

# SECRET



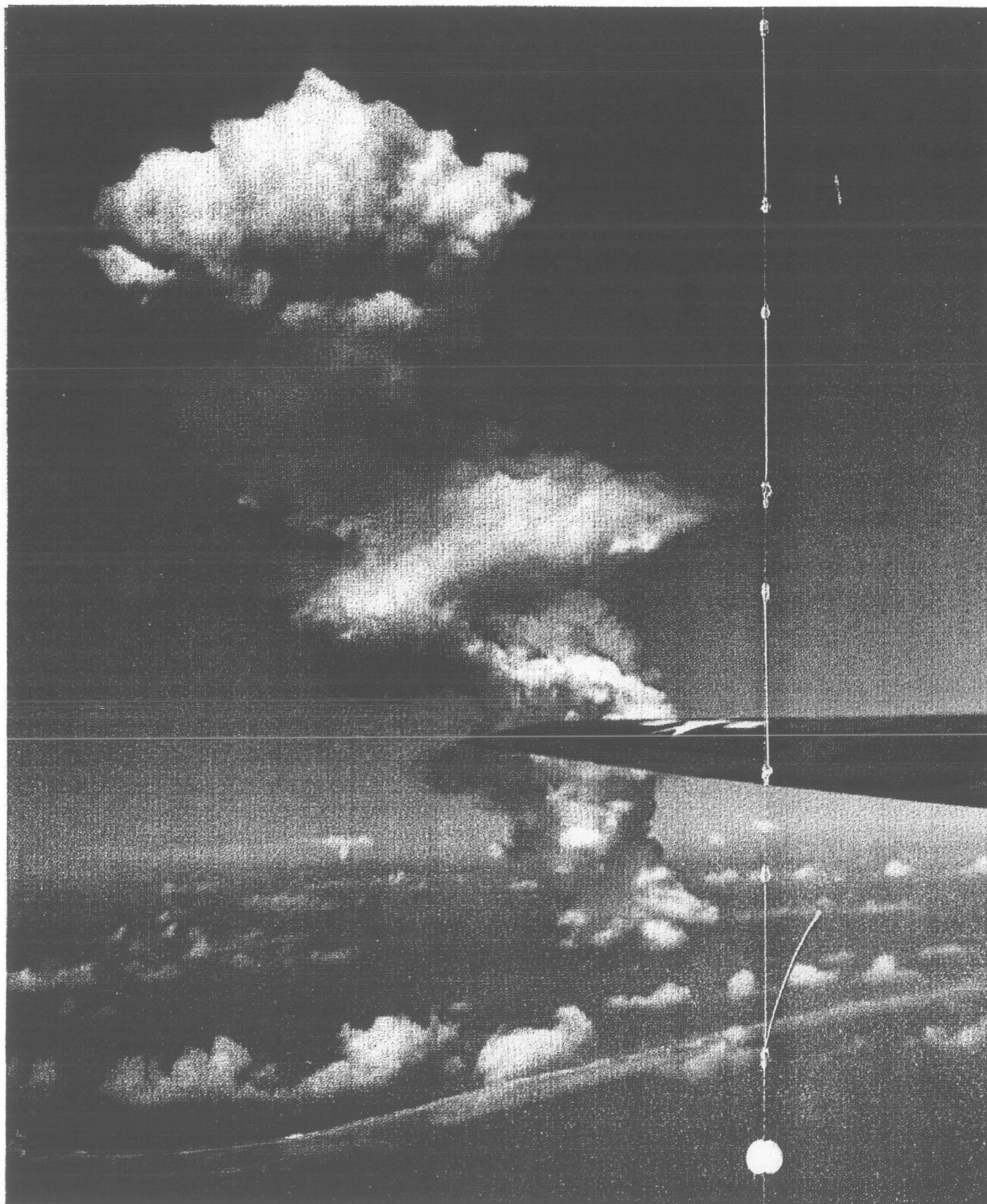
*by*

Wesley W. Stout



WESTINGHOUSE PH

*All the pure uranium metal to be had in 1941 came from the laboratory of a Westinghouse lamp plant at Bloomfield, N. J.*



U. S. NAVY PHOTO

# Foreword

**I**N the tremendous endeavor which produced the atom bomb, and thus brought World War II to a sudden close, Chrysler Corporation had an important part.

*This is a simple narrative of what was done to give man his first control over the energy locked in the atom.*

