INTRODUCTORY COLLEGE MATHEMATICS

HACKWORTH
and
HOWLAND

SAUNDERS SERIES IN MODULAR MATHEMATICS

Computers

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PREFACE

Computers

This book is one of the sixteen content modules in the Saunders Series in Modular Mathematics. The modules can be divided into three levels, the first of which requires only a working knowledge of arithmetic. The second level needs some elementary skills of algebra and the third level, knowledge comparable to the first two levels. *Computers* is in level 3. The groupings according to difficulty are shown below.

Level 1	Level 2	Level 3
Tables and Graphs	*Numeration*	*Real Number System*
Consumer Mathematics	*Metric Measure*	*History of Real Numbers*
Algebra 1	*Probability*	*Indirect Measurement*
Sets and Logic	*Statistics*	*Algebra 2*
Geometry	*Geometric Measures*	*Computers*
		Linear Programming

The modules have been class tested in a variety of situations: large and small discussion groups, lecture classes, and in individualized study programs. The emphasis of all modules is upon ideas and concepts.

Computers is appropriate for all non-science students especially education, business, and liberal arts majors. The module is essential for math-science and technical students with a need for understanding some basic knowledge of computers.

The module begins by presenting the early history of computing machines emphasizing the effect of need on their development. Then the emphasis is on switching circuits and computer applications. *Computers* ends by exmplaining the basic components of a computer, the elementary skills of flowcharting, and BASIC programming language.

In preparing each module we have been greatly aided by the valuable suggestions of the following excellent reviewers: William Andrews, Triton College, Ken Goldstein, Miami-Dade Community College, Don Hostetler, Mesa Community College, Karl Klee, Queensboro Community College, Pamela Matthews, Chabot College, Robert Nowlan, Southern Connecticut State College, Ken Seydel, Skyline College, Ara Sullenberger, Tarrant County Junior College, and Ruth Wing, Palm Beach Junior College. We thank them and the staff at W. B. Saunders Company for their support.

Robert D. Hackworth
Joseph W. Howland

NOTE TO THE STUDENT

OBJECTIVES

Upon completion of this module the reader is expected to be able to demonstrate the following skills and concepts:

