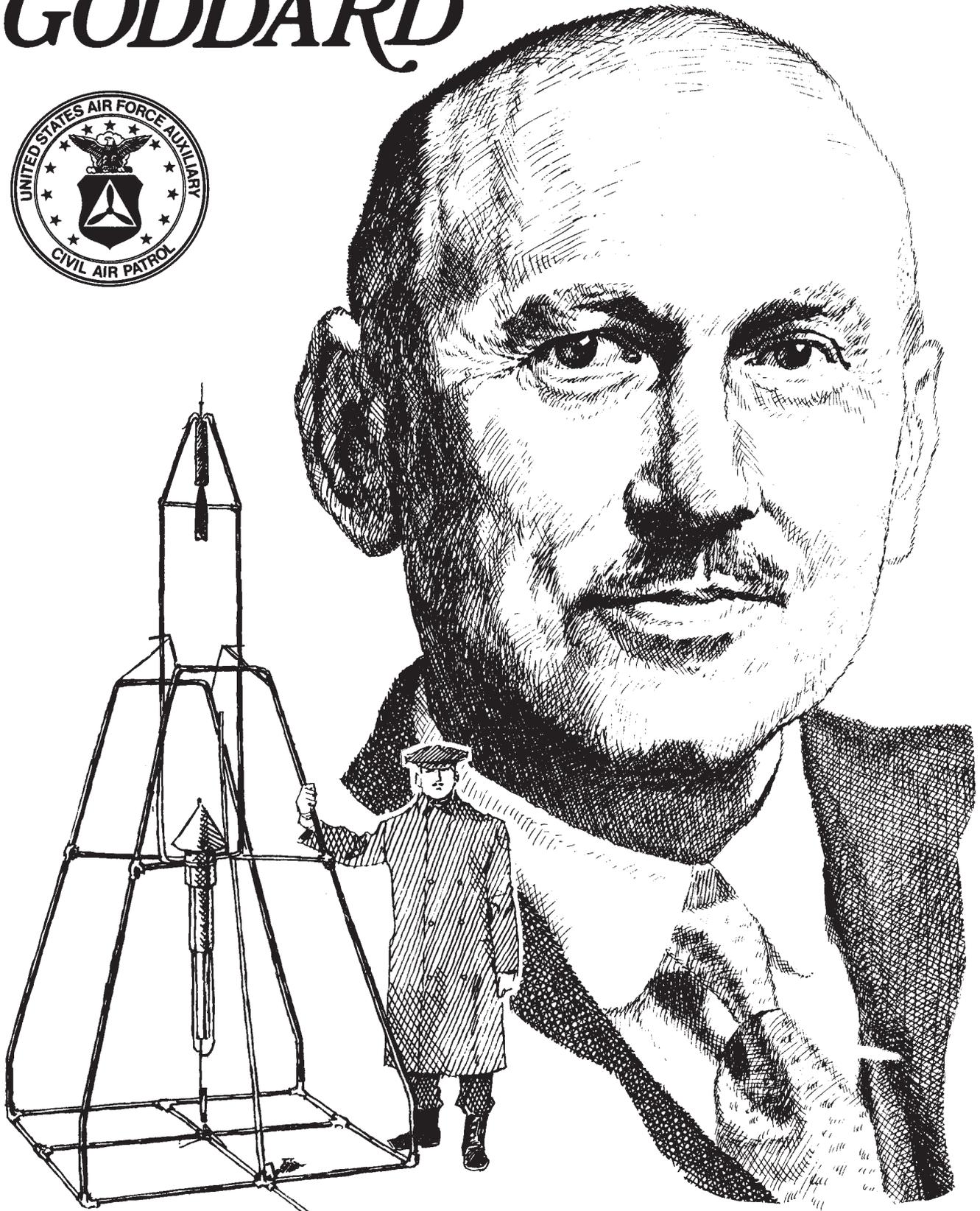


DR. ROBERT H. GODDARD



DOCTOR ROBERT H. GODDARD

LEARNING PACKET

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INTRODUCTION

Since World War II, there has been a need to provide classroom teachers with materials to aid them in teaching about the aerospace world. One area needing such help is the study of people who moved us from Kitty Hawk to the Sea of Tranquility and beyond. The feats of individuals that made history in this or any other field are often misunderstood, ignored, or forgotten after the first notoriety has been achieved.

This aerospace education learning packet contains information about Dr. Robert H. Goddard. During his lifetime, he made many contributions in the field of rocketry.

Dr. Goddard is best remembered for his contributions to liquid-propellant rockets, but he also made many contributions in solid-fuel rocketry. As a youth, he was a frail and sickly boy who was characterized as a dreamer. He loved to read and to experiment in many different scientific areas. He became particularly interested in the physics of rocket flight. Through much personal sacrifice and dedication, he became the world's leading authority on liquid-fuel rockets.

Understanding any subject requires a knowledge of the terminology associated with the subject. A background of the subject's origin and subsequent development is also required. This packet on Dr. Robert H. Goddard provides information in narrative form, and students will experience reinforcement of their knowledge as they complete the various task cards and study the accompanying posters. When used as a visual display, the posters will capture the students' attention and will provide information and motivation as they complete the task cards.

We have compiled this packet to include posters (artwork) and this booklet to assist the teacher. This booklet includes a recommended teaching method and a short text that covers the life of Dr. Robert H. Goddard. Also, there are a materials list, a test with a test key, a student record sheet, student task cards, suggestions for evaluating student activities, an aerospace education achievement award, and sheets of reproducible art.

The recommended teaching method is a list of steps you can take to guide your students down the path toward successful completion of the entire learning packet. You, of course, may diverge from the path any way you see fit. Use your academic discretion to arrive at the desired learning outcome. The materials list tells you what is required to complete each of the tasks. This list will allow you to gather all the materials necessary for the activities.

Also included in this booklet is a test with a test key. If you wish, you may use this evaluation tool as a pretest before the students begin work on their first task. After all tasks have been finished, it may be used again as a posttest to identify gained knowledge. If you use the test, a block is provided on the student record sheet for the scores and dates administered.

The student record sheet gives you and your students a record of their progress through the packet. Students will enter start and finish dates for each of the tasks and will, in return, expect your initialed acceptance of that work in the block provided for your initials plus any comments necessary.

The task cards are designed for study and activities. Each card provides information and instructions for completing a related activity. There are 20 task cards. Subjects covered in the task cards include mathematics, language, spelling, social studies, geography, values clarification, careers, science, health, art, and music.

A list of suggestions is provided which you may find useful in evaluating the work done by your students as they progress through the tasks.

The blank aerospace education achievement award may be copied on the school duplicating machine for presenting to your students.

Sheets of reproducible art are provided for use as transparencies or as handouts.

TEACHING METHOD

PREPARATION

- Cut each task card along the dashed line and glue to a piece of card stock.
 - A student may accomplish this job.
 - The cards will last longer if they are laminated in plastic.
- Provide materials and supplies in a designated place.
 - Materials list is included.
- Display the enclosed posters (artwork) on a bulletin board where they will be visible and can serve as a source of information.
- Make two tagboard packets and label them **SELECT** and **FINISHED**.
 - With this organization, there is less chance of loss. Also, you can quickly see if the cards are being used.
- Write or type the following directions on a 3 x 5 card and tack it between the two tagboard packets.

<p>DIRECTIONS</p> <ol style="list-style-type: none">1. Take a task card from the SELECT packet.2. Enter the date on your record sheet when you start the task. <p style="text-align: center;">AFTER YOU HAVE FINISHED EACH TASK</p> <ol style="list-style-type: none">1. Enter the date on your record sheet.2. Place your work in your folder.3. Place the task card in the FINISHED packet.

- Prepare a personalized folder for each student.
 - Duplicate a copy of the student record sheet for each student.
-

PRESENTATION

- Introduce the bulletin board materials.
 - Explain the information that is provided as part of the display.
- Instruct the students on:
 - The text.
 - How to use the task cards.
 - Where the materials are located.
- Assign task cards or instruct the students to select them in the order of their choice.

- Hand out personalized folders and copies of students' record sheets.

- Explain how to fill out the record sheets.
 - Assign a location for the folders.

- Administer the pretest before the students begin their activities.

- The test key is included.
 - Record the scores on the students' record sheets.

- Inform students of their next assignment.

NOTE: If small groups will be doing the tasks, it is beneficial to have heterogeneous groups with a stronger reader assigned to a weaker reader.

EVALUATION

- Have students bring in their folders during individualized instruction or reading time, conference time, or at some other acceptable time.

- Go over assignments and initial students' record sheets.

- Unacceptable work should be returned for reaccomplishment, completion, or proofreading. Make appropriate comments on the students' record sheets.

- Meet with small groups to evaluate and schedule future plans (skits, etc.). Initial acceptance when appropriate.

- Students may monitor and accept assignments but only with your permission.

- Administer the posttest and record the scores on the students' record sheets.

- Present an Aerospace Education Achievement Award to students who have satisfactorily completed the activities given on the task cards and who have shown a gain in knowledge of Dr. Robert H. Goddard.

DR. ROBERT H. GODDARD

EARLY YEARS

Robert H. Goddard was born on October 5, 1882, in Worcester, Massachusetts. His parents were Nahum D. Goddard and Louise H. Goddard. In 1883, the Goddard family moved to Boston where Nahum found employment with a manufacturer of machine knives. Robert grew up in Roxbury, a suburb of Boston, in a comfortable, quiet, middle-class neighborhood.

At an early age, Robert's father started him thinking about innovative things. This was the time—the 1880s—when new conveniences were coming into use. The Goddards had incandescent lamps and a phonograph, and these new inventions fascinated young Robert. His father took the time to encourage his curiosity by discussing the inventions and by frequently saying, "I wonder what they will think of next?"

Experiments occupied much of Robert's time. His father provided him with all kinds of paraphernalia to "putter" with, including a telescope, a microscope, and a subscription to *Scientific American*. Mr. Goddard also took Robert on long trips to the woods to acquaint him with the wonder and beauty of nature.

YOUNG ADULTHOOD

In 1898, Robert entered high school but he soon had to drop out because of illness. His mother was also very ill—she had tuberculosis. Because of Mrs. Goddard's illness and Robert's poor health, the family moved back to Worcester to live with Robert's grandmother. Eventually, Robert's illness was also diagnosed as tuberculosis and he had to remain out of school for a very long time.

However, learning did not cease for Robert. He was provided with many books on a wide variety of subjects, and he began to educate himself. On an afternoon in October 1899, Robert climbed a cherry tree in his backyard and, for some unknown reason, he began to imagine a "centrifugal-force" device spinning faster and faster as it lifted upward. At this point he began to think seriously about the possibilities of spaceflight. Robert considered this date, October 19, 1899, his "Anniversary Day."

In the fall of 1900, he returned to school but once again he became ill and had to drop out—so, it was back to his personal educational program. During his confinement, Robert read voraciously and was intensely interested in the early experiments in aerodynamics. In September 1901, he was finally well enough to return to high school. He was almost 19 years of age

but he had done a good job of educating himself and therefore mastered the academic requirements quickly. Robert soon became friends with his physics instructor who took extra time to enter into long discussions about "space travel" with him.

COLLEGE AND EARLY EXPERIMENTS

Following his graduation from high school in 1904, Robert enrolled at Worcester Polytechnic Institute. He quickly delved into the sciences with a particular interest in physics. While completing his studies at Worcester, he considered many methods of traveling in space and to the planets—the use of solar power to propel a spacecraft, ion propulsion, and even suspended animation for the occupants of a craft on a long space voyage.

In 1909, Robert entered graduate school at Clark University. He earned his master's degree in 1910 and his doctor of philosophy degree in 1911. While at Clark University, he was fortunate to have Dr. Gordon Arthur Webster as his physics instructor. Doctor Webster was a recognized expert on dynamics and electromagnetism and with his help, Goddard achieved an understanding of Newton's third law of motion. He now understood that spaceflight would have to be by rocket propulsion and that the most efficient propellant for his visionary rocket would be one using liquid hydrogen as the fuel and liquid oxygen as the oxidizer. Doctor Goddard returned to Clark University in the fall of 1911 as an honorary fellow in physics and, after a year at Clark, accepted a fellowship at Princeton University's Palmer Physical Laboratory.

Doctor Goddard became seriously ill in March 1913. He now had tuberculosis in both lungs and his doctors gave little hope that he would survive the attack. But Dr. Goddard was a determined man and he began a program of deep-breathing exercises and other self-treatment techniques. By the spring of 1914, his health had improved remarkably and he was able to resume a more active life.

Even while confined, he continued to work on his ideas for rocketry. He enlisted the help of a friend, Charles T. Hawley, a junior member of a law firm and a patent attorney, to help him apply for patents relative to rocket development. These patents covered the use of a combustion chamber with a nozzle, the feeding of propellants into the combustion chamber, and the principle of the multiple, or step, rocket. Later in the year, he was also granted several more patents covering rocket components and their uses.

In the fall of 1914, Dr. Goddard returned to Clark University to engage in research. He studied the designs of rockets of that time and, working with various propellants, made significant improvements in the efficiency of solid rocket propellants. He also proved that a simple power rocket was much more efficient in a vacuum than in the atmosphere. These experiments were time-consuming and costly. In 1916, Dr. Goddard petitioned the Smithsonian Institution for funds to continue his work and received a \$5,000 grant for atmospheric research.

Worcester Polytechnic Institute allowed Dr. Goddard to use an abandoned magnetic experiments laboratory, and he spent many hours shuttling between his teaching duties at Clark University and the laboratory. When the United States became involved in World War I, the Army showed an interest in his rocketry ideas and agreed to provide \$20,000 toward rocket research. Professor George C. Hale, director of the Mt. Wilson Solar Observatory, offered the Mt. Wilson workshop for Dr. Goddard's research.

At the Mt. Wilson workshop, Dr. Goddard and his assistants worked toward perfecting the idea of multiple-charge rockets—solid-propellant charges fed into the combustion chamber in a manner similar to a rapid-fire gun. They had all kinds of problems. There were minor explosions, fires, and injuries. Even so, progress was made and, at a demonstration firing in September 1918, Army representatives were amazed at the sophistication of Dr. Goddard's single-charge, solid-propellant rockets. Of particular interest was a three-inch rocket fired through a thin steel launching tube. Funds for development were promised but the war ended before the promised support was received. However, the work done by Dr. Goddard would be used twenty years later as the famous bazooka antitank weapon.

Dr. Goddard again returned to Clark University. In January 1920, his monograph, "A Method of Reaching Extreme Altitudes," was published by the Smithsonian Institution, and the newspapers made front-page news of it. Of course, news accounts capitalized on Goddard's speculations for eventual space travel via rockets to the moon, and his serious propositions were ignored. For three years, the "moon rocket" was kept alive much to the detriment of Dr. Goddard's reputation.

In mid 1920, Dr. Goddard began research for the United States Navy. Upon completion of his contract in 1923, he had developed a workable rocket-assisted depth charge and a rocket-propelled, armor-penetrating warhead. The years 1923 and 1924 were highly significant ones for Robert Goddard. In 1923, Dr. Goddard was selected to serve as the head of Clark University's physics department, and on June 21, 1924, Robert Goddard married Esther Kisk.

For the next two years, Dr. Goddard concentrated his research on liquid-propellant rockets, and on March 16, 1926, he tested his first flyable version of the liquid-propellant rocket. The launch was made from a field near Auburn, Massachusetts, on his Aunt Effie's farm and was witnessed by Henry Sacks, Percy Roope, and Mrs. Goddard. The world's first liquid-propellant rocket reached an altitude of only 41 feet above the ground.

Encouraged by the success of this small rocket, Goddard built a rocket 20 times larger. Problems grew with the size of the rocket, and in September 1927, he abandoned the project and resumed work to perfect the smaller version. By 1929, he had developed a rocket that was 11.5 feet long. The new rocket was much more sophisticated and contained a barometer, a thermometer, and a camera. However, repeated test flights were unsuccessful and resulted in bad publicity and restrictions for further testing.

Charles Lindbergh came to Dr. Goddard's rescue. Lindbergh was convinced that Goddard's dreams would become reality and he offered to help him find financial backers to continue his research. They first approached the Du Pont organization, but Dr. Goddard sensed that Du Pont scientists were too inquisitive about the details of the program so nothing came of the meeting. Next, they met with a group representing the Carnegie Foundation and obtained a grant of \$5,000. This was a start but not nearly enough for any real progress. Lindbergh's close association with Harry Guggenheim soon resulted in more financing, and the Guggenheim's special fund for promoting aeronautics made \$50,000 immediately available to Dr. Goddard for a two-year project. An equal amount was promised at the end of that period to fund the project for an additional two years.

GODDARD MOVES TO NEW MEXICO

Seeking a location that had good weather and a low-population density, Dr. Goddard chose Roswell, New Mexico. At that time, Roswell's population was only 11,000, and it had daily railroad service which would facilitate the shipment of any equipment and supplies they might need. The location was ideal for both rocketry experiments and Dr. Goddard's health, so early in August 1930, Dr. Goddard leased the Mescalero Ranch, a spacious house with eight acres of land located three miles northeast of town.

A local man, Mr. Oscar White, offered Dr. Goddard the use of his field for any and all types of rocket-launching activities. To Goddard's amazement, what Mr. White considered a field turned out to be some 16,000 acres. Thus, with a machine shop constructed near the ranch house, a launching tower erected on the field, and all assistants on hand, the rocketry work was ready to go forward. Working without the interruption of other duties, the liquid-propellant rocket was ready for test flight in

December 1930; its performance on December 30 was spectacular. "Nell," as each Goddard rocket came to be known, blasted off and achieved 2,000 feet of altitude plus another 1,000 feet of lateral flight before striking the ground.

He continued to work on the pump mechanism for the propellant and devised a gyroscopic stabilizer that moved vanes to deflect the rocket's exhaust, changing the course of the rocket as necessary. The first gyroscopically stabilized rocket was test-flown on April 19, 1932. It rose from the tower, made a short ascent, and then crashed. However, examination of the wreckage proved conclusively that the new control system had worked. Another try later in the month was also unsuccessful, and this was to be the last test for some time. The United States was at the peak of the Great Depression, and Guggenheim's funds had diminished to a point that the second half of the grant could not be paid.

In the fall of 1932, Dr. Goddard returned to Clark University to teach. He continued working on the centrifugal pump problem and filing for patents on his ideas. During this time, he tried unsuccessfully to interest the Army and Navy in his rockets. In 1933, he received another small grant from the Guggenheim fund. In 1934, the grant was renewed in full. Dr. Goddard returned to New Mexico where he was visited by Charles and Ann Lindbergh. The visitors created much excitement in the area, and Dr. Goddard was especially pleased to be able to show the Lindberghs his rocket facility.

After many static tests, a much larger "Nell" was finally ready to try her improved components. Flight tests began in January 1935, and in March, "Nell" achieved an altitude of 4,800 feet with lateral travel to the point of impact measuring 13,000 feet. On May 31, this altitude was exceeded by 2,700 feet. Although these flights were remarkable achievements, financial backers expected flights of 10 to 20 miles. Dr. Goddard realized that larger rockets and more money were needed to reach higher altitudes.