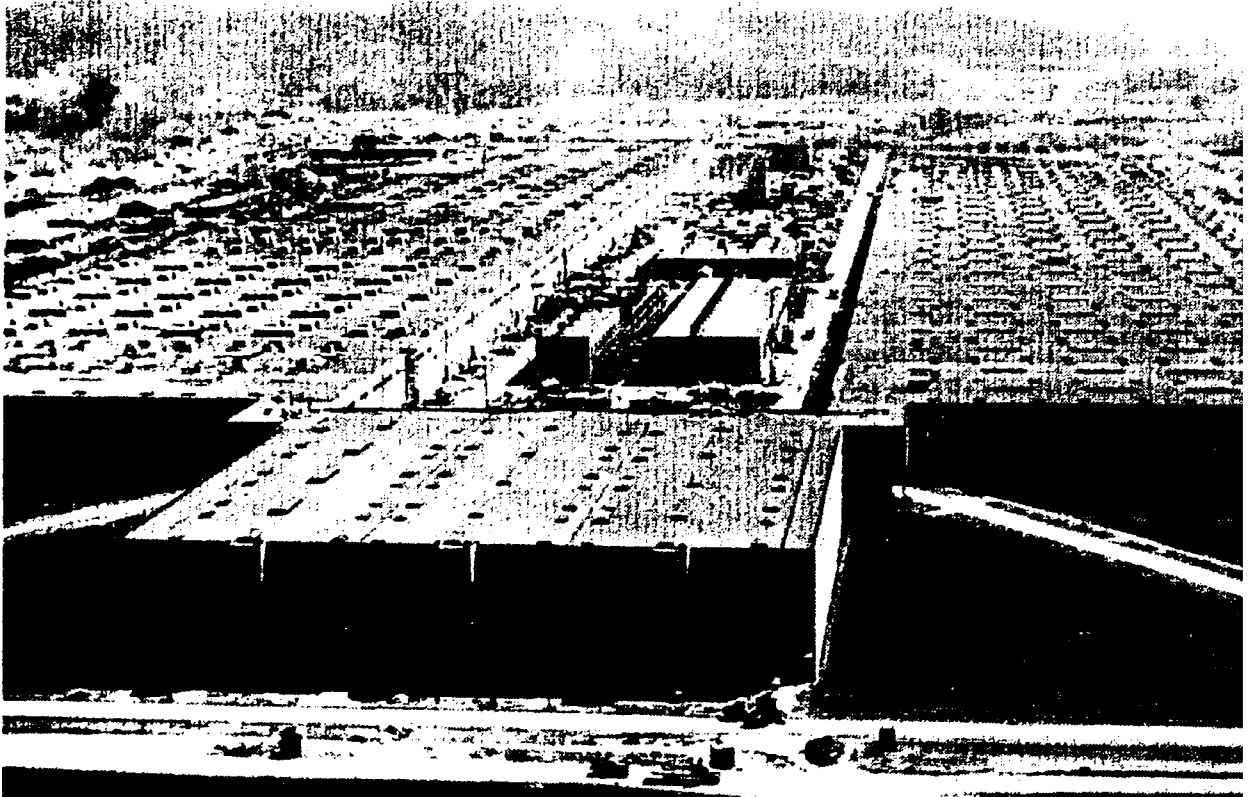
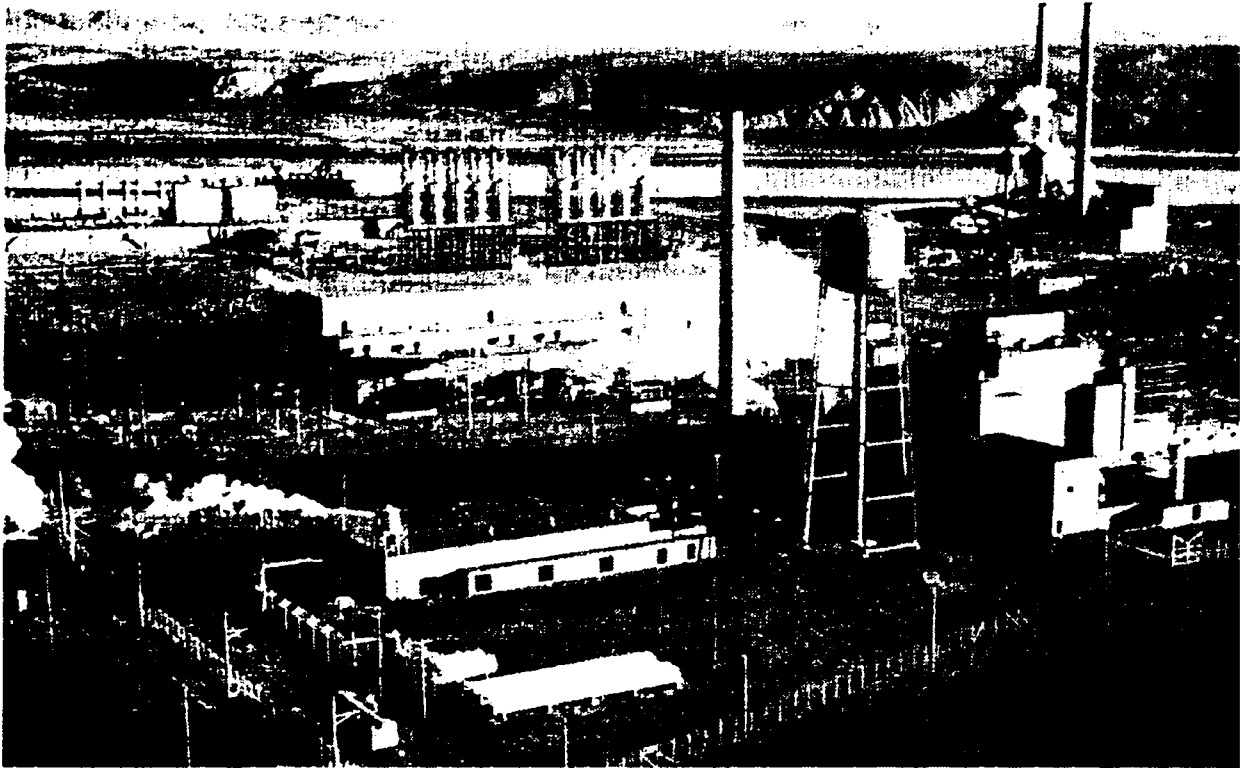
*The presence of this new force at man's command, and the stark terror that imagination gives to atomic weapons carried to their still distant ultimate development, has stirred anew the determination of good men to create at long last in the world a state of permanent peace.*

*Peace never has been made by outlawing a given weapon. History shows new wars beginning where old ones left off. To keep peace men must honestly recognize and eliminate the things they do and that nations do which culminate in bloodshed. Perhaps the dire possibilities of atom power will some day bring men to this point.*

*Meantime science and industry will be working on ways to employ the atom's energy for men's benefit; ways that might even in time utterly overshadow the first destructive application.*

**K. T. KELLER**  
*President*

**Test Baker—Bikini—July 1946**



*Part of the huge Hanford, Washington, plutonium works, built in a sage brush desert and (below) the U-shaped gaseous diffusion U-253 plant at Oak Ridge, Tenn., for which Chrysler built the diffusers.*

U. S. ARMY PH

\* The text of this book has been reviewed and permission for its publication has been given by the U. S. Army, Corps of Engineers, for the War Department.

