THE INVENTION OF THE ELECTRONIC DIGITAL COMPUTER AT IOWA STATE COLLEGE, 1930-42

by William Silag

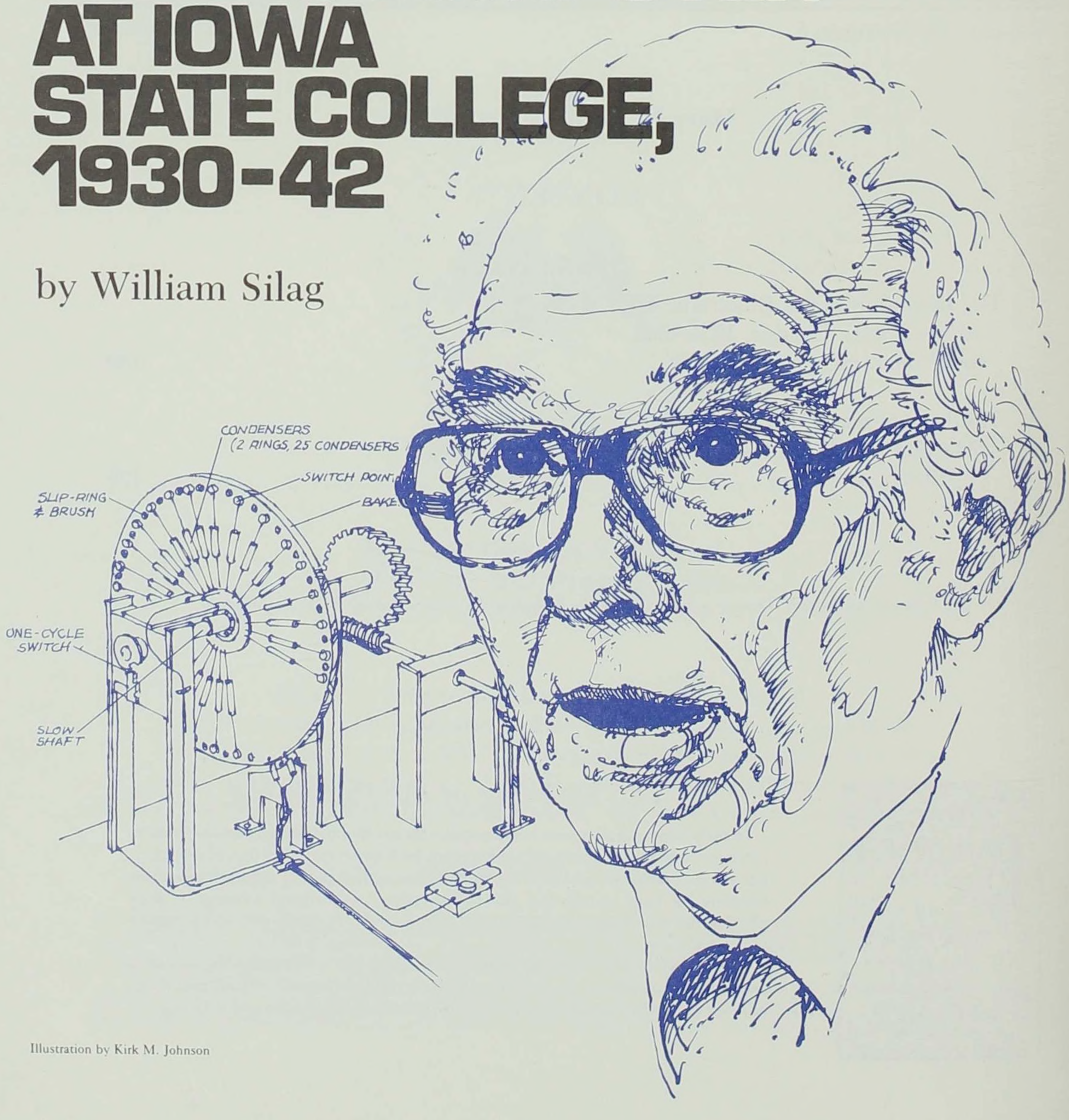


Illustration by Kirk M. Johnson

One night in the winter of 1937-38, Professor John Vincent Atanasoff walked out of his office at Iowa State College, got into his Ford V-8, and headed for the highway. Turning onto Route 6, the thirty-four year old physicist pushed the car up to seventy miles an hour and drove eastward for several hours without stopping. He sometimes took drives to relax. "The pavement was clean and dry, and I was forced to give attention to my driving," Atanasoff said later. He didn't think about where he was going till he crossed the Mississippi River bridge. Entering Rock Island on the Illinois side, he pulled up to a roadhouse and went inside. He took off his overcoat, ordered a drink, and began to think.

"Now, I don't know why my mind worked then when it had not worked previously, but things seemed to be good and quiet. There weren't too many people in the tavern, and the waitress didn't bother me particularly with repetitious offers of drinks. I would suspect that I drank two drinks perhaps, and then I realized thoughts were coming good and I had some positive results."

In the roadhouse that night, the Iowa State professor forged together four new ideas that pointed the way to the modern electronic digital computer. For centuries automatic calculation had been an object of worldwide research and speculation, yet the best "computers" as of 1930 were, for the most part, refinements of a simple gear-driven adding machine invented by the French mathematician Blaise Pascal in 1642. These machines did basic arithmetic — adding and multiplying — but could not handle complicated arithmetic statements of the kind encountered by twentieth century scientists and engineers. John Vincent Atanasoff jumped into the future when he devised a way to represent numbers as states of electrical charge, which could then be manipulated to solve mathematical problems. His ideas about the possibilities of such electronic arithmetic, and the computing machine he built to prove their soundness, showed the world a cheap, reliable method of machine calculation adaptable enough to make the automatic computer a commercial possibility.

World War I and After

The search for an automatic computer had intensified during World War I, a war in which frustrated artillery units first confronted the challenge of enemy aircraft. Pressed into service, mathematicians worked day and night to provide firing tables to help their army's field forces take aim at the enemy aloft. Shell trajectories involved angle of fire, air temperature, force of charge, and other variables; firing tables showed artillerymen how the variables would affect individual trajectories. In compiling the tables, the army's mathematicians solved many complex differential equations, that is, equations describing the simultaneous interaction of several variables. The calculating of the tables was sheer drudgery, but every single calculation had to be precise if the enemy targets — in the most complex cases, moving airplanes — were to be hit.

In a dramatic way, the wartime experience pointed to a widening gap between theoretical descriptions of physical phenomena and the antiquated mathematical apparatus available to analyze these descriptions. The problem was already familiar to scientists working in areas of applied physics other than ballistics. Hydrodynamics, electromagnetics, and acoustics, to name three areas of active research in the early twentieth century, abounded in differential equations describing complex physical relationships. On the one hand, humans couldn't be expected to solve such complicated equations; there were just too many numbers. On the other hand, the unsolved equations were a serious bar to further scientific progress.

Something had to be done.

During the 1920s the nation's leading electrical engineering research centers (including the Bell Laboratories, the Massachusetts Institute of Technology, and the General Electric Laboratory) vigorously worked on the problem of automatic calculation. The most active research was carried on at the Massachusetts Institute of Technology [MIT], where Vannevar Bush invented an analog computer called the differential analyzer, an instrument designed to solve complex systems of equations like those used by ballistics teams in creating firing tables. Bush's differential analyzer computed by mechanically simulating the workings of many variables with a system of rods and gears driven by the rotation of a metal wheel on a glass disc. Bush explained the basic principle with an example familiar to engineers, the problem of determining how a proposed bridge would sway in the wind. By setting up the differential analyzer's mechanical elements so they acted in exactly the same way as the forces acting on the bridge, the machine's operator could predict the behavior of the bridge before it was built.

Differential analyzers were not simple machines, mechanically or theoretically. They were huge, filled large rooms, and weighed tons. They were also expensive; the early ones cost several hundred thousand dollars each. Later models — built in the early 1940s — cost more. Setting up a differential analyzer to solve a mathematical problem involved adjusting scores of interconnecting differential and fixed-ratio gears, shafts, couplings, right-angle gears, and so on. The operation took days. Once set up, however, a differential analyzer solved equations with surprising accuracy.

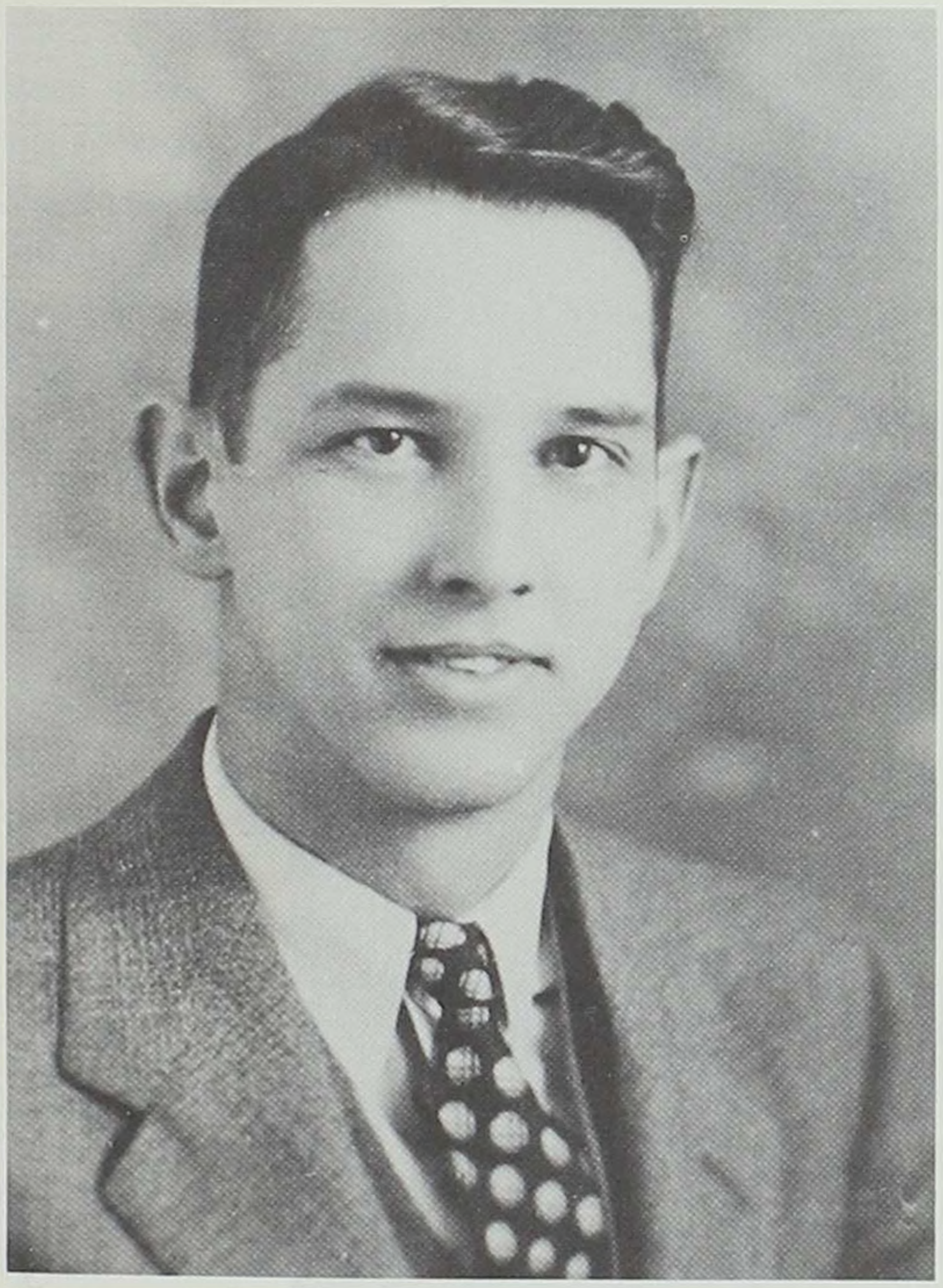
Differential analyzers were best suited for problems that required many solutions to one set of equations, such as the calculation of thousands of bullet trajectories for a firing table, or where the volume rather than the complexity of calculations exceeded reasonable human limits. They could not be adapted easily to solve other kinds of problems. In addition, their high cost put them beyond the reach of most institutions. Aside from MIT, only the Moore School of Engineering in Philadelphia and the Army's Aberdeen Testing Ground in Maryland were ever able to build them.

Search and Invention at Iowa State College, 1930-1937

At Iowa State College in Ames, Professor John Vincent Atanasoff experienced firsthand the frustrations of complex calculations. As a doctoral candidate in theoretical physics at the University of Wisconsin in 1930, Atanasoff had worked extensively with differential equations for his thesis — a study of the behavior of the helium atom in an electrical field. "This was my first experience in serious computing. Such calculations required many months of hard work on a desk calculator, such as the Monroe, which was all that was available at the time."

