VAST ENERGY FREED BY URANIUM ATOM

Split, It Produces 2 'Cannonballs,' Each of 100,000,000 Electron Volts

HAILED AS EPOCH MAKING

New Process, Announced at Columbia, Uses Only 1-30 Volt to Liberate Big Force

The splitting of a uranium atom into two parts, each consisting of a gigantic atomic "cannonball" of the tremendous energy of 100,000,000 electron-volts, the greatest amount of atomic energy so far liberated by man on earth, was announced here yesterday by the Columbia University Department of Physics in a statement by Dean George P. Pegram of the Columbia Graduate Faculties.

The splitting of the uranium atom, it was said, constitutes an entirely new atomic process, the possibility of which did not even occur to any of the world's atom smashers. This new process, it was added, "yields the largest conversion of mass into energy that has yet been obtained by terrestrial methods."

Small Force Used for Splitting

One of the most startling phenomena in this newly discovered atomic process is the relatively small amount of energy necessary to liberate the enormous amounts developed through the splitting of the uranium atom. The uranium atom is split by means of neutrons, that is, neutral atomic particles carrying no electrical charge. These neutron bullets travel with energies of only one-thirtieth of a volt. Yet they produce two atomic "cannonballs" of a total of 200,000,000 electron-volts, representing an energy 6,000,000,000 times greater.

The Columbia announcement came under dramatic circumstances, following word received here last week of startling developments along similar lines in physical laboratories in Germany and Denmark. Two European Nobel Prize winners in physics, both of whom are now in this country, took a prominent part in the work. They are Professor Enrico Fermi of Rome, Italy, now at Columbia University, and Professor Niels Bohr of Copenhagen, Denmark, now at the Institute for Advanced Study at Princeton, N. J.

It was Professor Fermi who first fired neutron bullets into uranium, the heaviest element found in nature. Professor Fermi believed he had succeeded in creating an element heavier than uranium, which, being unstable, disintegrated into an isotope (twin of an element) of radium.

The work was continued at the Kaiser Wilhelm Research Institute for Chemistry at Berlin-Dahlem, Germany, by Dr. Lise Meitner and Professor Otto Hahn, who had been working together for many years. Dr. Meitner was discharged last year for racial reasons and she went to Stockholm, Sweden.

Professor Hahn continued his research with a new associate, Dr. F. Strassmann. On checking on Dr. Fermi's work they found to their great amazement that the uranium bombarded with neutrons, instead of disintegrating, as Professor Fermi thought, into an isotope of radium, a close neighbor of uranium on the atomic scale and nearly of the same atomic weight, formed the much lighter element barium. Uranium has an atomic weight of 238, that of radium is 225, whereas the atomic weight of barium is only 137.

Professor Hahn and Dr. Strassmann reported their startling observations on Jan. 6 without offering any theory to explain the new phenomenon. Never before had it been observed, or even suspected, that an element so far removed on the atomic table (uranium occupies No. 92 on the Periodic Table of Elements, while barium occupies No. 56) and so much lighter could be created from another element so much heavier.

Process Analyzed in Sweden

The exiled Dr. Meitner, in Stockholm, was continuing this work in collaboration with Dr. R. Frisch, a colleague of Dr. Bohr at the Institute of Theoretical Physics of the University of Copenhagen. When the work of their German colleagues came to their attention they came to the conclusion that they were here dealing with a new atomic process. They were the first to realize that what was happening was the actual splitting of the uranium atom, of atomic weight 238, into two lighter atoms, barium, of atomic weight 137, and possibly masurium, of atomic weight 97, or krypton, of atomic weight 82.

While the creation of the barium has been determined by physico-chemical tests, the identity of the second element split off the uranium is still undetermined.

Dr. Frisch told of his and Dr. Meitner's findings to Dr. Bohr, who, in turn, told Dr. Fermi on his arrival in this country recently. Dr. Fermi computed that if heavy uranium was split in two an enormous amount of energy, approximately 200,000,000 electron volts, must be liberated. He proposed last week that the experiment be performed at Columbia, where the new 150,000-pound cyclotron (atom-smasher) had just been installed.