1. To be able to indicate the basic features of a computer.

2. To be able to state the difference between a calculator and a computer.

3. To be able to state the needs that prompted computer development.

4. To be able to identify the early computer pioneers and their work.

5. To be able to indicate when current will flow through a switching circuit.

6. To be able to categorize computer applications.

7. To be able to draw a flowchart from a simple algorithm.

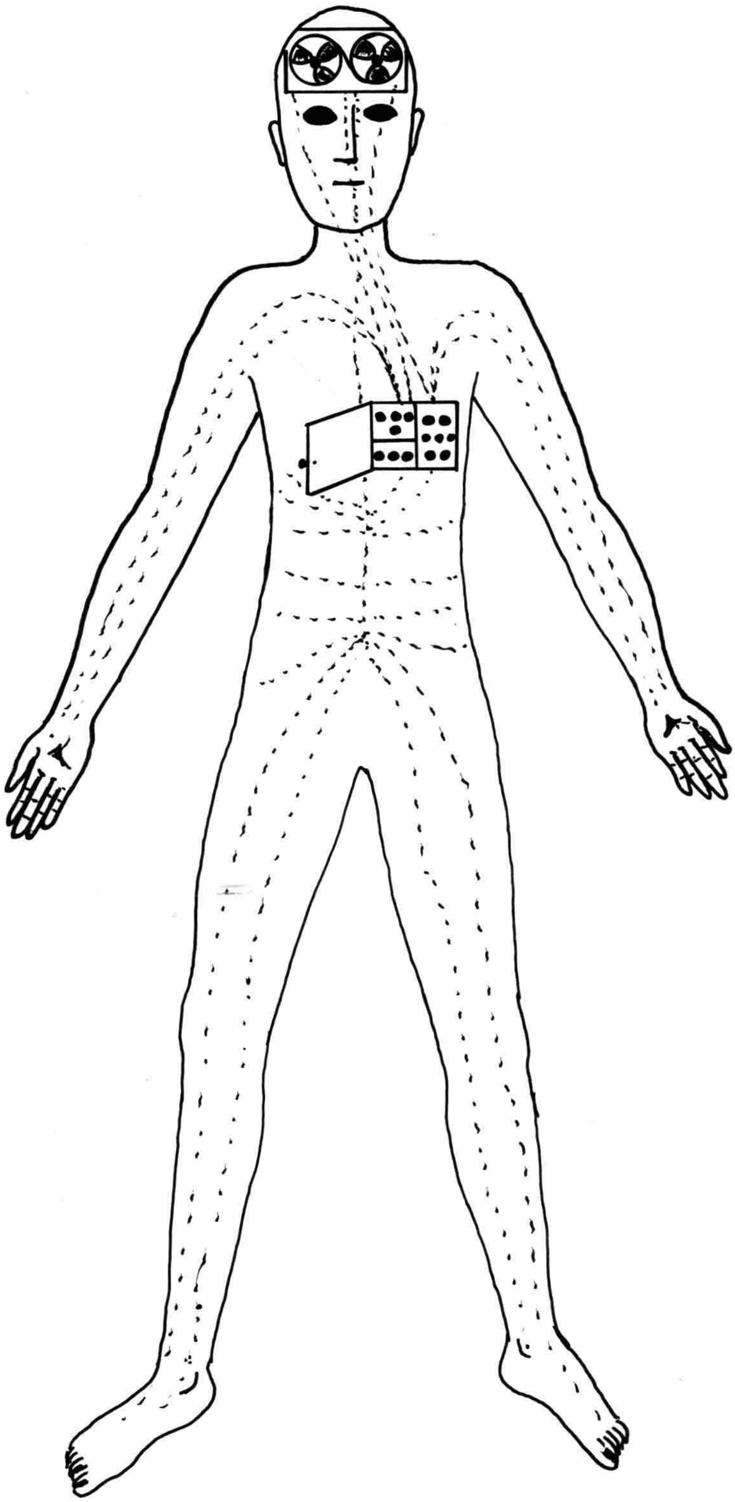
8. To be able to write a program in BASIC from a simple flowchart.

Three types of problem sets, with answers, are included in this module. Progress Tests appear at the end of each section. These Progress Tests are always short with only four to six problems. The questions asked in Progress Tests always come directly from the material of the section immediately preceding the test.

Exercise Sets appear less frequently in the module. More problems appear in an Exercise Set than in a Progress Test. Section I of the Exercise Sets contains problems specifically chosen to match the objectives of the module. Section II contains challenge problems.

A Self-Test is found at the end of the module. Self-Tests contain problems representative of the entire module.

To promote learning, the student is encouraged to work each Progress Test example and Exercise Set in detail as it is encountered, checking each answer, and reviewing when difficulties are encountered. This procedure is guaranteed to be both efficient and effective.



CONTENTS

COMPUTERS

INTRODUCTION

"Computers are going to think for us."

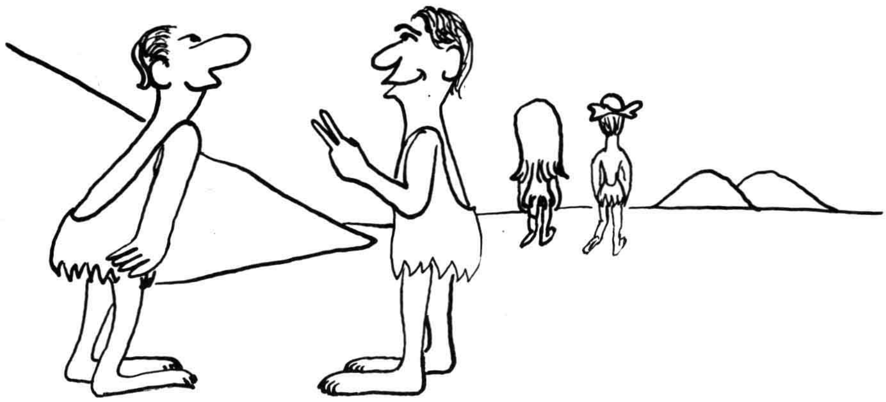
"People are going to be replaced by computers."

