use in practically every country in Europe, though in some there are still very few and these are of foreign manufacture. Such machines have been built in sixteen European countries, of which seven are producing them commercially. The map above shows the computer geography of Europe and the Near East. It is somewhat difficult to rank the countries on a one-dimensional scale both because of the many-faceted nature of the computer field and because their populations differ widely in size. Nevertheless, Great Britain clearly comes first (after the U. S.). She is followed by (West) Germany, the U. S. S. R., France, and Japan. Much useful information on commercially available computers and other interesting developments appears in a recent paper [1] by Isaac L. Auerbach. Thus, we shall concentrate on the countries whose work in this field is less well known [2]. No slight to the work of other countries is intended; in several cases it is simply too vast to be done justice in this brief survey.

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Communist Countries

U. S. S. R. A very thorough account of Soviet computer work is given in the report edited by Willis Ware [3]. To Ware's collection of Russian machines can be added a computer at the Moscow Power Institute, a school for the training of heavy-current electrical engineers (Figure 1). It is described as having a speed of 25,000 fixed-point operations or five to seven thousand floating-point operations per second, a word length of 20 or 40 bits, and a 4096-word ferrite-core memory, supplemented by a fixed 256-word store on paper printed with condensers plus a 50,000-word magnetic-tape store. The clock rate is stated to be 100 kc, though this number does not appear to square with the operation speed. This computer, which is transistorized, was built by students in three years, beginning in 1957.

Hungary, Bulgaria and Albania. Within the Soviet Colonial Empire, Poland appears to be the most advanced in the computer field, followed by Roumania, East Germany, and Czechoslovakia. A number of Polish computer men have recently spent some time working in the West. In Bulgaria there is some interest in computers. Use is made of the Roumanian computing facilities, and the Mathematical Institute of the Bulgarian Academy of Sciences plans to get a computer. There does not appear to be any work in this field in Albania, but Hungary is reported to have a Russian M-3.

Poland. The principal organization in the computer business in Poland is the Zakład Aparatów Matematycznych (Institution of Mathematical Machines) of the Polish Academy of Sciences in Warsaw; it employs several hundred people and has built a number of digital computers. The first of these is called the XYZ1 (Figure 2); work on it began in 1957 and ended in 1958. Since that time, the machine has been fully loaded on three shifts with a wide variety of problems coming from all over the country, and students from universities in several cities have done practice work on the XYZ1. It is a serial machine using tubes, with a 36-bit word length, a 512-word mercury-delay-line store, and an 8192-word drum. Its clock rate is 700 kc and its speed is 800 operations per second. Bull punched-card equipment and Creed paper-tape devices are used for input and output. In Poland such auxiliary equipment seems to come more often from the West than from the U. S. S. R.

By now, a engineered copy of the XYZ1, called ZAM 2 (Figure 3), should have been completed for the Institute of Aircraft, and another four should be completed late in 1961. ZAM 2 differs from XYZ1 in having twice as capacious a drum and in having an index register. The design of an advanced computer, ZAM 3, is under way; it is to be a multiprogrammed parallel, single-address machine incorporating fixed- and floating-point arithmetic and performing 5,000 operations per second. It will be transistorized but will use diodes and magnetic amplifiers as the basic logical elements. Its memory will consist of one to four units, each holding 4096 48-bit words of ferrite-core storage, and up to sixteen magnetic-tape units. The clock rate is 200 kc. In a second model of this computer, the ferrite cores will be replaced by permalloy cores, and the arithmetic speed will be doubled.

Programs for XYZ1 are generally written in a language called SAKO, similar to FORTRAN, which is translated into machine language by a 3000-word program. The Institution hopes that SAKO will be adopted as a standard throughout the U. S. S. R. and its empire.

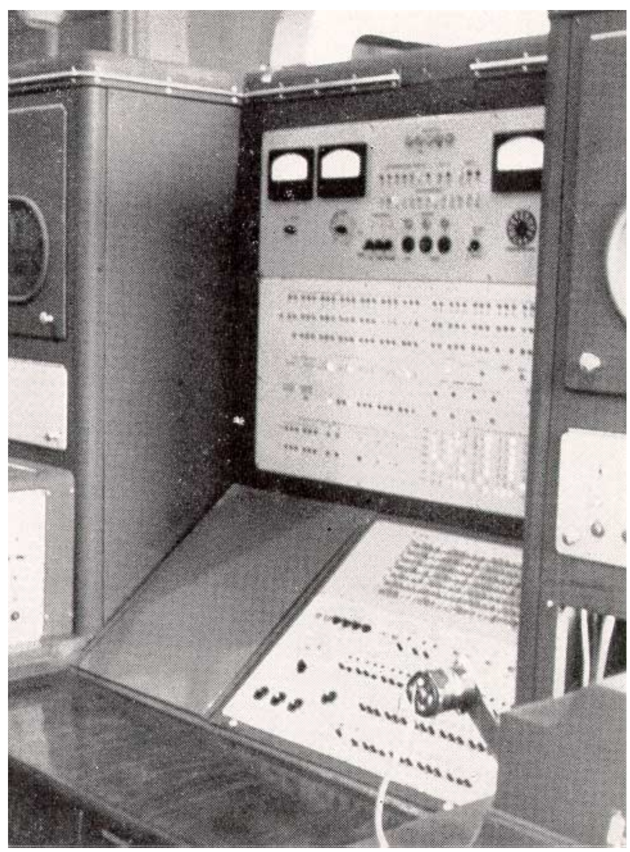
The Institution has also built SKRZAT 1, a control computer similar to the Moore School operational flight trainer. It uses diode-core logic and has a word length of 20 bits, which can represent two single-address commands. The base of the number representation is -2. There are two memories, one fixed, with 4096 cores, each storing one word with a 2.5-microsecond access time, and the other erasable, with two cores per bit, storing 256 words. The clock rate is 200 kc; addition takes 130 microseconds, and multiplication takes 650 microseconds.

