drum memory computer that was installed at Wayne State University in Detroit in 1953, and the E-101, a desk-sized business computer.

In 1956, Burroughs purchased the ElectroData Corporation of Pasadena, California. ElectroData engineers, in conjunction with the Norwegian scientist Ernst Selmer (1920–), had developed the Datatron, a medium-sized drum memory computer that was completed in 1954. The Datatron was the first commercial computer to have index registers, which had been developed at the University of Manchester. About 100 Datatrons were sold between 1954 and 1960. The Burroughs 220, which had core memory, was completed in 1958.

In the early 1960s, the Philadelphia center developed the D825 **transistor** computer for military customers. It was the first multiprocessor computer. Burroughs was late in bringing a large-scale transistor computer to the commercial market. The first B5000 was not delivered until 1963. However, the B5000 featured a very innovative design, using a hardware stack **architecture** to provide an efficient platform for programs written in the **ALGOL** language. Due to its late appearance, Burroughs sold only 33 units of the B5000. Meanwhile a separate line of small business computers (B100, B200, and B300) maintained the company's position in the banking market.

Soon after the announcement of the IBM System/360, Burroughs responded with its third-generation B5500, which was an improved version of the B5000. It was a commercial success, and various successor versions appeared through the 1970s and 1980s. Burroughs also developed medium-scale (B2500 and B3500) and small (B1700) computer lines. In 1986, Burroughs merged with Sperry Corporation to form **Unisys**. The B5500 architecture is still implemented in the Unisys ClearPath MX series.

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—*George Gray*

Bus

A bus is a transmission path in a computer; it consists of a bundle of conducting lines across which signals are transmitted from one device to another. All the devices connected to the bus can read the signals being transmitted, but only one of them *writes* to the bus (i.e., injects a signal into it). The processor in a computer, for example, is connected to the memory through a bus that sends the address of a memory word and the contents. There is one wire for every bit that has to be transmitted in parallel.

In 1970, **Digital Equipment Corporation** introduced the PDP-11/20, the first **minicomputer** to interface all system elements to a single bidirectional bus, called the *unibus*. Instead of using different communication channels between the processor and each device, a single bus provided a common communication medium for all devices. Any compatible peripheral could be attached to the bus and become an integral part of the system. Devices connected to the bus were controlled by accessing special *addresses* associated only with them. A teletype, for example, was assigned a set of addresses so that when the processor wrote through the bus to these special addresses, it wrote to the teletype and not to memory. This is called *memory-mapped input–output* and was pioneered by minicomputer manufacturers. Modern single buses operate on the same basic principles as the unibus.

The **Apple II**, introduced in the 1970s, pioneered an *open expansion bus* architecture. The full specifications details of the bus were delivered along with the programming documentation, so that anybody could easily develop new cards for the slots available in the motherboard. This approach was also followed by **IBM** when the IBM **personal computer** (PC) was introduced.

Various buses have been used in the IBM PC, including the ISA (Industry Standard Architecture) bus, used in the original PC, the EISA (extended ISA) bus, Micro Channel, and the PCI (peripheral component interconnect) bus. The size of a bus, known as its *width*, is important because it determines how many data can be transmitted at once. Whereas the original ISA bus could transmit only 16 data bits in parallel, the PCI bus transmits 32 bits in a 124-pin connection

(and 64 bits in a 188-pin connection in an expanded implementation).

Examples of other buses are the NuBus used in several models of the **Macintosh**, TURBOchannel, Multibus STD bus, and the VMEbus, which was very popular for workstations. The main difference between the different kinds of buses is the clock speed (i.e., the transmission speed), the width of the bus (number of data and control lines), the protocol used, and if they are multiplexed. In a multiplexed bus, some lines are used alternatively to send addresses or data; this saves some lines but makes the communication protocol more complex.

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—Raúl Rojas

Bushnell, Nolan

1943 –

U.S. Entrepreneur

Nolan Bushnell is one of the pioneers of computerized **games** and founder of the Atari Corporation.

As a young man Bushnell worked in an amusement park, dreaming that someday he would work for Walt Disney. He had always been interested in games and was an avid chess and Go player. While studying electrical engineering at the University of Utah, he spent many nights at a PDP-1 playing Spacewar!, an interactive graphical game created by Steve Russell at the Massachusetts Institute of Technology in 1962. Bushnell thought of creating a commercial version of it, but computers were too expensive at that time.

In 1970, Bushnell was working for Ampex as a research engineer. The first **microcomputers** were being introduced, and he saw a way to implement the game in hardware. He and his co-worker Ted Dabney wrote a refined version of Spacewar!, which they called Computer Space. They sold the game to Nutting Associates, a manufacturer of coin-operated trivia games; 1500 units were manufactured, but the game did not sell well. Bushnell reasoned that the game was too complicated for the average person. Nutting wanted Bushnell to develop another game and continue to work as an engineer, but Bushnell wanted more. He left Nutting Associates and together with Dabney, founded Atari, Inc. in 1972. Their initial capital was U.S.$500, the amount they had received for Computer Space.

Their first product was to be a driving game, but Bushnell suggested to Atari's first employee, Alan Alcorn, that they start with a simpler game. Alcorn implemented Pong, a table-tennis-style game that was similar to a game Bushnell had seen some time before at a Magnavox Odyssey videogame presentation. Bushnell tried to sell the game to a manufacturer, but when he noticed that it was a big success in a local bar, he decided to start manufacturing it himself. Atari sold 8500 machines in one year and practically initiated the entire videogame industry.

In 1976 Bushnell sold Atari to Warner Communications for U.S.$28 million. A year later he opened the first Chuck E. Cheese's Pizza Time Theater, a fast-food restaurant combined with electronic games and animatronic stage show. In 1981 he founded the Catalyst Group, to provide seed money and assistance for start-ups. However, Bushnell's spin-off companies drained money from Pizza Time Theater, Inc., drawing it to the brink of bankruptcy. Bushnell left Pizza Time in 1983. Bushnell has been involved in numerous other ventures. His latest project is the Professional Gamer's League (PGL), an attempt to operate computer game championships and make them as popular as sports events.

BIOGRAPHY

Nolan Bushnell. Born 5 February 1943 in Ogden, Utah. B.S. in electrical engineering from the University of Utah, 1968. Engineer, Ampex Corporation, 1970–72. Designed Computer Space, the first arcade game released to the public, with Ted Dabney in 1971. Founded Atari in 1972 with Ted Dabney; sold to Time-Warner, 1976. Founded Pizza Time Theater, 1977; left company, 1983. Founded Catalyst Group, 1981.

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