"The computer goofed."

"Computers will take over the world."

The previous statements are some of the myths existing about computers. When the module is completed, the reader will realize that some of these statements are partially true and others completely false.

A computer is a machine that assists man in solving problems. One of a computer's most important features is its ability to follow a set of instructions until the problem is solved. A typical problem is that of receiving, storing, and printing out on demand the records of traffic violations of drivers for a State Bureau of Public Safety. If done by hand the recording, filing, and recalling of traffic violations is a time consuming job, yet the procedure itself is not difficult. Such a job is ideal for a computer; it never gets tired or bored and can do hundreds of thousands of consecutive operations without a mistake. Computer storage of information is one illustration showing how computers fill a need. The following history of the computer will show that the evolution of computers came about because men sought easier and better ways to solve problems.

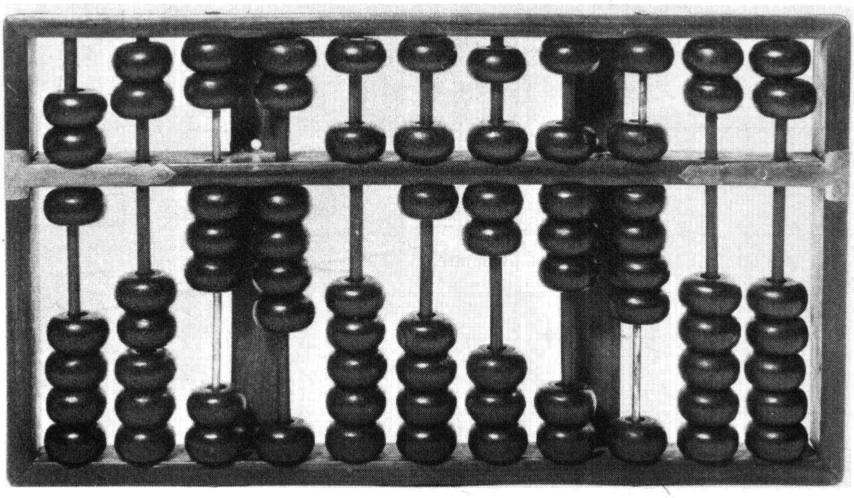


EARLY HISTORY

As primitive man learned to count, fingers could be considered part of one of the original computers. A cave man may have lifted a finger each time a woman ran past. In this way, he was putting data or input into his computer (brain). His fingers also served a memory function. When his buddy asked him how many women had run into the glade, he could look at his fingers for the answer. What these cave people did after this early streaking exercise is not in the realm of this module. That is because it concerns the various uses of computer produced data.

When the memory capability of the cave man's brain was exceeded, sticks, stones, notches on sticks and other devices were used to aid in counting. All these devices provided a way to put information into the machine's "input," hold the information in the "memory" and give the answer as "output."

As man's activities became more sophisticated, his counting needs became more complicated. One of the devices that was developed to help solve mathematical problems was the abacus. Its earliest form was probably rows of grooves in a smooth sand table. Stones were placed in the grooves and moved toward one end of the groove as objects were counted. A stone in the first groove could represent a one, in the second groove each stone represented a ten, in the third groove each stone represented one hundred, and so forth. Therefore, the abacus had the capacity to represent large numbers in a compact form. Adding, subtracting, multiplying and dividing can all be done quickly on the abacus. In fact, in its present form consisting of a frame holding rows of beads, a skilled abacus operator can calculate faster than an electric calculator. However, the most skillful abacus operator cannot keep pace with a person using the cheapest of the modern hand-held electronic calculators. There is evidence that the abacus has been used from about 500 B.C. to the present day.



An abacus.

Abaci are widely used hand powered machines to aid man in computation. They have some of the features of the modern electronic computer: input, memory, and output. But they do not have the distinguishing features of the electronic computer: the ability to automatically follow a set of instructions and to make decisions.