Atanasoff became an assistant professor at Iowa State College later in 1930. He and his students at Ames faced similar computing difficulties with complex systems of equations. Working with such equations was a discouraging prospect: "You can't solve them in any ordinary sense. About all you can do is to approximate the answer. There are too many functions necessary to solve those equations, they are all over the map, there are things you've never heard of before and you just can't get at the solution that way. You have to approximate it and you commence to approximate it."

Even the approximations required arduous calculation. "You could sit down with a piece of paper and solve two or three equations and two or three unknowns." But the systems of equations his students wanted to solve had dozens of equations and dozens of unknown variables. "If this were done by human hand, it would take a



A young John Vincent Atanasoff. (courtesy J.V. Atanasoff)

year or so." Nevertheless, the calculations had to be done one way or another if the problems were to be solved. "My graduate students needed computers," Atanasoff recalled. "[More] than any other problem [this is what got] me interested in the computing art . . . we needed practical solutions for practical problems."

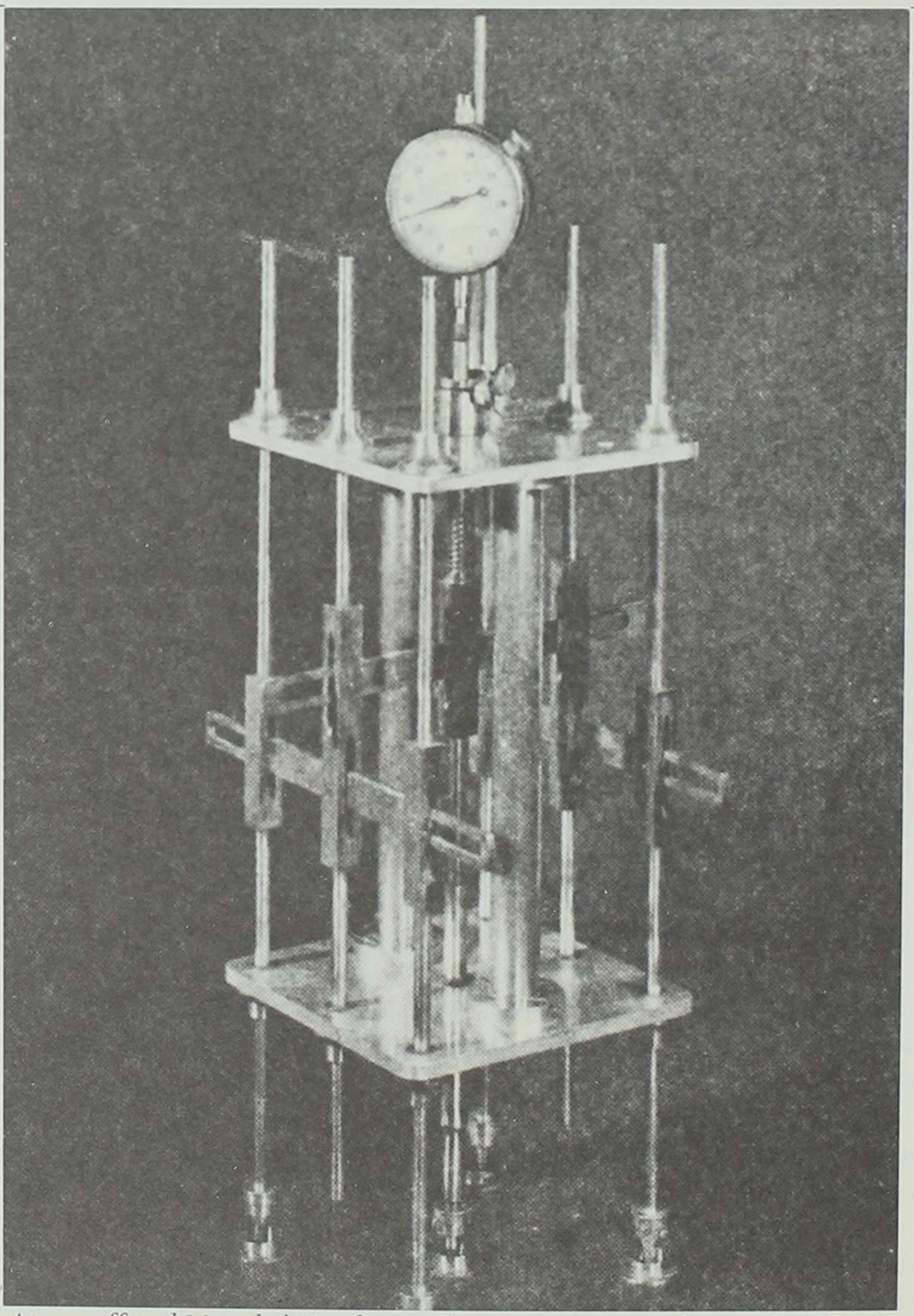
In 1933 Atanasoff began to think about mechanizing the complex arithmetic needed to solve these equations. "As I felt the basic need for more powerful methods of computing, I commenced to take stock of what methods and apparatus existed. It soon became evident that one could divide all calculators and computers into two classes — analog and digital. I believe *that* division was ours."

The difference is simple but important: digital machines count; analog machines measure. During the mid-1930s Atanasoff conducted scientific experiments on both kinds of automatic calculators.

The digital experiment involved one of IBM's best adding machines, the sorter-tabulator type used by insurance firms or magazine subscription offices to handle client records and correspondence. Assisted by A.E. Brandt, a professor of statistics at Iowa State College, Atanasoff wired an IBM tabulator to a compiling device he had built and succeeded in solving a set of equations. The results of the experiment, published in 1936, included a discussion of the utility of such equipment for handling a complex calculation, noting the tabulator's accuracy, trouble-free performance, and general commercial availability.

Despite the apparent success of the sorter-tabulator approach, however, Atanasoff decided it was too slow an operation to handle large sets of equations effectively, and so he abandoned it. This decision came as no great disappointment to IBM, which, on becoming aware of the experiment, had subsequently sent Atanasoff a letter warning him not to tamper with IBM machinery again.

Atanasoff then built a little analog calculator for analyzing the geometry of surfaces. This "Laplaciometer," measuring three inches by three inches and standing fourteen inches high, was a cage in which five rods — moving vertically — shaped in paraffin a three-dimensional representation of an equation. It was Atanasoff's lone foray into nondigital calculation. He did the work in Ames with an Iowa State College atomic physicist, Glenn Murphy, in 1936, but the results weren't published till 1949. Despite the project's success (the professors' Laplaciometer held errors down to the engineering standards of the day), Atanasoff found no grounds to endorse analog calculation. The technique involved a worrisome dependence on ideal performances by the machinery itself — only perfect machine parts produced perfect results in an analog cal-



Atanasoff and Murphy's Laplaciometer, an instrument for nondigital calculation. (courtesy the Department of Special Collections, ISU library)

culator's conversion of mathematical abstractions into workable physical representations. For Atanasoff the price in time and effort necessary to assure ideal conditions and performance exceeded his confidence in the certainty of the results, and so his search continued.

At this point he had been looking about four years (since 1933) for clues which would lead to the development of an automatic calculator able to solve complex equations. By early 1937 he was beginning to believe the search was futile. "I did not think my career would stand the loss of my best time in what some felt was a wild idea." Yet Atanasoff was productive in these years. In addition to several papers on his various experiments published in major professional journals, he contributed to the degree progress of a number of graduate students. Still, he was troubled. Atanasoff's frustration reached a peak in the winter of 1937, "a desperate one for me because I had this problem and I had outlined my objectives but nothing was happening. As the winter deepened, my despair grew . . . I had a few ideas, but nothing seemed to jell . . . I tried again and again to sort them out. Nothing seemed to work.

"After months of work and study I went to the office again one evening but it looked as if nothing would happen. I was extremely distraught," Atanasoff recalled. "I got in my automobile and started to drive . . . Every once in a while I would commence to think about my efforts to build a computer and I didn't want to do that so I would drive harder so I could not think . . . When I finally came to earth I was crossing the Mississippi River, 189 miles from my desk.

"You couldn't get a drink in Iowa in those days, but I was crossing into Illinois. I looked ahead and there was a light and of course it was a tavern and I stopped and got out and went in and hung up my coat . . . and sat down at the table and got a drink and then I noticed that my mind was very clear and sharp. I knew what I wanted to think about and I went right to work on it and worked for three hours and then got in my car and drove slowly back to Ames. I had made four decisions."

Atanasoff's Four Concepts, 1937-1938

Any one of Atanasoff's four concepts — digital electronic logic circuits, regenerative memory, binary enumeration, or serial calculation — would have represented an important advance in the development of automatic computation; their combination in a single machine marked a critical turning point in the history of the modern computer.

In the midst of his frustrations, Atanasoff had convinced himself of the superiority of digital calculation over the analog approach, even though the decision to use electricity as the medium for computing had worried him for some time. Without exception, the advanced calculators of the day — Monroe adding machines, IBM tabulators, MIT's differential analyzers — did their counting mechanically, usually by means of a rotating shaft driven by some system of interconnecting gears. The technique was as old as Pascal's adding machine, built in 1642, in which the shaft did the actual counting within the machine. "I must admit I was inclined to follow this [con]cept," Atanasoff wrote recently. "I suppose that a feeling persisted that a computer needed stability, and that this would be obtained by a mechanical system." Such stability took a lot of hardware — rods, gears, nuts, and bolts — needing constant maintenance.

Unimpressed with the differential analyzer and dissatisfied with the results he and Glenn Murphy had achieved with the analog Laplaciometer, Atanasoff began to consider electricity as an alternative to the rotating shaft in 1936: "I had studied electrical engineering and physics, and I had also studied and experimented with electronics, then in its infancy. So it was perhaps natural that my mind turned to this medium in which I had my greatest expertise." But the choice was not obvious. "One must remember that this was a long time ago, and the control of electricity was less effective than it is now." A wandering charge, for example, could create undetectable errors in the heart of an electrical computing mechanism. Under control, however, the same charge offered exceptional advantages as a medium for representing numbers. Electricity meant fewer moving parts, and thus less maintenance; it also meant faster computing action than a rotating shaft could provide. "My engineering training had taught me to select materials and methods very carefully for the job at hand, so that each time I felt inclined toward an electrical/electronic system, I wondered if I could make it, and in particular its electronic tubes, sufficiently stable." As his basis for calculation, Atanasoff simply wanted to turn electricity on and off. The electronic vacuum tube would be the critical element in his computer. He imagined many of them wired together in a box. At any given moment, some would be lit and some not lit, with different arrangements representing different numbers. The wiring of the logic circuitry would provide the means of connecting the electronically-represented numbers so they could be combined in a calculation. Atanasoff had decided in the tavern that there was no way to know how well electricity would work until one tried it.

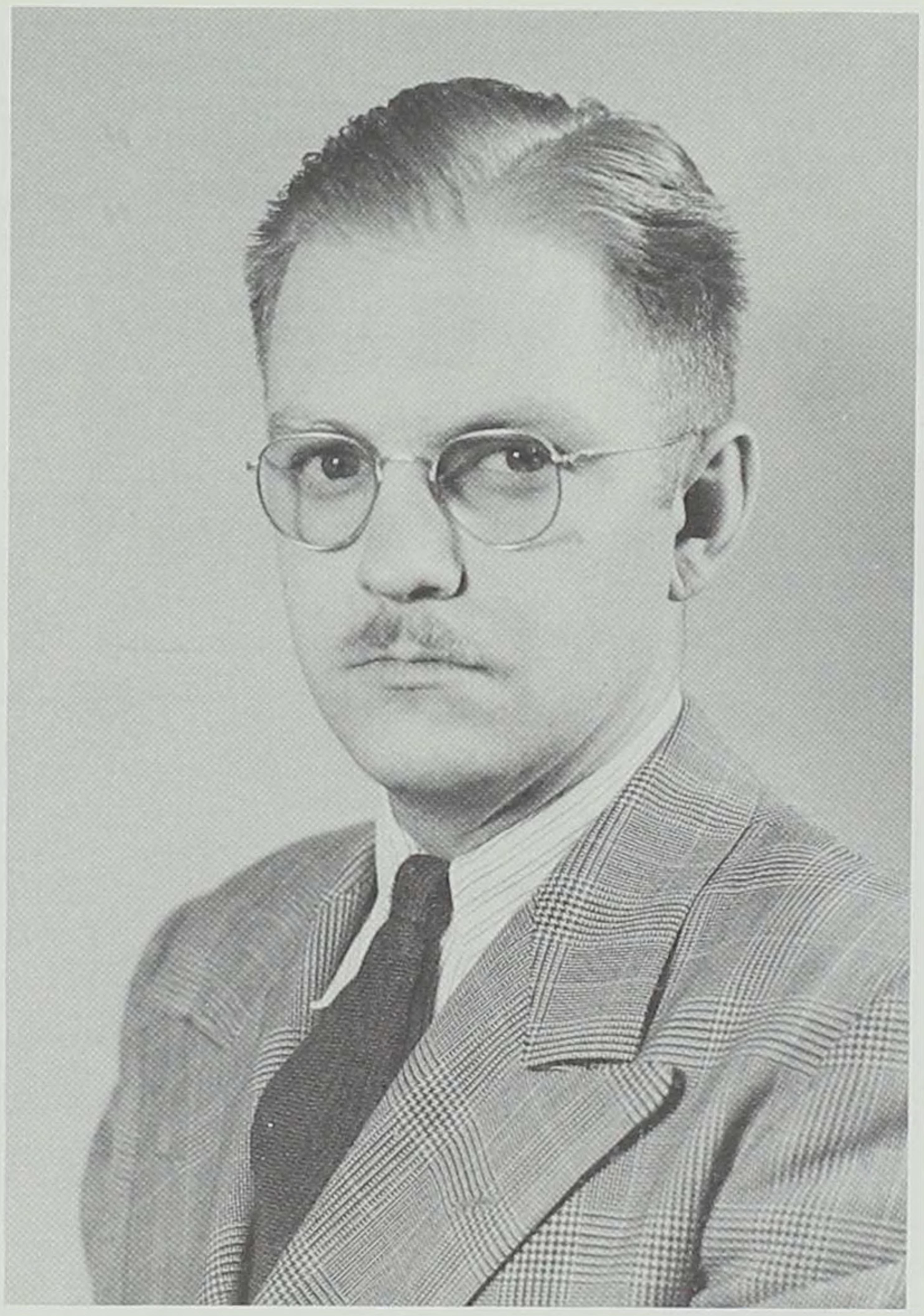
Atanasoff's commitment to an electronic computing medium grew more complete with the passing months, and by the end of 1938 he had moved from preliminary investigations of vacuum tubes to the design of logic circuits — the counting mechanism in which the tubes would operate. The task involved not only the arrangement of the hardware itself but also the creation of an algorithm — a sequence of mathematical steps — for carrying out computing operations within the electrical circuitry. The capacitor memory elements had to be created as well, for they were needed to get the numerical data in and out of the logic circuits during computing operations.