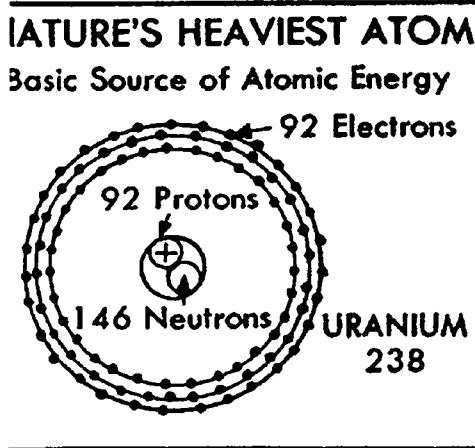
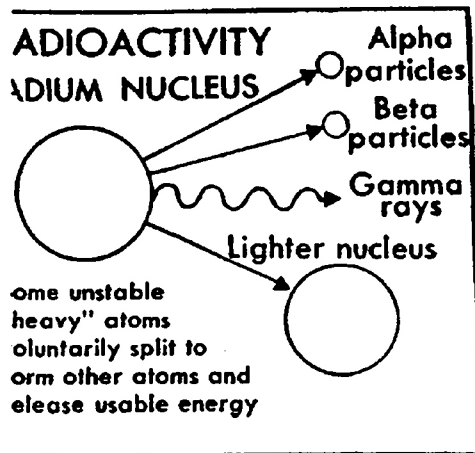
The war ended, in effect, in the New Mexican desert at dawn of July 16, 1945, when the first atomic bomb was set off experimentally. What followed at Hiroshima on August 6th, and at Nagasaki three days later, was, like the formal Japanese surrender in another five days, predestined four weeks earlier at Alamogordo.

Chrysler Corporation was a major industrial contributor to the atomic bomb itself, as well as the largest source of the engines which powered the B-29 Superfortresses which dropped the bombs.

The bomb first was proposed to Chrysler in the spring of 1943. The top war secret of all, it was known within the Corporation only as X-100 and all knowledge of its nature and purpose limited to a few key men.

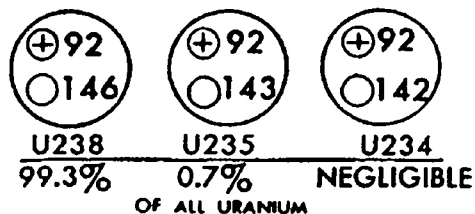
What may come of atomic fission, for good or for evil, is enough to stagger any imagination, but the atomic bomb itself is no awesome mystery. Its how and why can be understood by any one who doesn't shut his ears and mind.

If you think of the tapping of atomic energy as a detective story, the first meager clues were found



## ISOTOPES

Chemically the same element and their nuclei contain the same number of protons. Only the number of neutrons differs. Thus the uranium isotopes are:



MCGRAW-HILL PHOTO

about fifty years ago when a German, William Roentgen, discovered the X-ray and a Frenchman, Antoine Becquerel, discovered what we call radioactivity when he found uranium salts had developed a photographic plate in the dark. From this point, Pierre and Marie Curie, pupils of Becquerel, went on to discover radium, the first known radioactive element and always present in uranium.

How to account for radioactivity, this giving off of faint charged particles? Science deduced that this energy could be nothing less than a breaking down of the element, a conception which stood the science of physics on its head; for all the elements in Nature, her basic building blocks, had been thought to be unchanging and unchangeable.

As radium dissipates its energy, it eventually turns into lead, but this natural decay is very, very slow. Dangerous to human flesh and bone as exposure to radium is, a gram of it would be one hundred years in giving off enough heat to

boil a small cup of water. So no one then dreamed of trying to harness mechanically such a feeble force.

What is an atom? Everything is made up of invisibly small particles. We call these particles atoms from the Greek root meaning “uncuttable,” and when many of us were in school we still were taught that the atom is the least particle existing in Nature; that it was indivisible. Yet as early as 1900, Sir J. J. Thompson, the British physicist, had identified the electron, a minute particle of the atom. By 1918 his pupil, Lord Rutherford, had chipped a fragment from an atom and discovered the proton, another particle. And in 1932 Sir James Chadwick discovered a third particle which he called a neutron.

Rutherford had reasoned on circumstantial evidence that the atom must consist of a number of negatively charged electrons flying around a central charged body, the nucleus or core. Now we know that this is true, and we know much more. This tiny core is only one five-thousandth part of the atom in size, though it is so dense that it contains nearly all the atom’s weight. The rest is empty space enclosed by a cloud of electrons which move around the nucleus much as the earth and the other planets move around our sun.