Another ancient machine is called the Antikytheria Device. It was probably developed a few hundred years after the abacus. As a calculator, it was probably not widely known because the only model of the device (and possibly its inventor) was lost in a shipwreck off the island of Antikytheria in the Mediterranean Sea. The Antikytheria Device was a primitive form of a planetarium, consisting of brass gears, axles, and sliding rings. It was used to locate the position of the stars. It even had a sliding adjustment to compensate for the quarter of a day gained every four years in the calendar. The setting of the device, when it was found, agreed with the location of the stars in the year 80 B.C. according to present calculations. Other evidence in the wreck also indicated the ship had sunk in 80 B.C. The existence of gears and axles in the device showed the advanced technology of the time. These skills seem to have been lost with the rise of the Roman Empire, as no other computing device was developed for about 1700 years.

An early calculating machine called Napier's bones or Napier's rods invented by John Napier (1550-1617) could perform multiplication. It consisted of lengths of bone or ivory each inscribed with a number from one to ten. Multiples of the number were arranged in diagonal fashion below the number as shown in the figure below. By sliding the rods up and down in relation to each other, multiplication answers can be easily found.

X	1	2	3	4	5	6	7	8	9	0
1	0/1	0/2	0/3	0/4	0/5	0/6	0/7	0/8	0/9	0/0
2	0/2	0/4	0/6	0/8	1/0	1/2	1/4	1/6	1/8	0/0
3	0/3	0/6	0/9	1/2	1/5	1/8	2/1	2/4	2/7	0/0
4	0/4	0/8	1/2	1/6	2/0	2/4	2/8	3/2	3/6	0/0
5	0/5	1/0	1/5	2/0	2/5	3/0	3/5	4/0	4/5	0/0
6	0/6	1/2	1/8	2/4	3/0	3/6	4/2	4/8	5/4	0/0
7	0/7	1/4	2/1	2/8	3/5	4/2	4/9	5/6	6/3	0/0
8	0/8	1/6	2/4	3/2	4/0	4/8	5/6	6/4	7/2	0/0
9	0/9	1/8	2/7	3/6	4/5	5/4	6/3	7/2	8/1	0/0

X	8	7
1	0/8	0/7
2	1/6	1/4
3	2/4	2/1
4	3/2	2/8
5	4/0	3/5
6	4/8	4/2
7	5/6	4/9
8	6/4	5/6
9	7/2	6/3

Napier's Bones

To multiply 87 by 4, put the X box by the 8 and 7 boxes. Both 32 and 28 are next to 4 on the X bone. How are they used to find the product? A hint for the procedure may be found in the calculation on the right.

```
  87
  x4
  28
 32
 348
```

The product of 489 and 9 may be found by arranging bones as shown on the right.

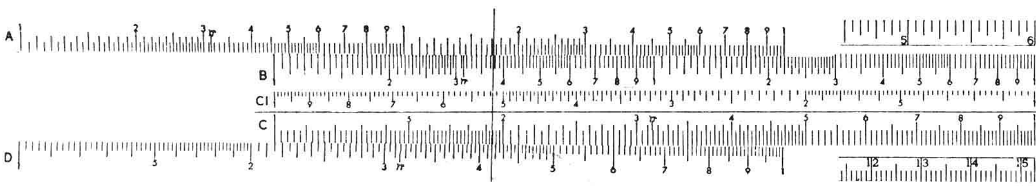
X	4	8	9
1	0/4	0/8	0/9
2	0/8	1/6	1/8
3	1/2	2/4	2/7
4	1/6	3/2	3/6
5	2/0	4/0	4/5
6	2/4	4/8	5/4
7	2/8	5/6	6/3
8	3/2	6/4	7/2
9	3/6	7/2	8/1