In this work, as with his use of vacuum tubes, there wasn't much to guide him. "In designing such devices today, we would use an abstract kind of mathematics called Boolean algebra and the so-called truth table." Boolean algebra is a symbolic language that describes logic and thinking concisely and graphically. Greek philosophers and early modern mathematicians such as Leibniz had searched for a "mathematics of human thought," or a symbolic alphabet that could express rational thought. But it was not until George Boole's work in the 1850s that this intellectual notion produced any results. Boole discovered a way to state the principles of logic in a binary system composed of zeroes and ones, which, he argued, could be proven to be "a verifiable, universal language for expressing formal logic symbolically." Decades later Alfred North Whitehead and Bertrand Russell, using Boole's system, devised a method by which the binary symbols could be computed. Logical problems could be solved by means of a "truth table," a series of statements shown to be either true or false (true statements represented as "1", false statements represented as "0"). The binary results could then be manipulated and analyzed mathematically. Boolean algebra pointed a way toward calculating machines that could use a binary system for both logic and mathematics. Atanasoff knew something about all this in the 1930s, but apparently did not draw on it in devising his electrical logic circuits. "At that time," he wrote, "I had studied this algebra a little, but I did not recognize its application to my undertaking, and I obtained my result by trial, at first, and then by a kind of cognition."

When Atanasoff started thinking about computer memory (a computing machine's ability to retain data as it moves through a complex calculation), again there was little to guide him. An eighty-column IBM sorter-tabulator of the type he had used with Professor Brandt in 1936 held about 266 bits of information on its internal dials. No machine available in the 1930s had any more capacity. Yet any calculator capable of solving the systems of equations that interested Atanasoff would require a far larger memory. More than a half-century earlier an English inventor, Charles Babbage, had designed a mechanical computer — called an "Analytical Engine" — with a data-storage capacity equivalent to several thousand bits of information. Though practical engineering difficulties had prevented the completion of the Analytical Engine in Babbage's lifetime, his ideas and design plans continued to interest scientists long after his death in 1871. As a boy Atanasoff had read about Charles Babbage and his Analytical Engine in the *International Encyclopedia*. Babbage's data-retaining "store" had been part of the calculating mechanism in the Analytical Engine — that is, one component handled both the computing and the memory functions. By contrast, Atanasoff conceived the computer's calculating and storage functions as distinct components, operating separately. He recalled that for some time before his long drive across Iowa the idea of a two-state memory element, built from a material that could hold an electrical charge, had been taking shape in his mind.

At the tavern, he had imagined a memory element using capacitors that could regenerate and thus maintain their own state — whether charged or uncharged, plus or minus, or zero or one in binary digits — by coaction with the vacuum tubes of the logic circuits. Atanasoff called this coaction of the memory and calculating elements "jogging." Designing the transfer of these binary signals from the memory elements into the logic circuitry and back out again didn't take Atanasoff long once he had figured out the more complicated internal scheme of the logic circuits themselves. He remembered spending just a week or two designing the memory circuits.

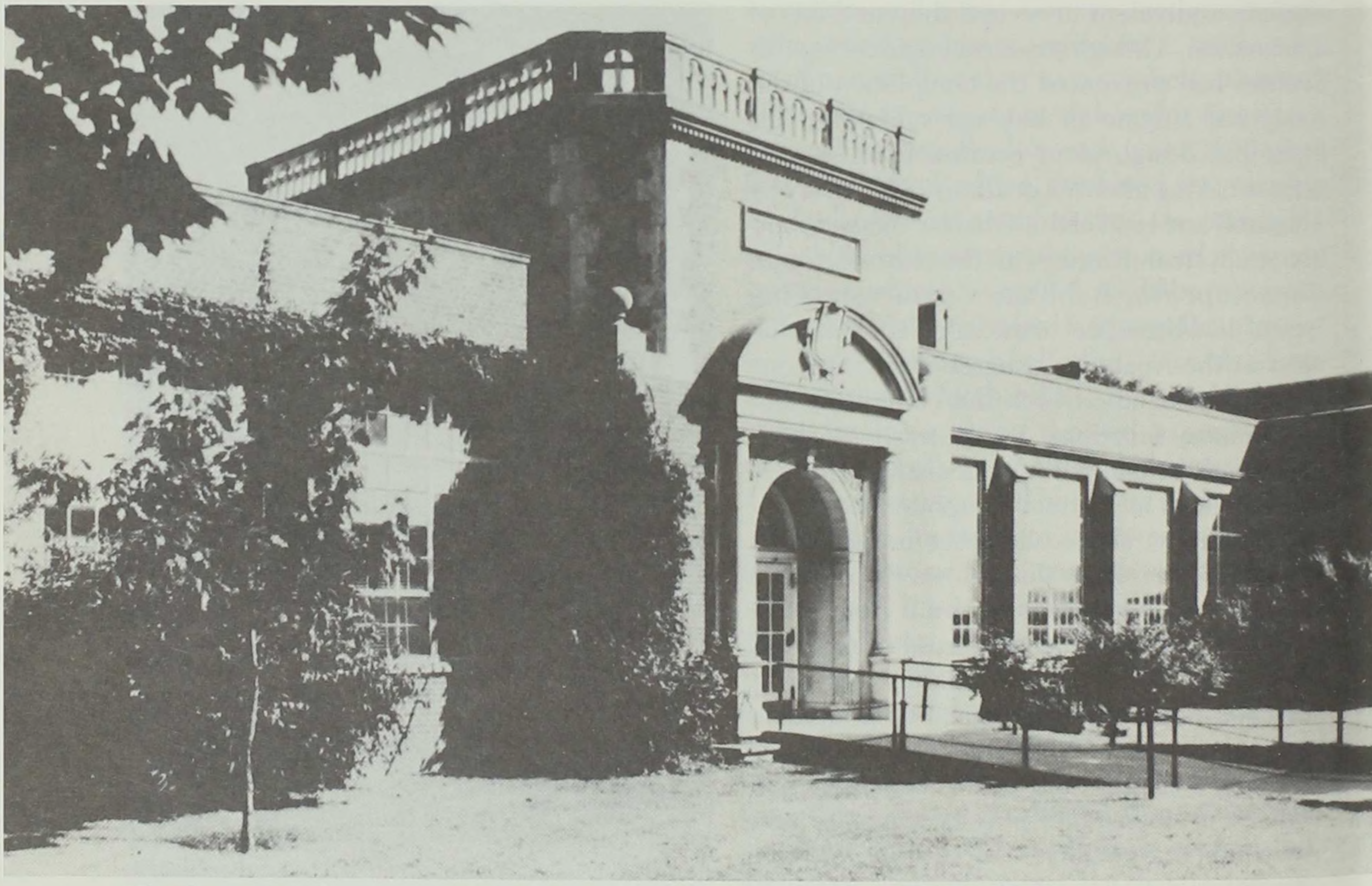
"I was delighted with the concept of jogging. Jogging is reminiscent of the little boy going to the grocery store and reciting, 'a dozen eggs, a pound of butter, and so on,' over and over, hoping to arrive at the store before his memory has failed. Jogging may be employed when a memory element has two states (for instance) and when the deterioration of time or use could cause it to pass from one state to the other. Before this can happen, an electronic circuit



Clifford E. Berry, Atanasoff's assistant between 1939 and 1942, when the ABC was built. (courtesy J.V. Atanasoff)

recognizes the original state and brings the element back into the preferred value in that state. The grids of the input tubes of the calculating mechanism would float on small capacitors, which were to be charged by momentary contact with a memory capacitor. Mounted on a rotating drum, the memory capacitors moved at regular intervals into contact with the logic circuits, thereby keeping the binary data ready for processing by the add-subtract mechanism. For some time, this concept of mine has been called 'regeneration,' which is not quite correct; today another word 'refresh,' has taken this role."

In 1938 Atanasoff had worked his four concepts into a preliminary architectural design for an automatic computing machine. He now



The Physics Building at Iowa State College, where the ABC was built and stored. (courtesy the Department of Special Collections, ISU library)

knew what his logic circuits would look like and how they would function with the memory elements. He also knew how the logic circuits would count. "I planned to use serial addition or subtraction, that is, to operate on the numbers digit by digit," he explained. Other digital machines, the IBM sorter-tabulators, for example, used a ratcheting principle that accumulated entire numbers, one at a time, as they counted. Serial calculation tallied numbers like people do, moving up and down, and then across, the columns of figures.

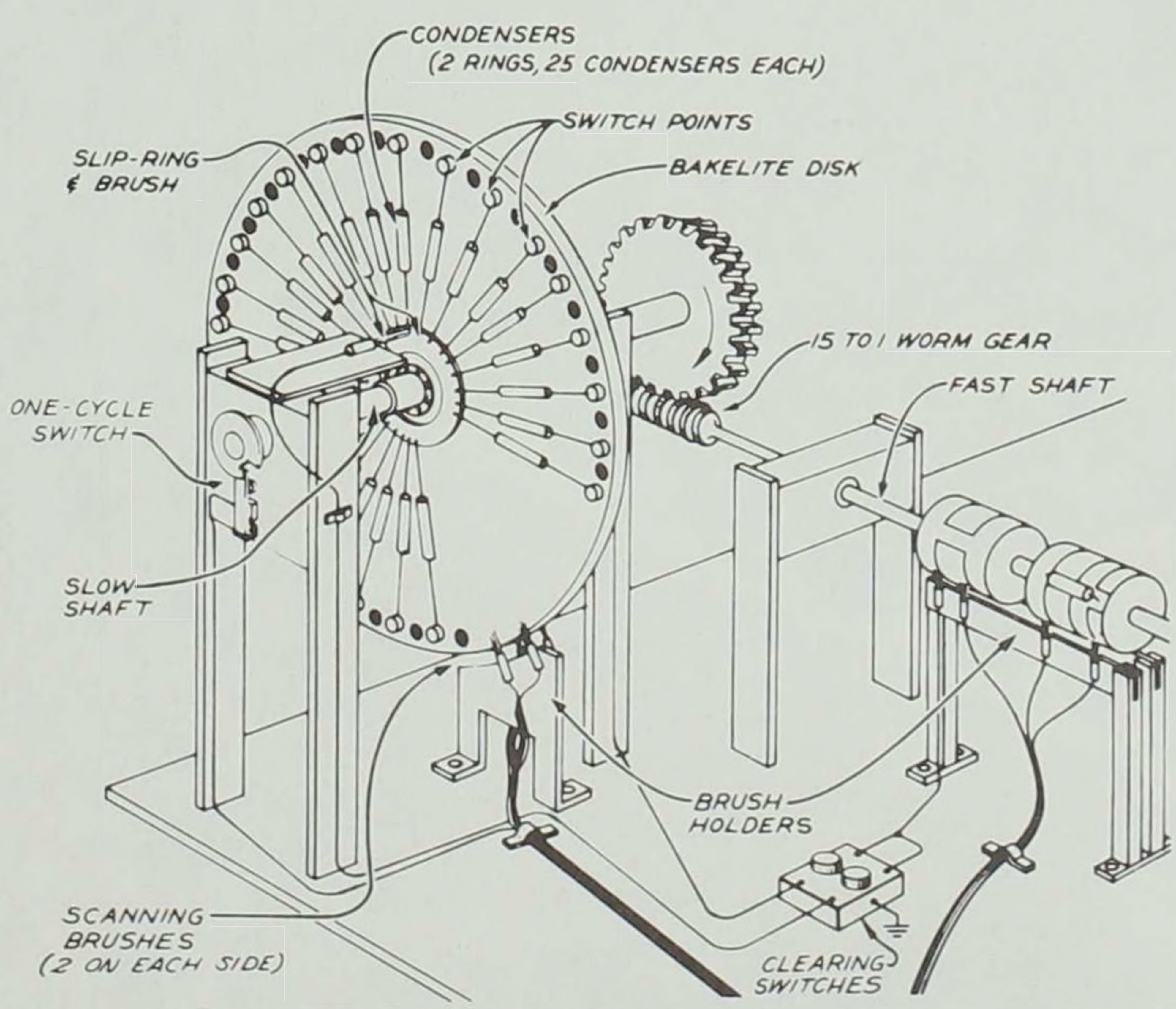
Atanasoff's computing machine would add and subtract in binary code. He had recurrent misgivings about this, not for any technical reason but because he feared rejection of his computer by a public unfamiliar with the binary (or base-two) number system. In terms of the machine itself, there was no doubt that base-two arithmetic required less machine effort than automatic calculation using the more familiar decimal (or base-ten) number system. He proved this to himself mathematically several times over, knowing that any change from conventional base-ten notation would mean building additional machine components to convert back and forth between the two number systems. "I expected to have much criticism for changing such a thing as the base of numbers," Atanasoff recalled. "It is something like the metric system, calendar reform, and changes in the alphabet; one does not do such things. I gave myself solace by saying that this was for scientific purposes, requiring high precision, and most people would not need to use it."