Meanwhile, German scientists backed by government support, were making rapid progress in rocket development using and improving on Dr. Goddard's research and development. They were developing the air-breathing pulse-jet engine that Dr. Goddard had invented.

Goddard had perfected the gimballed engine flight control and his rockets were becoming more and more sophisticated with each launching. On August 9, 1938, a much larger rocket was launched and worked almost perfectly reaching an altitude of 5,000 feet. Harry Guggenheim and Charles Lindbergh felt that Dr. Goddard had developed his rocket to the point that other scientists should be invited to work toward improving the rocket's elements. Dr. Goddard reluctantly agreed, with the provision that these scientists would work only on components without learning details of the total rocket. Understandably, other scientists were not interested in working on something

they could not see as a whole, and the cooperative venture failed.

In 1939, Lindbergh again visited Dr. Goddard at the Mescalero. He told him of the German's reluctance to discuss rocketry with him—they were quite open and proud of their aircraft, but when asked about rockets, they offered no information. This news, plus the fact that German scientists had stopped making inquiries as to Dr. Goddard's progress, convinced him that the Germans were converting rockets into instruments of war. He was correct.

LAST YEARS

During late 1941 and early 1942, Goddard developed a jet-assisted takeoff (JATO) unit for the U.S. Navy, and in September 1942, the unit was affixed to a Navy PBY seaplane and tests were begun. The haste of the operation concerned Dr. Goddard, but the Navy was in a hurry to get the unit into mass production and operation. On the last of the six tests, the rocket got the plane into the air but it also set the craft on fire. The crew survived, but this was the end of the JATO rocket unit. However, the Navy's disappointment with the JATO was short-lived when Goddard demonstrated a variable thrust unit that could go into an idle phase and return to full thrust as the operator desired. This was the answer to rocket-powered airplanes, and this same type unit was later used to power the X-2 and X-15 aircraft.

In 1943, Dr. Goddard's health began to fail. He continued his work for the Navy but devoted his spare time to patent application and getting his notes of thirty years in order. The most obvious indication of his failing health was the hoarseness of his voice, and medical examination disclosed a growth on his vocal cords. Although his father had died of throat cancer, his doctors did not believe that Dr. Goddard could have cancer and tuberculosis simultaneously. He continued work for two more years. Unable at times to speak, he communicated by written notes or messages tapped out in Morse code.

In 1945, Goddard got the opportunity to examine a German V-2 rocket and to note the striking similarity between it and his rocket. It was obvious that the Germans had gained access to his ideas and had copied them. Financial backing by the German Government had paved the way for their success. Dr. Goddard had tried to get that kind of backing from the United States Government but, because he was so extremely secretive about his research, had been unable to do so. In 1934, he had patented the propulsion unit used by the Germans for their V-1 "Flying Bomb" but no one in the U.S. Government paid any attention to it.

In June 1945, his throat condition worsened and physicians decided to operate. The growth was malignant and it was necessary to remove his larynx. All of this trauma caused a recurrence of the tuberculosis that had plagued him for years, and on August 10, 1945, Dr. Robert H. Goddard died quietly.

MATERIALS LIST

TASK	MATERIALS NEEDED
1. MATHEMATICS	Pencil and paper.
2. MATHEMATICS	Pencil and paper.
3. MATHEMATICS	Pencil, paper, and atlas or map.
4. LANGUAGE	Pencil, paper, and dictionary.
5. LANGUAGE	Pencil and paper.
6. LANGUAGE	Pencil, paper, envelope, and stamp.
7. LANGUAGE	Pencil and paper or VCR camera and player.
8. SPELLING	Pencil, paper, and dictionary or science book.
9. SOCIAL STUDIES	Pencil, paper, and library resources.
10. SOCIAL STUDIES	Pencil, paper, atlas or encyclopedia.
11. SOCIAL STUDIES	Pencil, paper, and the biographical profile.
12. GEOGRAPHY	Colored pencils, paper, and an atlas.
13. VALUES CLARIFICATION	Pencil, paper, poster board, glue, and library resources.
14. VALUES CLARIFICATION	Pencil and paper.
15. CAREERS	Pencil, paper, envelope, stamp, and library resources.
16. SCIENCE	Pencil, paper, and library resources.
17. SCIENCE	Pencil, paper, envelope, and stamp.
18. HEALTH	Pencil, paper, and library resources.
19. ART	Poster board, watercolor paper, and watercolors.
20. MUSIC	Records, record player, pencil, and paper.

TEST

NAME _____ DATE _____

1. In which of the following states was Robert H. Goddard born?
 - a. Utah.
 - b. Maine.
 - c. Indiana.
 - d. Massachusetts.

2. Who invented the liquid-propellant rocket?
 - a. Hermann Oberth.
 - b. Robert H. Goddard.
 - c. Wernher von Braun.
 - d. Konstantin Tsiolkovsky.

3. What is the name of the foundation which helped finance early liquid-propellant rocketry in the United States?
 - a. Ford.
 - b. Smithson.
 - c. Guggenheim.
 - d. Rockefeller.

4. In what year was the first liquid-propellant rocket flown?
 - a. 1903.
 - b. 1926.
 - c. 1932.
 - d. 1945.

5. What is the name of the person who is accepted as the "Father of Modern Rocketry?"
 - a. Robert Goddard.
 - b. Hermann Oberth.
 - c. Wernher von Braun.
 - d. Konstantin Tsiolkovsky.

6. In which of the following states were testing sites for early liquid-propellant rockets located?
 - a. Florida.
 - b. New York.
 - c. New Mexico.
 - d. New Hampshire.

7. What was the disease that affected Robert Goddard's early life?
 - a. Cancer.
 - b. Diabetes.
 - c. Diphtheria.
 - d. Tuberculosis.

8. What was Doctor Goddard's favorite hobby?

- a. Writing.
- b. Painting.
- c. Wood carving.
- d. Horseback riding.

9. Newspapers ridiculed Dr. Goddard in 1920 because he had mentioned a flight to

- a. Mars.
- b. the moon.
- c. other galaxies.
- d. the outer planets.

10. Why was Dr. Goddard's "Anniversary Day" important to him?

- a. He graduated from college.
- b. He launched his first rocket.
- c. He developed the liquid-propellant rocket.
- d. He began to think seriously about space travel.

TEST KEY

1. d
2. b
3. c
4. b
5. a
6. c
7. d
8. b
9. b
10. d

STUDENT RECORD SHEET

ROBERT GODDARD

BY

STUDENT'S NAME _____

	Started	Finished	Comments	Initials
Task 1—MATHEMATICS				
Task 2—MATHEMATICS				
Task 3—MATHEMATICS				
Task 4—LANGUAGE				
Task 5—LANGUAGE				
Task 6—LANGUAGE				
Task 7—LANGUAGE				
Task 8—SPELLING				
Task 9—SOCIAL STUDIES				
Task 10—SOCIAL STUDIES				
Task 11—SOCIAL STUDIES				
Task 12—GEOGRAPHY				
Task 13—VALUES CLARIFICATION				
Task 14—VALUES CLARIFICATION				
Task 15—CAREERS				
Task 16—SCIENCE				
Task 17—SCIENCE				
Task 18—HEALTH				
Task 19—ART				
Task 20—MUSIC				

Pretest Score: _____	Date: _____	Posttest Score: _____	Date: _____
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STUDENT TASK CARDS

TASK 1—MATHEMATICS

Charles Lindbergh was Dr. Goddard's friend and he helped him get the money he needed for his rocket research and development program. They visited the Du Pont organization, the Carnegie Foundation, and finally Daniel Guggenheim in search of funds.

Guggenheim granted him \$50,000 for the first two years of the program and another \$50,000 for an additional two years.

If you had a job earning \$250 a week take-home pay and you work a 40-hour week, how many weeks would it take you to earn (a) \$1,000, (b) \$10,000, (c) \$50,000?

PLACE YOUR WORK IN YOUR FOLDER. DATE YOUR RECORD SHEET.

TASK 2—MATHEMATICS

Of the twentieth century explorers, Dr. Goddard was among the boldest. He was dedicated to a mission so complex that teams of scientists, technicians, and mechanics were needed to accomplish it.

On March 17, 1926, Dr. Goddard launched the world's first liquid-fuel rocket. It was a crude assembly of pipes and chambers which rose only 41 feet into the air before crashing back to Earth. In December 1930, near Roswell, N. Mex., a new and improved rocket was test-fired. This rocket ascended 2,000 feet above the prairie before descending to the drylands a half-mile away.

1. How many years elapsed between the rocket launchings described above? How many months?
2. Was the ascent of the first rocket greater or less than that of the second rocket? By how many feet?
3. Did the vertical flight of the second rocket exceed or fall short of the distance of its horizontal flight? By how many feet?

PLACE YOUR WORK IN YOUR FOLDER. DATE YOUR RECORD SHEET.

TASK 3—MATHEMATICS

An intercontinental ballistic missile travels between 200 and 300 miles a minute in its high trajectory. Supposing speeds of this magnitude were possible on the surface of the Earth, use a recent atlas or map and figure out how long it would take to travel from New York to New Orleans, Louisville to Minneapolis, Cincinnati to Kansas City, and Los Angeles to Miami at (1) 200 miles per minute and (2) 300 miles per minute.

PLACE YOUR WORK IN YOUR FOLDER. DATE YOUR RECORD SHEET.

TASK 4—LANGUAGE

The *design* and operation of today's *rockets* and *spacecraft* are the result of long years of study and many experiments. There were *disappointments*, *tragedies*, and *failures* along the way but hard work, *research*, and the *desire* to *conquer* the *unknown* led to steady *progress*.

World War II and the German V-2 missiles stepped up the *development* of rockets, but rocketry really came into its own when the world *realized* the *unlimited* benefits which could result from the *exploration* of space.

Using your dictionary, look up ten of the italicized words. Write the words and their meanings on a sheet of paper. Use each of the words in a sentence.

PLACE YOUR WORK IN YOUR FOLDER. DATE YOUR RECORD SHEET.

TASK 5—LANGUAGE

Robert and his father were great pals. When he was 13, his father took him on a summer trip to Worcester, Mass. It was Robert's first experience in the country. The beauty of the woods and his interest in the wildlife made a deep and lasting impression on Robert.

Write two paragraphs about a trip to the country or a summer vacation trip you and your family have taken. Describe anything that happened to make the trip a lasting memory.

PLACE YOUR WORK IN YOUR FOLDER. DATE YOUR RECORD SHEET.

TASK 6—LANGUAGE

Dr. Goddard died before the National Aeronautics and Space Administration was created. To honor his memory, NASA, in the late 1950s, built The Goddard Space Flight Center 10 miles northeast of Washington, D.C.

Write a letter to the center asking what the center's role is in spaceflight. Be sure to format the letter properly.

The Goddard Space Flight Center
Greenbelt, Maryland 20771

PLACE YOUR WORK IN YOUR FOLDER. DATE YOUR RECORD SHEET.

TASK 7—LANGUAGE

Pretend you are a newspaper or television reporter. Choose a point in the life of Dr. Goddard that interests you and pretend you are interviewing him. You will have to pretend to be both the reporter and Dr. Goddard or have a friend play one of the parts.

Write down the questions and answers or if you have access to a VCR camera, record the interview and play it back to the class.

PLACE YOUR WORK IN YOUR FOLDER. DATE YOUR RECORD SHEET.

TASK 8—SPELLING

The following words or phrases all have definitions relating to space travel, rockets, or rocket propellants:

- | | |
|-----------------------|-------------------|
| 1. hydrogen | 8. radiation |
| 2. oxygen | 9. ionosphere |
| 3. gimbal | 10. atmosphere |
| 4. combustion chamber | 11. atomic energy |
| 5. gyroscope | 12. thrust |
| 6. nozzle | 13. lift-off |
| 7. solar energy | |

Look the words up in your dictionary or science book and study their meanings and how to spell them. When you are ready, have a friend test you. Write your answers on a sheet of paper.

PLACE YOUR WORK IN YOUR FOLDER. DATE YOUR RECORD SHEET.

TASK 9—SOCIAL STUDIES

Robert Goddard was born in Worcester, Mass. When he was very young, he and his family moved to Boston. Boston is a city rich in history—the famous “Boston Tea Party” is one example.

Go to your school or community library and look up Boston in an encyclopedia, a geography book, or a history book. Make a report to your class telling of Boston’s location, main industry, points of interest, and any facts of historical significance that you may have uncovered in your research.

PLACE YOUR WORK IN YOUR FOLDER. DATE YOUR ANSWER SHEET.

TASK 10—SOCIAL STUDIES

From the solitude of the prairies of New Mexico, Dr. Goddard conducted many experiments in rocketry. The climate in New Mexico was ideal for his rocketry experiments.

Look up New Mexico in an encyclopedia or atlas. In what part of the United States is it located? What climatic conditions would be most general? Why was this a good area for Dr. Goddard to conduct his experiments?

PLACE YOUR WORK IN YOUR FOLDER. DATE YOUR ANSWER SHEET.

TASK 11—SOCIAL STUDIES

The “Father of Rocketry,” as Dr. Goddard came to be known, began his scientific experiments at an early age. On October 19, 1899, he began to think seriously about the possibility of travel into space. He always referred to that day as “Anniversary Day.”

Dates played an important part in Dr. Goddard’s life story. Read the biographical profile and tell what important events took place on the following dates:

1. June 21, 1924.
2. March 16, 1926.
3. April 19, 1932.
4. August 9, 1938.
5. August 10, 1945.

PLACE YOUR WORK IN YOUR FOLDER. DATE YOUR RECORD SHEET.

TASK 12—GEOGRAPHY

Dr. Goddard spent most of his lifetime in Massachusetts and New Mexico. Draw an outline map of the United States and place New Mexico and Massachusetts in their proper locations. Show the state capitals, major rivers, and population densities of the two states.

PLACE YOUR WORK IN YOUR FOLDER. DATE YOUR RECORD SHEET.

TASK 13—VALUES CLARIFICATION

The Smithsonian Institution published a report by Dr. Goddard entitled “A Method of Reaching Extreme Altitudes.” In this report, he casually mentioned a lunar landing.

Dr. Goddard received his author’s copies of the report on January 3, 1920. Nine days later on January 12, 1920, Dr. Goddard and his “theory” were front-page news. The headlines read: “Modern Jules Verne Invents Rocket to the Moon,” “Aim to Reach the Moon with New Rocket,” and “Claim Moon May Soon be Reached.” These headlines mocked Dr. Goddard’s dream of eventual space travel and caused him embarrassment for many years to come.

Look up the term *sensationalism* in your dictionary. Can you find examples of this in your daily newspaper? Is it considered a responsible method for reporting the news? Make a report to your class on your findings. Cut headlines from newspapers and glue them on poster board as illustrations for your talk.

PLACE YOUR WORK IN YOUR FOLDER. DATE YOUR RECORD SHEET.

TASK 14—VALUES CLARIFICATION

Esther Goddard, Dr. Goddard’s wife, was an eager worker in civil organizations. She was active in the Roswell Music Association, the Women’s Club, and the Shakespeare Club. She founded a book club and also won a writing contest.

Dr. Goddard loved to read mystery stories for relaxation. He also enjoyed good jokes, good cigars, and painting the colorful landscape of New Mexico.

It is important that each of us have recreational outlets and hobbies. Write down some of your hobbies and recreational pursuits. Do you enjoy them with your family or do you do these things alone? Why do you think these activities are important?

PLACE YOUR WORK IN YOUR FOLDER. DATE YOUR RECORD SHEET.

TASK 15—CAREERS

The fields of rocketry, space research, space travel, and exploration offer a wide variety of career opportunities. There are engineering jobs, jobs for scientists and astronauts, and jobs for computer specialists, to name only a few.

Go to your school or community library and research rockets and space exploration. Write to the National Aeronautics and Space Administration, Washington D.C. 20546, and ask for information about career opportunities.

Make a list of all the careers you gather information about. Choose one of these careers and pretend that you are presently "on the job." Give a report to the class telling why you chose your career, some of the things which make your job an interesting one, and the opportunities available for others to enter your career field.

PLACE YOUR WORK IN YOUR FOLDER. DATE YOUR RECORD SHEET.

TASK 16—SCIENCE

From early manhood, Dr. Goddard dreamed of man being able to journey beyond the Earth. He performed calculations to prove that space exploration was possible.

Today, the exploration of space is a reality and plans are underway for even more distant journeys to the outer planets.

Using science books, NASA publications, or periodicals containing accounts of ventures into space, read about the Apollo program. When you have finished your research, make a report to the class. What was the name of the rocket used to boost the Apollo capsule into space? How did the astronauts maneuver the craft? How was the landing on the moon's surface accomplished? What did the astronauts find on the surface of the moon? Include these and other facts in your report.

PLACE YOUR WORK IN YOUR FOLDER. DATE YOUR RECORD SHEET.

TASK 17—SCIENCE

Have you ever wanted to launch a rocket? There are many rocket clubs sponsored by schools, churches, and scout troops. Estes Industries produces rockets for these clubs and a newsletter for educators. Write the company and ask for information on model rocketry.

Estes Industries
1295 H Street
Penrose, CO 81240

PLACE YOUR WORK IN YOUR FOLDER. DATE YOUR RECORD SHEET.

TASK 18—HEALTH

Robert Goddard and his mother both suffered from a disease called tuberculosis. Robert had to drop out of school because of his illness.

Look up tuberculosis in an encyclopedia or a dictionary and answer the following questions: (1) How does tuberculosis affect the patient? (2) What organs of the body are affected most? (3) Is it a communicable disease? (4) Can tuberculosis be cured?

PLACE YOUR WORK IN YOUR FOLDER. DATE YOUR RECORD SHEET.

TASK 19—ART

One of Dr. Goddard's friends in New Mexico was Peter Hurd, an artist. They went on painting expeditions together. Dr. Goddard loved the contrasts of New Mexican color and became totally immersed in his surroundings when painting a landscape. Painting with oils and watercolors was Dr. Goddard's favorite hobby. Maybe it will become yours also.

Using poster board or art board and watercolors, paint your version of a New Mexican landscape.

Display your painting and compare it with others done by your classmates.

PLACE YOUR WORK IN YOUR FOLDER. DATE YOUR RECORD SHEET.

TASK 20—MUSIC

Dr. Goddard was a mild-mannered man who enjoyed the companionship of close friends, especially at holiday times.

On Christmas Eve, the Goddards gathered their friends around them and exchanged funny gifts. Dr. Goddard would lead the group in singing Christmas carols.

Find music that was popular during Dr. Goddard's lifetime. Listen to the music. Do you like it? If so, why; and if not, why? How does it compare to present-day music?

PLACE YOUR WORK IN YOUR FOLDER. DATE YOUR RECORD SHEET.