The experiment was undertaken last Wednesday. Protons (nuclei of hydrogen atoms), catapulted with energies of 10,000,000 volts, were hurled at lithium atoms. This liberated neutrons of approximately the same order of energies. These neutrons, in turn, were slowed down to one-thirtieth of an electron-volt and fired at the uranium atoms.

Those who participated in the Columbia experiments with Professor Fermi were Professor John R. Dunning, Dr. G. Norris Glasoe, Dr. Eugene T. Booth, Dr. Herbert L. Anderson and Professor Francis G. Slack of Vanderbilt University.

Word of these experiments spread and on Friday the physicists at the Carnegie Institution in Washington corroborated the Columbia results.

VAST POWER SOURCE IN ATOMIC ENERGY OPENED BY SCIENCE

Relative of Uranium Found to Yield Force 5 Million Times as Potent as Coal

GERMANY IS SEEKING IT

Scientists Ordered to Devote All Time to Research—Tests Made at Columbia

By WILLIAM L. LAURENCE

A natural substance found abundantly in many parts of the earth, now separated for the first time in pure form, has been found in pioneer experiments at the Physics Department of Columbia University to be capable of yielding such energy that one pound of it is equal in power output to 5,000,000 pounds of coal or 3,000,000 pounds of gasoline, it became known yesterday.

The discovery was announced in the current issue of The Physical Review, official publication of American physicists and one of the leading scientific journals of its kind in the world.

Professor John R. Dunning, Columbia physicist, who headed the scientific team whose research led to the experimental proof of the vast power in the newly isolated substance, told a colleague, it was learned, that improvement in the methods of extraction of the substance was the only step that remained to be solved for its introduction as a new source of power. Other leading physicists agreed with him.

A chunk of five to ten pounds of the new substance, a close relative of uranium and known as U-235, would drive an ocean liner or an ocean-going submarine for an indefinite period around the oceans of the world without refueling, it was said, for such a chunk would possess the power-output of 25,000,000 to 50,000,000 pounds of coal, or of 15,000,000 to 30,000,000 pounds of gasoline.

Uranium ore, in which the U-235 also is present, is found in the Belgian Congo, Canada, Colorado, England and Germany, in relatively large amounts. It is 1,000,000 times more abundant than radium, with which it is associated in pitchblende ores.

Tested With Atom-Smasher

Until about two months ago not even an infinitesimal drop of the substance had been isolated in pure form and the task of doing so appeared hopeless from a practical point of view. Toward the end of February a minute fraction of a gram was isolated at the University of Minnesota Physics Department, under the direction of Professor Alfred O. Nier. The sample was rushed at once to Columbia University, where Professor Dunning, in collaboration with Dr. E. T. Booth and Dr. Aristid V. Grosse, submitted it to tests with the Columbia 150-ton cyclotron (atom-smasher).

The sample, however, was so small that the results, while striking, served merely to stimulate the scientists at Columbia and Minnesota to further efforts. So fast has the work progressed since the beginning of March, the report in the Physical Review says, that the yield has been increased 200-fold.

Such an increase in two months has given new hope that a process for isolating the substance in larger quantities, in grams and pounds instead of millionths of a gram, will be found in the not too distant future. While scientists refuse to make predictions, it is not impossible that a few months or a year hence may see the realization of this quest.

Industrial Laboratories Aid

The fact that industrial laboratories also have taken up the quest and are lending to their university colleagues the vast experimental resources at their disposal is revealed in the same issue of The Physical Review, in a report from the research laboratories at the General Electric Company by Dr. K. H. Kingdon and Dr. H. C. Pollock, also signed by Professor Dunning and Dr. Booth. The report reveals that the G. E. scientists also have set up an apparatus similar to that of Professor Nier and in their turn have separated a relatively large sample of the U-235. This sample was submitted also to experimental tests at Columbia and corroborated the results obtained from the University of Minnesota samples.

The main reason why scientists are reluctant to talk about this development, regarded as ushering in the long dreamed of age of atomic power and, therefore, as one of the greatest, if not the greatest, discovery in modern science, is the tremendous implications this discovery bears on the possible out-

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NEW POWER SOURCE OPENED BY SCIENCE

Continued From Page One

come of the European war, it was explained.