At the Warsaw Polytechnic, one computer has been built and two others are under way or have recently been completed. The first, which is already doing useful computing, is a drum machine, apparently having 4000 34-bit words of storage. The number base is -2, and the speed is one or two hundred operations per second. It uses tubes and has teletype input/output. The second is also slow but its base is $+2$; it has an adjustable set of microprograms. The third is reported to use magnetic amplifiers. The Institution of Organization and Technique of Office Work has been making use of the first of these machines but anticipates delivery of a computer with 10,000 words of drum memory and 100 words of quick-access storage. Its word length is to be 11 dits and sign, and its speed is to be 1500 to 2000 operations per second.

Roumania. Computer work in Roumania appears to be centered at the Institut de Fizică Atomică near Bucharest, which receives the largest budget of any research facility in Roumania and is, therefore, able to surpass the general level of technology in the country. Roumanian computer work, which had its beginnings in 1953, is centered in this institute, which has built three computers of similar characteristics, CIFA-1, CIFA-2, and CIFA-3, and is currently constructing a fourth, CIFA-101, which has a 36-bit word length, operates in the serial mode, and has a magnetic-core memory. CIFA-3 was built for the University of Bucharest. Work on contact networks and sequential circuits is done at the Institute of Mathematics of the Roumanian Academy in Bucharest, but it does not appear to be computer-oriented.

The first three machines all operate asynchronously in the parallel mode and have parallel drum memories; their word length is 31 bits, which can represent two single-address instructions. They have very small repertories of orders and very simple input-output equipment, which is in short supply. CIFA-1, which was completed in 1957, has punched-tape and typewriter input and only typewriter

Fig. 1. Computer at the Moscow Power Institute



output. Its drum stores 1024 words, while that of CIFA-2 holds only 512. On CIFA-1, addition and subtraction take 0.15 ms plus access time (10-ms average), while on CIFA-2 they take 0.5 ms; on CIFA-1 multiplication and division take 5 ms, while on CIFA-2 they take 19 ms, being controlled by a 2-kc clock, which requires 30 cycles. However, while CIFA-1 uses 1500 tubes, CIFA-2 uses half as many, along with 2500 germanium diodes. The drums are made at the Institute, but many of the electronic components are imported from the U. S. S. R. or East Germany.

CIFA-2, which was completed in October 1959, is run on a 12-hour-per-day schedule to supply computing services to a wide variety of paying customers. A dozen or more students have used it for masters' theses. However, the art of programming and of using the computer as efficiently as possible has not advanced rapidly at this institute; such ideas may have to come from a meeting to be held this year in Warsaw concerning programming languages.

Czechoslovakia. Czechoslovak computer work is centered in the Výzkumný Ústav Matematických Strojů (Research Institute of Mathematical Machines) of the Ministry of Precision Engineering in Prague, which has built one stored-program computer, SAPO (Figure 4), and is completing another, EPOS. At the Ústav Theorie Informacé a Automacé, special-purpose computers have been built for random-number generation and for automatic quality-control decision making. An URAL I, bought from the U. S. S. R., is located in Prague, perhaps at this institute.

SAPO, whose design dates from 1951, was completed early in 1958. It is a parallel, floating-point, binary, drum computer with a speed of three operations per second. It uses 350 tubes, mainly in connection with the drum, and 8000 relays, which perform the logic. Its most novel feature is the triplication of arithmetic units. If two of them agree, computation continues, but 128 bits of information are printed out to describe any disagreement. The drum, which stores 1024 32-bit words (of which one bit is a parity check), has a constant access time of 40 ms; i.e., two revolutions. Each instruction fills two words, refers to five addresses (two for the next instruction, depending on the sign of the result), includes two orders (one for controlling input/output equipment), and requires eight drum accesses (including reading back what it writes on the drum). There is only one address track on the drum; it contains a special sequence of 1024 binary digits and is read by ten heads, spaced at intervals of 101 bits. The sequence is such that each of the 1024 addresses appears on the heads at some time during a revolution. In spite of its very slow speed, SAPO is able to do a useful amount of computing, as it is quite reliable and needs no routine maintenance. The Institute also uses a large amount of punched-card computing equipment.

The Institute is working on a faster machine, EPOS, which is to be different in nearly every respect. Only in the duplication of the arithmetic unit will it resemble SAPO. It will have normal drum addressing, its instructions will involve a single address, and its word length will be 10 decimal digits, which will be handled in the serio-parallel mode. Decimal digits will be represented by a modification of the biquinary scheme referred to as a residue-class representation with base (2,3,5). Its clock rate will be 1 mc, addition will take 33 microseconds, and multiplication 100 microseconds.

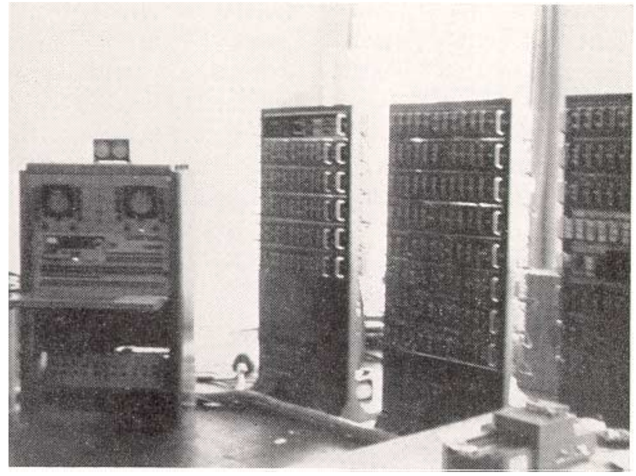


Fig. 2. The Polish XYZ1

The Institute has also worked on special-purpose computers for punched-paper-tape control of machine tools.