SUGGESTIONS FOR EVALUATING STUDENT ACTIVITIES

TASK 1—MATHEMATICS

- Four weeks.
- Forty weeks.
- Two hundred weeks.

TASK 2—MATHEMATICS

- Four years; 57 months.
- Less; 1,959 feet.
- Fell short of; 3,280 feet.

TASK 3—MATHEMATICS

New York—New Orleans.

$$1,350 \div 200 = 6.75 \text{ min.}$$

$$1,350 \div 300 = 4.50 \text{ min.}$$

Louisville—Minneapolis.

$$720 \div 200 = 3.60 \text{ min.}$$

$$720 \div 300 = 2.40 \text{ min.}$$

Cincinnati—Kansas City.

$$449 \div 200 = 2.25 \text{ min.}$$

$$449 \div 300 = 1.50 \text{ min.}$$

Los Angeles—Miami.

$$1,470 \div 200 = 7.35 \text{ min.}$$

$$1,470 \div 300 = 4.90 \text{ min.}$$

Accept answers that are close—maps may vary slightly in mileage.

TASK 4—LANGUAGE

design—a preliminary sketch or outline showing the main features of something to be executed.

rockets—jet engines that consist essentially of a combustion chamber and an exhaust nozzle, carries either liquid or solid propellants, used primarily as a propulsion unit or weapon.

spacecraft—a manned or unmanned device designed to orbit the Earth or to travel beyond the Earth's atmosphere.

disappointments—frustrations, failing to meet the expectations or hope of.

tragedies—misfortunes; calamities; disastrous events.

failures—lack of success; falling short of the expected result.

research—careful or diligent search; studious inquiry or examination.

desire—the longing or hoping for.

conquer—to gain mastery over or win by overcoming obstacles.

unknown—something yet to be discovered, identified, or clarified.

progress—a gradual betterment.

development—the act, process, or result of developing.

realized—became fully aware of.

unlimited—unrestricted; boundless, infinite.

exploration—the act of penetrating or ranging for purposes of discovery.

TASK 5—LANGUAGE

Evaluate composition and creativity.

TASK 6—LANGUAGE

Evaluate the letter and the results.

TASK 7—LANGUAGE

Look for basic journalistic questions of who, what, where, when, etc.

TASK 8—SPELLING

hydrogen—a colorless, odorless highly flammable gas.

oxygen—a colorless, odorless gas in the atmosphere (often involved in combustion processes).

gimbal—a device that permits a body to incline freely in all directions or suspends it so that it remains level when its support is tipped.

combustion chamber—a chamber in a gas turbine or jet engine in which combustion occurs.

gyroscope—device consisting of a wheel mounted so that its spinning axis is free to rotate about either of two other axes perpendicular to itself and to each other; once set in rotation, its axle will maintain a constant direction, even when the Earth is turning under it.

nozzle—a part of a rocket engine that accelerates the exhaust gases from the combustion chamber to a high velocity.

solar energy—the energy that can be obtained in the form of heat and power from the sun's radiation.

radiation—the process of emitting radiant energy in the form of waves or particles.

ionosphere—the part of Earth's atmosphere beginning at an altitude of about 25 miles and extending outward 250 miles or more.

atmosphere—the whole mass of air surrounding the Earth.

atomic energy—energy that can be liberated by changes in the nucleus of an atom.

thrust—the forward directed reaction force produced by a high speed of fluid discharged rearward from a nozzle.

lift-off—the initial motion of a space vehicle or ballistic missile as it rises from the launch stand under rocket propulsion; the takeoff.

TASK 9—SOCIAL STUDIES

Evaluate the presentation, composition, and creativity.

TASK 10—SOCIAL STUDIES

Evaluate composition and creativity.

TASK 11—SOCIAL STUDIES

1. June 21, 1924—married Esther Kisk.
2. March 16, 1926—tested first liquid-propellant rocket.
3. April 19, 1932—first gyrostabilized rocket flown.
4. August 9, 1938—larger, more sophisticated “Nell” launched.
5. August 10, 1945—death of Dr. Goddard.

TASK 12—GEOGRAPHY

Evaluate the maps on neatness and attention to detail.

TASK 13—VALUES CLARIFICATION

Evaluate the project on creativity, content, neatness, and detail.

TASK 14—VALUES CLARIFICATION

Evaluate composition and creativity.

TASK 15—CAREERS

Evaluate the letter, results, and presentation.

TASK 16—SCIENCE

Evaluate composition and creativity.

TASK 17—SCIENCE

Evaluate the letter and results.

TASK 18—HEALTH

Tuberculosis (TB) is a communicable disease of humans and animals caused by the microorganism, *Mycobacterium tuberculosis*. Ninety percent of the cases of TB involve the lungs; however, practically any organ of the body is susceptible to the organism. Age, sex, race, and location of the disease can affect the type of symptoms displayed. These symptoms can include—fatigue, irritability, weight loss, fever, shortness of breath, wheezing, and indigestion. This disease can be cured using general medical and hygienic care, chemotherapy and surgery. There is no quick cure for tuberculosis. Treatment may go on for months and even years before the patient is free of the disease.

TASK 19—ART

Evaluate the creativity and effort that went into the painting.

TASK 20—MUSIC

Evaluate the music selected and the answers to the questions.

AEROSPACE EDUCATION ACHIEVEMENT AWARD



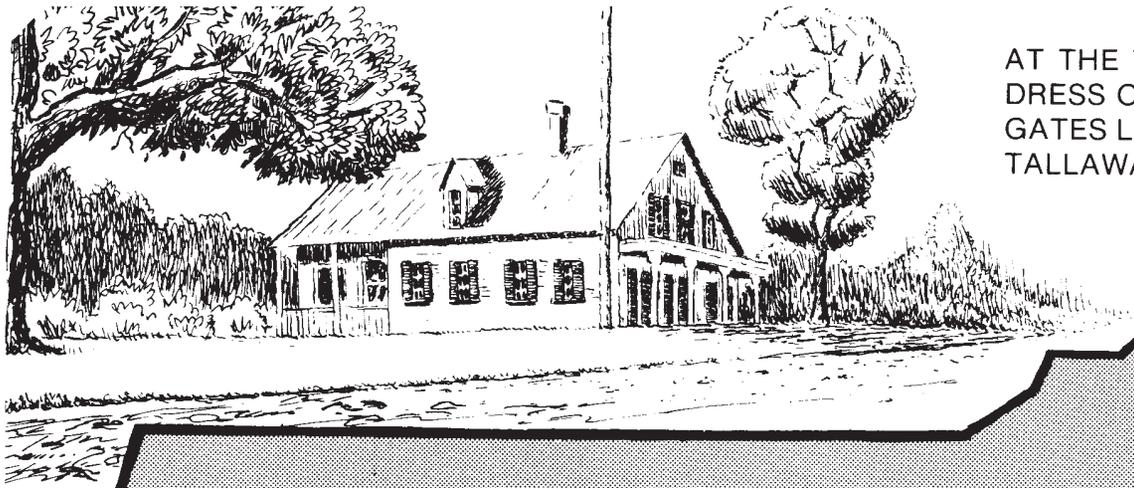
has successfully completed
THE AEROSPACE EDUCATION LEARNING PACKET ON
DOCTOR
ROBERT H. GODDARD

Given this _____ day of _____ 19____

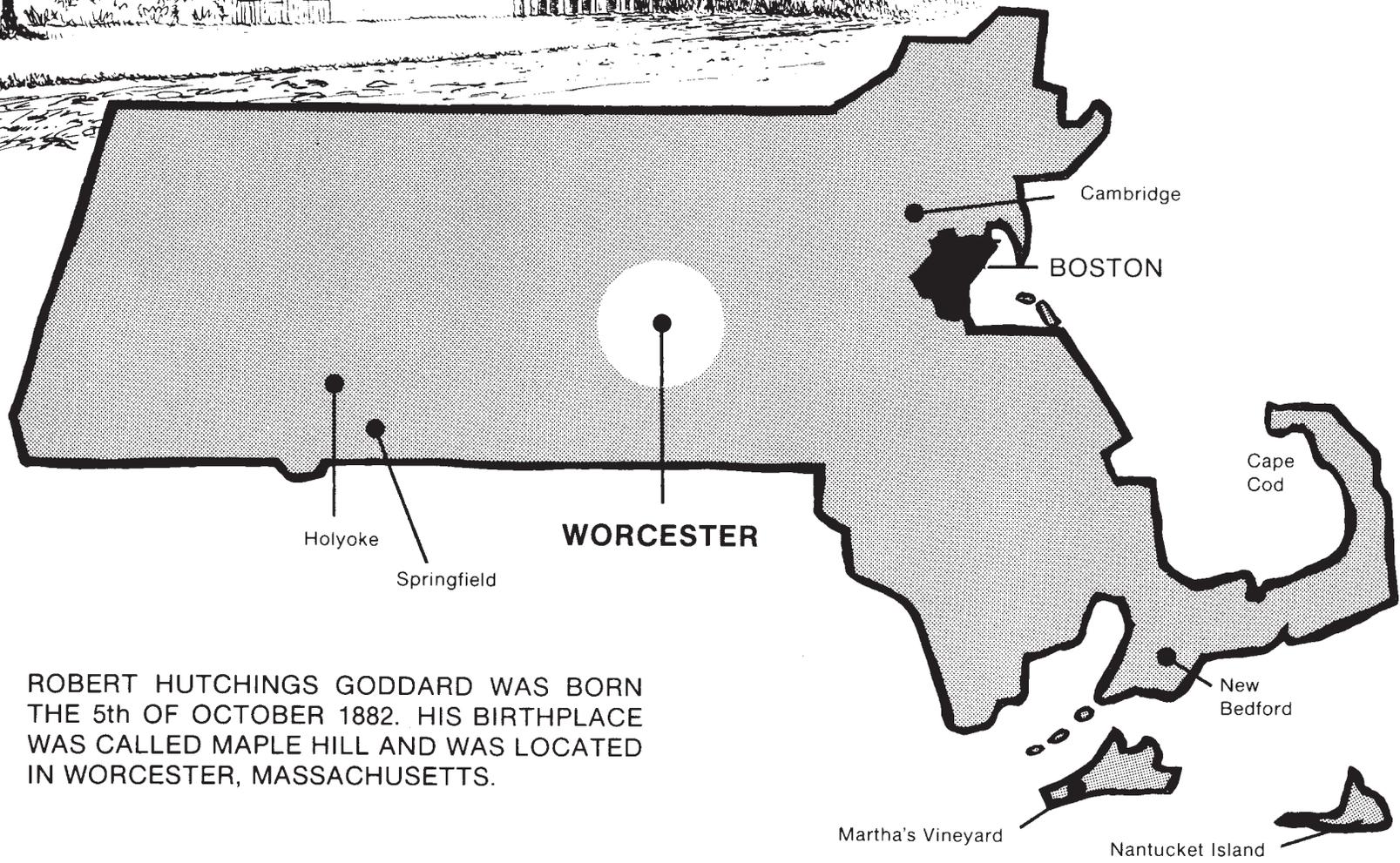
Teacher



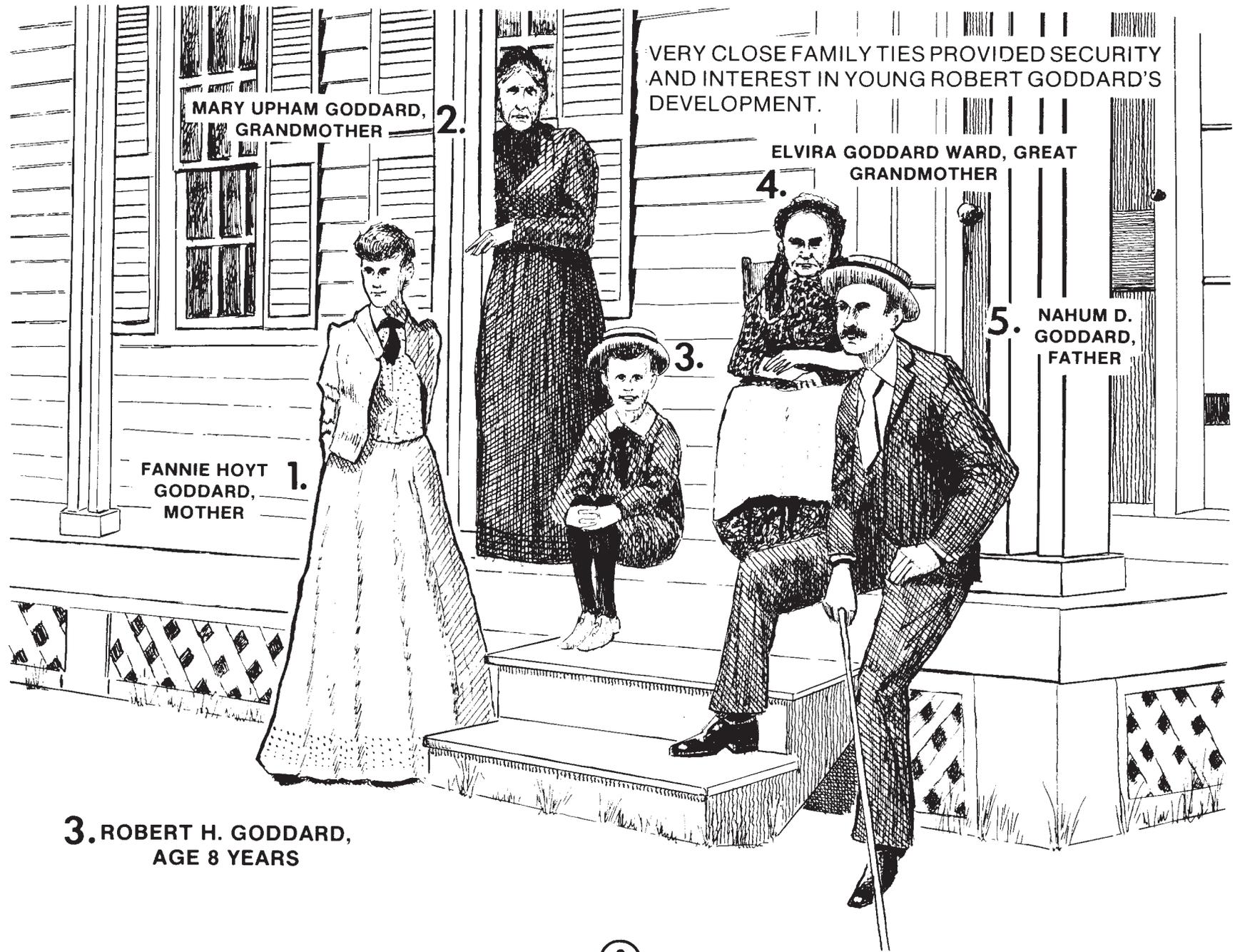
Principal



AT THE TIME OF HIS BIRTH, THE ADDRESS OF THE GODDARD HOME WAS GATES LANE. IT IS NOW KNOWN AS #1 TALLAWANDA DRIVE.



ROBERT HUTCHINGS GODDARD WAS BORN THE 5th OF OCTOBER 1882. HIS BIRTHPLACE WAS CALLED MAPLE HILL AND WAS LOCATED IN WORCESTER, MASSACHUSETTS.



**MARY UPHAM GODDARD,
GRANDMOTHER**

2.

VERY CLOSE FAMILY TIES PROVIDED SECURITY
AND INTEREST IN YOUNG ROBERT GODDARD'S
DEVELOPMENT.

**ELVIRA GODDARD WARD, GREAT
GRANDMOTHER**

4.

**5. NAHUM D.
GODDARD,
FATHER**

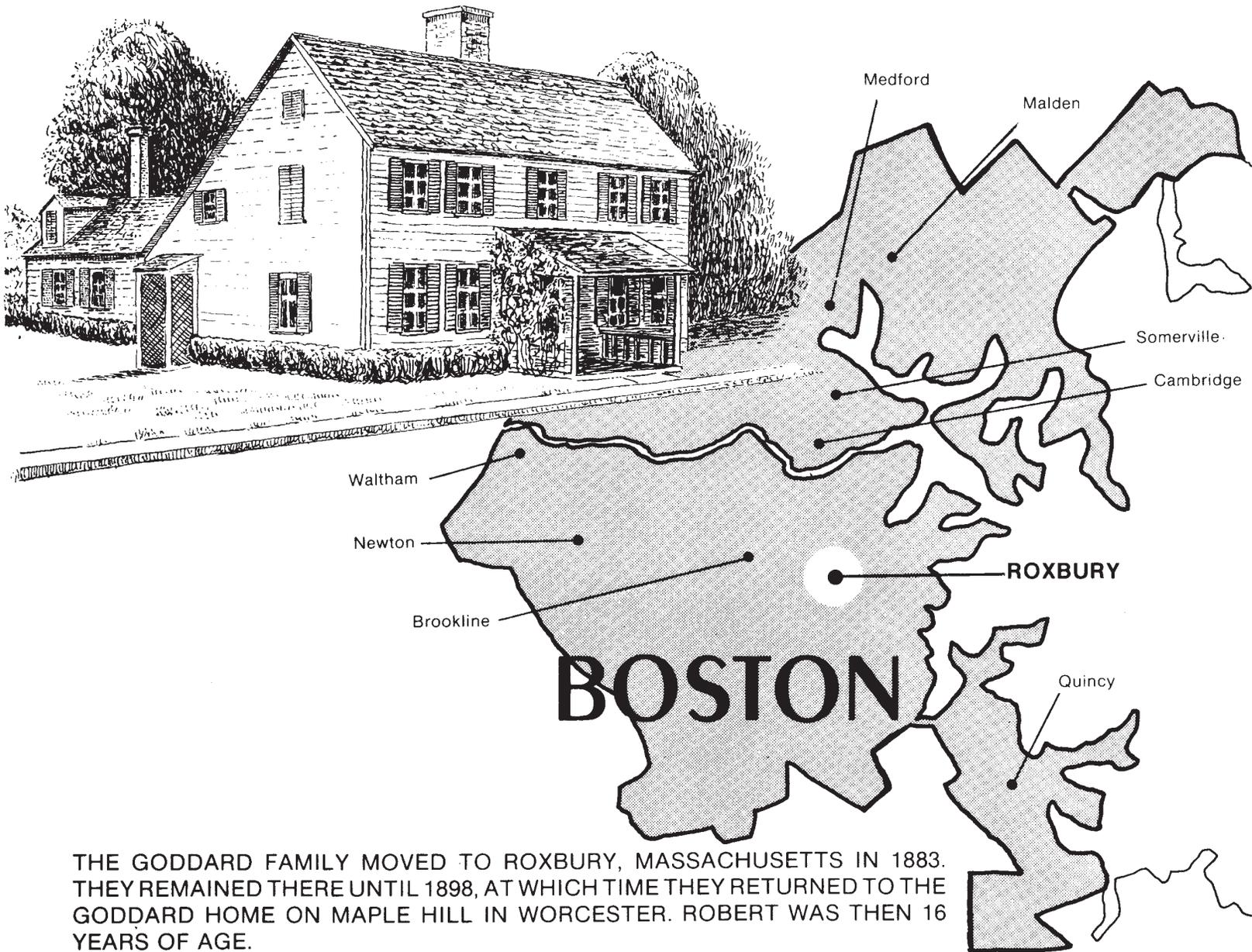
5.