The Prototype, 1939

Progress on the computing machine had thus far been achieved at Atanasoff's desk in Iowa State College's Physics Building rather than in a laboratory or workshop. "All of my work on the capacitor memory and the add-subtract mechanism was entirely theoretical; no experiments were used in deriving the circuits or in checking them." By the end of 1938, however, he was eager to begin building a prototype. "Since the trip to Illinois, I had used more than a year working mostly on jogging and logic circuits for adding and subtracting. I now felt much more confident that the project would be a success and I knew that I could not go on alone." Early in 1939 Atanasoff applied for financial support for the project in the form of a grant from Robert Buchanan, dean of the graduate school at Iowa State College. The requested money, whch was to be used for materials and shop work as well as for an assistant's salary, totaled $650. Buchanan approved the request later that spring, and Atanasoff hired Clifford E. Berry, a young graduate student in engineering from Ames. Berry began work with Atanasoff at the start of fall semester 1939.

The two men got along well together from the beginning. "Berry was one of the best things that could have happened to the project," said Atanasoff. "After he had worked for a short time, I knew that he had [not only] the requisite mechanical and electronic skills, but also that he had vision and inventive skills as well."

Clifford Edward Berry was just beginning his graduate career when he went to work for Atanasoff. He had read through Atanasoff's plans for the computing machine during the



The prototype of the ABC. (courtesy the Department of Special Collections, ISU library)

summer of 1939, and had a good grasp of Atanasoff's goals when he joined the project in September.

Atanasoff had meticulously worked out designs for some parts of the proposed computer, but he had only rough ideas of the remainder of the machine. There was also the complicated business of perfecting the sequence of mathematical steps the computer would use for solving systems of equations, which was, after all, the machine's principal objective. Atanasoff had been thinking about these steps in the preceding months of planning: "I had begun to consider other problems of mathematics and physics to which the new method [of calculation] could be applied. To this end, I suggested to Clifford that we momentarily forget the 'solution of systems' and build a computer. We of course realized that such a computer should and must be a simple gadget. We did not dare to build everything into our plans. Our skill as inventors depended on how well we chose between these factors, the indispensable and the impossible."

In a few weeks a prototype computer began to take shape in their basement workshop in the Physics Building. It was the size of a breadboard, with electrical components mounted on one surface, and could be moved easily around the workshop. "This prototype was designed to work out all of the aspects which worried us about this kind of a computation," Atanasoff explained. It included the key components of a complete calculating machine in scaled-down form and without many of the accessories needed for practical operation, but it allowed the inventors to see where their ideas were leading them. "Almost as soon as the prototype was completed, it began to work very well. The assembly procedure for the logic circuits which Berry had devised made them perfect." The first demonstrations of the prototype were conducted in October 1939. "Our visitors who understood what was going on were surprised to find so much structure giving additions and subtractions that were correct."

Atanasoff admitted that the prototype was a very crude device. "It could just add and subtract the binary equivalents of decimal numbers having up to eight places. Nevertheless, Clifford Berry and I regarded this machine as a great success. It settled many doubts about how an electronic computer should be built. . . . [W]e both knew we could build a machine that could do almost anything in the way of computation." A demonstration of the prototype for college officials in December 1939 resulted in a grant of $810 from the Iowa State College Research Council to build a full-scale machine capable of solving systems of equations. Construction of the larger machine, later named the "Atanasoff Berry Computer" [ABC], began immediately after the winter holidays.

The Atanasoff Berry Computer, 1940-1942

"In order to get started fast, I decided to take a chance and estimate the size of the machine. I knew a few dimensions of the various parts that were to go into it [and] without very much figuring, I made an estimate of the size of the total machine and arrived at roughly the size of an office desk." Soon after Christmas, Atanasoff ordered some angle iron for a frame and asked Clifford Berry to start putting it together. "I think I was lucky," he once said, referring to his quick estimates of the size of the frame. "As we progressed we did not often have to redo portions once they were built."

Atanasoff's pioneering vacuum-tube circuitry proved trustworthy in the tests he and Berry conducted with one of the machine's add-subtract mechanisms in January 1940.

Left: Clifford E. Berry holding vacuum tubes that were part of the ABC's memory bank, c. 1941. (courtesy the Des Moines Register*)*

Subsequent work on the ABC proceeded with only a few minor difficulties during 1940 and 1941. In May 1942 Atanasoff and Berry completed construction of the machine and began demonstrations and troubleshooting. They had spent about $5,000 on the project, with Berry's salary accounting for much of the money spent. The mathematical processes and most of the engineering features of the Atanasoff Berry Computer seemed faultless: "during the construction of the computer, we had tested and corrected each subsystem, and so the shakedown did not require much time except for one flaw." The flaw had to do with the reliability of the ABC's electric-spark method of punching holes in binary cards. "We had tested the base-two card system rather carefully, but the number of tests was not sufficient to find an error which occurred once in 10,000 or 100,000 times. This meant that when we tested the complete machine, in the spring of 1942, we discovered that the card system was rather good, but not good enough." Determined to establish an error-free computing operation,

Analog computer: A computer that operates by converting numbers into measurable physical quantities, such as the lengths of rod, rotations, or voltages. [A conventional watch offers an example of analog measurement. Time is measured by the relative positions of the hands on the face of the watch. For example, 1:17 is represented by the hour hand between the 1 and 2, and the minute hand between the 3 and 4.]

Binary: A number system using two digits, usually 1 and 0. It is the most common system used in computers. The value of a number is determined by the relative position of 1's and 0's. For example:

decimal number	*binary equivalent*
1	00000001
2	00000010
3	00000011
4	00000100
5	00000101
6	00000110
7	00000111
8	00001000
9	00001001
10	00001010

Binary system of counting: Blocks of 1, 2, and powers of 2 ($2\times2=4$, $2\times2\times2=8$, $2\times2\times2\times2=16$, etc.) are used to build numbers that we associate with the decimal number system. A binary number is built from the right column to the left: a 0 in a column indicates that no block of that number is needed, while a 1 in a column indicates that a block of that power of 2 is needed to build the desired number. Thus, the number 3 is built from 1 1-block, and 1 2^1-block (or $1+2=3$). The number four is built from 0 1-block, 0 2^1-block, and 1 2^2-block (or $0+0+4=4$). The number seven is built from 1 1-block, 1 2^1-block, and 1 2^2-block (or $1+2+4=7$). The number ten is built from 0 1-block, 1 2^1-block, 0 2^2-block, and 1 2^3-block (or $0+2+0+8=10$). Large numbers can thus be simply represented for computers using only a system of 1's and 0's.

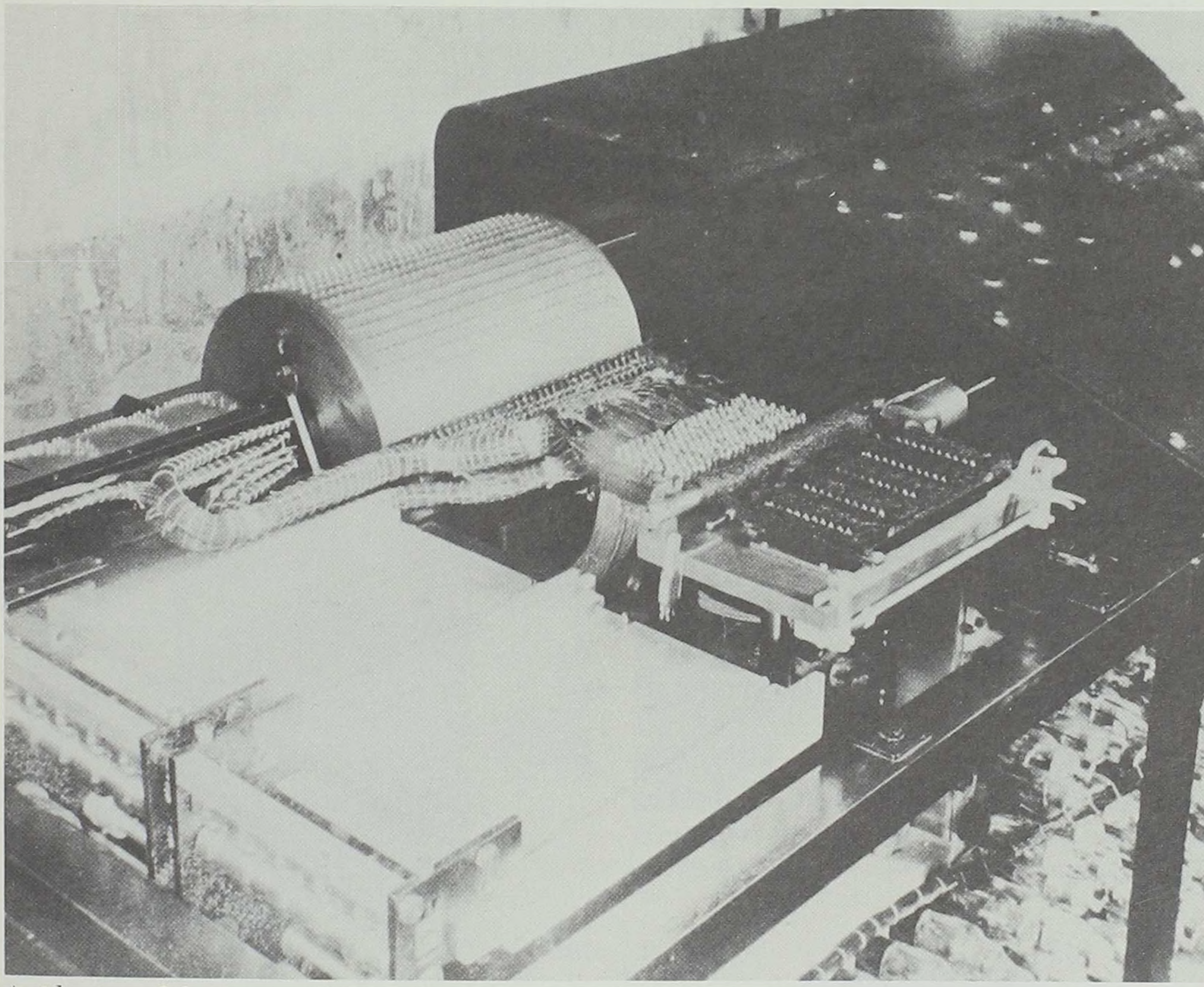
Bit: A single binary digit, a 1 or 0. A bit is one-eighth of a byte.

Byte: A cluster of eight binary digits. A byte is composed of eight bits.

Capacitor: A device for storing an electrical charge, also called a condenser.

Decimal: The number system using ten digits, 0 through 9. It is the most common system used by people for counting.

Digital computer: A computer that operates with numbers expressed in digits, whether in a decimal, binary, or other number system. [A digital watch indicates time directly in numbers, such as 1:17.]