Eastern Germany. In 1955, the Carl Zeiss optical firm in Jena built OPREMA, a relay computer using 25,000 relays, and by now they should have completed ZRA 1, a fairly sophisticated, serial, magnetic-drum computer employing ferrite-core logic. Except for the 12,000-rpm 4096-word drum, which yields a 200-kc clock, it is not especially fast, but it incorporates fixed- and floating-point arithmetic and seven immediate access registers, which can be used for address modification by means of a separate adder or for storing an operand. The word length is 48 bits including one parity bit and two markers, and it is filled by one single-address instruction; 100,000 types of instructions can be written, including such features as indirect addressing, index modification, conditional jump, etc. Punched cards are used for input and a 150-number-per-minute line printer for output. Zeiss may manufacture modified copies of this machine; the ZRA 1 is for its own use.

It has been reported that the Technical University of Dresden is building a computer, but no details were provided. Considering the fact that Eastern Germany is part of the same country as Western Germany and that there is quite a lot of computer work going on in the latter, some of it rather advanced, it is not unlikely that other work, too, is in progress in Eastern Germany.

Yugoslavia. As in Roumania, the principal site of computer work in Yugoslavia is a well-supported Institute of Nuclear Sciences—the Boris Kidric Institute in Vinča, near Belgrade. By now, this organization should have completed a serial, fixed-point, partly transistorized, computer with a 4096-word parallel core store and a 100-kc clock. The word length was to be 30 bits, which can represent a single one-address instruction. Punched tape was to be used for input and output. However, the Institute's forte is analog computer work.

An IBM 705 has presumably been installed in Belgrade to do census work with the help of someone from the U. S. Bureau of the Census, and there are a number of small Remington Rand electronic computers in Yugoslavia.

The Eastern Mediterranean

Greece. Greece's first electronic digital computer was an IBM 650, delivered to the National Bank of Greece late in 1959. Perhaps other machines have been delivered since that time, but there appears to be no work or instruction in Greek universities in this field.

Turkey. Turkey entered the computer field similarly, with the delivery in 1960 of an IBM 650 to the General Directorate of Highways in Ankara. Large amounts of punched-card machinery are in use in some of the government bureaus in Ankara, and they will no doubt be supplemented eventually by electronic computers.

There are no regular courses at Turkish universities on numerical analysis or on the application or design of computers, but the Technical University of Istanbul offers courses bordering on these fields, and Robert College, outside Istanbul, has a weekly seminar on computers, for which no credit is given.

Israel. In Israel, computer research is done in the scientific department of the ministry of defense, which has been concerned with getting the most from a limited financial investment in hardware. This group is completing a small computer and has recently bought a Philco TRANSAC S-2000.

At the Weizman Institute in Rehovoth, the WEIZAC was completed in 1955. This computer, which belongs to the JOHNNIAC family, has done much useful computing. The Institute acquired a Swedish WEGEMATIC 1000 in 1960, but it has so far not seen much use. However, Israel appears to lack curricula in the design and application of digital computers at its universities; neither the Hebrew University in Jerusalem nor Technion in Haifa has an electronic digital computer.

Israel's neighbors, Lebanon, the United Arab Republic and Jordan, have no computers or training in this field, but the U. A. R. government has expressed an interest in getting started in this direction and has joined the International Computation Center in Rome.

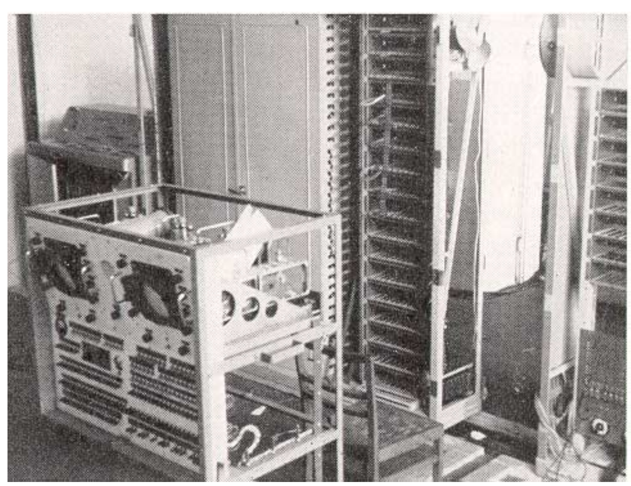
Scandinavia

Sweden. Of the three Scandinavian countries, Sweden is the most advanced in the computer field and is the only one manufacturing these machines commercially. It was also the first to build an automatic computer, the plugboard-programmed relay machine BARK, which, with governmental support, was put into operation in 1950 by the Working Group of the Board for Computing Machinery (Matematikmaskinnämndens Arbetsgrup) in Stockholm. This group has done much hardware and programming research as well as providing a widely used computing service. In 1954 the BARK was supplanted by the BESK, designed and built by this group but patterned after the Institute for Advanced Study (Princeton) computer. This fixed- and floating-point machine, which was put together very neatly and proved quite reliable, has been copied in modified form (without floating-point arithmetic but with core store doubled to 2048 words) and sold commercially under the name FACIT EDB by Åtvidabergs Industrier, Stockholm, which also has developed its own random-access magnetic-tape memory called "Carousel", sold for $25,000. It has aroused much interest, as the Carousel is a wheel holding 64 spools of 8-channel magnetic tape, each of which stores 8192 40-bit words on 128 feet of tape with an access time of 1.9 seconds to any block.

The Swedish Board for Computing Machinery has developed a programming language called "alphacode" for its BESK and FACIT EDB, and programs are frequently received by teletype in this language. This group is developing a high-speed alphanumeric output display exhibiting a 64×64 array of characters at the rate of 4000 or 5000 characters per second, each selected from an 8×8 array and scanned at 150 kc by a television raster having 30 lines.