**FANNIE HOYT
GODDARD,
MOTHER**

1.

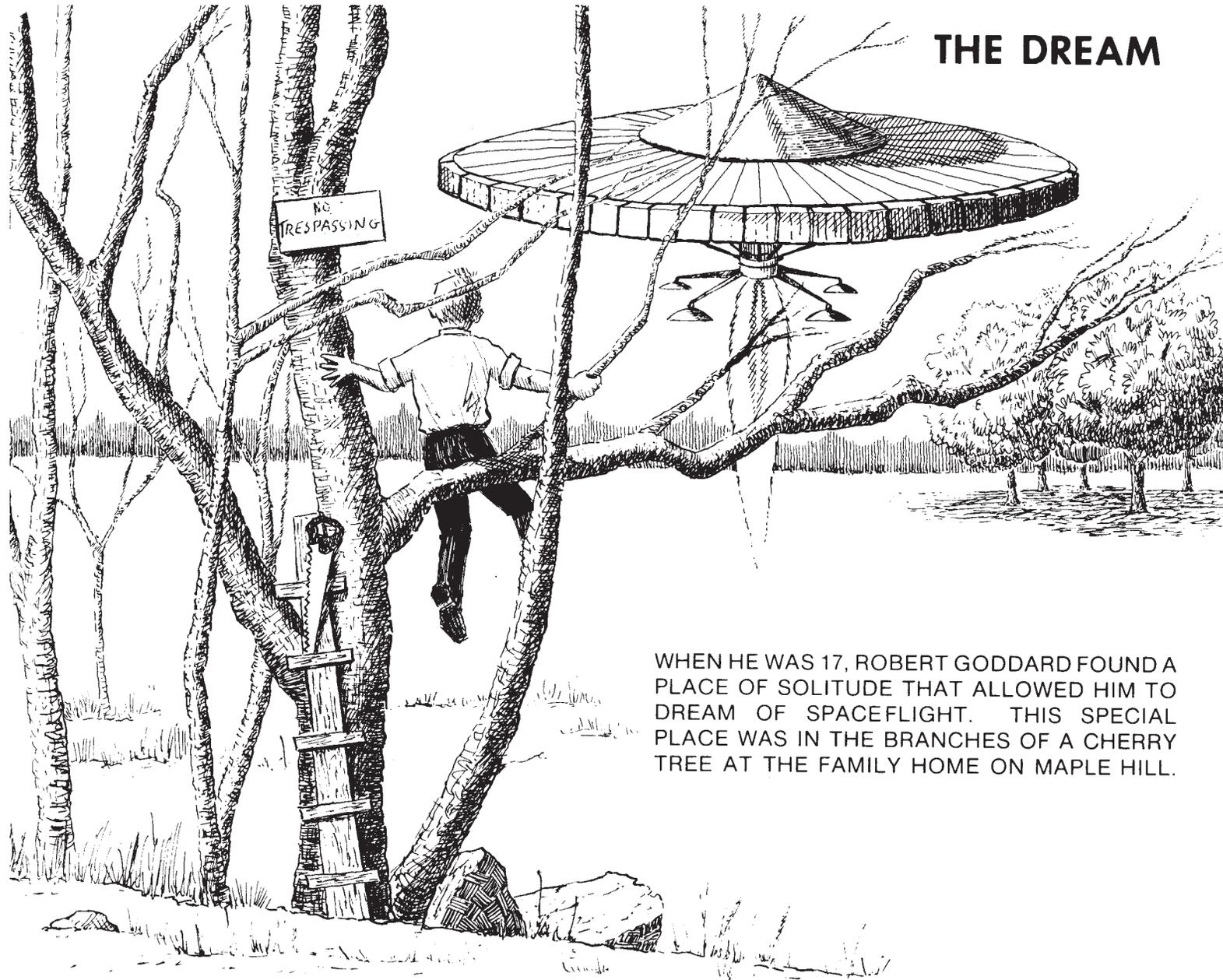
3.

**3. ROBERT H. GODDARD,
AGE 8 YEARS**



THE GODDARD FAMILY MOVED TO ROXBURY, MASSACHUSETTS IN 1883. THEY REMAINED THERE UNTIL 1898, AT WHICH TIME THEY RETURNED TO THE GODDARD HOME ON MAPLE HILL IN WORCESTER. ROBERT WAS THEN 16 YEARS OF AGE.

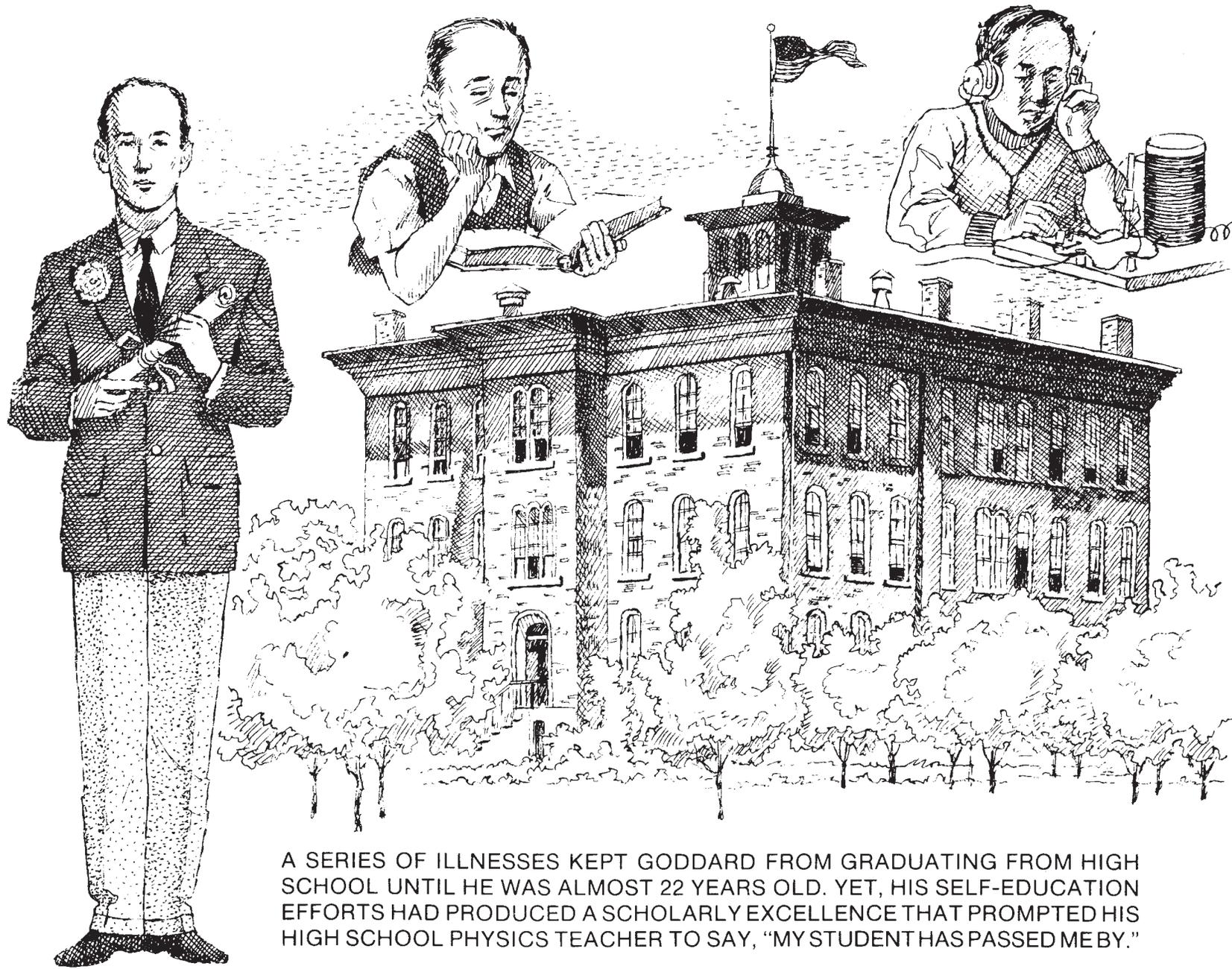
THE DREAM



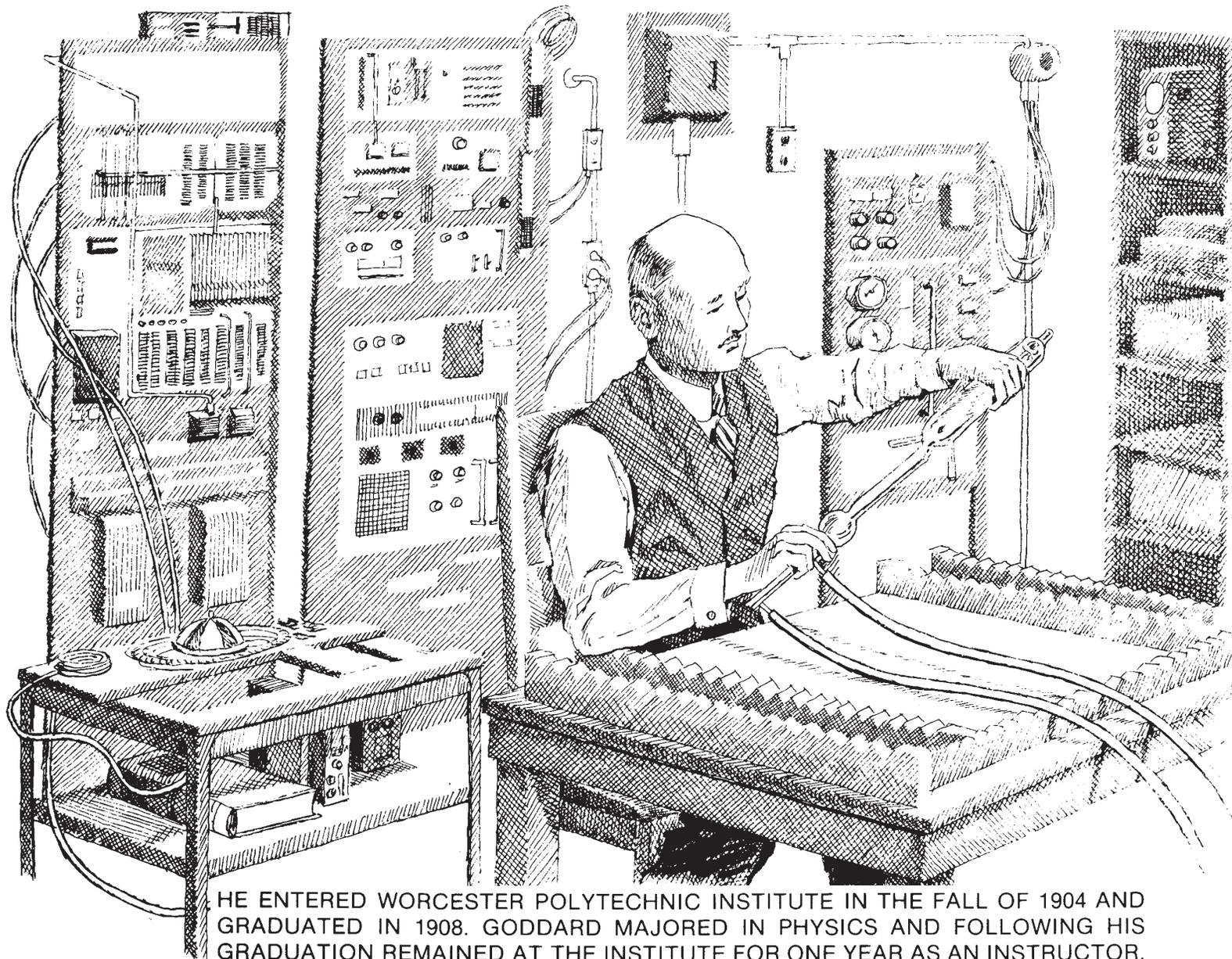
WHEN HE WAS 17, ROBERT GODDARD FOUND A PLACE OF SOLITUDE THAT ALLOWED HIM TO DREAM OF SPACEFLIGHT. THIS SPECIAL PLACE WAS IN THE BRANCHES OF A CHERRY TREE AT THE FAMILY HOME ON MAPLE HILL.

ROBERT GODDARD WAS DESCRIBED AS A "FRAIL BOY," VERY SUBJECT TO ILLNESS. THIS TRAIT FORCED HIM TO DROP OUT OF SCHOOL FOR LONG PERIODS OF TIME BUT HE CONTINUED TO LEARN ON HIS OWN BY READING AND EXPERIMENTING.





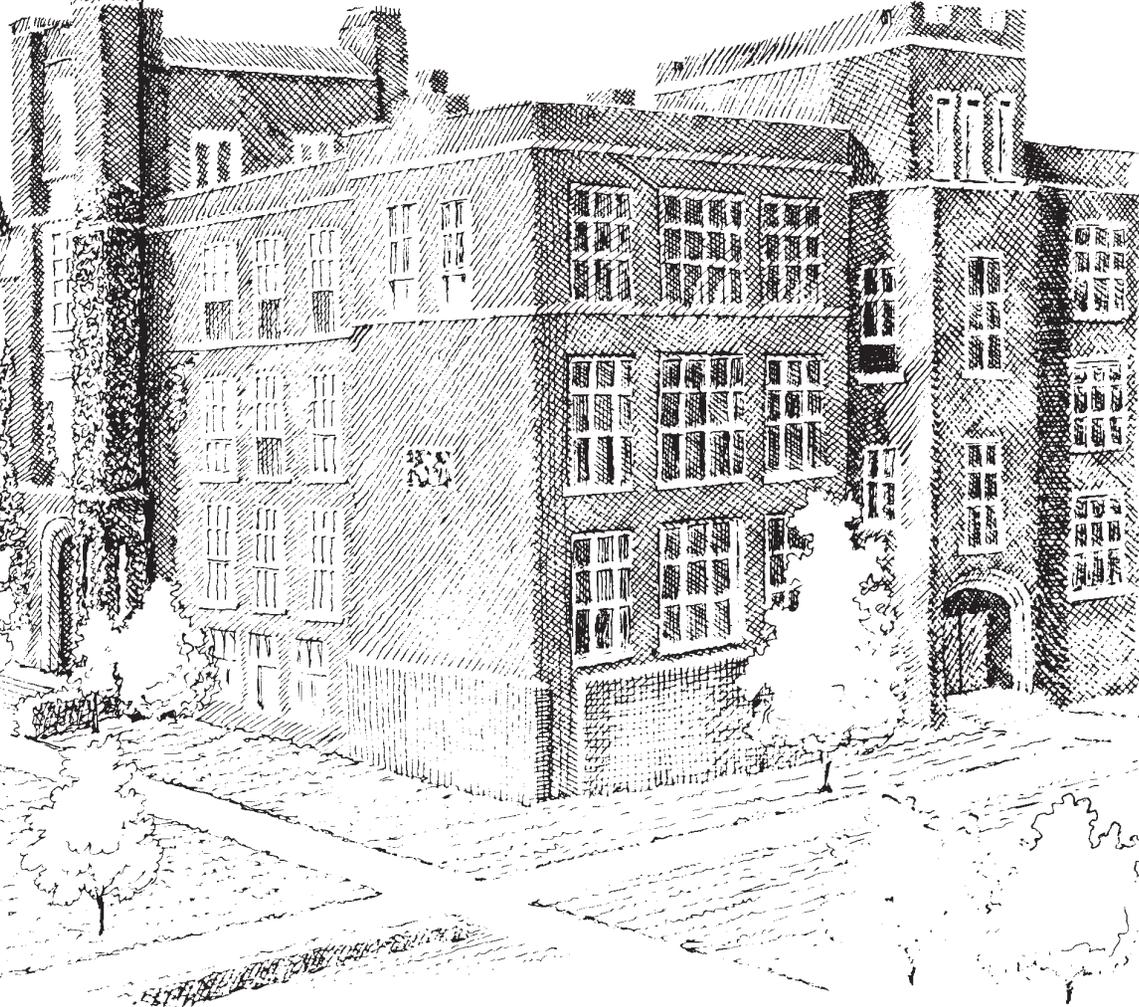
A SERIES OF ILLNESSES KEPT GODDARD FROM GRADUATING FROM HIGH SCHOOL UNTIL HE WAS ALMOST 22 YEARS OLD. YET, HIS SELF-EDUCATION EFFORTS HAD PRODUCED A SCHOLARLY EXCELLENCE THAT PROMPTED HIS HIGH SCHOOL PHYSICS TEACHER TO SAY, "MY STUDENT HAS PASSED ME BY."

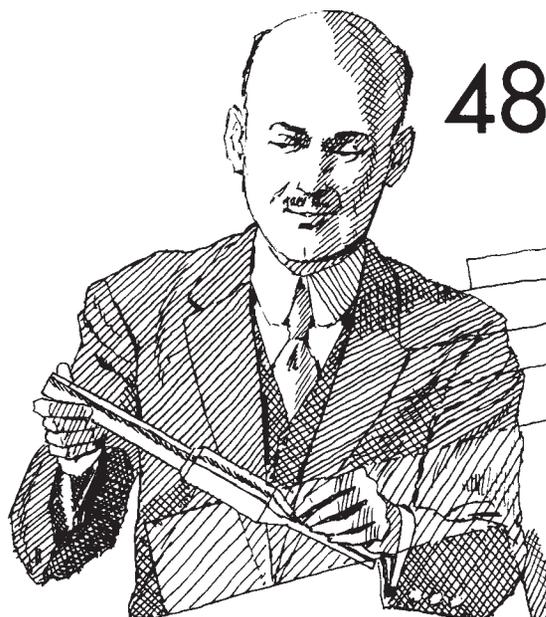


HE ENTERED WORCESTER POLYTECHNIC INSTITUTE IN THE FALL OF 1904 AND GRADUATED IN 1908. GODDARD MAJORED IN PHYSICS AND FOLLOWING HIS GRADUATION REMAINED AT THE INSTITUTE FOR ONE YEAR AS AN INSTRUCTOR.



GODDARD ENTERED CLARK UNIVERSITY IN 1909 WHERE HE EARNED A MASTER OF SCIENCE DEGREE (M.S.) IN 1910 AND THE DEGREE OF DOCTOR OF PHILOSOPHY (Ph.D.) IN 1911. EXCEPT FOR A ONE-YEAR RESEARCH FELLOWSHIP AT PRINCETON UNIVERSITY (1912-1913), HE REMAINED IN CLOSE ASSOCIATION WITH CLARK UNIVERSITY THROUGHOUT HIS LIFE.