A side view of the Atanasoff Berry Computer, c. 1942. (courtesy the Department of Special Collections, ISU library)

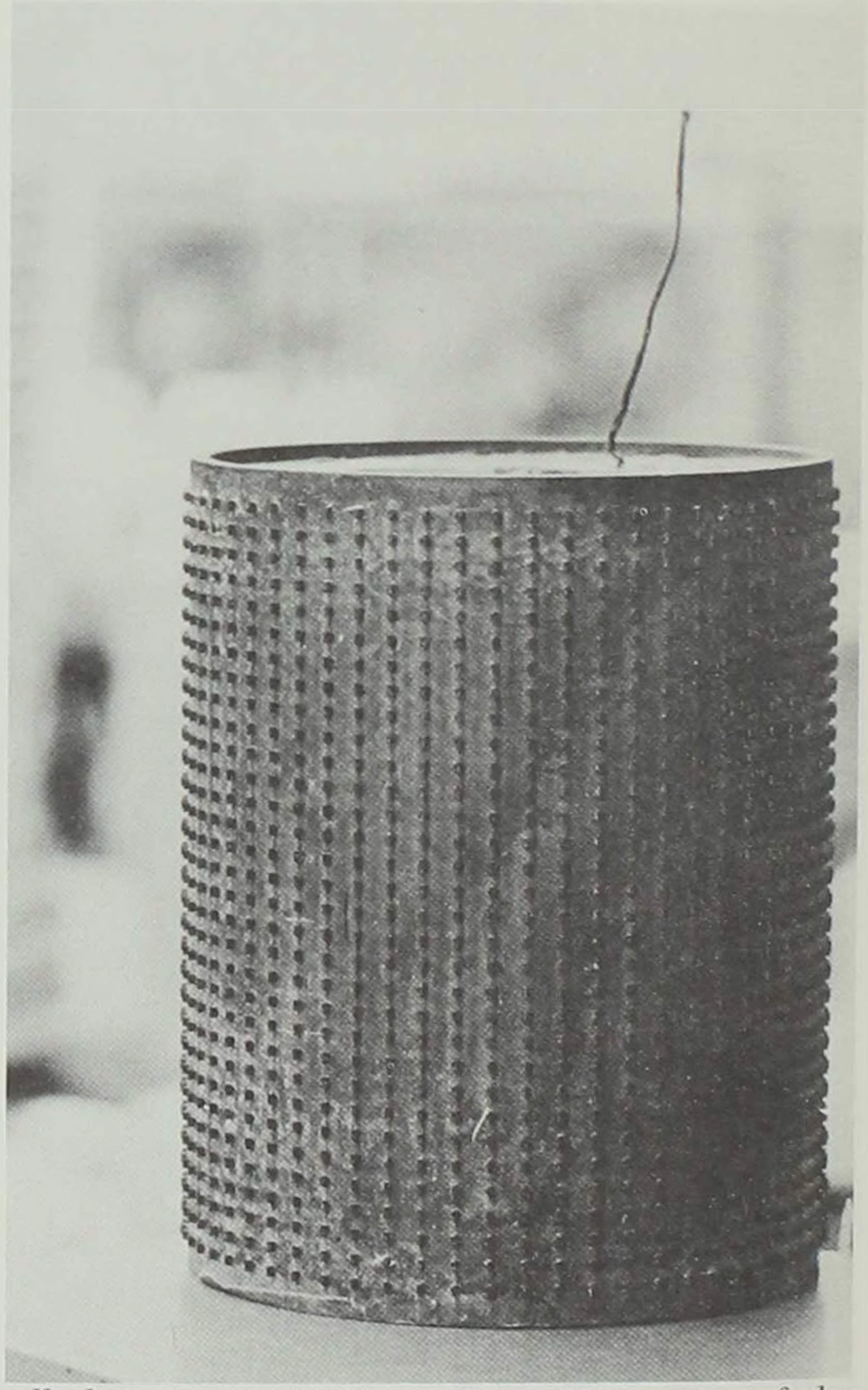
Atanasoff and Berry were working on the troublesome card-handling system when the 1941-1942 school year ended. They continued tinkering with the calculating machine throughout that summer.

The Fate of the ABC, 1943-1973

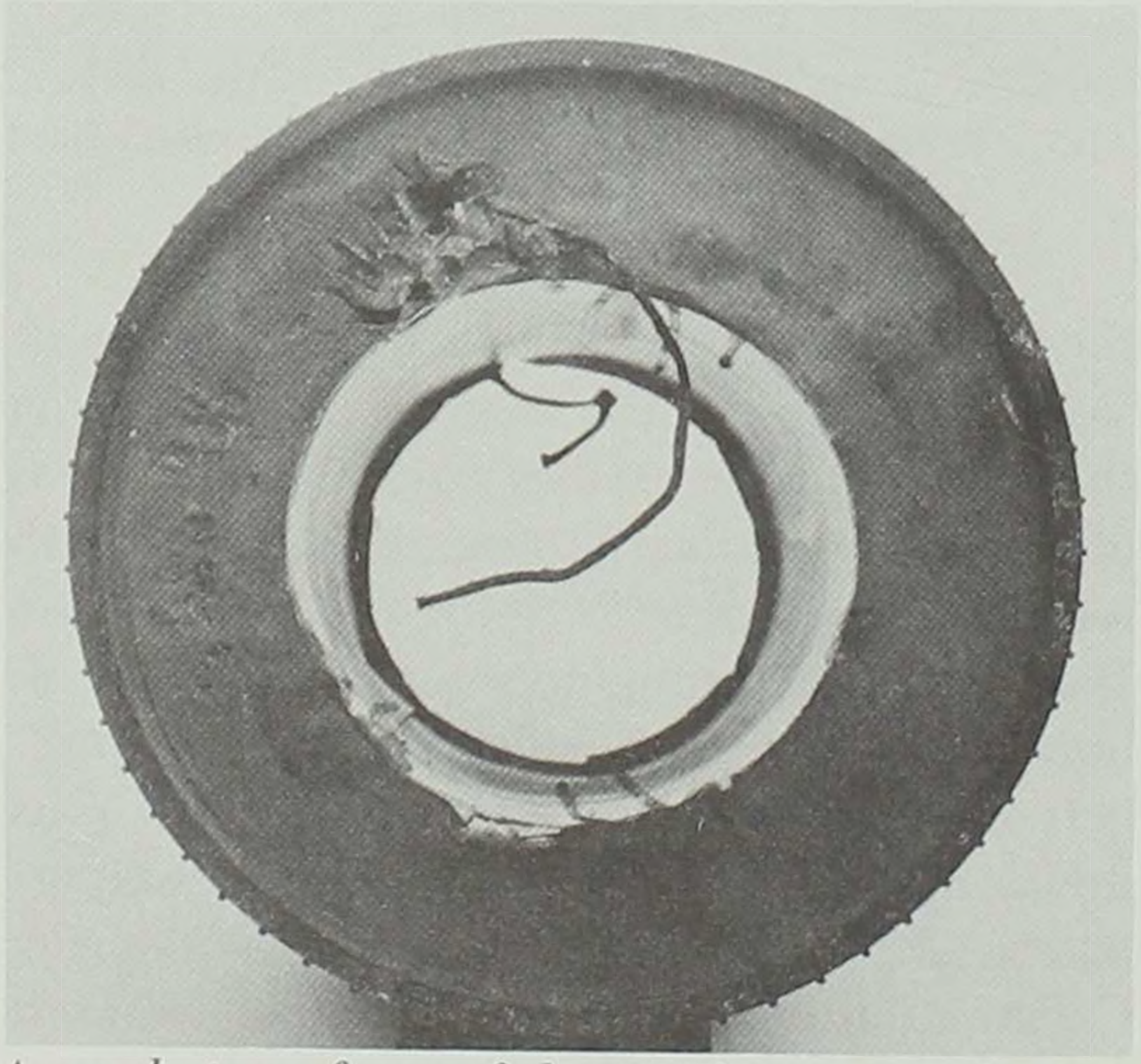
In September 1942 Atanasoff and Berry stopped work on the ABC. Both men had accepted government jobs and soon left Ames to become involved in the United States war effort. The ABC remained in the basement of the Physics Building. No one else could run it. Very few people knew much about it. During the war the two inventors went into new areas of research. Atanasoff became involved with weapons research in Washington, D.C., while Berry worked in engineering physics in California. They did not collaborate on any projects after the war. Having invented numerous devices for the armed services in wartime, Atanasoff formed the Ordnance Engineering Corporation in the early 1950s. Berry worked for many years as technical director for a Pasadena engineering firm. By the mid-1950s both men were successful corporate engineers and neither had any inclination to return to work in Ames. Back at Iowa State College, where the ABC had been stored, the machine was finally dismantled.

Meanwhile, the computer industry had begun to develop and in the mid-1950s patent controversies arose that caused corporate lawyers to begin tracing the ancestry of the electronic digital computer. Several lawyers, working independently, and on different cases, "discovered" Atanasoff, Berry, and the ABC. The first discovery was made by an IBM lawyer in 1954 but Atanasoff did not become a major center of attention in the patent controversies until the mid-1960s, when lawyers for the Honeywell Corporation began building a case that challenged the legitimacy of a patent by which the Sperry Rand Company (manufacturer of the UNIVAC computer) was collecting royalties from its competition, including Honeywell.

The case went to trial in Minneapolis, home of the Honeywell Corporation, in the late 1960s and a decision invalidating the Sperry Rand Company patent was made by Federal



All that remains at Iowa State University of the Atanasoff Berry Computer. (courtesy the Department of Special Collections, ISU library)



An end view of one of the ABC's memory drums. (courtesy the Department of Special Collections, ISU library)

Judge Earl Larson in 1973. Judge Larson's decision named John Vincent Atanasoff as the originator of several of the major engineering concepts on which the rise of the electronic computer, and the computer industry, had taken place in the late 1940s and 1950s. While the court did not grant Atanasoff or anybody else either monetary reward or reassignment of patent rights, the court destroyed all other claims pertaining to the invention of the electronic digital computer, including those advanced by Sperry Rand.

Atanasoff is happy enough with the court's decision. "What each man accomplishes

IOWA STATE HISTORICAL DEPARTMENT

Office of the State Historical Society

news for members

Carol Ulch, Deputy Director of the ISHD

On 1 July 1984 Carol L. Ulch became deputy director of the Iowa State Historical Department. She is responsible for overseeing the department's Iowa City operations, and will be directly involved with the various activities of the State Historical Society of Iowa.

Carol comes to the Iowa State Historical Department from Bradley University at Peoria, Illinois, where she was a member of the Department of Geography for the past fifteen years. She is very much at home in both Iowa and Iowa City, however. She grew up near Solon on a farm homesteaded by her great-grandfather in the 1860s. After graduation from Solon High School, Carol attended the University of Iowa where she received a bachelor of arts degree in history/education, a master's degree in political science, and a doctorate in geography. Her most recent academic work has been in an M.B.A. program, with emphasis on management, marketing, and planning for nonprofit agencies.

Carol is the author or coauthor of an impressive list of papers and articles, the most recent being a paper which she presented at the national meeting of the Association of American Geographers in April of this year. Her research activities have resulted in her receiving numerous grants and awards. Between 1980 and the time she joined the ISHD's staff, Carol served as director of the Center for Social Research and Community Affairs at Bradley University. As director, she was responsible for the entire range of the center's project activities. Typically, these projects were needs assessments for community agencies, social/environmental impact analyses, location analyses for public and private facilities, and marketing analyses for nonprofit agencies. Carol participated in all phases of all Center projects, from contract negotiation through research design and research performance to the writing of the final project reports and their presentations.