X	4	8	9
9	3/6	7/2	8/1
4	4	0	1

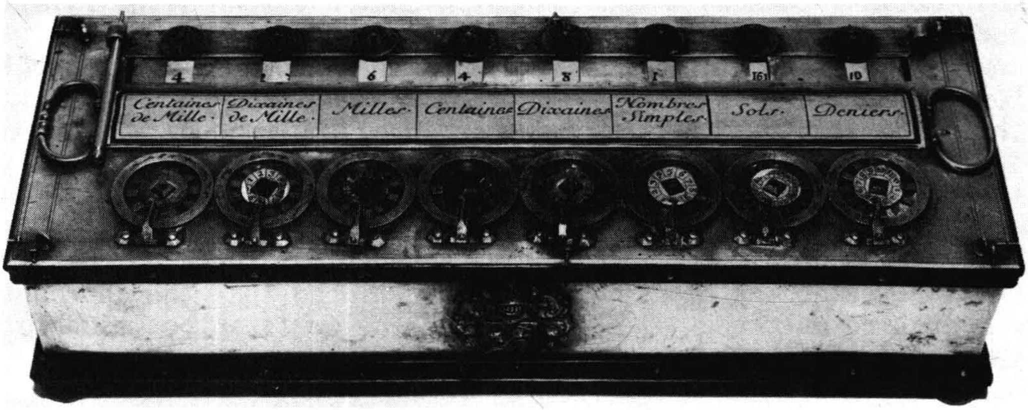
```
  489
  x 9
   81
  72
 36
 4401
```

Besides invention of the simple calculator mentioned previously, Napier is credited with much of the development of logarithm mathematics. His work led to the invention of the slide rule; another simple calculator which can find products, quotients, powers and roots using the basic laws of exponents (logarithms). Long a familiar sight at the belt of the engineering students, the slide rule has now been superseded by the hand-held electronic calculator. The slide rule's effectiveness is no match for the speed, accuracy, and economy of the hand-held calculators.

Like the "bones" shown previously, answers are found on the slide rule by moving the center part of the rule so that the appropriate numbers are matched. The "slip stick" below is in position to show that 214 (under 1 on the C scale)• 194 = 41516 (under the hairline).

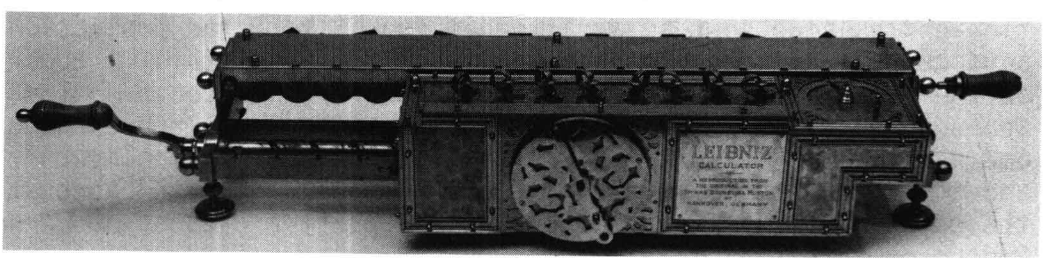


In 1642, Blaise Pascal built a mechanical calculator as an aid for relieving the wearying routines of his tax accountant office. His invention consisted of a series of toothed wheels arranged side by side. Each wheel had ten teeth to correspond with the digits 0 to 9. To enter a 3 into the machine, Pascal moved the first wheel to the third tooth. To add 4 to 3 he moved the wheel 4 more teeth. The invention he made to handle the situation when a sum was 10 or greater is still used today in counting devices such as speedometers. When the sum of two numbers contained two digits the second wheel was advanced one tooth by a projection placed on the first wheel. Each wheel had a projection on its side so that as it moved from 9 to 0 the projection advanced the next wheel one position. Because of this, a tooth on the first wheel represented the number one. A tooth on the second represented ten. A tooth on the third wheel represented one hundred and so forth. Consequently, Pascal's calculator and the abacus could represent large numbers. Like the abacus, the calculator had input, memory and output features as do modern computers.



Pascal's calculator.

The next advancement in calculator design was made by Gottfried Wilhelm Leibniz, a German mathematician and philosopher. Leibniz, besides being the creator of the calculus along with Isaac Newton, built a mechanical calculating device using stepped cylinders. The stepped cylinders made multiplication an operation of successive addition. Leibniz's machine was not widely used, but shows the level of invention and technology relative to computational devices of his time.