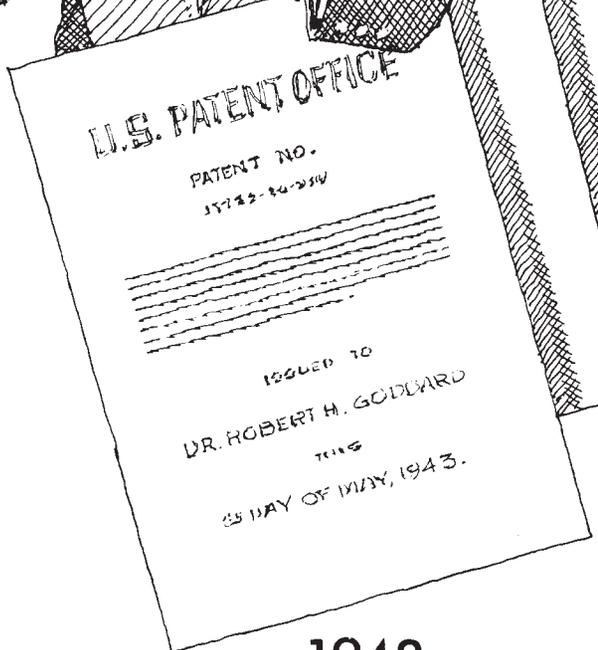




48



1914



1943

+166



FORTY-EIGHT PATENTS WERE ISSUED TO DOCTOR GODDARD DURING HIS LIFETIME--THE FIRST IN 1914 AND THE LAST IN 1943. AFTER HIS DEATH, HIS WIFE, ESTHER C. GODDARD, APPLIED FOR AND RECEIVED 166 MORE PATENTS.

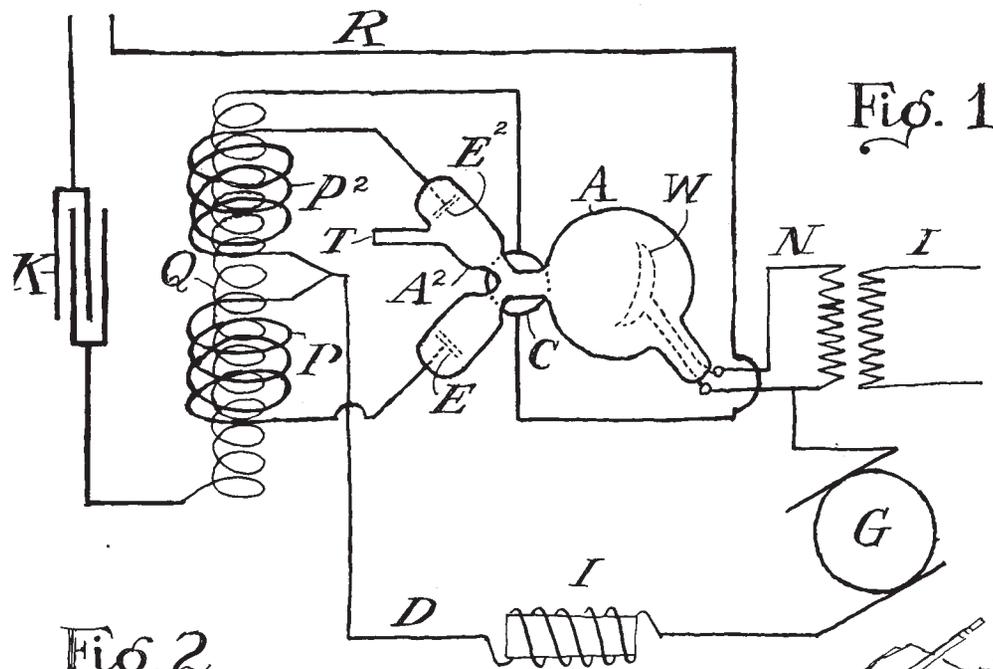
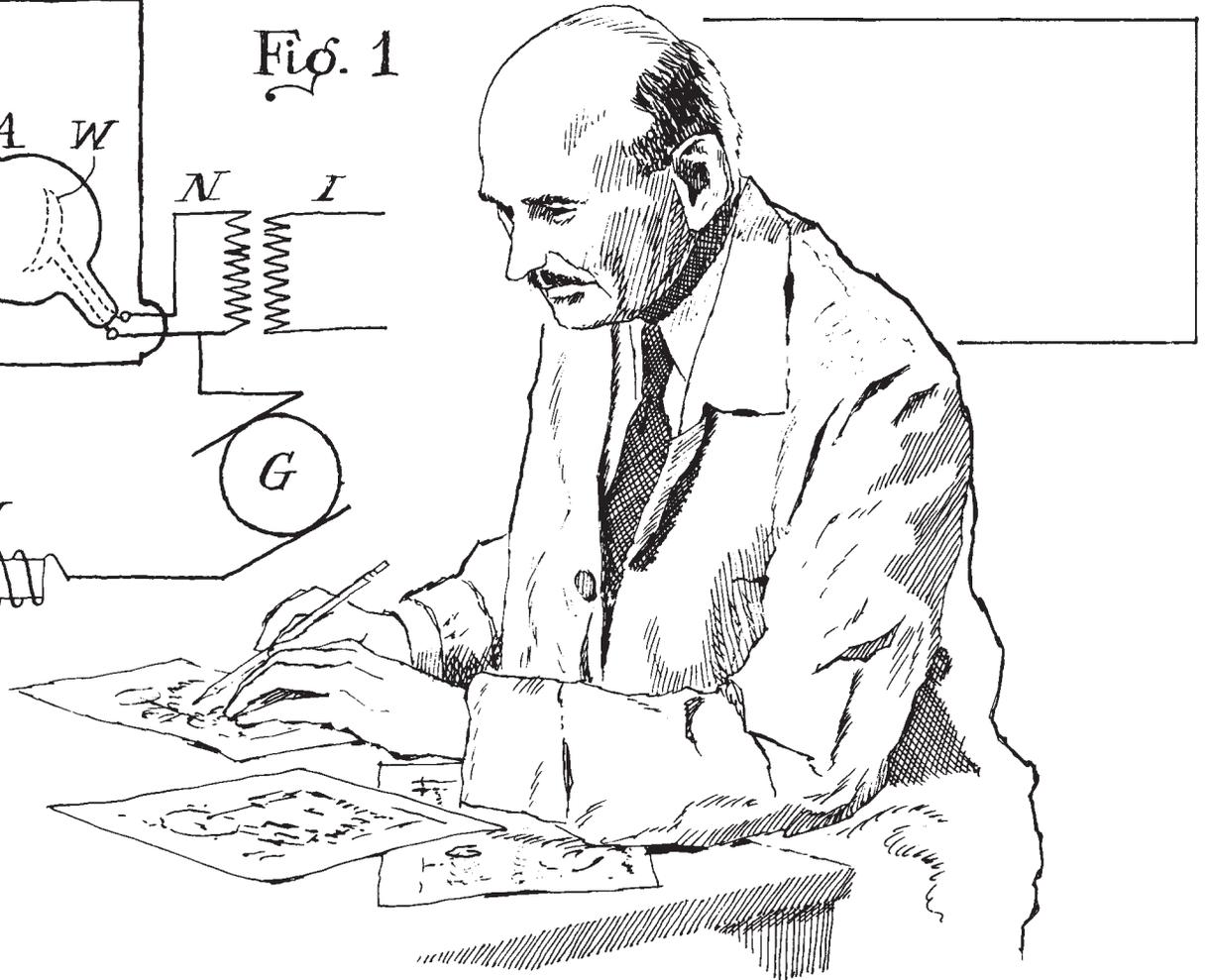
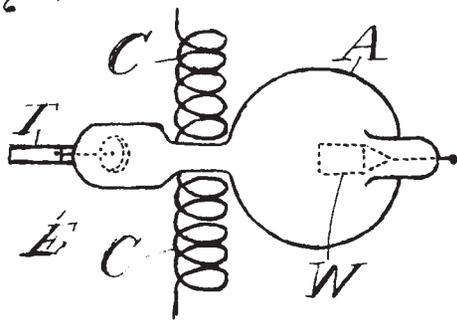


Fig. 1

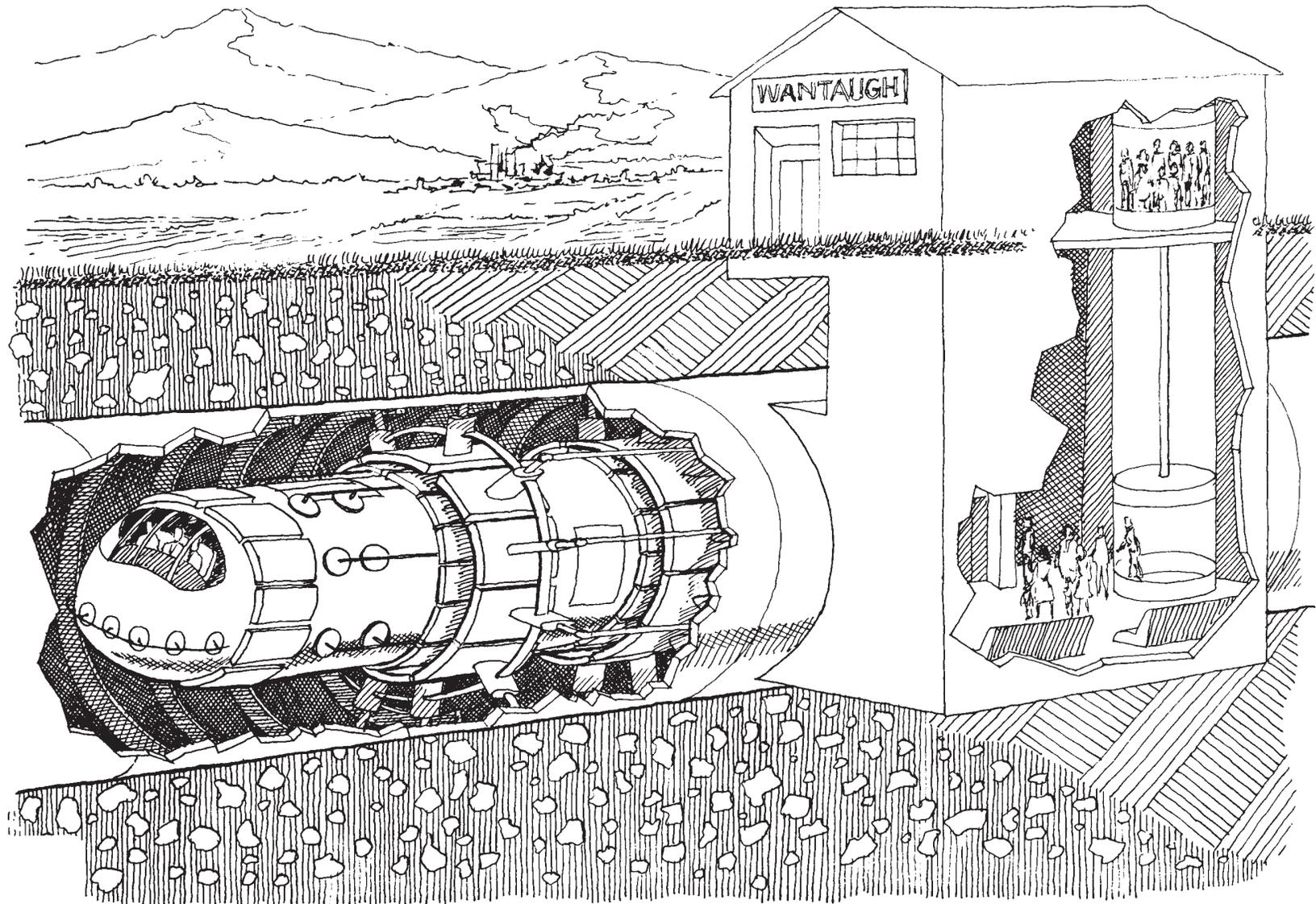
Fig. 2



IN 1912, ROBERT GODDARD INVENTED AN OSCILLATOR TUBE WHICH HE PATENTED IN 1915. THIS INVENTION PRECEDED THE DEFOREST/ARMSTRONG PATENT WHICH WAS USED IN THE IMPROVEMENT OF LONG-DISTANCE COMMUNICATIONS.

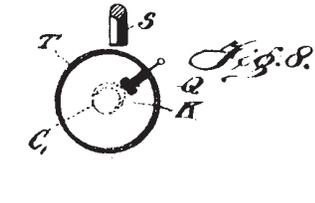
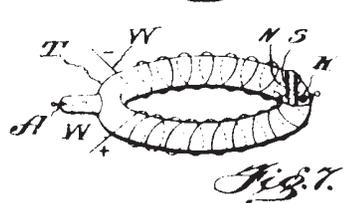
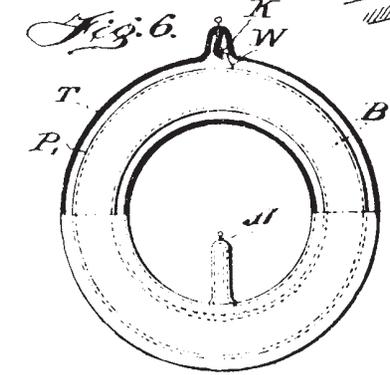
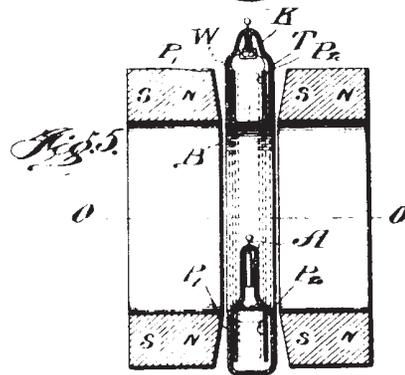
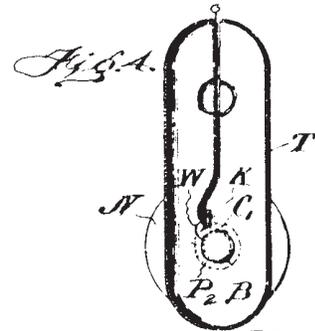
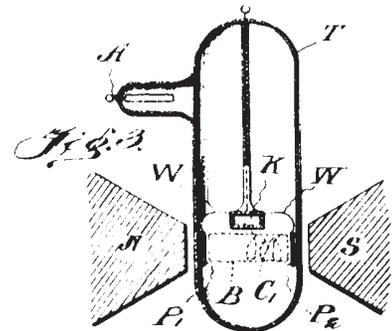
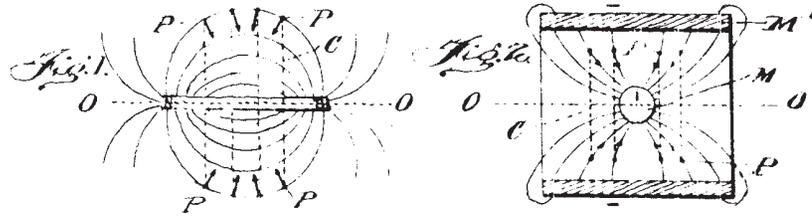
IN 1929, DR. GODDARD THEORIZED "RAPID TRANSIT BY ELECTROMAGNETIC CONDUCTION." THIS IDEA OF SUBSURFACE VACUUM TUNNELS IN WHICH TRAIN-TYPE CARS WOULD

BE SUSPENDED AND PROPELLED BY ELECTRO-MAGNETISM REMAINS A FUTURE POSSIBILITY FOR OUR COUNTRY.

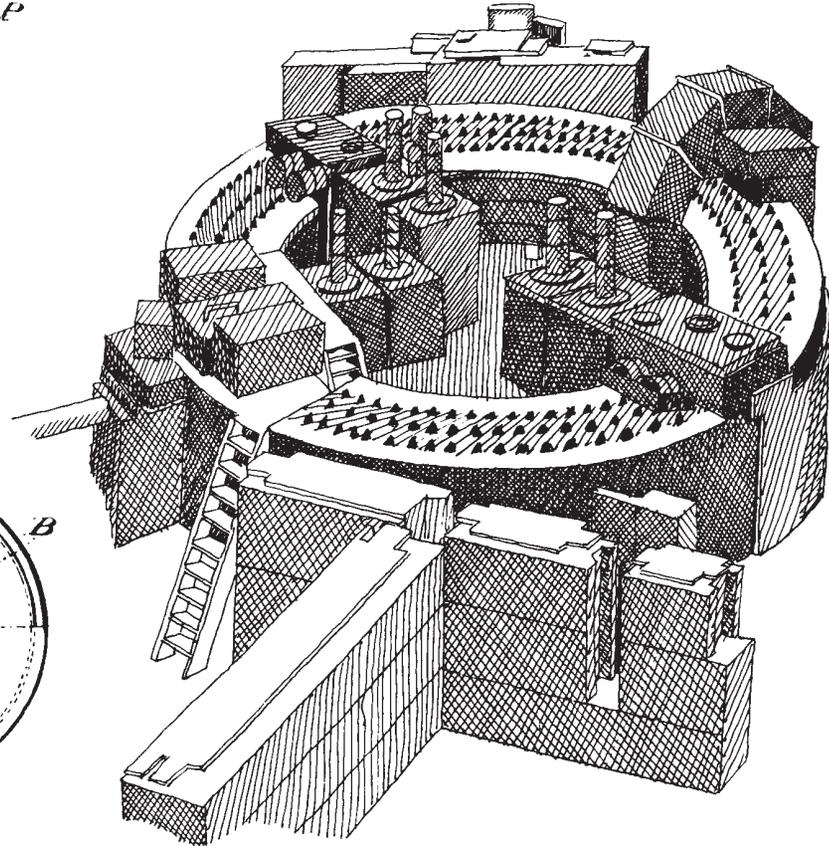


1,137,964.

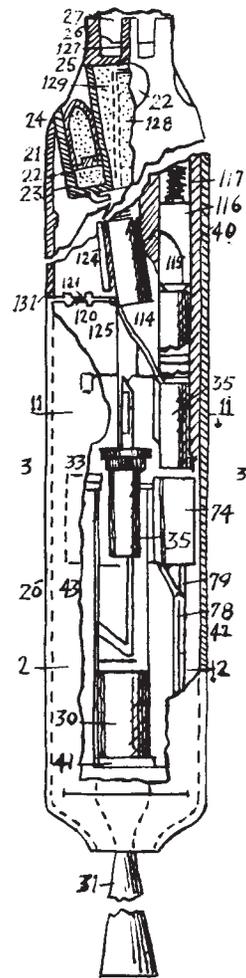
Patented May 4, 1915.