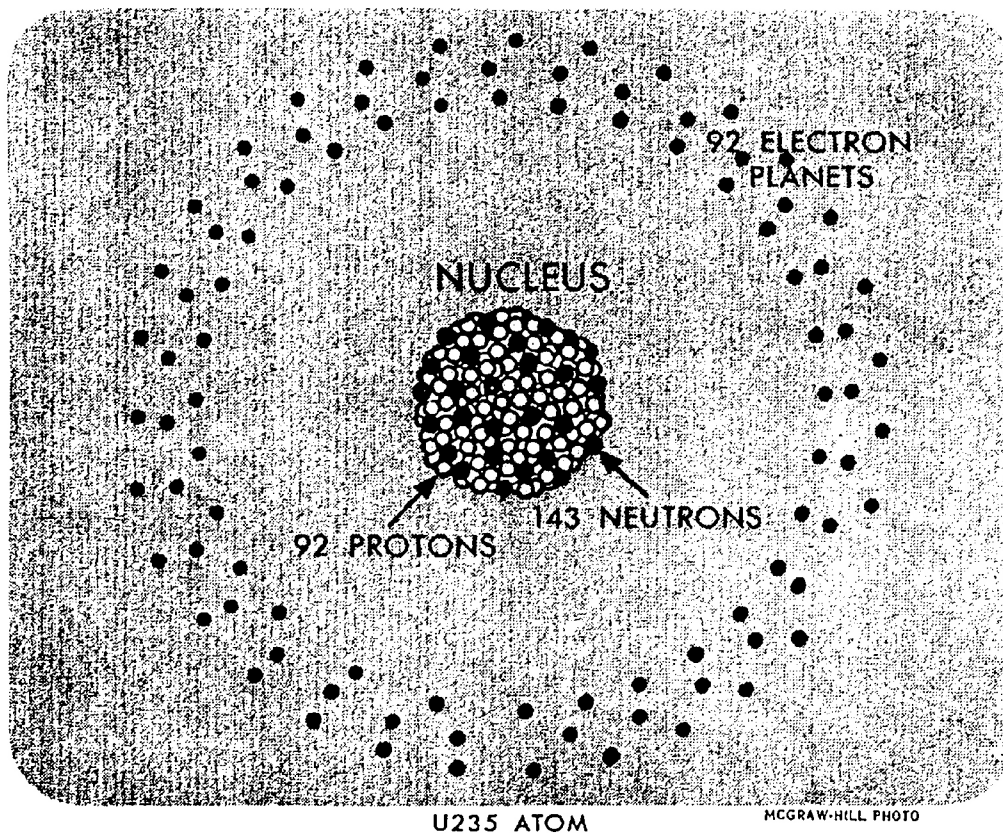
The positively charged nucleus and the negative electrons attract each other, but the electrons are held out in their orbits by the centrifugal force of their great speed, something as the earth is held away from the strong pull of the sun.

The nucleus itself is made up of two kinds of smaller particles, as many as 200 of them, tightly locked together. Some are Rutherford's positively charged protons, others are Chadwick's neutrons, which are neither positive nor negative. Imprisoned in each of these cells is a force many thousand times more powerful than the pull of gravity, a force that seems to be the ultimate source of all life and energy.

Though all atoms are made up of the same three parts—protons, neutrons and electrons—each of the 96 known elements (four new ones have been found or created since 1938) has its own atom. It is the proportion of protons which makes one element differ from another. That is to say, except that both are heavy, gold and mercury are as unlike as night and day, yet the difference between them is one proton only. If you could knock off one of the 80 protons which play on the mercury team you would have an atom of gold. Or if you could chip off one proton from the eight in an atom of oxygen you would have an atom of nitrogen.

For each proton in the core there is one electron in the cloud flying around the core, for plus and minus must balance in the atom. In other words, hydrogen, lightest of known elements, has one proton in its nucleus and only one electron planet while uranium, heaviest element known until recently, has 92 protons and 92 planet electrons flying around its core.

No one has ever seen an atom, let alone a proton, a neutron or an electron. This is far beyond the power



*This diagram of an atom is necessarily distorted: the core or nucleus actually is only one five-thousandth part of the atom in size.*

of the strongest existing microscope. And if Science often has been wrong in the past, why should we believe what it now says about something no one can see, feel, taste or smell?

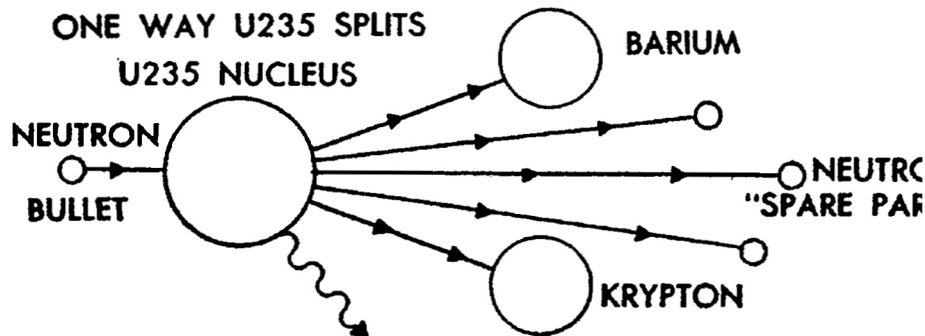
Well, no Jap is in a doubting mood. The atomic bomb should be its own proof to a layman, for it began with deductions no one could prove by any of the senses. Acting on these theoretical assumptions, Science put the bomb together, prevented it from exploding in the process, exploded it at the desired moment, got exactly the result it had foreseen.