The ALWAC IIIE, of which the Swedish Board for Computing Machinery has one, is now being manufactured in Tyresö, near Stockholm, by the Bo Nyman Aktiebolag, which has modified it (of course) and renamed it the WEGEMATIC 1000. They are also completing the development of the ALWAC 800, a larger machine under the name WEGEMATIC 8000. It is a parallel, decimal machine with magnetic-core logic and some transistors, a 500-word core

Fig. 3. ZAM2, an engineered copy of the XYZ1



memory having 32-microsecond access time, and facilities for including many drums and tapes. Its basic addition time is 6 microseconds.

Svenska Acroplan AB. (SAAB) in Linköping has built its own copy of the BESK, called SARA, with 2048 words of core storage, an 8192-word drum, and six magnetic tapes. Recently they have entered into a business arrangement with FACIT and have also built a parallel, transistorized, 2.5-mc, fixed-point computer called D2 with 20-bit word length and single-address instructions including 32 types of orders. There are two core memories, one with 4096 words for instructions and the other with 2048 words for numbers. Instruction addresses can be modified on execution, but the instruction memory is not altered during the execution of a program. Addition takes 7 microseconds including access; multiplication 23 microseconds.

On the campus of the Royal Technical University in Stockholm is located the computation center of the semi-private firm Atomenergi, equipped since 1959 with a Ferranti Mercury. Several hundred hours of computing time are available to the University each year. The Institute of Theoretical Physics at the University of Lund has its own copy of the BESK, called SMIL, with a 4096-word memory, and the Chalmers Technical University in Gothenburg has a computing center equipped with an ALWAC IIIE, which gives eight hours a day to the University and sells the rest. To it, magnetic tapes and a WEGEMATIC 8000 are to be added. FACIT and WEGEMATIC computing centers are also operated by the manufacturers, and the FACIT group is programming an ALGOL and a business compiler.

The Royal Technical University has about a hundred students each year in its computer-programming course. Some learn to use the BESK, some FACIT, some WEGEMATIC 1000, some the IBM 650, and some MERCURY. At the Chalmers Technical University, work is being done on solid-state devices for computers. Thus, Sweden appears to be relatively advanced in the construction and utilization of computers.

Denmark. The DASK, another "copy" of the BESK has been built at the Institute of Computing Machinery (Regnecentralen or Matematikmaskininstitut) of the Danish Academy for Technical Sciences in Copenhagen, where it has been in operation for three years now. This Institute has recently designed and built a more advanced and much more compact machine called GIER, of which five copies are being built for Danish Universities and institutes. Remarkably, it cost half as much as the DASK to build; i.e., only about $70,000. The GIER, which is intended for the Geodetic Institute, is fully transistorized; only five people were involved in its construction. Its memory consists of 1024 42-bit words of Philips core storage and a 24,000-word Standard Elektrik magnetic drum. Its order code includes indirect addressing and random numbers produced by noise and is very flexible; like the TELEFUNKEN TR4, it includes a single order for polynomial evaluation or for computing a continued fraction, and additional orders can be included by means of plugboards. Each instruction includes indications of jump condition, address modification, index-register modification, and repetition.

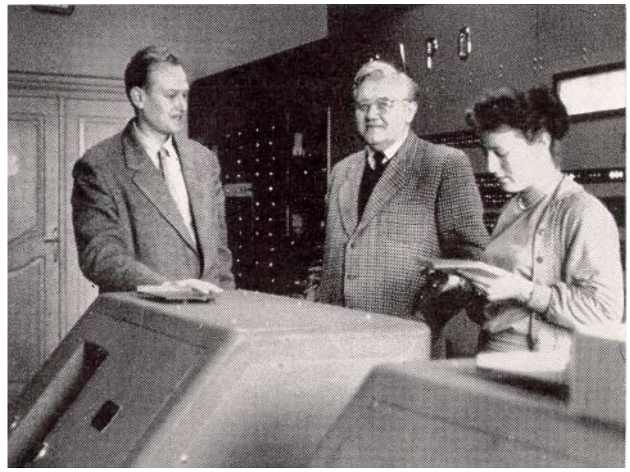


Fig. 4. SAPO, a Czechoslovak stored-program computer

Work has been done on an ALGOL compiler for GIER, and a 1024-word fixed store with 50-microsecond read-out time has been constructed to aid in translating from ALGOL to GIER language. Each word is wired through 40 large cores. The GIER's arithmetic and control units are combined and together have five address registers and four accumulators, any of which can serve as control register, accumulator, multiplier register, etc. The Institute has a staff of about fifty, half of whom are involved in engineering and maintenance, and the rest of whom specialize in a good variety of computer applications.

Students at both the University of Copenhagen and at the Danish Technical University in Copenhagen learn to use these machines. Thus, considering its population (4,500,000), Denmark is evidently progressing reasonably well in the computer field.

Norway. Next to Iceland, which is evidently too small (170,000) to support any significant effort in the computer field, Norway is the least populous (3,500,000) of the Scandinavian countries, and relatively little has been done there on the construction of computers. A small drum machine, NUSSE patterned after A. D. Booth's APE(X)C was built in 1953 at the Norwegian Computing Center at the University of Oslo. This machine has a 1-ms basic addition time and a 250-ms average multiplication time, with a 512 32-bit words of memory. A small digital differential analyzer called DIANA has been built at the Norwegian Technical University in Trondheim, but there has been comparatively little interest in such machines in Europe. (The Royal Aircraft Establishment in England, however, has been working along such lines, and there is a DDA in Naples.) This university has, evidently, recently gotten a WEGEMATIC 1000.