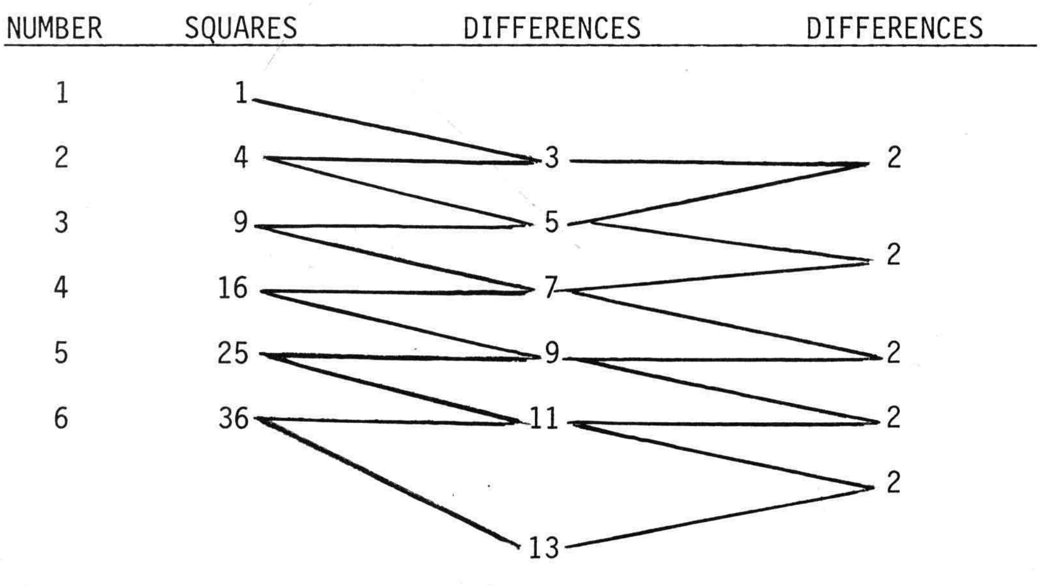


Leibniz's calculator.

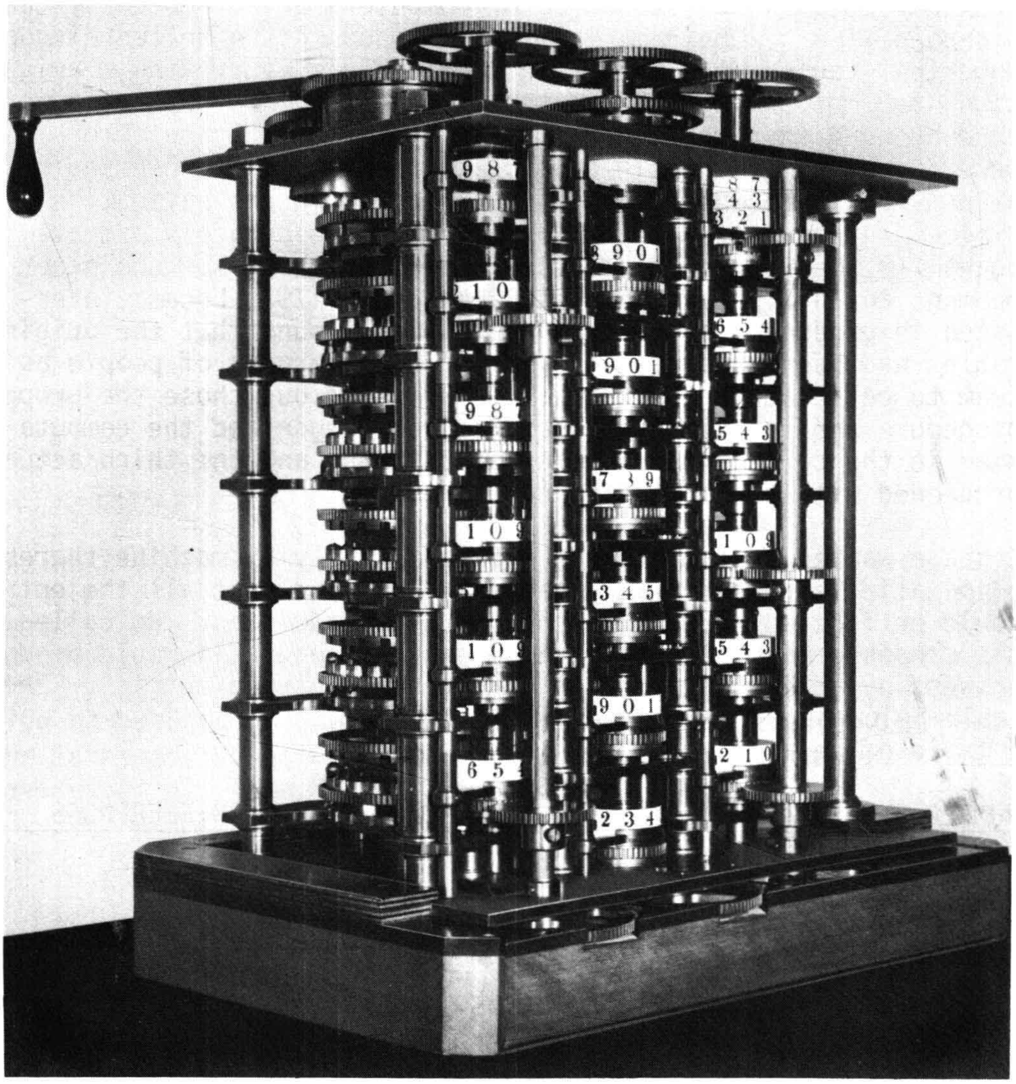
In 1820, a German, Hahn, built a practical variation of Leibniz's machine that could add, subtract, multiply and divide. Copies of this machine were used all over Europe and the United States. The desk calculators used today, except for the electronic calculators, are direct descendants of Hahn's machine.