The news has leaked out, through highly reliable channels, that the Nazi government had heard of the research in American laboratories and had ordered its greatest scientists to concentrate their energies on the solution of this problem. Every German scientist in this field, physicists, chemists and engineers, it was learned, have been ordered to drop all other researches and devote themselves to this work alone. All these research workers, it was learned, are carrying on their tasks feverishly at the laboratories of the Kaiser Wilhelm Institute at Berlin.

The American scientists, it was said, are in the dark as to what their German colleagues are doing and what progress, if any, they have made. It is believed, however, that the American scientists are in the lead, as Germany does not possess the powerful cyclotrons of American laboratories, and these machines are necessary for carrying out the most effective experiments in studying the energies within the nuclei (cores) of atoms.

However, it was asserted that while cyclotrons are a prime requisite for determining the amount of energy contained in the new substance, the apparatus necessary for its isolation in small quantities was relatively simple and inexpensive, so that the Germans, on learning of the American research, no doubt could duplicate it.

On the other hand it is not believed that this particular apparatus will ever be useful in separating U-235 on a large scale. New plans are being made to isolate the substance on a practical scale, but the plans and the designs for these will be kept a secret to be given only to the United States Government, to do with as it sees fit.

A startling discovery about the new power source, also made as a result of the Columbia experiments, is the simplicity of the method of liberating its vast energy. All that is needed to put it to work running motors and steamships is to place it in a tank of water and keep it supplied with a constant flow of cold water.

Left by itself the substance would be inactive. As soon as it touched water of ordinary temperature it would automatically start to liberate its energy. The water would be turned into steam and the steam would drive powerful turbines. The new water supplied would keep the process going indefinitely. To stop it, all that would be necessary would be to cut off the water supply.

Thus the process would be the nearest practical approach to a form of perpetual motion, for as long as the U-325 would be supplied with water it would keep on liberating its energy until exhausted.

Teriffic Explosive Power

It was figured out, by way of another example, that one pound of the U-235 contains as much energy as 15,000 tons (30,000,000 pounds) of TNT, or 300 carloads of fifty tons each. If this one pound of U-235 exploded within 1/10,000ths of a second, as does ordinary TNT, the pressure produced would be on the order of 100,000,000,000 atmospheres (ten to the seventeenth power dynes to a square centimeter), about 1,000,000 times the pressure produced by TNT or by nitroglycerin.

On the other hand, it was estimated by an explosion expert, the explosion of such a pound of U-235 would produce a crater much less than 300 feet in radius and probably only seventy-five feet in radius.

The largest amount of explosives ever to have been exploded was 6,000 tons of a mixture of ammonium nitrate and ammonium sulphate in Oppau, Germany, about fourteen years ago. That explosion was accidental, as the mixture was supposed to be a fertilizer. The resulting crater was about 600 feet wide and 250 feet deep.

The U-235 is what is known as an isotope, or chemical twin of ordinary uranium. Even its existence was not known until a few years ago, and its properties had been unsuspected until a short time ago.

Up to a few months ago it was believed to exist in minute amounts in association with ordinary uranium, the proportion of the two having been regarded as being of the order of 1,000 parts of uranium to one part of the U-235, or about one-tenth of 1 per cent.

Suspicion first was cast on the possible nature of the U-235 as a great energy source, on purely theoretical grounds, by Professor Niels Bohr, Noble Prize winning physicist of the University of Copenhagen, Denmark, who carried on his researches last Summer at the Institute for Advanced Study at Princeton, N. J., and by Dr. John A. Wheeler of Princeton University.

Dane Speeded Tests Here

Professor Bohr was one of the first to learn of the discovery in Germany, in January, 1939, that when an ordinary sample of uranium, containing mixtures of three chemical twins, is bombarded with neutrons (fundamental atomic constituents carrying no electric charge) the uranium produces among the debris of its atoms the much lighter element barium.

Immediately communicating these results to his colleague, Professor Enrico Fermi, another Nobel Prize winning physicist, at Columbia University, and to other leading physicists, the true nature of the results obtained in Germany soon was determined. Repeating the German experiments at Columbia, Johns Hopkins, the Carnegie Institution of Washington and other laboratories, the physicists came upon the discovery that they were witnessing here for the first time a release of the binding energy within atoms on a scale greater than ever before.