The Norwegian Defense Research Institute in Kjeller, near Oslo, has a Ferranti MERCURY. The MERCURY is especially favored by nuclear-reactor groups—in France (Saclay), Belgium (Mol), Switzerland (CERN), Sweden (Atomemergi), etc., as well as in England (Harwell, et al.). The Central Bureau of Statistics in Oslo has an English Electric DEUCE and plans to get an IBM 1401, and the Norsk Meteordogisk Institut is getting a FACIT EDB with two Carousel memories.

Finland. Finland's State Institute for Technical Research near Helsinki has a copy of the floating-point, paper-tape-controlled Göttingen magnetic-drum computer, which has a speed of about 20 operations per second. It has ten photoelectric tape readers, and its drum stores 1800 words of 52 bits. The Post Bank in Helsinki is using an IBM 650.

Iberia

Little information seems to be available about computers in Portugal outside of the fact that there is a Standard Electric ZEBRA at the National Laboratory of Civil Engineering in Lisbon.

Spain has probably recently acquired its first couple of computers, one—perhaps an IBM 650—for the preparation of railroad timetables, and the other—perhaps a Sperry-Rand Solid-State Computer—for the Junta de Energía Nuclear. A modest amount of computer-component research is done at the Instituto de Electricidad y Automática at the University of Madrid, supported in part by the U. S. Air Force. This group, consisting of eleven scientists, has been particularly concerned with ferroresonance. They have achieved switching speeds of 800 kc with an 11.5-mc carrier frequency in their ferroresonant flip-flops, but they have become interested in the use of nonlinear capacitances rather than nonlinear inductances in order to achieve still higher speeds and lower power consumption. Over a period of years, this group is constructing the various component units of a magnetic-drum computer, and they are also doing some interesting work with analog-computer components. At the University, a one-term course in digital and analog computers is given; it has an enrollment of eight post-graduate students.

Benelux

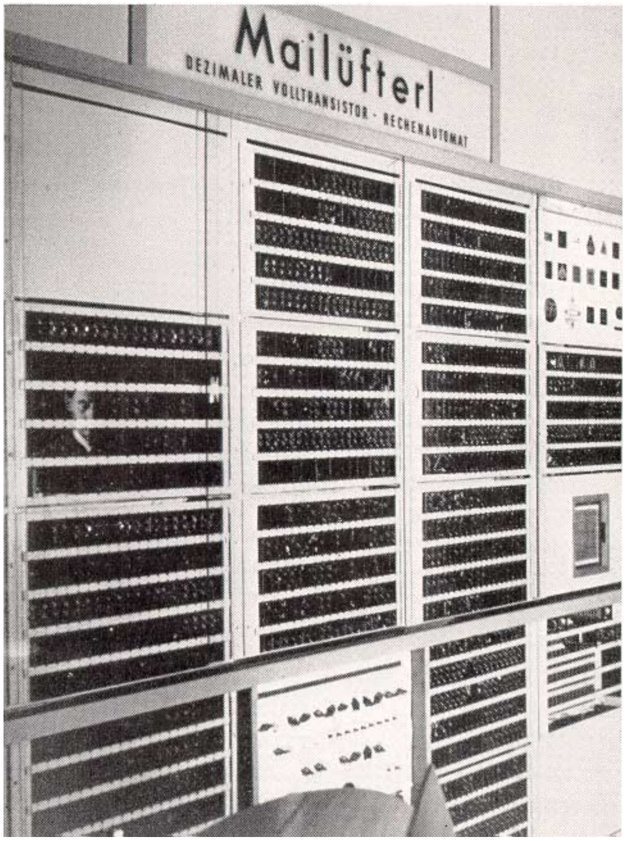
Belgium. While only one general-purpose digital computer has been built in Belgium—a large floating-decimal, serio-parallel, magnetic-drum machine based on Harvard MARK III and IV and on the Darmstadt DERA, which was completed in 1954 by the Bell Telephone Manufacturing Co. in Antwerp—computers are seeing widespread use in Belgium. As of early 1960, at least fifteen IBM 650's, four IBM 710's, three Burroughs E-101's, an Elliott 802, a Standard Electric ZEBRA, a Bull GAMMA 3, and the Ferranti MERCURY (at the Centre d'Etudes Nucléaires) had been placed in operation in Belgium. The ZEBRA and the Bell Telephone Mfg. Co. computer are located at the Centre d'Etudes et d'Exploitation des Calculateurs Electroniques in Brussels, which develops and builds a good deal of its own auxiliary equipment as well as supplying for customers all over the country extensive computing services. One of the E-101's is located at the Centre de Calcul Numérique of the Université Catholique de Louvain.

Despite this wide use of computers, neither numerical analysis nor computer design or application is taught in Belgian universities, although the Université Libre de Bruxelles has an IBM 650; revision of the curriculum takes a long time because the national government must approve any changes, but there is pressure for introducing computer courses.

Netherlands. Four or five different groups in the Netherlands have built electronic digital computers. First among them was the Mathematisch Centrum in Amsterdam, which completed its first—a quite useful drum computer called ARRA—at the end of 1953. In 1952 the Center had built and dismantled a relay version of the same machine. A copy of the ARRA, called FERTA, was put into operation by the Royal Dutch Airplane Factory in 1955. In 1956, the ARRA was supplanted by the ARMAC, a fixed-point, single-address, binary, serial, drum computer of fairly conventional characteristics except for the inclusion of 32 words of core storage, communicating by means of a 32-word core buffer with the drum. All core and drum words were directly addressable. Thus, the speed was limited by the addition time, 416 microseconds. Multiplication took 5.4 ms; division was not incorporated. This computer should by now have been replaced by an ELECTROLOGICA X-1 and have been given to a museum. Besides doing research and applied work in mathematics and statistics, the Center has provided extensive computing services for the Netherlands and neighboring countries and has participated in the development of ALGOL.