The next step in the evolution of computers was prompted by the sad condition of the numerical tables used in the United Kingdom. Numerical tables were needed in architecture, surveying, navigation, and accounting. Since the calculators in every table were done by hand they contained many errors. Some of the errors were discovered, to their dismay, by ship captains when their ships wrecked because of incorrect figures in the navigation tables. As someone remarked, it seemed a desperately extravagant way to find errors in the tables. Luckily for the other seamen, an Englishman, Charles Babbage, in 1792, became interested in producing error free tables. He found that the original tables had been constructed by using three groups of people as a team to calculate the entries. The first group chose the proper procedure and formulas, the second group organized the computation in the correct sequence of operations, and the third actually proceeded with the computation.

Babbage wanted to compute the tables entirely by machine thereby eliminating errors from the tables. He found that all the entries could be figured using only the operation addition. He called his proposed machine a difference engine because it would produce answers by adding the correct differences between entries. The table below shows how successive differences can be used to build a table of squares.



Notice that every entry in the column of squares can be reached by adding the differences in proper sequence. Working the tables backwards from Difference to Squares was one of Babbage's contributions to table building.



Babbage's difference engine.

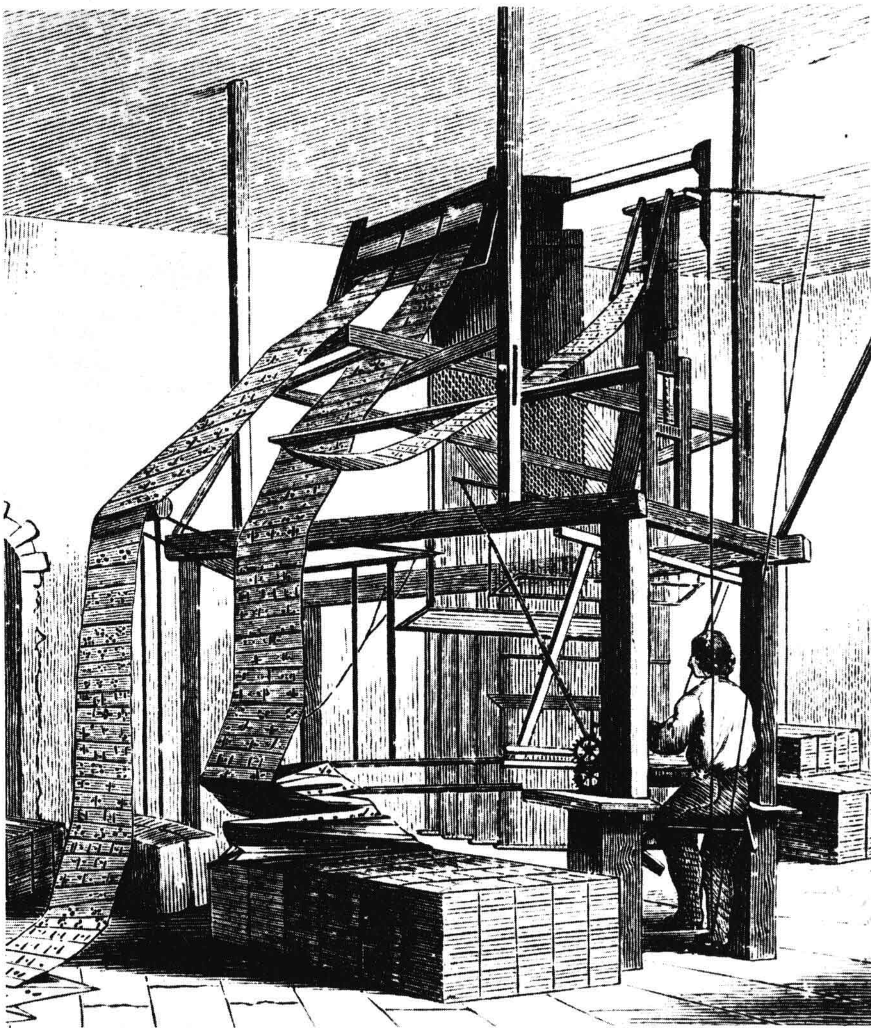
Progress Test 1

1. Make a table of cubes similar to Babbage's table of squares so that the table could be extended forever by adding the differences shown in the table. (Hint: Make three difference columns.)
2. Write a short research paper on Charles Babbage, Gottfried Leibniz, Blaise Pascal and John Napier.

Even though Babbage obtained money from the government to build his machine and made very precise drawings of every part required, the machine was never finished. Before his first machine could be built, Babbage had already moved on to design what he called an analytical engine that would be able to solve many different types of calculations.