What was happening, they discovered, was a splitting of the heavy uranium atom into two parts, one of which was barium of atomic weight 137, thus accounting for the barium observed in the German experiments by Professor Otto Hahn and Dr. Lise Meitner. In the process of the splitting (fission) of the uranium atom by the neutrons, the binding energy holding the uranium atom together was liberated to the extent of 200,000,000 electron volts.

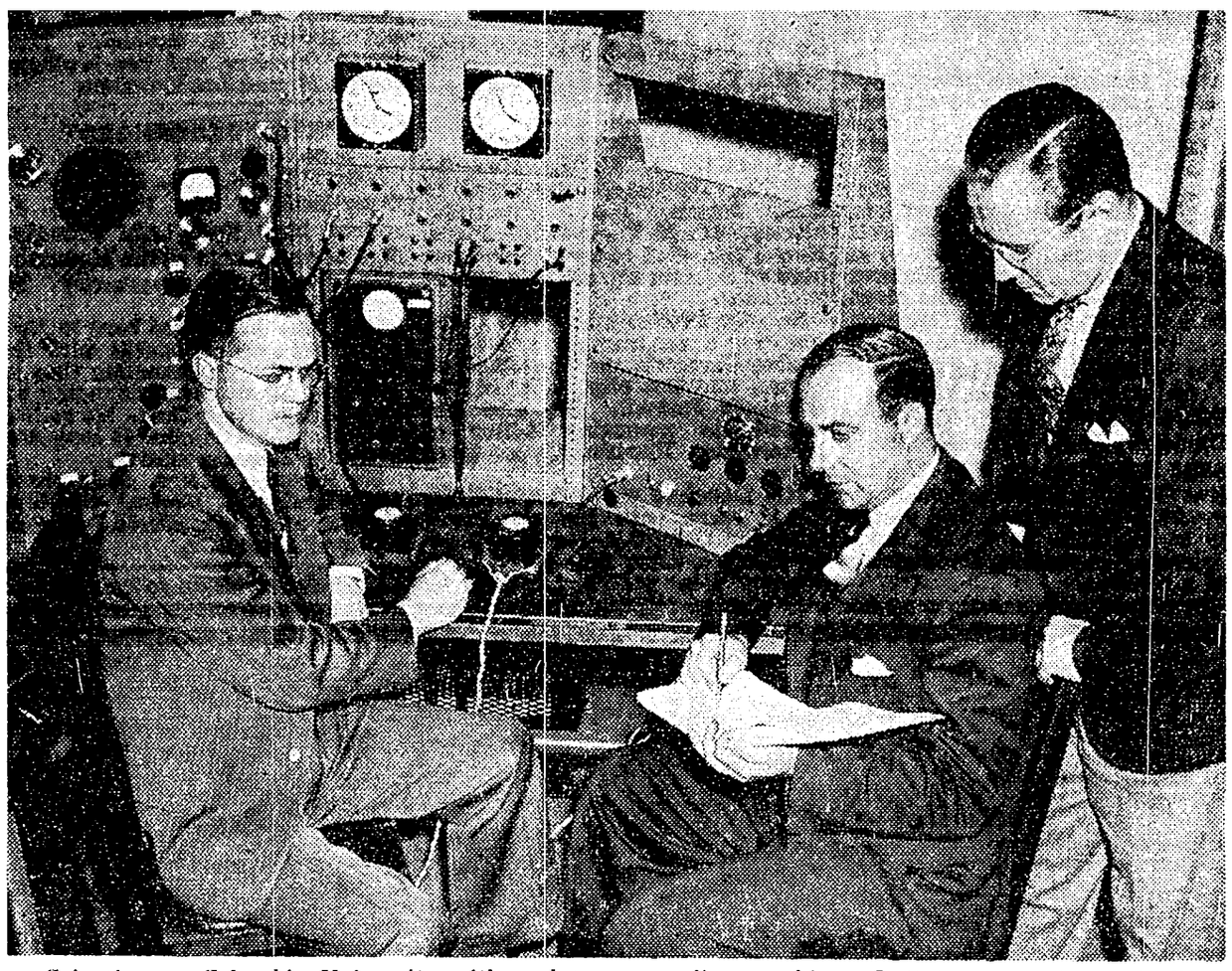
It was then for the first time (it took place in the early Spring and Summer, 1939) that attention was called to the neglected and unsung uranium isotope of atomic weight 235. Basing their reasoning on observations that atoms of even atomic weight are inclined to be less stable than atoms of odd atomic weights, Professor Bohr and Dr. Wheeler presented the theory that it was the minute fraction of U-235 in the uranium sample that was responsible for the release of the 200,000,000 electron volts when the uranium atom was split by a neutron.