In order to get the Center out of the computer-building business, the Electrologica Company was formed in 1956 by engineering personnel of the Mathematisch Centrum, with outside financial backing. This organization has developed the X-1 computer and has so far delivered at least ten of them. The X-1, which is transistorized, comes with from one to 512-word matrices of core storage with 32-microsecond cycle time and 512-word units of fixed storage. Addition takes 64 microseconds and multiplication 500; typewriter, punched-tape, and punched-card input/output equipment are available, and the latter can automatically interrupt the program. The word length is 27 bits—one single-address instruction.

The ZEBRA, manufactured by Standard Electric in England, was actually developed in the Netherlands Post-Telephone-Telegraph Laboratory, and at least nine ZEBRAS have been installed in the Netherlands. Some of them are located in the Technical University of Delft and the State Universities of Utrecht and Groningen. These drum computers generally run unattended—at night as well as during the day. At the PTT Laboratory, a coding language called "simple code" was developed for the ZEBRA and a compiler written. Nearly all coding is done in this language, and work has been done on an ALGOL-to-simple-code translator. The ZEBRA is an improvement on



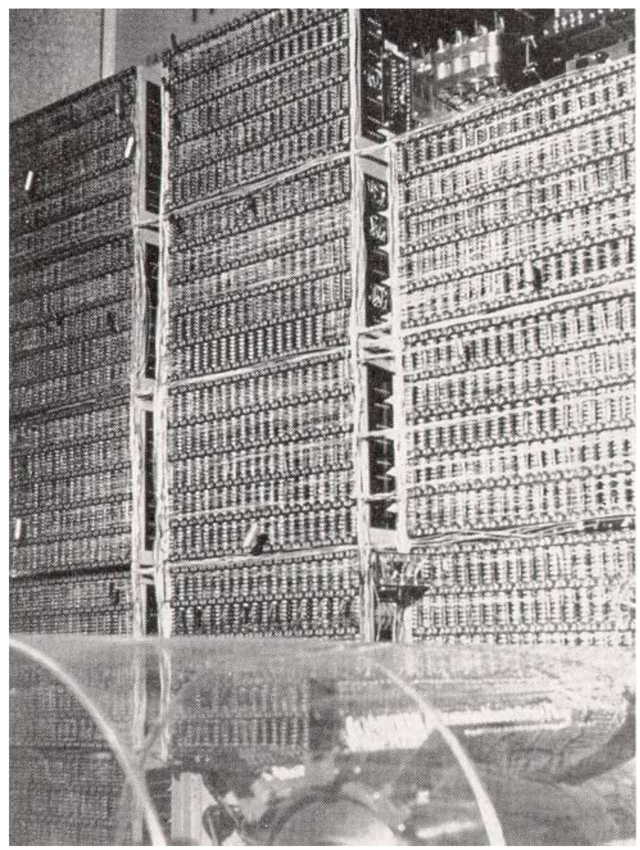


Fig. 5. The Mailüfterl, in Vienna

the PTERA, which was completed at the PTT Laboratory in 1953 and remained, performing 20 operations per second with low reliability, until 1958, when the ZEBRA was delivered.

Two computers, PETER and PASCAL, have been built at the Philips Research Laboratory in Eindhoven. PETER, which was completed in 1956, has a 2048-word serial drum store, 32 words of core storage, and a parallel-type arithmetic unit. The intention was to gain experience in the computer field, and the word length is only 20 bits, but it has been found quite useful for computing. Addition basically takes 20 microseconds and multiplication 700.

PASCAL is a fast, parallel, fixed-and-floating-point, single-address, machine with 2048 words of word-organized core storage and a 16,384-word drum. The word length is 42 bits with two instructions per word. These can refer to eight 21-bit instruction-modifier registers. The average speed is estimated at 70,000 operations per second (7.5 microseconds minimum for addition and 70 for multiplication). A copy of PASCAL, called STEVIN, is being built for Philips's use, but the company appears to have no intention of selling computers, possibly because several of its customers do so.

Fourth-year students at the Technical University in Delft are taught boolean switching theory, and fifth-year students do "thesis" work in the Electrical Engineering Laboratory, which obtained most of its personnel from the PTT Laboratory. There, they had developed special-purpose digital computers for military purposes. Thus, this thesis work is sometimes quite good, and one student (a Jesuit) designed and built a two-integrator digital differential analyzer.

Evidently, the Netherlands leads the Benelux countries in the computer field. Luxembourg, with a population of 320,000, is, of course, in no position to compete.

Austria

The MAILÜFTERL, a fully transistorized, serial, fixed-point, decimal-and-binary drum computer with 50 words of immediate-access core storage, was completed at the Technische Hochschule in Vienna in May 1958. The 3000-rpm drum stores 10,000 48-bit words. Instructions are of the one-address type, fully utilizing a whole word, as they include references to the core store, condition on execution, and indication of how the address is to be modified or interpreted, etc. The order code is patterned after those of the ZEBRA, ZUSE Z-22, and ERMETH. Addition takes 0.8 ms, and there is a separate adder for address modification. Multiplication and division are effected by subroutines, multiplication taking 26 ms. The MAILÜFTERL was intended to provide experience with transistors and such things as ALGOL translation rather than with numerical computing. The Mathematisches Institut at the Technische Hochschule has an IBM 650 to provide the latter service. As of mid-1959, Austria had two other general-purpose digital computers, a Z-22 at the Stickstoffwerk in Linz and a Sperry-Rand Solid-State computer at the Versicherungsanstalt der Bundesländer in Vienna. Two computer journals are published in Austria, attesting to a healthy interest in this field.