The analytical engine was a general purpose computer rather than a special purpose machine like the difference engine. Strangely enough, the development of an automatic loom in France by Jacquard, patented in 1801, played an important part in Babbage's plans for his engine. Jacquard's revolutionary invention was to use punched cards to control the loom as it wove a design into cloth. The arrangement of the holes controlled the action of the loom to create the design desired. Jacquard, by using the punched cards to control the bobbin,was effectively programming the loom's actions. Punched cards have played a major part in computer operation since that time. The inventive Babbage saw the possibilities of using punched cards to control his analytical engine. It was said that Babbage wove mathematics with his machine just as Jacquard wove cloth with his loom.

Babbage called the calculating part of his machine "the mill," and the part that held the data "the store." Today, the mill would be called the arithmetic unit and the store would be called the memory. He planned to feed instructions and data into the mill using punched cards, a feature not possessed by previous calculators. The data would be held in the store to be recalled by the mill as indicated by the instructions. The answers or output of the engine would automatically be recorded on punched cards. Babbage's engine was entirely mechanical. Every operation was done by gears, cams, and axles, giving fifty place accuracy in its answers. Sadly, Babbage's ideas were years ahead of the mechanical technology of his time, so a model of the engine was not built until after his death. The years from 1820 to 1880 saw many advances in machine and electrical technology that made the implementation of Babbage's ideas more feasible.



Jacquard's loom.

The difficulties with tabulations involved in organizing the data from the United States census was the next problem that prompted further invention of computer design and technology. The tabulation of the 1880 census took seven years to complete manually. James Powers and Herman Hollerith, working for the census bureau, thought that twenty years might be required to tabulate the 1890 census. Consequently, these two men began development of a punch-card tabulating machine. Using cards punched to show certain information, the machine would take the data off the cards elec-