The reasoning by Dr. Bohr and Dr. Wheeler was as follows: When uranium 238 is hit by a neutron that enters its nucleus, the atomic weight of the uranium is increased to 239, an odd-numbered weight, and hence a stable, non-exploding atom. On the other hand, when uranium 235 is hit by a neutron that enters its nucleus the atomic weight becomes 236, an even-numbered atomic weight, and hence a non-stable, exploding atom.

This theory split the physicists into two camps, one agreeing with Dr. Bohr and Dr. Wheeler and the other disagreeing. The Columbia experiments have settled the question definitely in favor of the Bohr hypothesis, according to the report.

Another question that until now had remained unsettled, and upon which the crux of the whole matter depended, was whether an atom of uranium, once hit by a neutron and split into two, would release other neutrons from its nucleus and thus start a "chain-reaction," in the manner of a fire-cracker, that would keep the process regenerating by itself, without any further need for neutron-bullets from outside sources. Unless such a process took place naturally there would be no hope of putting the uranium 235 to work on a practical scale.

REPORT ON NEW SOURCE OF POWER



Scientists at Columbia University with cyclotron recording machine. Left to right: Dr. E. T. Booth, research physicist; Dr. J. R. Dunning, Professor of Physics, and Dr. A. V. Grosse, a John Simon Guggenheim Research Fellow.

Dr. Alfred O. Nier, associated with them in the discovery.

Times Wide World

This all-important question also has been settled by the Columbia experiments in favor of the "fire-cracker hypothesis," the experiments establishing definitely for the first time that only one neutron, slowed down by water to travel with very low energy (one-fortieth of a volt), behaves in the manner of a trigger that sets off the process of energy-liberation from the uranium 235, it was reported.

Moreover, it was pointed out, even this one "trigger" neutron is not necessary to be supplied from any apparatus. The air is full of minute amounts of radium that constantly liberate neutrons by hitting atoms in the air. In addition, there are the omnipresent, all-penetrating cosmic rays that constantly bombard the earth from outer space. These powerful radiations also liberate neutrons from air atoms, and in fact play a part in starting off the trigger action in neon signs, the starting of which needs free electrons that are supplied by the radiations in the air produced by the radium and cosmic rays.

A building such as the Empire State, it was asserted, contains scattered radium in minute amounts that would equal a whole gram, worth about $25,000 in current prices. Without such radiations in the atmosphere, it was explained, neon lamps would have to be supplied with free electrons from an outside source and would be much more expensive.

Starting Energy to Work

To start the "Philosopher's Stone" in the U-235 to work, it was explained further, all that is necessary is one neutron traveling at low energy, the lower the better. Now, neutrons, as they come out of the cores of atoms, travel with high energy, and it is therefore necessary to slow them down.

Fortunately, protons, the cores of hydrogen atoms, constituting two-thirds of the volume of water, have the power to make neutrons yield up their high energies and to slow them down to almost no energy at all. Hence, all that is necessary to start the U-235 liberating its great energy is to place it in an environment of ordinary water.

The process then becomes automatic and self-regenerating, it was explained. A neutron liberated by a cosmic ray hitting atoms in the air, for example, is slowed down by the water surrounding the U-235. This splits an atom of the substance into two parts, liberating 200,000,000 volts of atomic binding-energy. In doing so it also liberates other neutrons from the nucleus of the U-235. These neutrons, in turn, are slowed down also as they hit the water, and again split another U-235 atom. The process then continues as long as there are atoms left, and there are 2,500 billion billion atoms of U-235 to the gram, and 453.72 grams make one pound.

Not only is the energy-liberating process automatic and self-regenerating, it was explained, but it also is self-regulating. The energy liberated from the atoms heats up the water so that it turns into steam. When all the water supplied has been turned into steam, there is nothing left to slow down the fast-traveling neutrons, and fast neutrons just go through the uranium without breaking up its atoms and releasing its energy. This brings the whole process to a stop until more cool water is supplied.