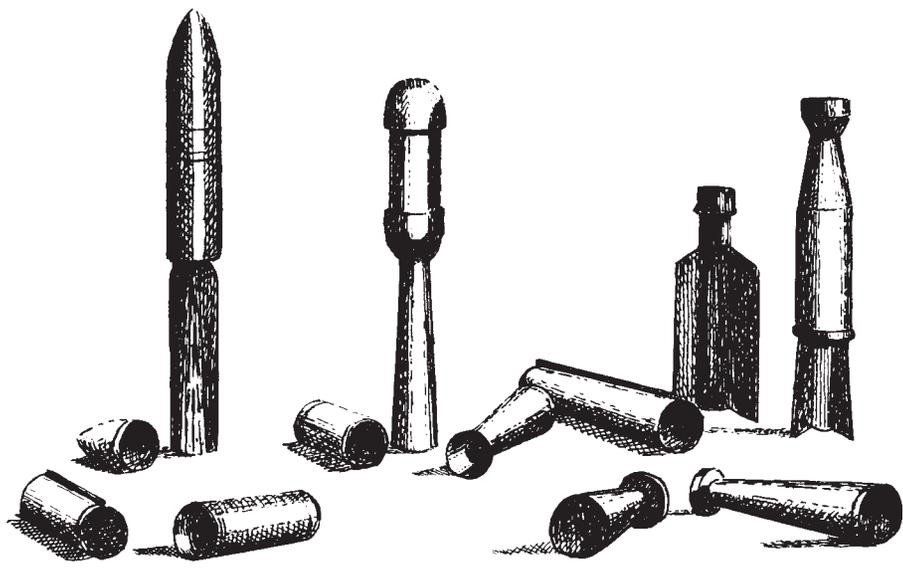
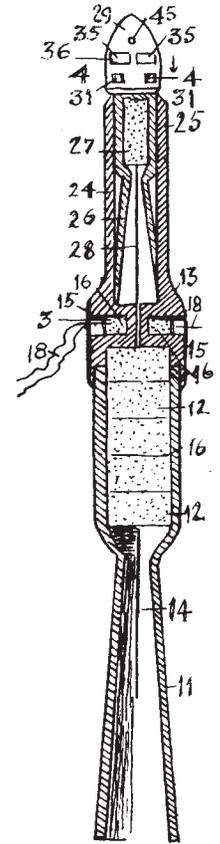
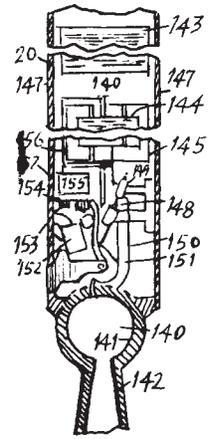
A DEVICE FOR ACCELERATING IONS BY MAGNETIC MEANS IN A CIRCULAR VACUUM TUBE WAS PATENTED IN 1915, ABOUT THREE YEARS AFTER DR. GODDARD THOUGHT OF IT. THIS DEVICE IS SIMILAR TO THE MODERN CYCLOTRON.



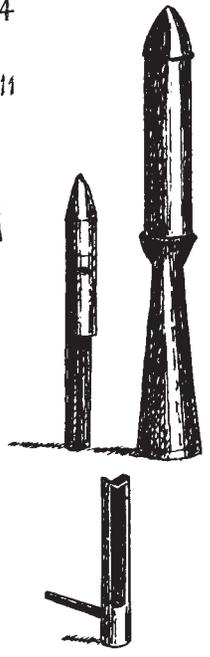
CALIFORNIA INSTITUTE OF TECHNOLOGY ELECTRON SYNCHROTRON (DEVELOPMENT OF THE CYCLOTRON)



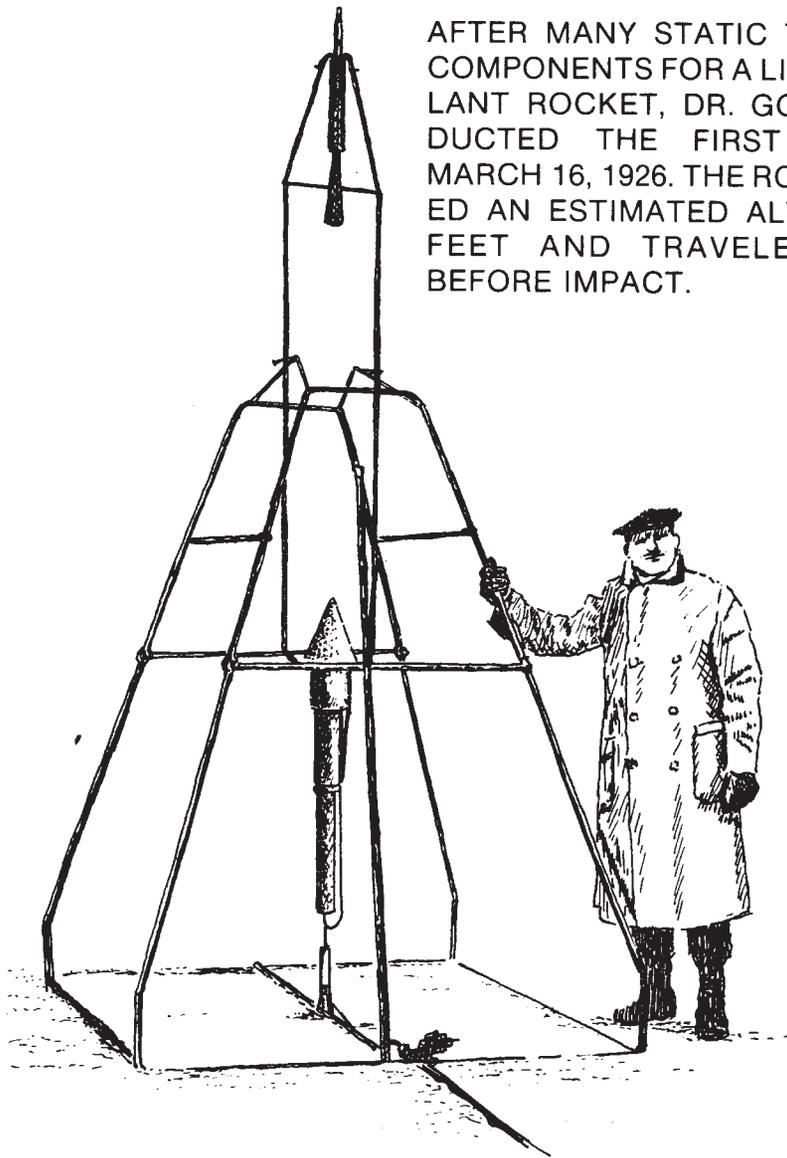
1914
MULTIPLE-STAGE
ROCKET DESIGN



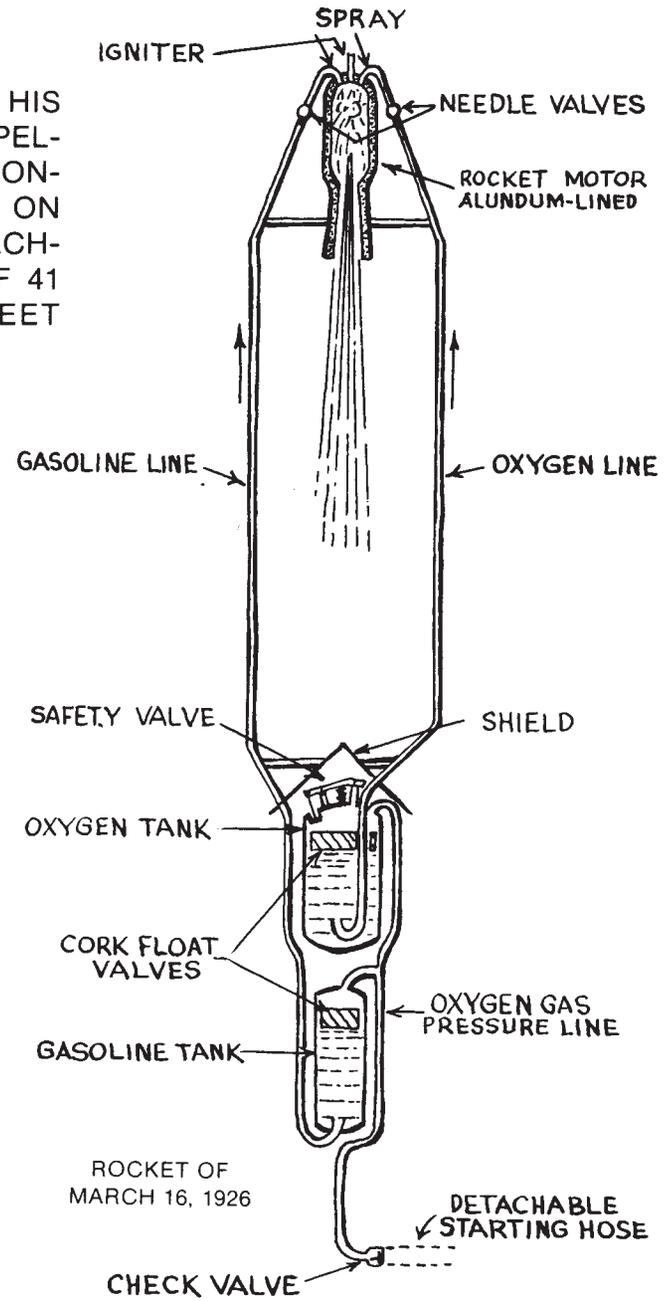
1918 ROCKET HARDWARE FOR
THE MILITARY



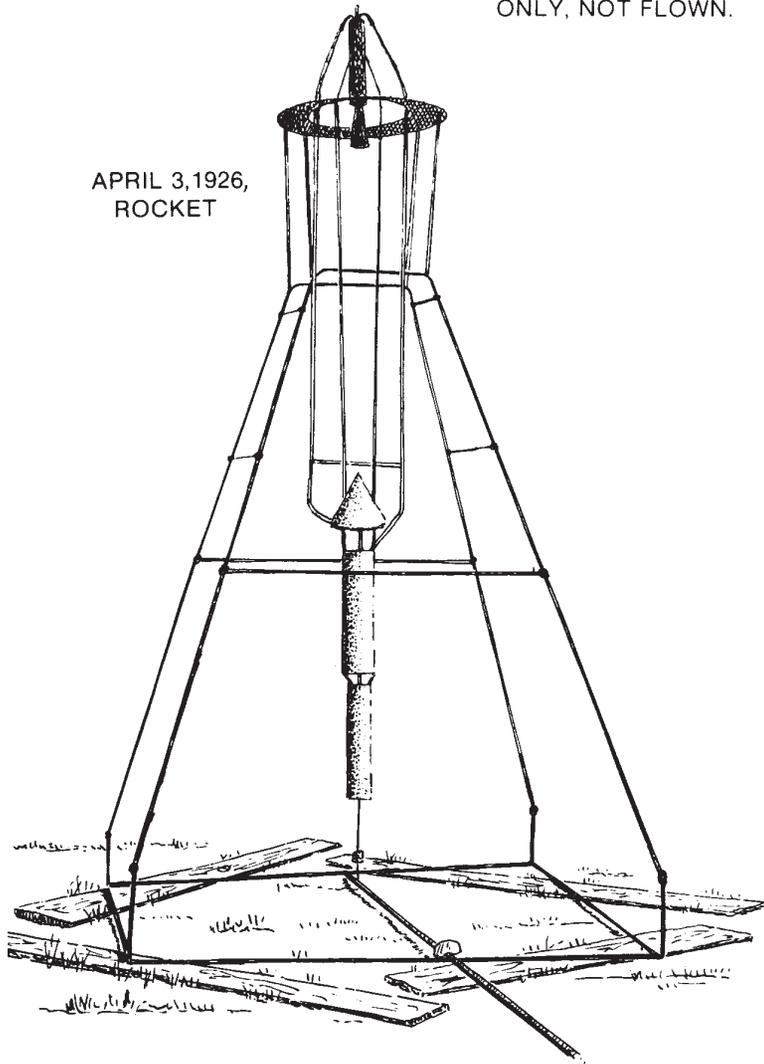
FROM 1915 TO 1920 DOCTOR GODDARD WORKED ON SOLID-FUEL ROCKETRY FOR MILITARY PURPOSES. DURING THIS SAME TIME PERIOD, HE ALSO WORKED ON ELECTRIC (ION) PROPULSION AND PLANS FOR LIQUID-PROPELLANT ROCKETS.



AFTER MANY STATIC TESTS OF HIS COMPONENTS FOR A LIQUID-PROPELLANT ROCKET, DR. GODDARD CONDUCTED THE FIRST FLIGHT ON MARCH 16, 1926. THE ROCKET REACHED AN ESTIMATED ALTITUDE OF 41 FEET AND TRAVELED 184 FEET BEFORE IMPACT.



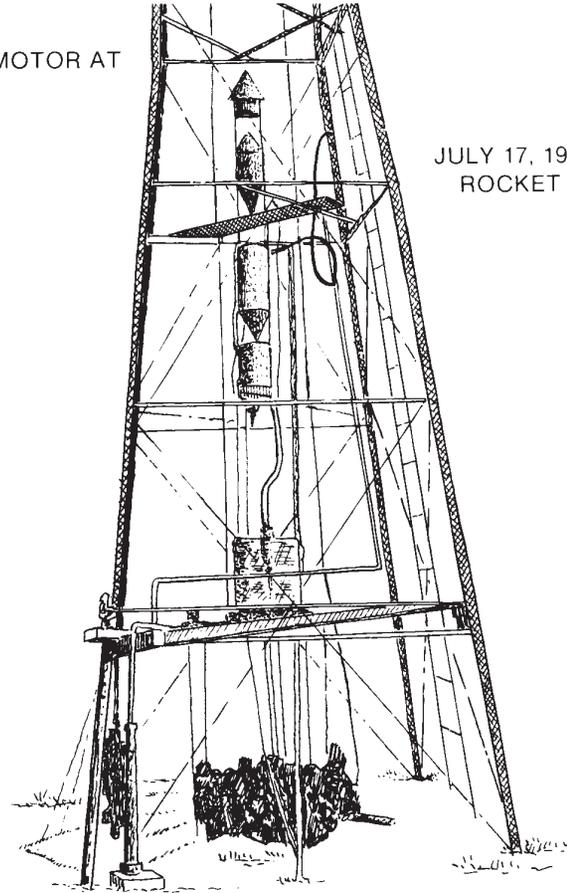
APRIL 3, 1926,
ROCKET



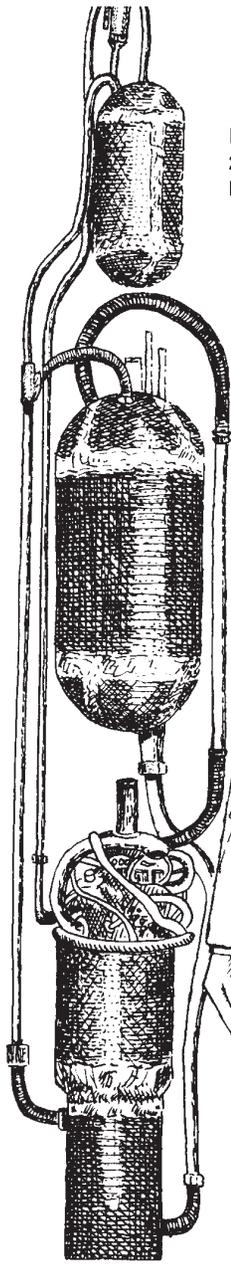
MAY 4, 1926, ROCKET. FIRST WITH MOTOR AT
THE BASE. TESTED
ONLY, NOT FLOWN.



JULY 17, 1929,
ROCKET



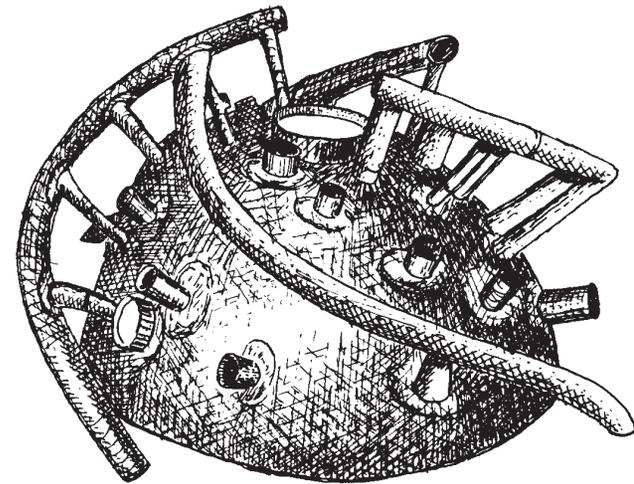
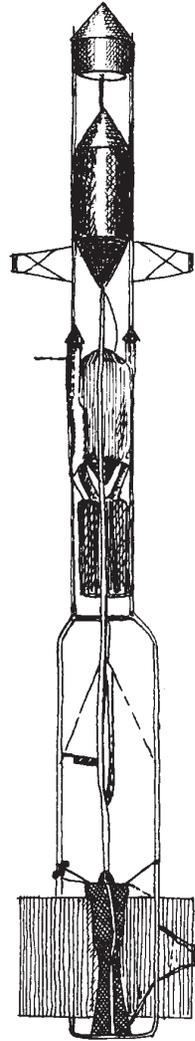
THE SECOND FLIGHT TOOK PLACE ON APRIL 3, 1926. THE THIRD FLIGHT DID NOT TAKE PLACE UNTIL JULY 17, 1929. BY THIS TIME DOCTOR GODDARD HAD POSITIONED THE ROCKET MOTOR AT THE BASE OF THE VEHICLE AND HAD ADDED A CAMERA, A BAROMETER, A THERMOMETER, AND A PARACHUTE FOR RECOVERY.



DECEMBER 1926 ROCKET,
20 TIMES LARGER THAN
FIRST ROCKET.