Switzerland

The Swiss Federal Institute of Technology (Eidgenössische Technische Hochschule) in Zurich has built a fixed-and-floating-point, serio-parallel, decimal, drum computer called ERMETH, which has been operating for about four years. The clock rate is 30 kc, although the digit rate on the drum is 300 kc; floating-point addition takes 5 ms and multiplication 20 ms, exclusive of access time. Nine "B" registers for address modification are incorporated; one-address instructions are used, each filling half a word. Coding for the ERMETH may be facilitated by a coding desk similar to that used with the Harvard MARK IV; a desk of this sort was started but never completed for the Bell Telephone Mfg. Co. computer in Belgium.

At the E.T.H. courses are offered in computer electronics, computer programming, and numerical analysis; its Institute for Applied Mathematics has done considerable work on automatic programming and universal languages for describing programs. The University of Lausanne has a ZEBRA. CERN in Geneva has a Ferranti MERCURY and an IBM 709, and other computers are in use elsewhere in Switzerland. The IBM Research Laboratory in Zurich concentrates on computer components.

Western Germany

There are four computer manufacturers indigenous to Western Germany: Zuse, Siemens & Halske, Telefunken, and Standard Elektrik. In addition, Schoppe und Faeser in Minden/Westfalen build LGP-30's, IBM has a factory in Sindelfingen, near Stuttgart, and Remington-Rand one in Frankfurt. Zuse was first in the program-controlled-computer field, having completed a machine using 3000 relays and having a 64-word relay store in 1941. Standard Elektrik, besides building the general-purpose ER-56, has built electronic booking systems and a large special-purpose system for a mail-order firm. It uses 14,000 transistors and 60,000 germanium diodes.

Other German computer builders include the Technische Hochschule in Darmstadt, which has built the DERA, a serial, decimal, drum machine with a 100-word immediate-access core store and with the accumulator on the drum. In 1955, the Technische Hochschule in Munich completed the PERM, a parallel fixed-and-floating-point, binary, one-address, magnetic-drum computer. The drum stores 8192 50-bit words in the parallel mode with a 4-ms maximum access time. In an instruction, 16 bits are used for the order code, which is thus rather flexible, and two bits indicate the type of address interpretation—direct, modified, or indirect. Exclusive of access time, fixed-point addition takes 4 to 8 microseconds and multiplication 100 to 1000. Three types of floating-point arithmetic are incorporated, one of which retains an indication of the accuracy of the result.

Several computers, G1, G1a, G2, and G3 have been built at the Max-Planck-Institut für Physik (Astrophysics Division) in Göttingen, which has since moved to Munich. The first two are punched-tape-controlled computers; three copies of the G1a have been built, one of which is in Finland (vide supra). G2 is a fixed-point, binary, serial, drum computer with 50-bit word length and a single address-modifier register, completed in 1955. G3 is a parallel machine with core memory.

However, Germany's most advanced computer is the TELEFUNKEN TR4, a fixed-and-floating-point, parallel, two-megacycle, fully transistorized machine with 52-bit word length and two single-address instructions per word. Besides 8192 to 57344 words of 6-microsecond-access core storage, it includes 1024 to 4096 words of 1-microsecond-access fixed storage and 256 16-bit index registers. The order code includes repeated operations and several successive instructions are worked on simultaneously. Addition takes 4.5 or 20 microseconds and multiplication 30.

Many German universities have been equipped with electronic computers and offer courses in their design and use. There are Zuse Z-22's at the Technische Hochschule in Stuttgart and at the Universities of Mainz, Freiberg/Brsg and Kiel, which also has an ELECTROLOGICA X-1; Standard Elektrik ER-56's at the University of Bonn and the Technische Hochschule in Stuttgart, which also has a Ferranti PEGASUS; Siemens 2002's at the University of Mainz and the Technische Hochschule in Aachen; and German-made IBM 650's at the University of Hamburg and the Technische Hochschule in Darmstadt, which should by now have an IBM 704 as well as the DERA. There are plans for equipping other universities with computers too. Clearly, Germany has a very strong computer program of long standing, dating back to the late thirties.

Italy

Early in 1960, there were fifty stored-program digital computers in operation in Italy and another hundred on order. Most of these belong to commercial organizations, but the universities of Bologna, Milan, Naples, and Rome, and the Politecnico in Milan have computer installations. A large, fast machine, the CEP, is being put into operation at the University of Pisa, and other universities will soon order computers. The Istituto Nazionale per le Applicazioni del Calcolo, a computing laboratory in Rome, first established in 1927, has a Ferranti MARK I* computer.

Italy has one computer manufacturer, Olivetti, whose prototype, the ELEA 9002, is installed in their computing center in Milan. Commercial models, called ELEA 9003, are in production. The 9003 is a transistorized, 100-kc, serio-parallel, alphanumeric computer with variable word length and core, drum, and magnetic-tape storage. The Provisional International Computation Center is located in Rome but it so far serves principally as a clearing house for information, as the convention setting up the permanent Center has not yet been ratified by ten countries, and it has no computing facilities of its own as yet. Japan, Ceylon, Mexico, Italy, Belgium, France, Libya and the U. A. R. adhere to the Center; West Germany and Argentina are likely to join soon.

The CEP is a parallel, asynchronous, fixed-and-floating-point, partly transistorized, single-address computer with units of 4096 36-bit words of core storage having a five- or six-microsecond cycle time. In addition, it has a 16,384-word drum and five Ampex tape units. One instruction fills a whole word, as it includes two 6-bit index-register references, which can be used for double address modification, for example. Besides 120 ordinary orders, its repertoire includes 220 pseudo-orders that are available in the form of aribtrary subroutines. Microinstructions are decoded by means of a wire screen into some of whose interstices ferrite rods are inserted, as in the fixed store of the MUSE in Manchester. The access time for each of the 230 microinstructions is 0.1 microsecond. Fixed-point addition, including two memory accesses and two address modifications, takes 16 microseconds. Fixed- or floating-point multiplication takes 130 microseconds. Eight people have been developing a FORTRAN compiler for the CEP; this is an unusually large effort for Europe. It is unfortunate that the CEP was not completed earlier than 1960, before the large-scale importation of foreign computers, when it might have had a wider influence on computers and computer applications in Italy. Nevertheless, it is certain to be useful both in computing and in training the people needed for other machines, who are in short supply in Italy. The computer manufacturers are presently being largely relied on to find and train personnel for their machines.