Science doesn't pretend to know all about the atom as yet. In fact, only lately it has identified still further

**ENERGY RELEASED** 11,400,000 kilowatt-hours per pound of U235

When nucleus of U235 atom is hit by neutron bullet it explodes to form lighter atoms and spare neutrons whose combined mass is less than mass of U235.

Lost mass is transformed into energy—see Einstein's Law —



11,400,000 kw.-hr. of energy per lb. of U235

and smaller atomic sub-particles it is calling positrons, mesotrons and neutrinos. But there could have been no bomb if these major assumptions had not been true.

The first of these was reasoned out in 1905 by Albert Einstein, whose name is likely to be as famous to our descendants as that of Galileo and Newton. In the same year that Rutherford first foresaw the structure of the atom, Einstein announced his conclusion that mass and energy are different forms of the same thing.

It has been said that no more than ten minds in the world can grasp some of the Einstein theorems, but this is not one such. He was saying that all matter in the universe is locked-up energy and that all energy (which includes light and heat) is unlocked or dissipated matter. As all matter is made up of atoms, this energy is frozen in the atom. How he

### EINSTEIN'S LAW:

One pound of anything = 11,400,000,000 kw.-hr.

When  $\left. \begin{array}{c} \text{mass} \\ \text{or} \\ \text{energy} \end{array} \right\}$  converts to  $\left\{ \begin{array}{c} \text{energy} \\ \text{or} \\ \text{mass} \end{array} \right.$

Applying this law to U235 split:

Explosion products of one pound of U235 weight 0.9990 lb., so 0.001 lb. of the mass is converted into  $0.001 \times 11,400,000,000 = 11,400,000$  kilowatt-hours of energy.

MCGRAW-HILL PHOTO

thought this through is beyond understanding by all but a few, but the conclusion is reasonably simple.

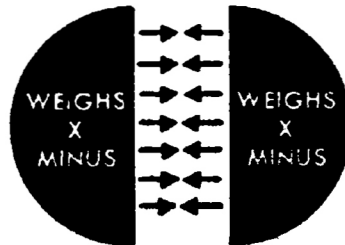
Einstein knew no way of unlocking this energy, but by his prophetic calculation of more than forty years ago, if 2.2 pounds (1 kilogram) of any matter could be converted into energy by the breaking down of its atoms, it would produce unbelievable power, as much as all the electrical generating capacity of the United States for two months. A lifetime's fuel for an automobile could be carried in a fountain pen. A cup of water could drive a liner across the Atlantic and back.

This seemed to have about as much practical value as the medieval speculation as to how many angels could stand on the head of a pin until, in 1919, Lord Rutherford announced that it should be possible artificially to cause small leaks of energy from stable elements by bombarding them with the particles

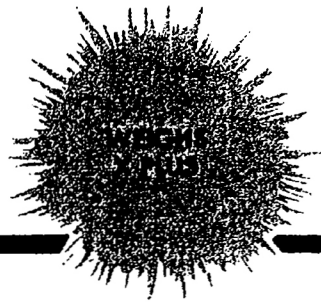
## WHY BOMB EXPLODES

**When block of rapidly assembled U235 passes secret critical size it explodes spontaneously**

HARMLESS



EXPLODING



MCGRAW-HILL PHOTO

thrown off by radium in its course of slow natural decomposition into lead.

Which means that Rutherford was predicting that man could tap the energy locked-up in the atom, though only in infinitesimally small amounts.

By 1934, the Curies' daughter, Irene, and her husband, Frederique Joliot, had followed the Rutherford trail to the point where they had made stable elements radioactive, giving off particles and radiation like radium.

Now the story moves down to the University of Rome where Dr. Enrico Fermi shortly got a more exciting result by bombarding a speck of uranium with Chadwick's newly identified neutrons, and by

first slowing these neutrons down.

To understand what he did, let's go back to 1919 and Rutherford, first man to chip a fragment off an atom. His great difficulty and the great difficulty of all physicists down to Fermi, was to score a direct hit. He found that he had to shoot a million sub-atomic particles from radium to get one bull's-eye. As late as 1934, Dr. Einstein complained that it was like "trying to shoot birds in the dark in a country where there were not many birds in the sky." The odds seemed so long that Einstein then wondered if man ever should succeed in releasing atomic energy in useful amounts.

Rutherford got his first hint of the atom's structure when he fired radium rays through a thin sheet of mica. They should have passed through this flimsy barrier like a battleship's shell through a canvas sail, yet he found their direction was changed slightly. They must be striking something strong enough to deflect them. Later, one of his assistants repeated the experiment with a thin sheet of gold—which should have been just as easy as mica for an atomic particle—and the rays were bent even more.

Recognizing this as an important clue to some mystery, Rutherford asked his assistant to repeat the experiment with great care, and this time some of the radium particles bounced back without penetrating the gold film. They had been thrown for a loss.

"It was quite the most incredible event that had ever happened to me," he said many years later. "On

consideration, I realized that it must be the result of a single concussion, and when I had made the calculations I saw that this was impossible unless you assumed that the greater part of the mass of the atom was concentrated in a minute nucleus.”