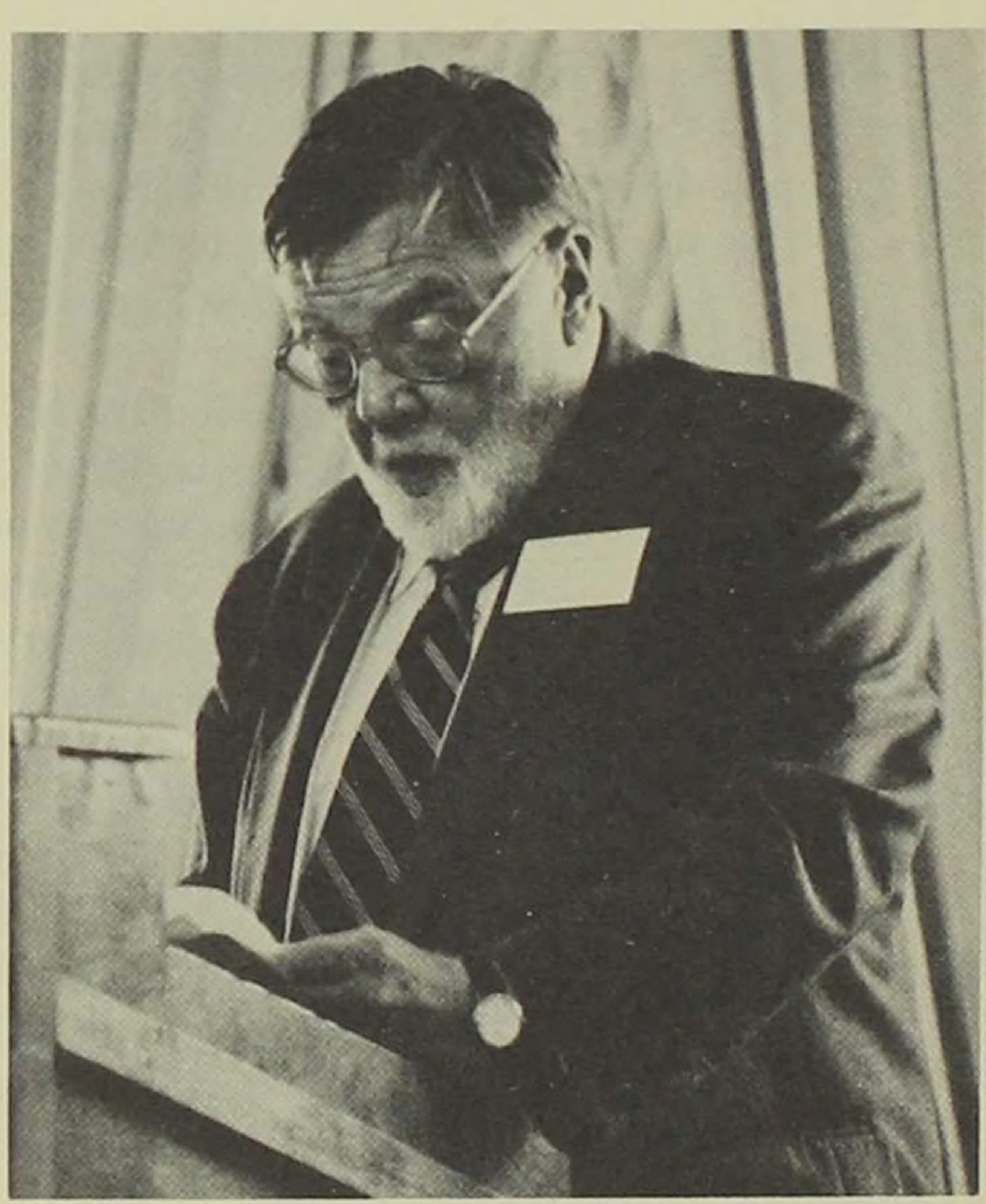
In Iowa City, Carol will be responsible for the personnel and programs of the department as well as the maintenance of the department's facilities. She will also serve as the executive director's representative to the State Historical Society of Iowa, as secretary to the Board of Trustees, as administrator of Society business, and as organizer of Society projects.

Carol has indicated that she will be very interested in the development of new programs for the department in Iowa City. This will undoubtedly involve her in the search for expanded program support through greater emphasis on grants and/or contracts. In addition to her administrative tasks and her facilitating of programs, Carol hopes to work toward the inauguration of a series of seminars and lectures for the staff, members of the professional historical community, and others interested in history. She hopes to find ways for the staff to become more active on the local, state, and national levels at professional meetings and regional seminars. She believes that the close ties already existing between the department, the university, and the education community generally can lead to a new kind of cooperation that will benefit the state through expanded programs, publications, and a more extensive use of existing facilities.

Much of Carol's work at the outset will emphasize planning. While at Bradley University, she was involved in the work of many committees, including the Strategic Planning Committee of the College of Liberal Arts and Sciences. Her experience should serve her well as she and the staff at Iowa City work out new and consistent directions for the Society and the Iowa City facility. Planning will be carried out not only in the program areas but will also be a part of the continued acquisition of library materials. It will be further reflected in the resolution of problems arising from projected increases in the holdings of manuscripts and other primary materials in Iowa City.

The deputy director hopes that the department in Iowa City will soon be able to expand the extent of its educational and community service programs with results clearly beneficial to the Society, its members, and Iowans everywhere.

SHSI's Annual Banquet in Burlington



The Annual Banquet of the State Historical Society of Iowa was held in the Regency Royale Room of The Holiday at Burlington on 16 June 1984. Robert J. Dietrich, a member of the Board of Trustees from Creston, introduced the members of the Board of Trustees and the Iowa State Historical Board who were present. He then presented the awards for achievement in state and local history and the 1984 Trustees' Award. A list of those who received achievement awards can be found elsewhere in *News for Members*.

The 1984 Trustees'Award for the best article published in the *Palimpsest* during the previous calendar year went to H. Roger Grant for his May/June 1983 article, "The Railroad Station Agent in Small-Town Iowa."

The banquet address, "People, Streets, and Civilizations," was delivered by Dr. Laurence Lafore, of the University of Iowa.

The banquet was thoroughly enjoyed by the more than 120 Society members in attendance.

Results of Trustees Election

In the recent election to fill four positions on the State Historical Society of Iowa's Board of Trustees, George McDaniel, Davenport, was reelected as an at large member, William Cochran, Red Oak, was elected as an at large member, Michael D. Gibson, Dubuque, was elected to represent the Second Congressional District, and Lynn Nielsen was elected to represent the Third Congressional District.

The Iowa Newspaper Project

The Iowa Newspaper Project needs your help. Newspapers are a very rich source of information about local people and events. Often they provide the *only* clues about how Iowa towns, cities, and counties developed — socially, culturally, economically, and politically. Yet newspapers are perhaps the most fragile resource available to genealogists, librarians, and historical researchers. They may suffer damage from fires, floods, vandalism, or even improper storage conditions. And newspapers are essentially "lost" if knowledge of their existence is limited to no more than a handful of people. The Iowa Newspaper Project is the most ambitious project ever undertaken to locate, catalog, and preserve the state's newspapers, past and present.

The Iowa Newspaper Project is part of a nationwide program sponsored by the National Endowment for the Humanities (NEH) to catalog, inventory, and preserve United States newspapers. Nancy Kraft, cataloger for the Iowa State Historical Department's library in Iowa City, is the project director. The project is divided into three phases. The planning phase, funded by the NEH and the ISHD, was completed in May 1984. The three-year second phase, budgeted at $405,000, involves locating and cataloging Iowa's newspapers. The third phase will involve a massive campaign to preserve the newspapers on microfilm.

Preparations for the inauguration of phase two are nearing completion, and soon the process of sending specially-trained catalogers to over 700 sites throughout Iowa will begin. Funding for this cataloging phase of the Iowa Newspaper Project is being provided primarily by an NEH grant of $156,812. Extensive statewide support for the project can be seen in the contribution of staff and computer time from the ISHD, Iowa State University, the University of Iowa, the Iowa Newspaper Association, and the Iowa Library Association. Several individuals representing other organizations have offered to share their time and knowledge. The project staff hopes that additional funds can be raised in local areas to cover the catalogers' transportation expenses as they visit various newspaper sites. Recently, the Scott County Iowa Genealogical Society made a generous contribution to the project which will be used to cover such miscellaneous expenses in its region.

Donations made by individuals or organizations are tax deductible and will be matched by the NEH. Checks or money orders should be made out to the Iowa Newspaper Project. Further information relating to donations may be obtained from **Nancy Kraft, Director, Iowa Newspaper Project, 402 Iowa Avenue, Iowa City, Iowa 52240.**

The catalogers will record the location at which each newspaper is found, the form in which it is found (bound issues, microfilm, microfiche, or other), and the dates for which it is available. It is a large task, made larger and more difficult by the numerous changes newspapers have undergone in title, frequency of publication, and even place of publication. The information collected about Iowa newspapers will then be added to a nationwide computer database.

There will be two cataloging centers for phase two: one in Ames and one in Iowa City. Iowa State University's library will be the cataloging center for the western half of the state, while the ISHD library in Iowa City will handle cataloging for the eastern half. The ISHD office in Des Moines, a major repository for Iowa newspapers, will provide support staff for the project. University of Iowa students will serve as cataloging and public relations interns.

An important part of the Iowa Newspaper Project will be searching for and locating Iowa newspapers. While a 1976 pilot project identified most of the Iowa newspapers published in the nineteenth and twentieth centuries, copies of many of them have yet to be found. In searching for them, the project staff needs the assistance of local groups. Computerized lists of the missing newspapers (by city or county) are available to anyone wishing to help in the search. A list of the newspapers in your area may be obtained by writing to the project director, Nancy Kraft, at the ISHD in Iowa City.

Iowa is one of four states selected by the NEH to be pioneers in the nationwide U.S. Newspaper Project. The NEH-sponsored projects in Iowa, Indiana, West Virginia, and Hawaii will establish guidelines for newspaper projects in other states. The successful completion of the three-year cataloging phase of the Iowa project will allow the ISHD to apply to the NEH for funds to preserve the state's newspapers on microfilm. It is a remarkably ambitious project, yet one with results that will prove invaluable to everyone interested in preserving Iowa's history.

The Annual Achievement Awards

The achievement awards presented by Trustee Robert J. Dietrich at the Society's annual banquet on 16 June 1984 included both Certificates of Merit and Certificates of Recognition. The individuals who received Certificates of Merit included: Elaine Estes, for Historic Preservation; Barbara Gearhart, for Overall Achievement; G. Nelson Nieuwenhuis, for Publications; and William J. Wagner, for Historic Preservation. Those individuals or organizations receiving Certificates of Recognition were: Patrice K. Beam, for Overall Achievement; Kevin Boatright, for Publications; Margaret J. Corwin, for Publications; Helen F. Hoy, for Publications; Edwin Madsen, for Historic Preservation; Val Martin, for Publications; Nancy Redfern, for Historic Preservation; the Sioux County Board of Supervisors, for Publications; and the Washington Chapter of the DAR, for Historic Preservation.

CALENDAR OF COMING EVENTS, 1984

Sept. 18-21	American Association for State and Local History, Louisville, Kentucky
Sept. 19-22	Association for Preservation Technology, Toronto, Ontario, Canada
Sept. 20-23	Oral History Association, Lexington, Kentucky
Sept. 25-28	Midwest Museums Conference, Green Bay, Wisconsin
Sept. 29-30	John Whitmer Historical Association, Des Moines, Iowa
Oct. 5-7	National Historic Communal Societies Association, Amana, Iowa
Oct. 6	Iowa College History Teachers Association, Pella, Iowa
Oct. 10-13	Western History Association, St. Paul, Minnesota
Oct. 10-14	American Folklore Society, San Diego, California
Oct. 18-20	Plains Anthropological Conference, Lincoln, Nebraska
Oct. 19-21	Midwest Anthropological Conference, Evanston, Illinois
Oct. 24-28	National Trust for Historic Preservation, Baltimore, Maryland
Oct. 27	Center for the Study of the Recent History of the United States, West Branch, Iowa
Oct. 27	Iowa Local Historical and Museum Association, Des Moines, Iowa
Oct. 27-28	Iowa Genealogical Society, Ames, Iowa
Oct. 29-30	Iowa Museum Association, Ames, Iowa
Oct. 31-Nov. 3	Southern Historical Association, Louisville, Kentucky
Nov. 1-3	Midwest Archives Conference, Kansas City, Missouri
Nov. 10	Iowa Chapter, Victorian Society in America, Des Moines, Iowa
Dec. 27-30	American Historical Association, Chicago, Illinois

A New Historical Editor

Katherine Scott began work on 16 April 1984 as a historical editor in the publications area of the Iowa State Historical Department. She will serve primarily as assistant editor of the *Annals of Iowa,* a scholarly journal of Iowa and midwestern history. Her responsibilities will also include the editing and production of some of the department's other publications.

Kathy received her B.A. and M.A. degrees from San Francisco State University and is presently earning a doctoral degree from the University of California at Santa Barbara. While at Santa Barbara she was book review editor of the *Public Historian.* Her experience with book reviews will serve her well in her work for the ISHD since she will also become book review editor of the *Annals of Iowa* this autumn.