France

Besides IBM France, there are three computer manufacturers in France, the Compagnie des Machines Bull, the Société d'Electronique et d'Automatisme, and the Société Nouvelle d'Electronique. Bull is the largest punched-card-machine manufacturer in Europe, selling its products in North Africa and South America as well as throughout western Europe. Its GAMMA 3 is basically a plugboard-programmed device which, with a full complement of auxiliary units added, is intended to compete with the IBM 650. Drum storage for the GAMMA 3 became available in 1956. More recently, Bull has come out with the GAMMA 60, a large-scale machine capable of handling several programs simultaneously with high efficiency. SEA has produced small numbers of each of several machines covering a range of sizes and speeds, for which France's military needs have been the motivation. SNE's KL 901 is a floating-point, partly transistorized, parallel machine with core storage and 36-track magnetic tape.

The Universities of Nancy and Toulouse and the engineering school in Nantes have IBM 650's; Bull GAMMA 3's with drums are located at the Universities of Grenoble and Strasbourg. Although this list must be incomplete, there is evidently relatively little instruction or academic research in the computer field in France except at the University of Grenoble. Much more work is to be found in this field in research institutes; for example, the Institut Blaise Pascal has a 650, a 704, an Elliott Bros. 402, and a GAMMA with drum, and many other imported computers of advanced types are to be found in other research and computing centers.

Great Britain

In at least one respect, Britain is the world's leader in the computer field; the first stored-program electronic digital computer, to be completed, the EDSAC, was put into operation in June 1949 in the University Mathematical Laboratory, Cambridge, where it was built. This Laboratory is still outstanding, having the EDSAC's successor EDSAC 2, which was put into operation in 1958, though the emphasis is now on the use rather than on the design of computers. At Manchester University, the emphasis is reversed; though there is much work on automatic programming going on too. A large number of computers have been built there including among others, the MARK I, completed in 1951, the MERCURY, and the MUSE to be completed in 1961, which is Europe's most advanced computer. It is being manufactured by Ferranti under the name ATLAS.

The ATLAS is a fully transistorized, fixed-and-floating-point, parallel, single-address computer with 48-bit word length, capable of operating on several programs simultaneously. Each instruction includes two seven-bit index-register references and can indicate any of a wide range of orders, including "extracode" operations programmed in the fixed store. The latter stores 8192 words with a 0.15-microsecond access time; it consists of wire meshes into some of whose interstices are inserted ferrite rods 1 mm in diameter and 5 mm long. The main memory consists of 16,384 words of core storage with a cycle time of 1.3 or 1.8 microseconds, but the drum store, consisting of four (extendable to 16) 24,576-word drums, can be regarded for programming purposes as part of the main store, as any "pages" (512 words) of drum storage to which frequent reference is made will automatically be held in core storage. Fixed- or floating-point addition takes 1.1 microseconds and multiplication 4 microseconds. The machine will be provided with a wide variety of input/output devices, including Ampex magnetic-tape units and a home-made electroluminescent graph plotter.

It would not be practical to go into any detail about the vast amount of computer work in progress in Great Britain. There are eight manufacturers of computers in England and others producing only peripheral equipment. The eight have marketed over twenty different machines and by the end of 1958 had delivered over 150 computers. They include Ferranti, Leo Computers, Elliott Brothers, the English Electric Co., International Computers and Tabulators (formerly British Tabulating Machine Co. and Powers-Samas), Associated Electric Industries (Metropolitan-Vickers), Standard Telephones and Cables, and E.M.I. Electronics. STC makes the ZEBRA, which was originally designed at the Netherlands P.T.T. Laboratory; Leo's first computer was an engineered version of the EDSAC 1; and a number of Ferranti designs came from Manchester University. In addition, several computers have been built by government research establishments.

At least fifteen British universities already have computers, and others are scheduled to acquire them. Liverpool and Glasgow Universities have English Electric DEUCE's; Southampton, Durham, and Leeds Universities and the Northampton College of Advanced Technology in London have Ferranti PEGASUS's; Manchester, Oxford, and London Universities have Ferranti MERCURY's; the Battersea College of Technology in London has the APE(X)C, which was built at Birkbeck College, London, and the latter has two other computers called MAC and M2; Imperial College, London, has built a relay computer; and the Wolverhampton Technical College has its own Dekatron computer. The situation in England resembles that in the U. S. not many years ago, and we can expect Great Britain to maintain her position in the field, second only to the U. S. Strong competition among her eight manufacturers may force her to expand her foreign markets.

CONCLUSIONS

The most striking difference between the European and American approaches to computer building lies in the difference in the number of people involved. Many European machines were built by a group of no more than five men over the course of one to three years. However, commercial machines are built by large teams just as in the U. S. Other significant differences are found in the order codes for these machines, which often include references to a fixed store containing useful subroutines that, in effect, expand the reportoire of operations. In a number of machines, new orders can be incorporated when they are found appropriate by rethreading wires through an array of large ferrite cores controlling the sequence of micro-operations associated with a command. In many European computers, a large number of digits are used to specify an operation, so that a single-address instruction fills an entire word. These digits can therefore control many functions, including SKIP, STOP, or JUMP conditions, reference to one or two index registers and the modification of their contents as well as of addresses, etc. It will be interesting to see which of these features will be found most useful when the computers are programmed automatically.

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