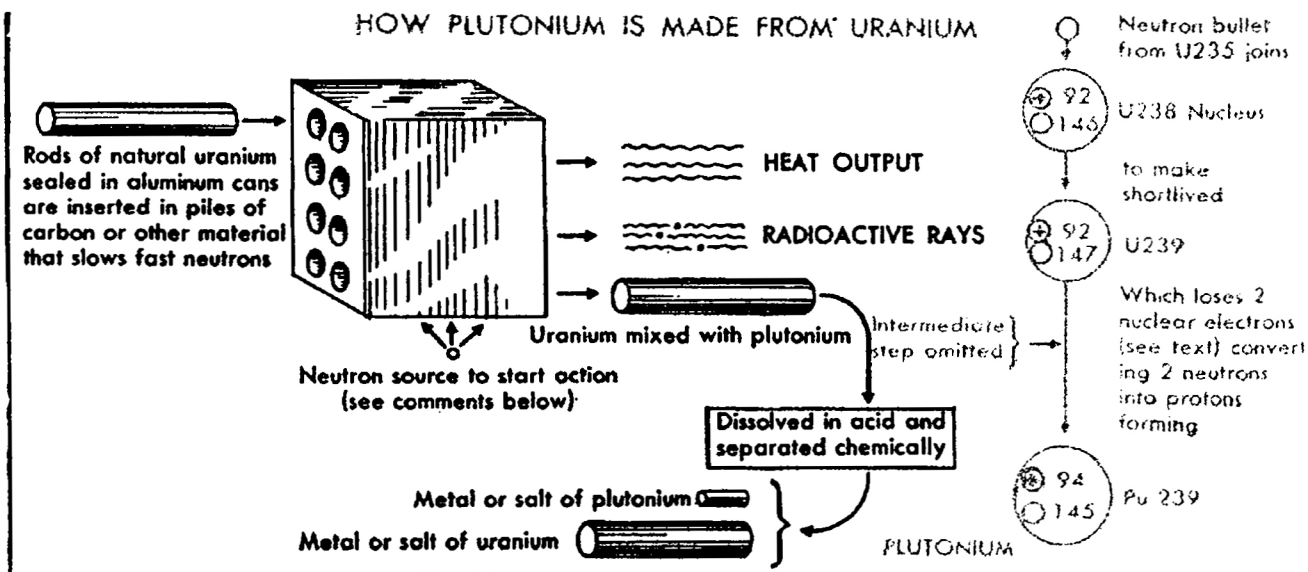
When the Rutherford conjecture was followed through, Science found that the cloud of electrons moving about an atom’s core protects the core from atomic projectiles much as sand bags shelter a soldier from bullets. This may be Nature’s way of insuring that the universe is not blown up by cosmic rays, those atomic particles from other worlds which come hurtling through space with such terrific speed that they usually drive through our atmosphere and deep into the earth.

From 1919 down to Fermi’s discovery, Science was building bigger and bigger atom-smashing machines to bombard atoms with streams of protons or other positively-charged particles with ever greater speed. This was thought to be necessary because the positively-charged particle had to batter its way into the atom’s core.

But by using the neutral particle, the neutron, as a bullet and by first slowing it down by passing it through hydrogen, Fermi scored a direct hit every time on the core of the atom.

Fermi was not looking for the atomic bomb, nor were any of the other many experimenters. He was hoping to create from uranium one or two elements heavier than uranium and unknown in Nature, and he