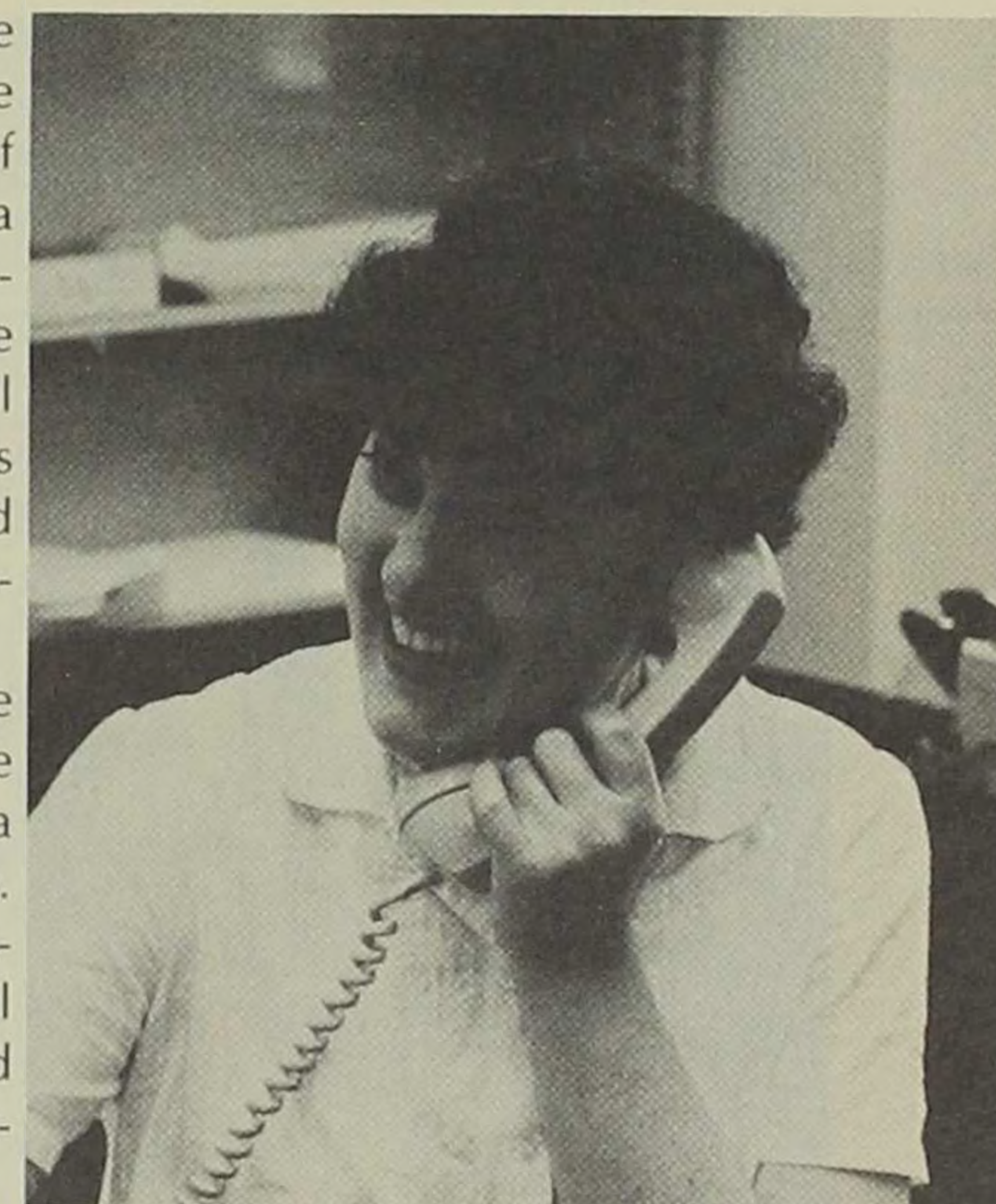
Kathy's doctoral specialization is "the history of hydropolitics," or the events and controversies that have surrounded the struggle for water supply and water rights, especially in the arid West. Her dissertation will be a study of the politics of water in Santa Barbara County. As a spirited public historian, Kathy hopes her monograph will serve as a guide for the local policymakers who commissioned it. Professor Robert Kelley, the founder of the university's public history program, is directing the project.

It will be a busy year for Kathy. She is getting married as well as taking her comprehensive doctoral examinations in the fall. Then she will return to learn more about her new job and her new home state.

Fellowships

The James Jerome Hill Reference Library will award a number of fellowships of up to $2,000 to support research in the James J. Hill Papers. The deadline for application is December 1, 1984. Grants may be awarded for any time in calendar 1985. For more information, contact W. Thomas White, Curator, James Jerome Hill Reference Library, Fourth & Market Streets, St. Paul, MN 55102.

SHSI's New Membership Clerk



Teri Lane Ennis, a former receptionist at the Iowa State Historical Department, has replaced Carol Scott as the Society's membership clerk. As the coordinator of membership and publication sales, Teri Lane has a wide variety of duties. She is responsible for maintaining the records for both old and new members of the Society. Moreover, she maintains inventory control over Society publications, handles publications sales and the subscription lists for the *Annals of Iowa* and the *Goldfinch,* and answers inquiries about the general programs of the historical department.

Teri Lane's work involves her increasingly in the computer operations of the Society, since all of the membership records have been transferred to the Iowa State Historical Department's new computer system. The publications inventory records will soon be maintained on this computer system also. The system will speed the renewal process for Society members and should increase the efficiency of the entire membership operation within the Society.

Teri Lane was born in Marshalltown and grew up in the Des Moines area. She attended the University of Iowa, where she received her bachelor of arts degree in English. It was while attending the university that she first came to work for the department. Normally we would describe Teri Lane as one of the more active members of the staff, but recently she broke an ankle and has been slowed down considerably. But we hasten to add that she has been slowed down only as a softball player, and not as your membership clerk.

A Word About the Iowa Historical Museum Foundation

The Iowa Historical Museum Foundation is carrying on a vigorous fund-raising campaign to raise $12,000,000, which is the public's share of a proposed $27,000,000 Iowa State Historical Building. The new Iowa State Historical Building will provide not only increased museum exhibit space but will also house the State Archives, provide public meeting rooms, and allow for a more effective operation of the Iowa State Historical Department. For those who might be interested in contributing to this most worthy cause, we are printing below the Foundation's enrollment form for their Trustees for Tomorrow.

Iowa Historical Museum Foundation
431 East Locust Des Moines, Iowa 50307 Phone 515-244-4939

Commitment . . . Showcase for Iowa History . . . Trustee for Tomorrow

I want to enroll as a Trustee for Tomorrow, to assist the Iowa Historical Museum Foundation in its commitment to the new Iowa State Historical Building.

Name ______________________________

Address ______________________________

City/State/Zip ______________________________

- ☐ $1,000 - Governor's Circle
- ☐ 500 - Patron
- ☐ 250 - Sponsor
- ☐ 100 - Associate
- ☐ 50 - Family
- ☐ 25 - Friend
- ☐ - Donor

Credit Card Users: ☐ Visa ☐ MasterCard

Card Number ______________________________

Expiration Date ______________________________

Signature ______________________________

Make checks payable to the Iowa Historical Museum Foundation. All gifts are deductible for tax purposes.

Danish Immigrant Museum Hires Director

(Photo by Dr. Signe T. Nielsen Betsinger)

June Stafford Sampson, right, will be the first director of the Danish Immigrant Museum, which is to be built in Elk Horn, Iowa. She holds a B.A. in history from Earlham College, Richmond, Indiana, and an M.A. in historical museum training from the State University of New York, Oneonta.

Sampson has served as museum curator for the South Dakota Historical Society at Pierre and as director of the W.H. Over Museum at the University of South Dakota, Vermillion. More recently, she has been the director of the Yellowstone County Western Heritage Center in Billings, Montana, where she planned exhibits, developed educational programs, and worked extensively with volunteers.

Sampson is married and has four children. She will assume her new position on September 15.

A Lecture Series on Nineteenth Century Women

The Iowa Chapter of the Victorian Society in America, in cooperation with the Iowa Humanities Board, the National Endowment for the Humanities, and the Des Moines Women's Club, will be presenting a lecture series, "Famous Women in the 19th Century," in the fall and winter of 1984-1985. Three lectures are scheduled in November 1984.

Saturday, November 10, 1984: "Susette La Flesche Tibbles: Omaha Indian," by Ann Polk Diffendal, Manuscripts Curator, Nebraska State Historical Society, Lincoln, Nebraska.

Wednesday, November 14, 1984: "The Victorian Lady: Life in a Doll's House," by Jeanne H. Watson, Executive Director, Morris County Historical Society, Morristown, New Jersey.

Wednesday, November 28, 1984: "Gertrude Käsebier: Photographer," by Barbara L. Michaels, Fine Arts Department, New York University, New York City, New York.

All of the lectures will be held at Hoyt Sherman Place, 15th & Woodland, Des Moines, Iowa, at 1:15 p.m.

ISPHL's Fall Tour

The Iowa Society for the Preservation of Historic Landmarks' fall tour will begin 5 October 1984 and will include a visit to the Ozark Folk Center in Mountain Home, Arkansas, with stops at Cape Girardeau and Ste. Genevieve, Missouri. One does not have to be a member of the society to join the tour. For further information contact: Elizabeth Craw, 1226 N. 24th Place, Fort Dodge, Iowa 50501.

Civil War Service Certificates

A certificate of service showing Civil War service information is now available from the State Archives of Iowa. Individuals who wish certificates are advised to provide as much information about the soldier as they can (name, place of birth, residence, company and regiment assigned to, etc.). There will be a charge of $3.00 for the first certificate for any individual soldier, $1.00 for each additional copy of a certificate that is requested at the same time as the first certificate, and $3.00 for each additional copy of a certificate that is requested at a later date. Prepayment is not recommended. Requests for certificates of service should be sent to: State Archives of Iowa, 4th Floor — Records and Property Center, East 7th and Court Avenue, Des Moines, Iowa 50319.

Certificate of Service

The State Archives of Iowa

This is to Certify, *That records in the State Archives show that*

....

late a .... *in Company* .... *of the* .... *Regiment*

of Iowa .... *Volunteers was* ....

.... *on the* .... *day of 18* ....,

.... *at* .... *, Iowa, was mustered*

into the military service of the United States on the .... *day of* .... *18* ....,

.... *at* ....

....

....

....

....

and ....

on the .... *day of* .... *, 18* ...., *at* ....

....

The records further show that said soldier when enlisted was .... *years of age* ....,

had .... *eyes,* .... *hair,* .... *complexion, was* ....

feet.................... *inches in height, and by occupation a* ....

In Testimony Whereof, *I have hereunto set my hand in the city of Des Moines,*

this .... *day of* ....,

in the year of our Lord, one thousand nine hundred ....

....

State Archivist

CPE-59930

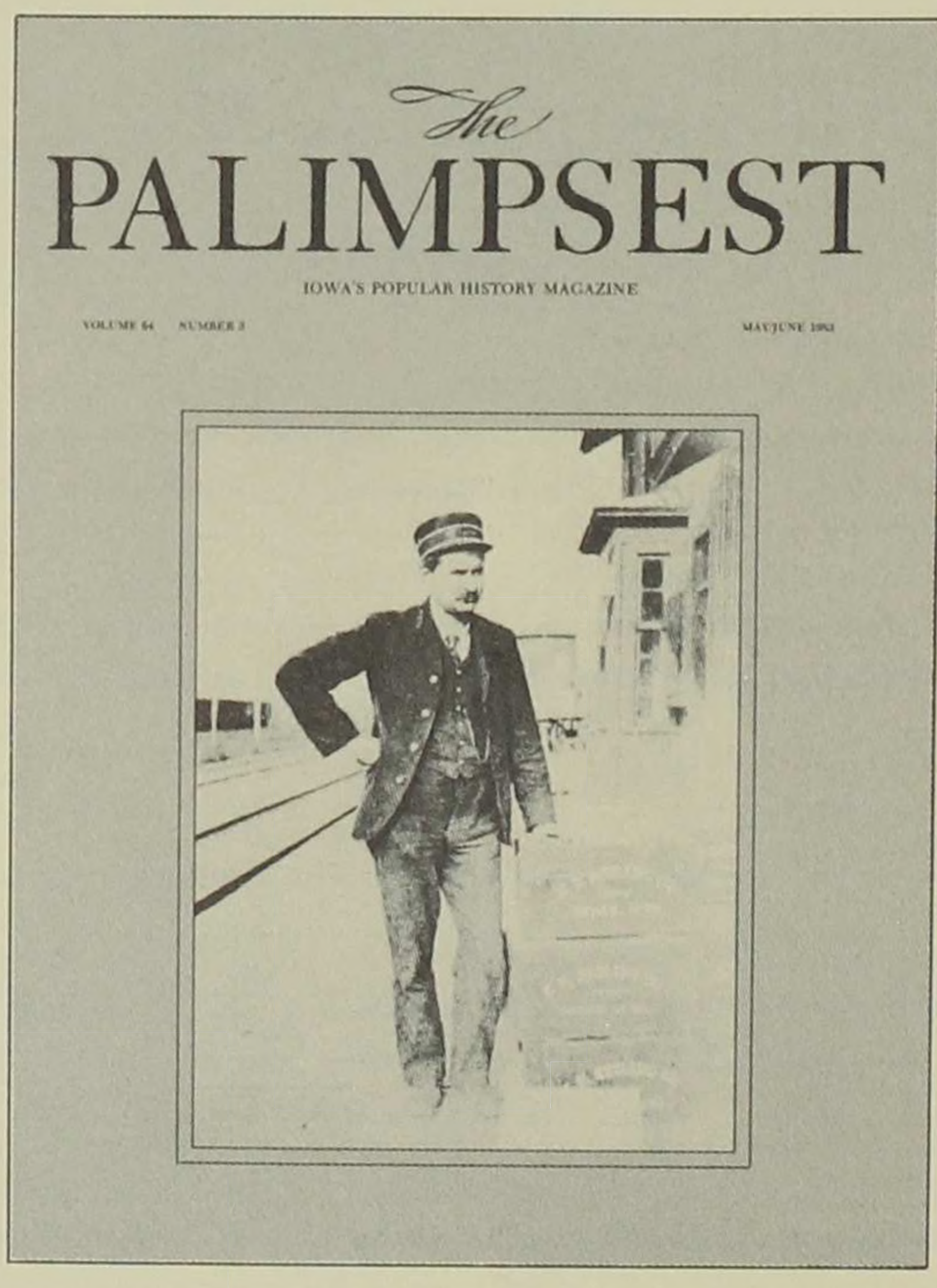
A Call for Papers

The Seventeenth Annual Dakota History Conference will be held on the campus of Dakota State College, Madison, South Dakota, on 12 and 13 April 1985. The director of the conference is requesting papers on the history of South Dakota, Dakota Territory, or the Upper Great Plains Region. Deadline for submission of papers is 31 January 1985.