As one leading physicist explained it, "the colder the water the better the reaction. The reaction is self-limiting because heat (generated by the split atoms) speeds up the neutrons, and the faster the neutrons the less the reaction."

"The faster you feed in the cold water," the scientist added, "the faster the water will come out red hot on the other side, because more neutrons will be slowed down, and thus more atoms split and more energy is liberated. Thus the process is admirably suited for power purposes."

Another significant discovery, of practical bearing on the question of isolating the substance in usable amounts, was the redetermination of the relative abundance of the U-235 by Professor Nier. Whereas it had been believed as recently as last year that it existed in a ratio of only 1,000 to 1, compared with ordinary uranium of atomic weight 238, Professor Nier found that the ratio is much smaller, 139 pounds of ordinary uranium containing one pound of the U-235. This finding alone has increased automatically the amount of the new "Philosopher's Stone" by more than seven times and therefore makes its isolation seven times easier.

Germany, it was asserted, may regret her act of having sent into exile Dr. Lise Meitner, who, with Professor Hahn, made the first observations that led to the discovery of the fountain-head of atomic energy that German scientists are so feverishly working to harness. Soon after her exile, when she settled at Stockholm, Sweden, Dr. Meitner revealed the results of her work with Professor Hahn to colleagues of Professor Bohr, who at once communicated it to his colleagues in America. Had Germany then realized the importance of the findings it is highly probable, it was said, that she would have kept it a strict military secret and possibly later would have surprised the world with it.

In addition to the uranium of mass 238 and the newly isolated uranium of atomic weight 235 there is a third and much rarer type of uranium, of atomic weight 234. This isotope exists in the ratio of 1 to 17,000, compared with ordinary uranium 238.

Neither uranium 238 nor uranium 234, small amounts of which also have been separated, has been found to liberate energy on being bombarded with slow neutrons. Uranium 238 responds to fast neutrons, but the process in this case would be impracticable, it was pointed out. The Columbia experiments have demonstrated also for the first time, Dr. Dunning and his associates report, that the uranium of mass 234 plays no part in the energy-liberating process.

Five-Pound Mass Necessary

Because of the nature of the neutrons, even the slow-traveling ones, it was explained further, it is necessary to have a mass of at least five pounds, and possibly as high as twenty, to make the process work on a practical scale. In a smaller amount even low energy neutrons would escape into the open without splitting the initial "trigger-atom" that sets off the process. To start the process it is necessary for the neutron to remain inside the mass, so that it would enter the nucleus of an atom to start the splitting process.

However, it was said, it would not be necessary to obtain a mass of five to twenty pounds of pure U-235 to start the process. A concentration of 10 to 50 per cent would be sufficient. In other words, a five-pound mass of uranium mixture, that contained half to two-and a half pounds of the U-235, would be sufficient for use as a prime motive power for submarines, and for other sources of power.

Such a mass, it was explained, "would make the most powerful cyclotron puny by comparison, and would provide neutron radiations thousands of times greater than that produced by any cyclotron. By comparison with such a mass, a cyclotron would be a mere plaything, and the mass would be much less expensive than a cyclotron.

The power from the U-235, it was added, could be applied in many other useful ways. It would provide the most powerful source of neutron rays that might possibly be used in the treatment of cancer, as neutrons are much more powerful than either X-rays or radium. The neutron from the U-235 could be used also for the creation of artificially radioactive elements more powerful than radium. They could even be used for making gold out of mercury, but scientists expressed themselves as disdainful of such uses for their newest creative tool.

One of the scientists explained the process of the energy-liberation from U-235 by comparing it with the burning of coal. Whereas coal uses oxygen to liberate its energy, he explained, the U-235 uses slow neutrons for the same purpose. The process of combustion in the case of the U-235, he added, is, atom for atom, 100,000,000 times as effective as is the case in the combustion of coal. However, as the atomic weight of the uranium is 235, compared with 16 for the oxygen and 12 for the carbon, there are fewer uranium atoms to a given weight than there are oxygen and carbon atoms. This reduces the energy relations of the U-235, compared with coal, to a ratio of 5,000,000 to 1.