## HOW PLUTONIUM IS MADE FROM URANIUM



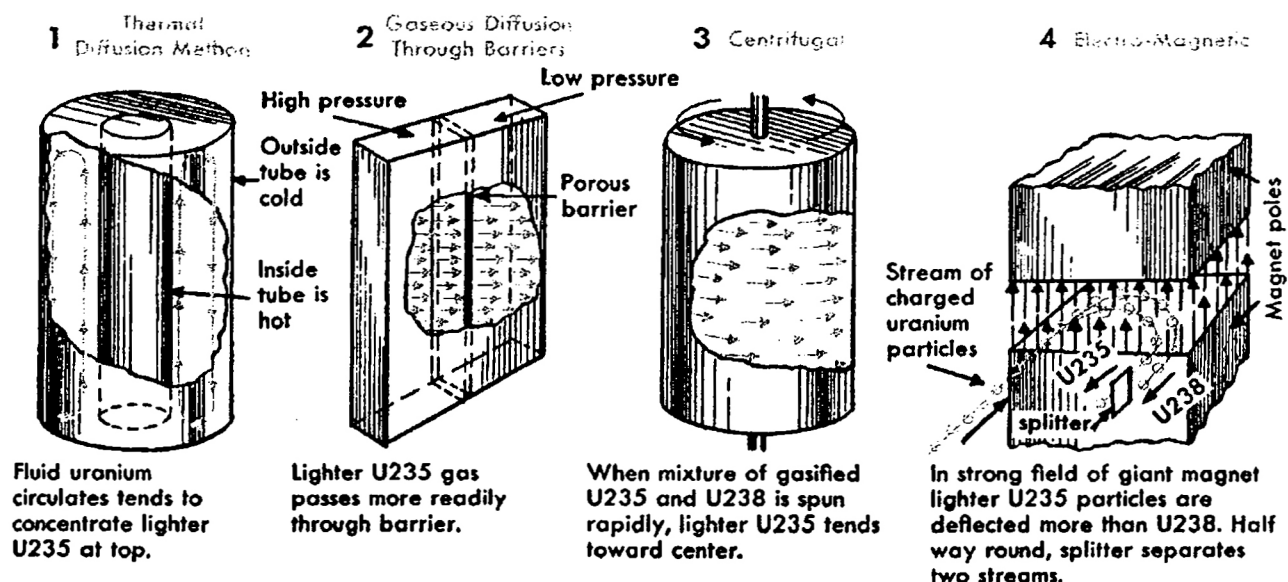
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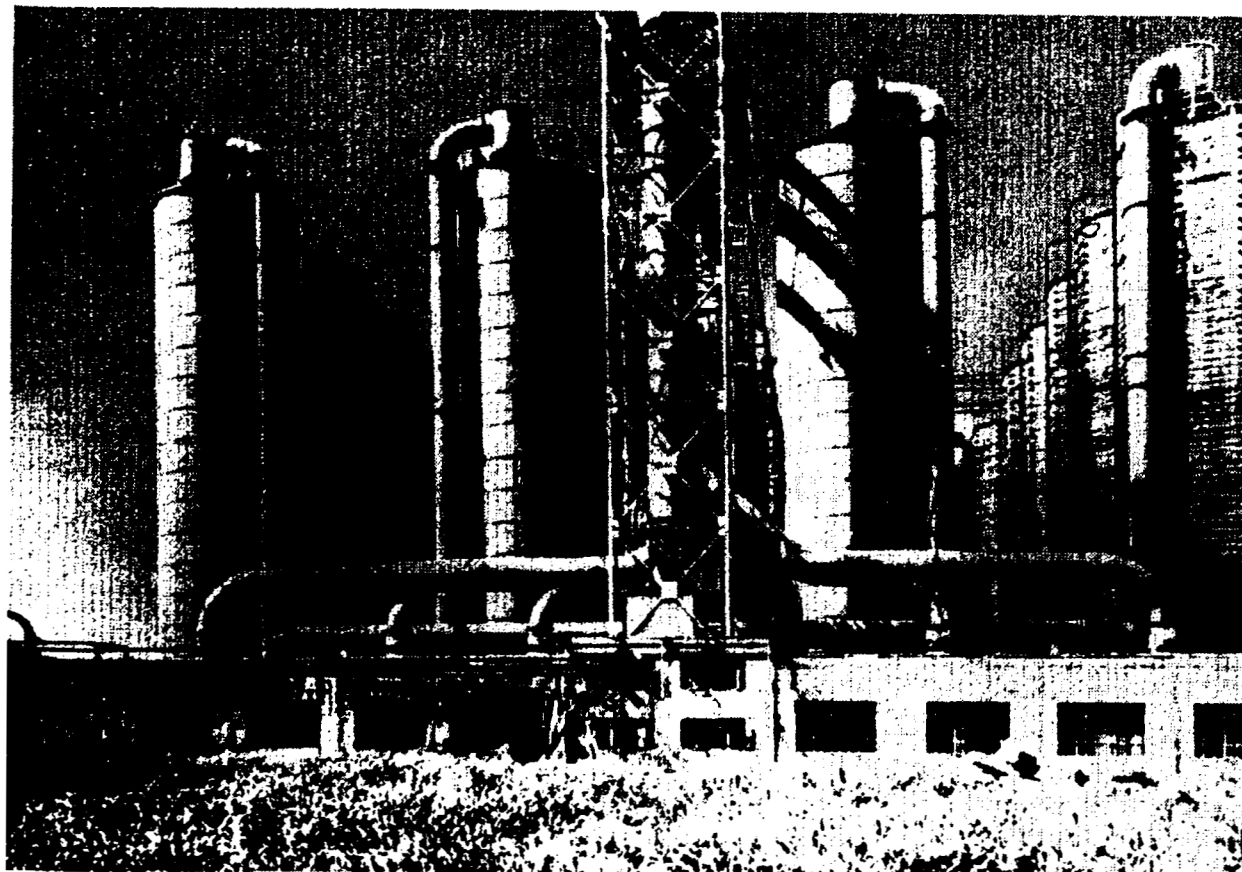
did get one such, an atom of 93 protons in its nucleus, one more than the protons in an uranium nucleus.

All over the world scientists now went to work with slowed-down neutrons. In Berlin, Prof. Otto Hahn, head of the great Kaiser Wilhelm Institute, assigned Dr. Lise Meitner to this research. The Nazis were in power and Dr. Meitner had Jewish blood, but Hahn managed to protect her until the end of 1938, when she was forced to flee to Stockholm, her work un-

MCGRAW-HILL PHOTO

## FOUR WAYS TO SEPARATE U235 FROM U238





*The British and Norwegians spent many lives in raids on this Nazi atomic bomb plant at Rjukan, Norway.* INTERNATIONAL NE

finished. Hahn and Dr. F. Strassman took over her data and continued her research.

Hahn quickly identified barium in the result which followed the bombardment of a speck of uranium with slowed-down neutrons. This was the all-important basic clue to the atomic bomb, but as barium is not even distantly related to uranium, Hahn was not too sure but what barium had been present all along in the uranium as an impurity. He published his findings in a German journal in January of 1939, seeing to it that a copy went to Dr. Meitner in Sweden.

Until now the most powerful atom-smashing machine had done no more than knock a few particles

off an atom, with a slow, tiny leak of energy, far less energy than that which went into the machine. But satisfied that no barium had been present in the uranium, Dr. Meitner reasoned that an atom of uranium actually must have been split roughly in half. And if one of the halves was barium, the other should be krypton because uranium has 92 protons, barium has 56 and krypton has 36; subtract 56 from 92 and you have 36.