Individuals interested in submitting papers should contact: H.W. Blakely, History Department, Dakota State College, Madison, SD 57042-1799.

The Second Annual Trustees' Award

The Trustees' Award for 1984 was announced at the annual banquet of the State Historical Society of Iowa which was held in Burlington on 16 June 1984. The choice of the members was H. Roger Grant for his article, "The Railroad Station Agent in Small-Town Iowa," which appeared in the May/June 1983 issue of the *Palimpsest*. The trustees would like to thank those members who voted this year and they hope the number of members participating in the selection process will increase again next year.



John Vincent Atanasoff in his Maryland workshop, c. 1967. (courtesy the Department of Special Collections, ISU library)

depends on his brains and energy," Atanasoff remarked in an interview a few years ago, "but also on the surroundings in which he works. In this, timing is important." And about the timing of the ABC, he said simply, "I am very grateful that fate should have placed me at the beginning of this great adventure." □

Note on Sources

This essay is based on a larger study of John Vincent Atanasoff and the Atanasoff Berry Computer now in preparation by the author. Primary sources include interviews with John Vincent Atanasoff; the scientific papers, speeches, and correspondence of John Vincent Atanasoff and Clifford Berry; pretrial testimony, recorded on videotape, by John Vincent Atanasoff in connection with United States District Court, Fourth Division, HONEYWELL, INC. V. SPERRY RAND, ET AL., No. 4-67 Civ. 138, decided October 19, 1973; Federal Judge Earl Larson, "Findings of Fact, Conclusions of Law and Order for Judgment," *U.S. Patent Quarterly* 180 (March 1974), 673-773; excerpts from John Vincent Atanasoff, "The Advent of Electronic Digital Computing," forthcoming in the *Annals of the History of Computing*; Arthur W. Burks and Alice R. Burks, "The ENIAC: First General Purpose Electronic Computer," *Annals of the History of Computing* 3 (October 1981), 310-399; and "From One John Vincent Atanasoff," a documentary film produced at Iowa State University under the direction of Steven Knudsen and released in 1983.

Among the secondary sources consulted were: Christopher Evans, *The Making of the Micro* (London, 1981); Kathryn Fishman, *The Computer Establishment* (New York, 1981); Herman H. Goldstine, *The Computer From Pascal to von Neumann* (Princeton, 1972); Dirk Hanson, *The New Alchemists: Silicon Valley and the Microelectronics Revolution* (Boston, 1982); and David Gardner's historical articles published in *Datamation*.

The author wishes to thank John Vincent Atanasoff and Alice Atanasoff for their generosity in responding to inquiries and supplying documentary material. The author is also grateful for assistance and encouragement provided by Steven J. Fuller and Loren N. Horton of the Office of the State Historical Society, by Steven Knudsen, David L. Lendt, Robert Lindemeyer, Richard Lowitt, Michael Mendelson, Robert Ottoson, and Jane Smiley, all of Iowa State University, and by the staff of the Special Collections Department at the Iowa State University library in Ames, particularly Becky Owings.

The Atanasoff Berry Computer

The Atanasoff Berry Computer embodied four complementary ideas: digital electronic logic circuits, binary enumeration, serial calculation, and regenerative memory. Atanasoff's memory component included a pair of electrical recording devices he called "abaci" elements; one called a keyboard abacus and the other a counter abacus (see illustration of the ABC on page 177). The ABC computed by adding a number on the keyboard abacus to a number on the counter abacus. "The numbers on the two abaci thus play different roles," Atanasoff wrote in 1940. "One is left unchanged, the other is enhanced or diminished by the first in the course of the operation." Atanasoff and Berry planned their machine to operate on thirty abaci of each type (2 × 30), each containing fifty (50) binary digits, for a total of three thousand bits of memory (2 × 30 × 50 = 3000).

For abacus elements Atanasoff used small tubular paper condensers, fifty per element. The condenser elements occupied radial positions at six-degree intervals within a hollow cylinder of bakelite measuring eleven inches long by eight inches in diameter. Each cylinder held thirty-two fifty-condenser abacus elements (two of the thirty-two were idle by design), arranged in rings along the inner wall of the bakelite cylinder. The condensers' inner terminals connected to a common lead; their outer terminals connected to contacts poking out through the wall of the cylinder. As the cylinder rotated on its horizontal axis, once per second, these contacts were read and recharged by brushes extending from the circuits of the add-subtract mechanism.

At the heart of the logic circuitry, a set of thirty add-subtract mechanisms did the actual computing. The add-subtract mechanism governing the coaction of the two abaci embodied the most significant electrical circuit developed by Atanasoff and Berry. Each add-subtract mechanism consisted of seven twin triode vacuum tubes interconnected to perform binary addition. Berry developed circuits in which the grids of the input tubes floated on small capacitors charged by momentary contact with a storage capacitor. Each add-subtract mechanism had three inputs, two for the digits being added and one to handle the carry-over from the previous place, and two outputs, one for the result in that place and one for the carry-over to the next place. The thirty computing units were identical in structure and rested on individual chassis piled in a five-by-six array within the larger angle-iron frame. The machine looked like a big office desk covered with wires and electrical hardware.

The add-subtract mechanism arranged the abacus elements in a specific correspondence, added or subtracted one from the other, and took care of carry-over or borrowing as necessay in the mathematical procedure. Able to recharge its data source continually, an add-subtract mechanism conducted its routine serial operations at a fixed pace, one operation per second as the cylinder completed its electrically-powered rotation.

The logic circuits could calculate binary numbers serially with impressive speed. Addition and subtraction could be accomplished in a single operation, while multiplication and division, which were carried out by successive *additions or subtractions, took a series of operations. Base-two calculation demanded only about a third the number of separate operations as base-ten calculation would have demanded on the same machinery. The prototype of 1939 suggested the potential of the circuitry by calculating pi (the ratio of the circumference of a circle to its diameter) to a thousand decimal places with ease, but it was the full-scale ABC that demonstrated the superiority of electrical calculation over mechanical calculation. For example, where MIT's differential analyzer took at least a few hours to set up and arrive at a solution for a variable in two complex equations, the ABC did the same work in no more than ninety seconds.*

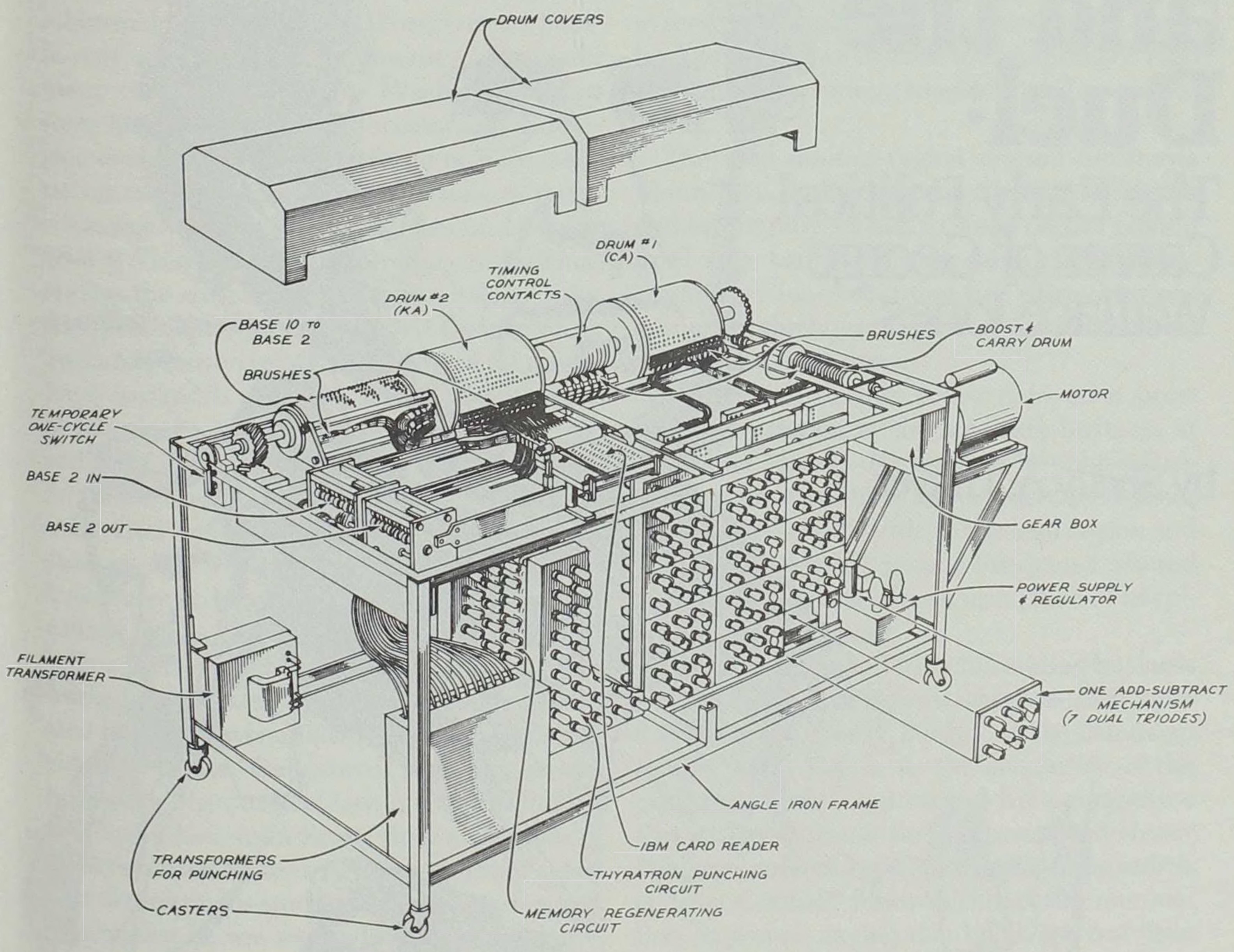
The ABC provided the results of intermediate steps in a mathematical operation on cards, issued by an auxiliary punching device receiving electrical signals from the add-subtract mechanism. The machine's operator could reinsert these cards later if they were needed in the operation. The ABC reported all such intermediate results in binary code (since the add-subtract mechanism did its work in base-two numbers, translation to base-ten in the midst of the mathematical operation made little sense). Moreover, the punched cards themselves (like the abaci elements) permitted the expression of thirty fifty-place base-two numbers, nearly triple the capacity of the same equipment using base-ten numbers. Atanasoff's desire to maximize the quantitative potential of the ABC thus reinforced his decision to adopt binary notation for the actual task of electronic calculation.

For loading information into the computer, Atanasoff and Berry devised a system of cards that could be read by passing an electrical charge through punched holes. Clifford Berry engineered the card-handling apparatus, which featured a novel method of initially punching cards by burning holes in them electrically. He geared this apparatus to the abaci shaft, thereby synchronizing the movement of the cards with the calculating operation. When a negatively charged contact touched a reading brush, an arc five thousand volts strong burned a hole through the card and then extinguished itself within a quarter of a second. All of this action took place as the card-handling mechanism whisked the cards along its steel rollers at the rate of one per second.

Subsequent readings of the data thus recorded on cards repeated several steps of the punching procedure. Cards to be read passed between electrodes — the same ones used for punching — which tested in proper sequence each possible hole position on a card. The electrode's card-reading voltage was low enough not to puncture the card but high enough to force a current through any point already broken down, and ranged from one-fourth to one-third of the card-punching voltage. When a hole on a card passed between the electrodes, a negative impulse—representing a number value of "one" — entered the input section of the add-subtract mechanism. Card positions bearing no hole were read as the number value "zero."

In order to make the results of the binary calculation readable to the person operating the ABC, an auxiliary device changed base-two numbers to base-ten by means of a conversion drum. Atanasoff estimated that five fifteen-place binary numbers could be transferred simultaneously in a total time of fifteen seconds, with faster rates of conversion possible for smaller numbers.

From the operator's point of view, the ABC was a streamlined affair. Manual controls included power switches and a keyboard, switches for starting card punching and reading operations, and switches to route numbers to a specific abacus. A flexible arrangement of plugs and jacks permitted special set-ups. Once a computing procedure was programmed, the operator fed in data cards and the results were reported on the ABC's output dials.



The Atanasoff Berry Computer. (courtesy the Department of Special Collections, ISU library)