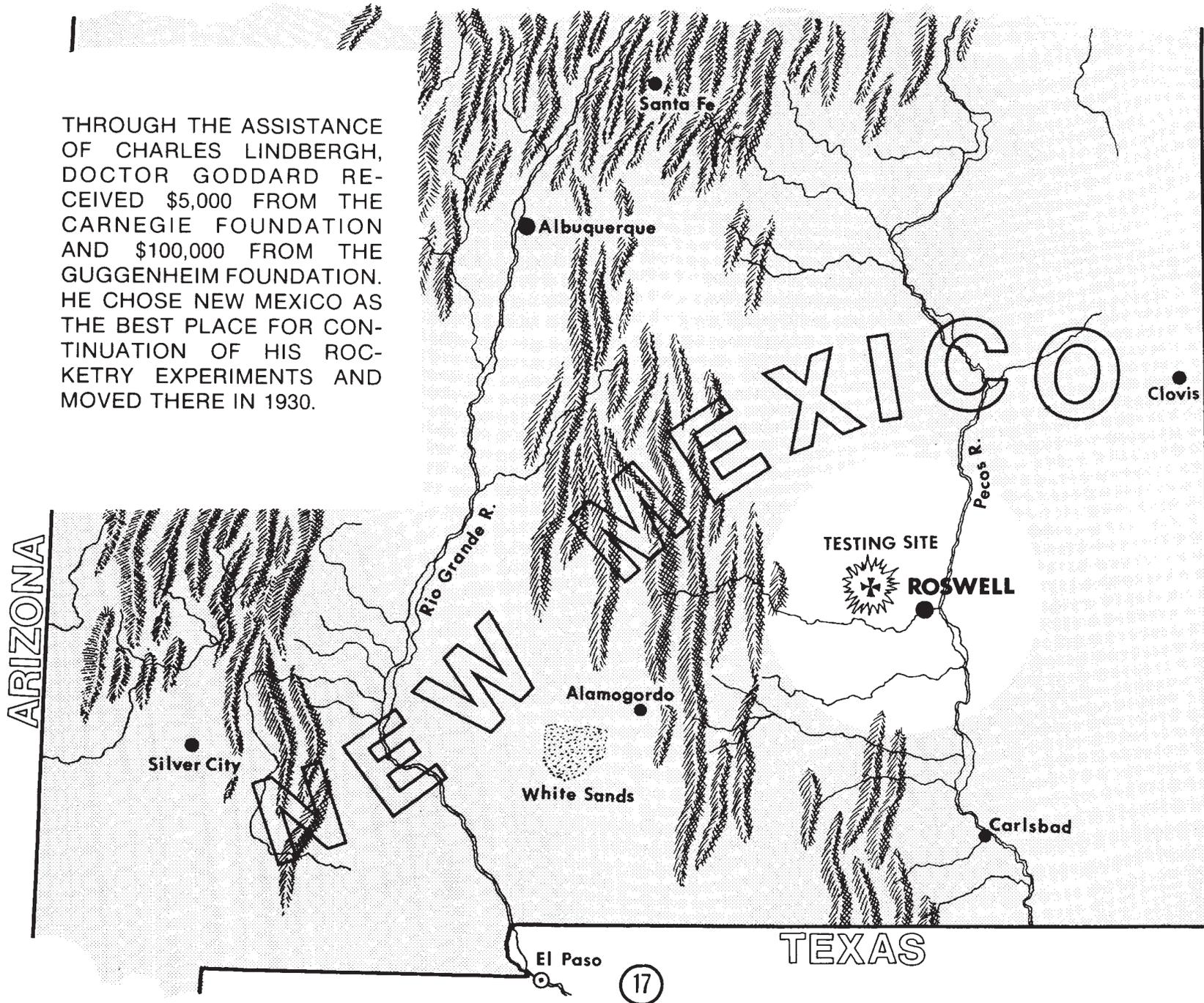


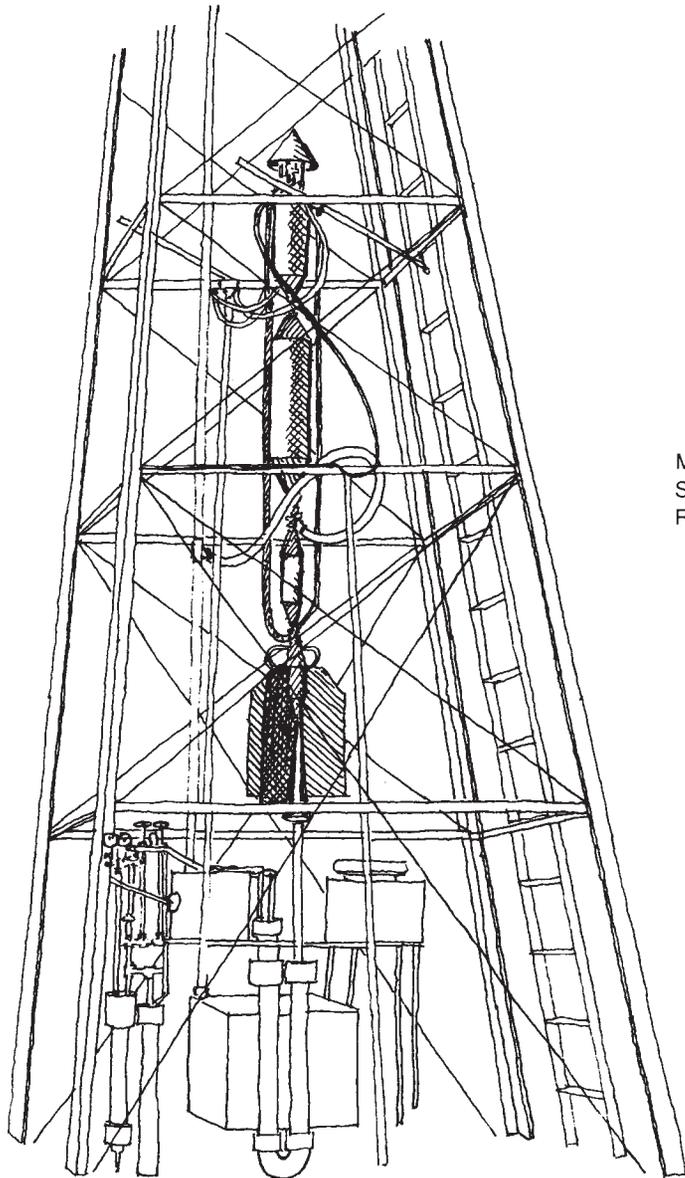
JULY 17, 1929, ROCKET,
4 TIMES LARGER THAN
FIRST ROCKET.



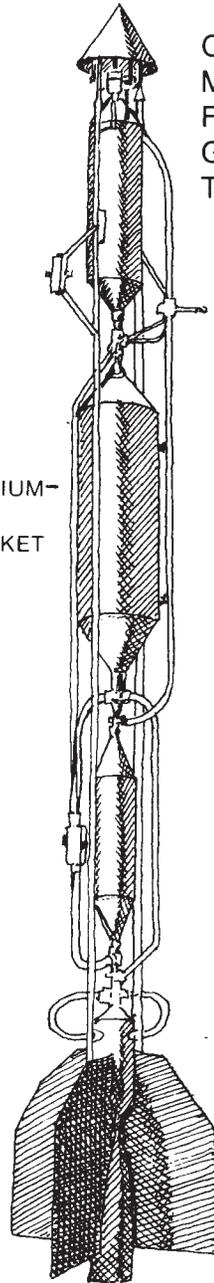
MULTIPLE FEEDING SYSTEM AT
TOP OF COMBUSTION CHAM-
BER, OCTOBER 1926.

THROUGH THE ASSISTANCE OF CHARLES LINDBERGH, DOCTOR GODDARD RECEIVED \$5,000 FROM THE CARNEGIE FOUNDATION AND \$100,000 FROM THE GUGGENHEIM FOUNDATION. HE CHOSE NEW MEXICO AS THE BEST PLACE FOR CONTINUATION OF HIS ROCKETRY EXPERIMENTS AND MOVED THERE IN 1930.





DECEMBER 30, 1930, ROCKET
IN LAUNCH TOWER.

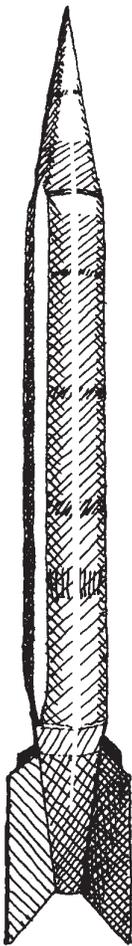


MEDIUM-
SIZE
ROCKET

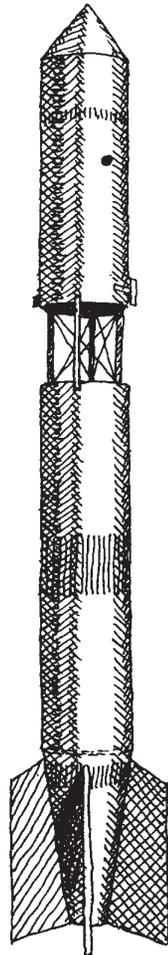
ON DECEMBER 30, 1930, GODDARD'S
MEDIUM-SIZE ROCKET REACHED 2,000
FEET ALTITUDE AND STRUCK THE
GROUND 1,000 FEET FROM ITS LAUNCH
TOWER.



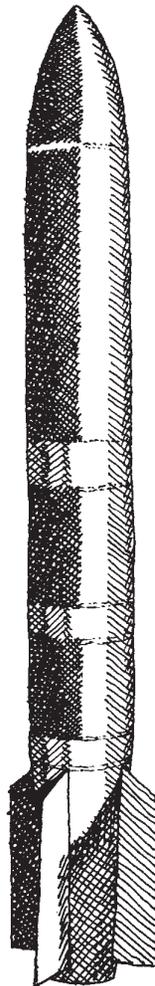
SIXTY-FOOT TOWER
USED FOR FLIGHT
TESTS AT ROSWELL,
NEW MEXICO.



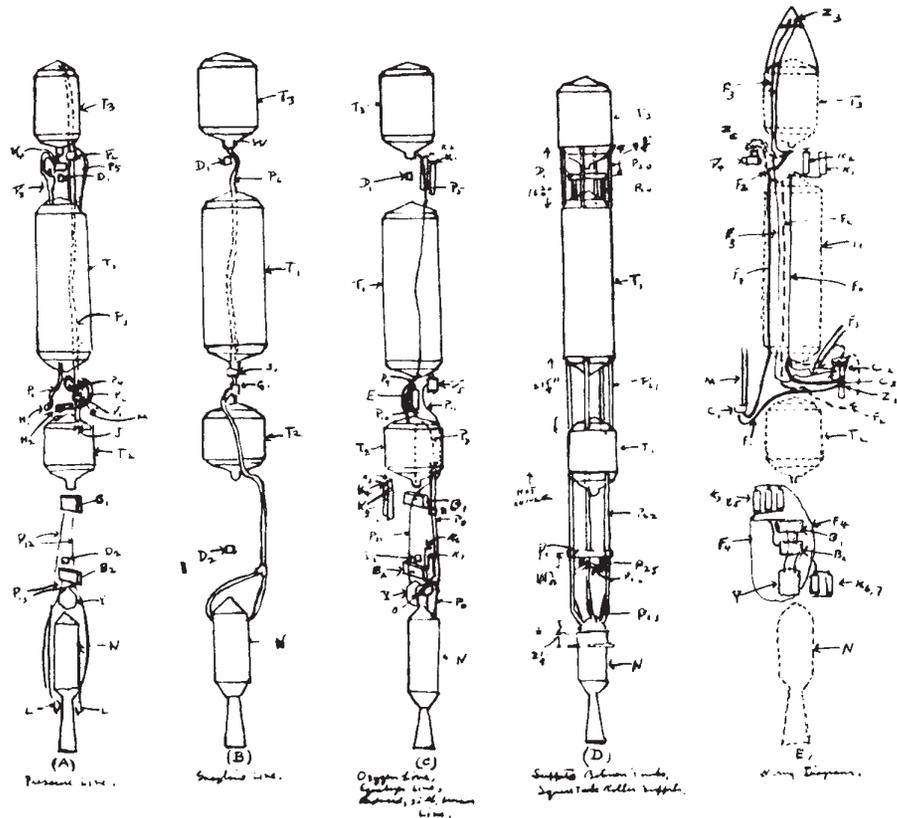
SEPTEMBER 29, 1931, ROCKET IN CASING



NOVEMBER 18, 1931, ROCKET

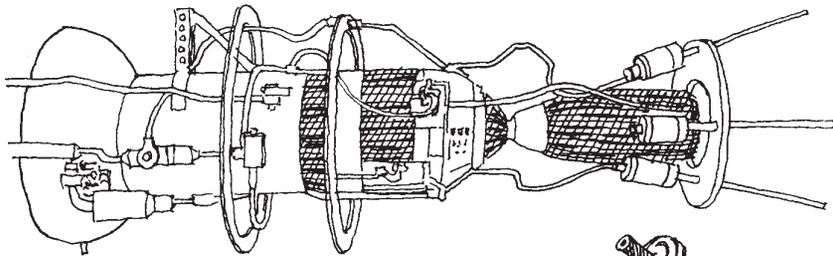


APRIL 19, 1932, ROCKET



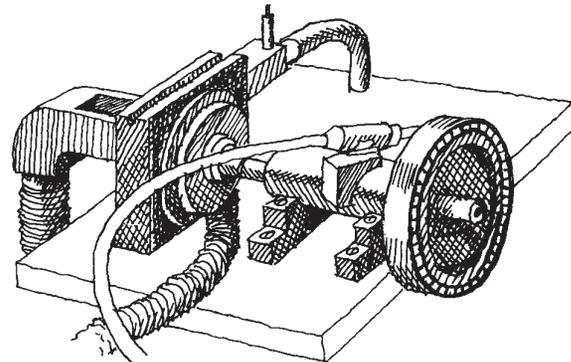
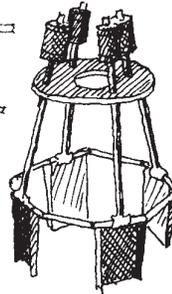
GODDARD'S ROCKET SKETCHES OF TEST L-11, FEBRUARY 1, 1937, SHOWING PRESSURE LINE, GASOLINE LINE, LIQUID-OXYGEN LINE, SUPPORTS BETWEEN TANKS, AND WIRING DIAGRAM.

DOCTOR GODDARD'S FAMILY OF ROCKETS GREW DURING THE ERA OF THE NEW MEXICO EXPERIMENTS. MANY FAILURES PRODUCED A FEW RESPECTABLE FLIGHTS. THE BEST OF WHICH REACHED AN ALTITUDE OF BETWEEN 8,000 AND 9,000 FEET.

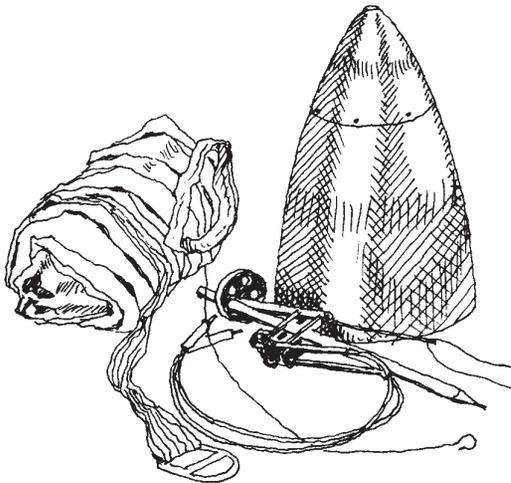


ROCKET MOTOR OF MAY 20, 1932,
SHOWING CURTAIN COOLING SYSTEM.

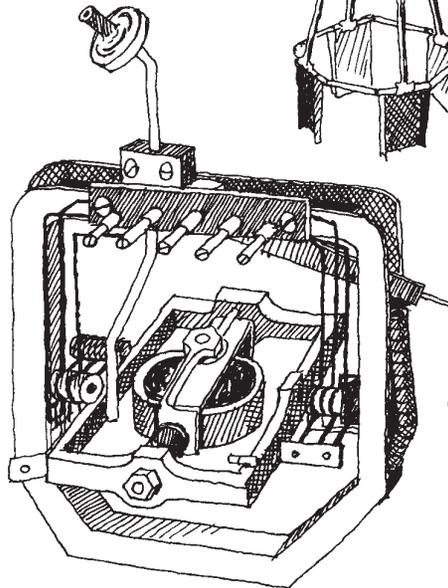
DEFLECTOR
GUIDANCE
VANES



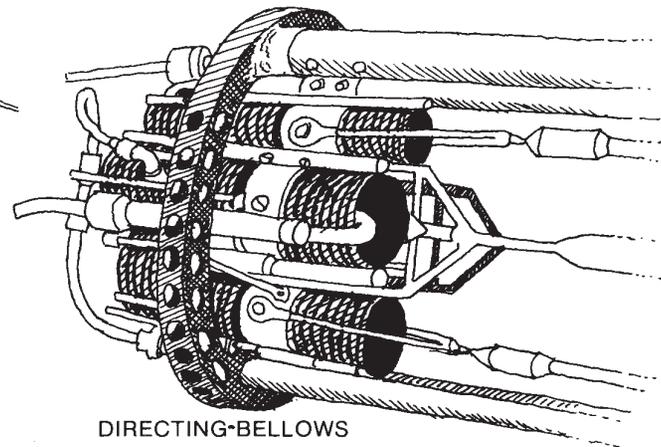
LIQUID-OXYGEN PUMP AND TURBINE
(MOUNTED ON TEST STAND)



PARACHUTE RECOVERY SYSTEM

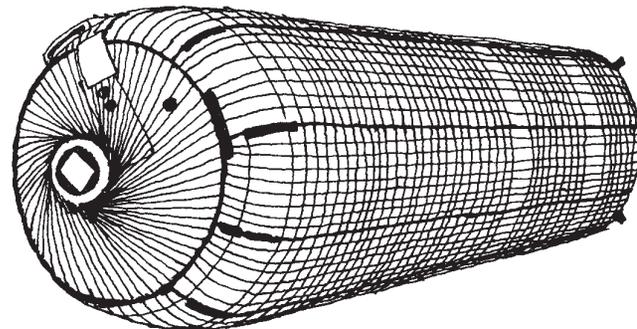


GYROSCOPIC STABILIZATION



DIRECTING-BELLOWS
ASSEMBLY FOR
GIMBAL STEERING

UPON CONCLUSION OF STATIC AND
FLIGHT TESTS IN NEW MEXICO, DOC-
TOR GODDARD HAD DEVELOPED
AND TESTED ALL MAJOR COMPO-
NENTS FOUND IN MODERN LIQUID-
PROPELLANT ROCKETS.



ALUMINUM
WIRE-WOUND
TANK



**Illustrierte flugtechnische Zeitschrift
und Anzeiger für das gesamte Flugwesen**

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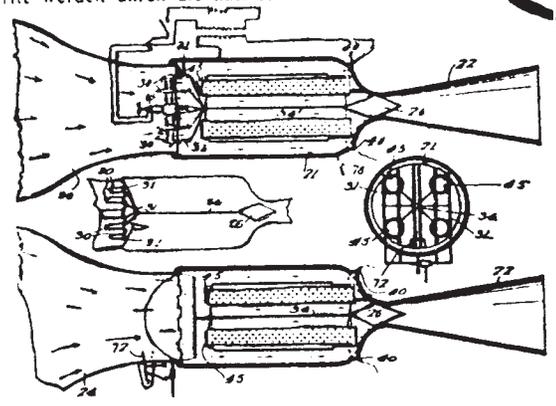
Nr. 1 4. Januar 1939 XXXI. Jahrgang
 Die nächste Nummer des „Flugsport“ erscheint am 18. Januar 1939.

Anfang 1939.

Die Vorbedingungen für Weiterentwicklung sind im vergangenen Jahre 1938 geschaffen worden. Die vollbrachten Leistungen scheinen, wenn man den Maßstab von vor 6 Jahren ansetzt, außerordentlich zu sein.

ein Ventil 37 anreibt, nachdem das Ventil 36 geschlossen und das Ventil 37 geöffnet worden ist.