This was sensational enough, but if an atom had been split in this manner, then, by the Einstein theorem, a great burst of energy should have been released—by rough estimate, about 200 million electron volts. The electron volt is a new yardstick, meaning the amount of force needed to move one

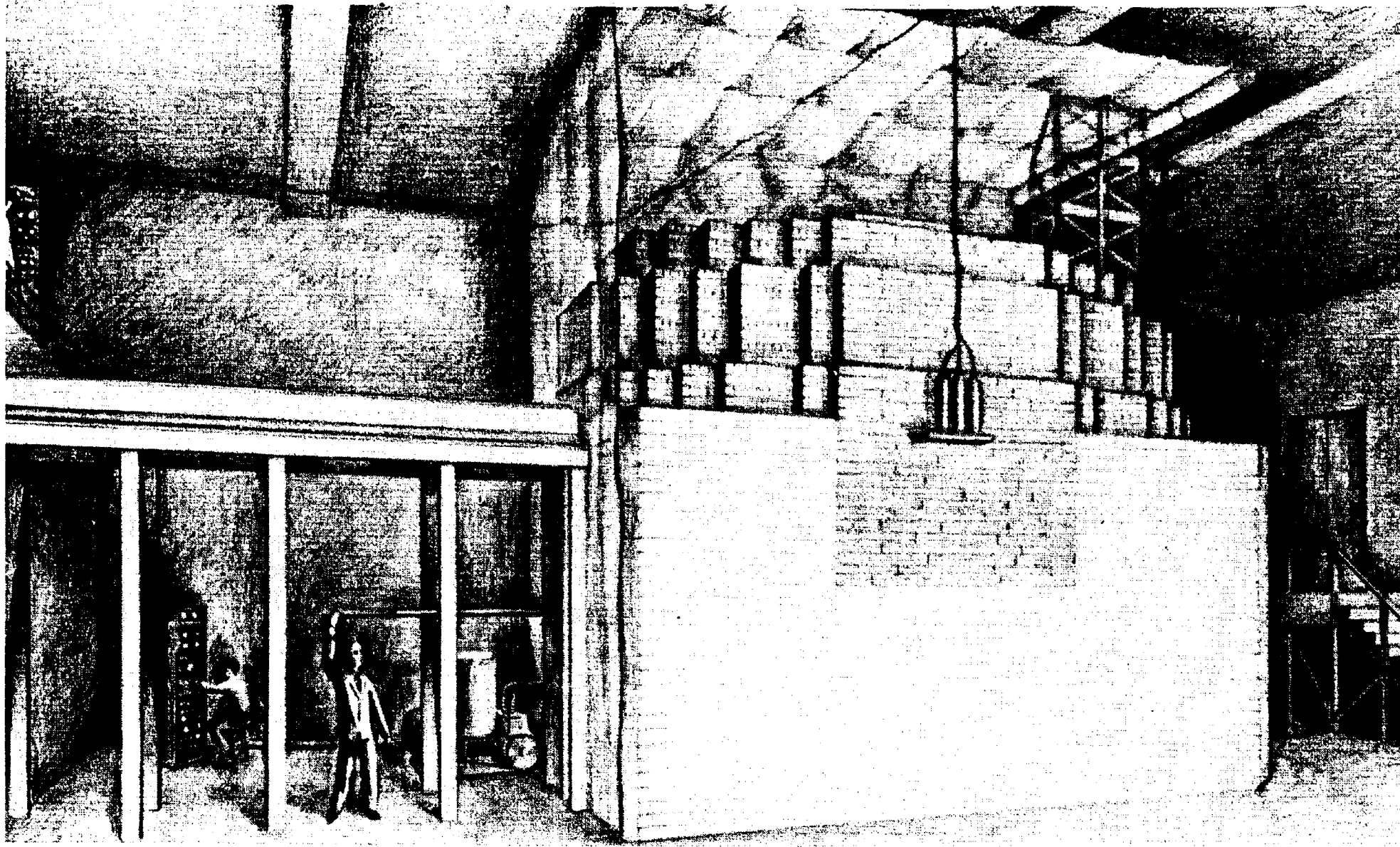
*Brig. Gen. T. F. Farrell, who commanded the atom-bombing of Japan; Mr. Keller; Col., now General, K. D. Nichols of the Manhattan Project; and Comm. F. L. Ashworth, ranking officer on the Nagasaki bombing flight.*



electron through a potential difference of one volt. And that brings up the fact that we now know what electricity is. Until the day before yesterday we knew only what it did, but nuclear physics has shown that it is a stream of electrons in motion. When you switch on a lamp, billions of electrons per second start bumping their way between the atoms of the copper wire to the lamp filaments.

By mail, Dr. Meitner discussed these conclusions with a confrere in Copenhagen, Dr. O. R. Frisch, also a refugee from Germany. Frisch is the son-in-law of Dr. Niels Bohr, one of the great names in atomic physics. Bohr had fled from Denmark by then and was in the United States working under the name of "Mr. Nicholas Baker" with Einstein at Princeton and with Fermi at Columbia. Fermi, who since has become an American citizen, was in exile from Fascist Italy.

Frisch was so excited that he cabled the substance of the Hahn-Meitner findings to his father-in-law. When the cable reached Dr. Bohr January 24, 1939, he quickly got in touch with Dr. George B. Pegram, dean of physics at Columbia, and Dr. John R. Dunning. Without knowing the full details of Dr. Meitner's calculations, they scribbled some figures on a pad and arrived independently at the same result. If the uranium atom had been split into barium and krypton, the parts should have flown apart like celestial cannon balls, each fragment travelling with a force close to 100 million electron volts. They proved it the next day in the laboratory.



COURTESY UNIVERSITY OF CHICAGO

*Official artist's sketch of where, beneath the stands of Stagg Field stadium, University of Chicago, atomic fission first was accomplished in a chain reaction Dec. 6, 1942. Courtesy University of Chicago.*