Der durch seine ergebnisreichen Versuche mit Abbrandtriebwerken und sein hierüber aussagendes Werk*) bekannt gewordene amerikanische Physiker R. H. Goddard hat in der amerikanischen Patentschrift 1.980.266 (angem. 7. Febr. 31) ein Heißluftstrahltriebwerk (Brennkammer mit konstantem Volumen) dargestellt, vgl. Abb. 41 bis 46. Luftein- und Gasaustritt werden durch die auftretenden Drücke selbsttätig gesteuert, und zwar mit Hilfe einer Feder 36 (Abb. 45) und in folgender Weise: Hat soeben in der Kammer 28 (Abb. 41) bei offenem Schließkegel 26 und geschlossenen Klappen 31 (Abb. 42) eine Zündung

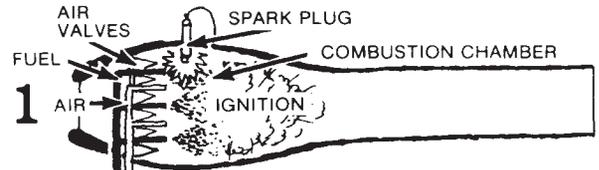


*) „A method of reaching extreme altitudes“, Washington 1919, ein Buch, das Anlaß zu der Raumschiff-Epidemie vor 10 Jahren gab.

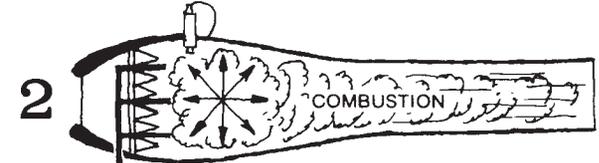
Abb. 41—44. Goddard 1931: Ein- und Austrittsverschlüsse regeln sich selbsttätig gemäß dem im Brennkammerinnern vorhandenen Druck.

GERMAN PUBLICATION OF GODDARD'S 1934 PATENT NO. 1,980,266 BASIC TO THE 1944 GERMAN V-1 "BUZZ BOMB."

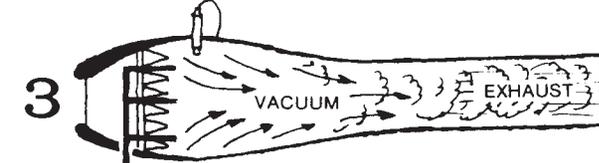
THE PULSEJET ENGINE



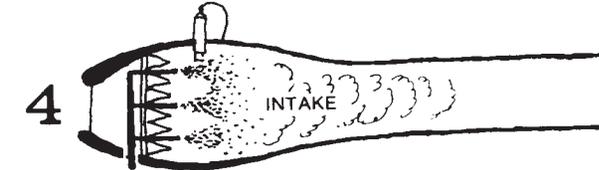
1 STARTING: AIR AND FUEL INJECTED UNDER PRESSURE INTO COMBUSTION CHAMBER; IGNITED BY SPARK PLUG.



2 COMBUSTION: EXPANDING GASES PREVENT FUEL FROM ENTERING COMBUSTION CHAMBER.



3 EXHAUST: EXPANSION OF GASES REARWARD CAUSES OPPOSITE REACTION FORWARD.



4 INTAKE: PARTIAL VACUUM AND PRESSURIZED FUEL CAUSES FUEL TO FLOW INTO THE COMBUSTION CHAMBER. HEAT OF COMBUSTION REMAINS TO IGNITE FUEL-AIR MIXTURE FOR NEXT COMBUSTION EVENT. SPARK PLUG NO LONGER NEEDED.

AIR VALVE POSITIONS



SPRING STEEL KEEPS AIR VALVE CLOSED.



SPRING STEEL KEEPS AIR VALVE CLOSED.



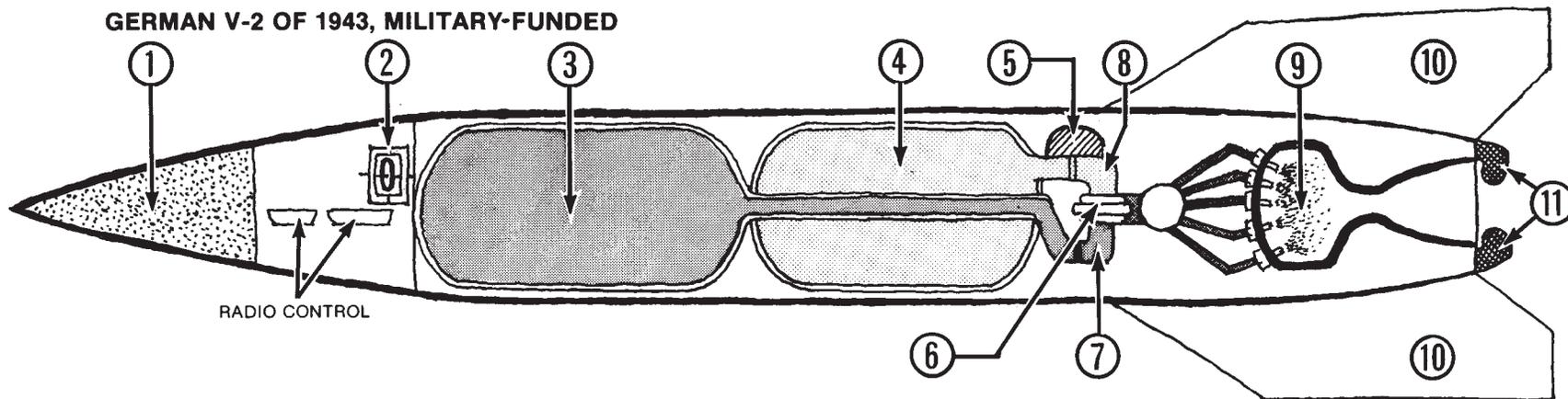
AT THIS POINT AIR VALVE BEGINS TO OPEN DUE TO VACUUM IN COMBUSTION CHAMBER.



PARTIAL VACUUM AND RAM AIR PRESSURE RESULTING FROM FORWARD MOTION CAUSES SPRING STEEL TO OPEN, ALLOWING AIR TO ENTER THE COMBUSTION CHAMBER AND MIX WITH THE FUEL. FORCED AIR USED FOR STARTING NO LONGER NEEDED.

DOCTOR GODDARD'S PATENT OF 1934 ENTITLED "PROPULSION APPARATUS" BECAME GERMANY'S POWER PLANT FOR ITS V-1 FLYING BOMB OF WORLD WAR II, LATER TO BECOME THE U.S. GUIDED MISSILE JB-2.

GERMAN V-2 OF 1943, MILITARY-FUNDED



- 1 PAYLOAD: GERMAN, WARHEAD; GODDARD, RECOVERY PARACHUTE.
- 2 GYROSCOPIC STABILIZATION.
- 3 FUEL: GERMAN, ALCOHOL; GODDARD, GASOLINE.
- 4 OXIDIZER: LIQUID OXYGEN.

- 5 PRESSURE GENERATOR: GERMAN, HYDROGEN PEROXIDE; GODDARD, GASOLINE AND LIQUID OXYGEN.
- 6 TURBINE.
- 7 CENTRIFUGAL FUEL PUMP.
- 8 CENTRIFUGAL OXYGEN PUMP.

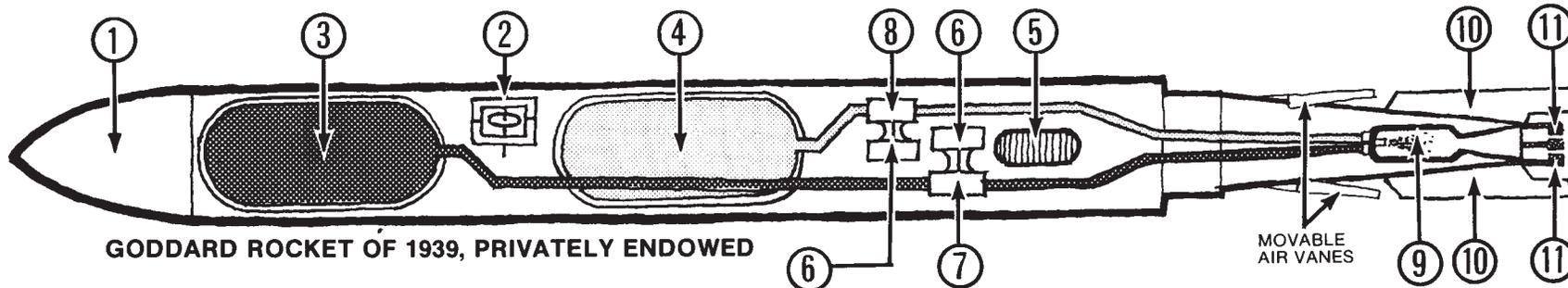
- 9 COMBUSTION CHAMBER.
- 10 FINS.
- 11 BLAST VANES.

COMPARATIVE SIZES



V-2, 46' LONG

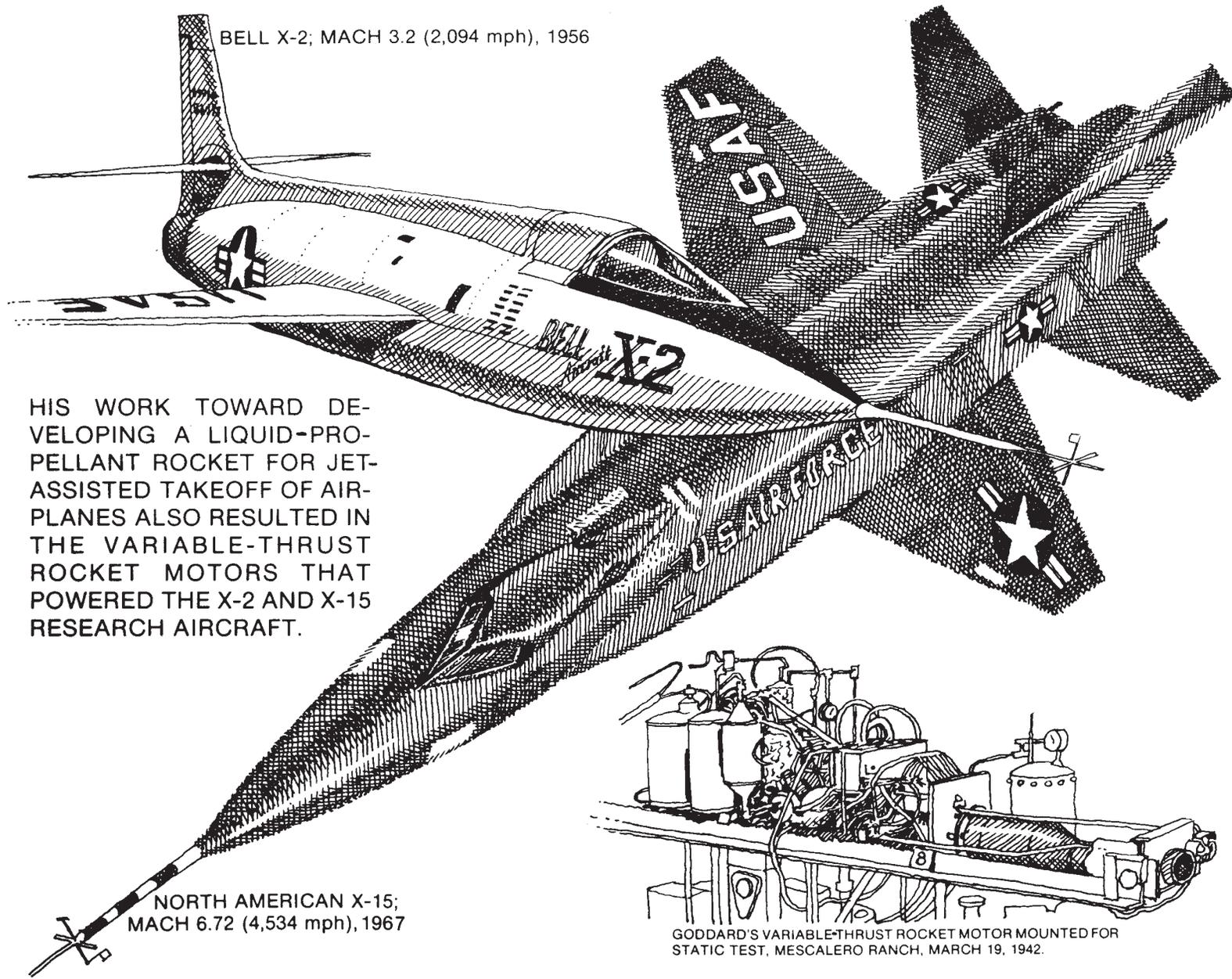
GODDARD, 22' LONG



GODDARD ROCKET OF 1939, PRIVATELY ENDOWED

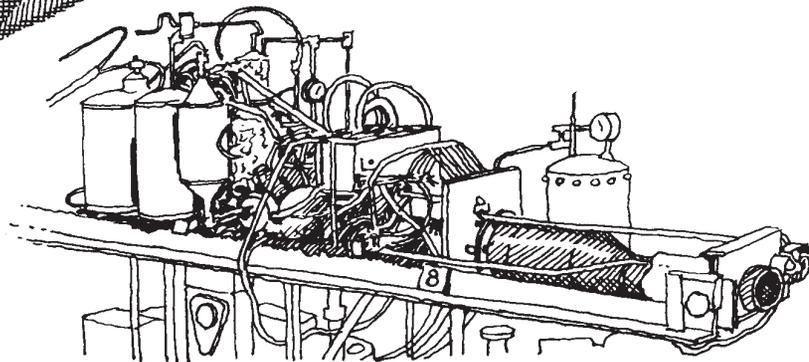
IN 1945, DOCTOR GODDARD INSPECTED A CAPTURED GERMAN V-2 ROCKET. MR. SACHS, ONE OF HIS ASSISTANTS, SAID, "IT LOOKS LIKE OURS, DR. GODDARD." DOCTOR GODDARD REPLIED, "YES, MR. SACHS, IT SEEMS SO."

BELL X-2; MACH 3.2 (2,094 mph), 1956



HIS WORK TOWARD DEVELOPING A LIQUID-PROPELLANT ROCKET FOR JET-ASSISTED TAKEOFF OF AIRPLANES ALSO RESULTED IN THE VARIABLE-THRUST ROCKET MOTORS THAT POWERED THE X-2 AND X-15 RESEARCH AIRCRAFT.

NORTH AMERICAN X-15;
MACH 6.72 (4,534 mph), 1967



GODDARD'S VARIABLE-THRUST ROCKET MOTOR MOUNTED FOR STATIC TEST, MESCALERO RANCH, MARCH 19, 1942.

Washington National Bank
2800 PENNSYLVANIA AVE.
WASHINGTON, D.C.

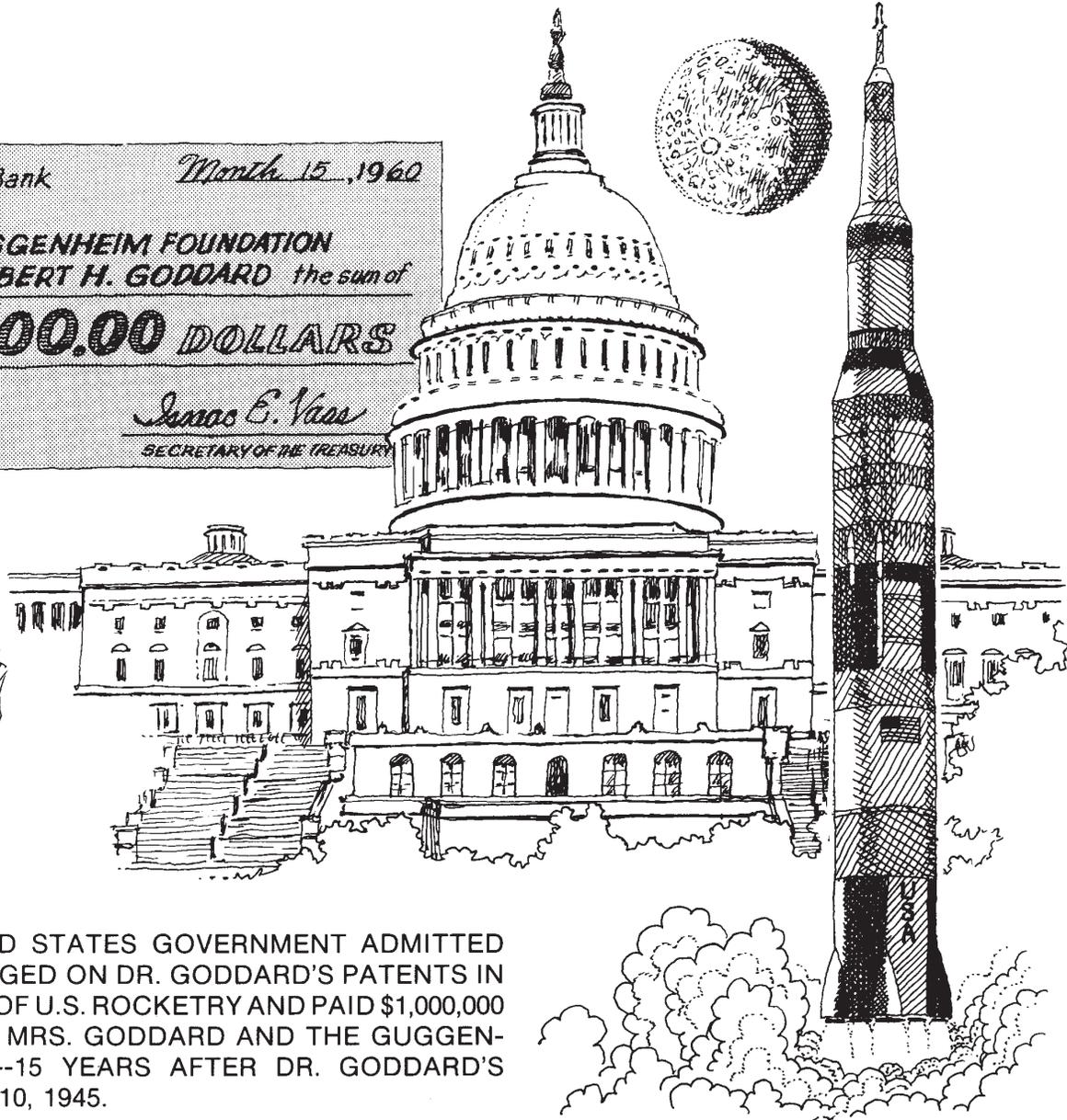
Month 15, 1960

Pay to the order of **THE GUGGENHEIM FOUNDATION**
MRS. ROBERT H. GODDARD the sum of

\$1,000,000.00 DOLLARS

4ZE-14EZ-43ZIE

James E. Vaas
SECRETARY OF THE TREASURY



IN 1960, THE UNITED STATES GOVERNMENT ADMITTED THAT IT HAD INFRINGED ON DR. GODDARD'S PATENTS IN THE DEVELOPMENT OF U.S. ROCKETRY AND PAID \$1,000,000 COMPENSATION TO MRS. GODDARD AND THE GUGGENHEIM FOUNDATION--15 YEARS AFTER DR. GODDARD'S DEATH ON AUGUST 10, 1945.