There are several new methods being considered for increasing the yield of the new substance to large-scale amounts. But as to this, scientists greet the questioner with a profound silence.

War Department Called Times Reporter To Explain Bomb's Intricacies to Public

Special to THE NEW YORK TIMES.

WASHINGTON, Aug. 6 — Behind the pounds of official reports and bales of War Department "handouts" designed to enlighten laymen on the working of the atomic bomb that was used for the first time over Japan yesterday lay several months of labor by an unassuming NEW YORK TIMES reporter, William L. Laurence.

Long a writer on scientific subjects for THE TIMES and Pulitzer prize winner, Mr. Laurence obtained leave from this newspaper at the War Department's request to explain the intricacies of the atomic bomb's operating principles in laymen's language.

The department's choice of Mr. Laurence was a natural one since he "discovered" for newspaper readers the method by which atomic energy was released by uranium fission as long ago as May, 1940. In an article published by THE TIMES at that time Mr. Laurence told its readers how the new material, U-235, was the most tremendous source of power known on earth.

Mr. Laurence then wrote:

"A chunk of five to ten pounds of the new substance, a close relative of uranium and known as U-235, would drive an ocean liner or an ocean-going submarine for an indefinite period around the oceans of the world without refueling, for such a chunk would possess the power output of 25,000,000 to 50,000,000 pounds of coal, or 15,000,000 to 30,000,000 pounds of gasoline."

Soon after this story was published the lid of military secrecy was clamped on scientific experimentation with the new material which the War Department then undertook in collaboration with leading scientists throughout the nation.

William L. Laurence
The New York Times Studio

ATOMIC BOMBING OF NAGASAKI TOLD BY FLIGHT MEMBER

Seething Pillar of Fire Rose 60,000 Feet From Blast—Planes High Up Rocked

ELECTRICAL STORM ON TRIP

Two Other B-29's Escorted Strike Ship—Enemy Flak Met Going In to the Target

Mr. Laurence, science writer for THE NEW YORK TIMES *and a Pulitzer Prize winner, is a special consultant to the Manhattan Engineer District, the War Department's special service that developed the atomic bomb.*

By WILLIAM L. LAURENCE

WITH THE ATOMIC BOMB MISSION TO JAPAN, Aug. 9 (Delayed)—We are on our way to bomb the mainland of Japan. Our flying contingent consists of three specially designed B-29 "Superforts," and two of these carry no bombs. But our lead plane is on its way with another atomic bomb, the second in three days, concentrating in its active substance an explosive energy equivalent to 20,000 and, under favorable conditions, 40,000 tons of TNT.

We have several chosen targets. One of these is the great industrial and shipping center of Nagasaki, on the western shore of Kyushu, one of the main islands of the Japanese homeland.

I watched the assembly of this man-made meteor during the past two days, and was among the small group of scientists and Army and Navy representatives privileged to be present at the ritual of its loading in the "Superfort" last night, against a background of threatening black skies torn open at intervals by great lightning flashes.

It is a thing of beauty to behold, this "gadget." In its design went millions of man-hours of what is without doubt the most concentrated intellectual effort in history. Never before had so much brainpower been focused on a single problem.

This atomic bomb is different from the bomb used three days ago with such devastating results on Hiroshima.

I saw the atomic substance befor it was placed inside the bomb, By itself it is not at all dangerous to handle. It is only under certain conditions, produced in the bomb assembly, that it can be made to yield up its energy, and even then it gives only a small fraction of its total contents—a fraction, how-

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Aftermath of Atomic Bomb: A City Laid Waste by World's Most Destructive Force

Nagasaki: Damage wrought on second city to be hit by missile. Large factory, right, is a mass of torn steel and rubble. Bridges over canal at left are either demolished or unusable

Associated Press Wirephoto

ATOMIC BOMBING OF NAGASAKI TOLD

Continued From Page 1

ever, large enough to produce the greatest explosion on earth.

The briefing at midnight revealed the extreme care and the tremendous amount of preparation that had been made to take care of every detail of the mission, to make certain that the atomic bomb fully served the purpose for which it was intended. Each target in turn was shown in detailed maps and in aerial photographs. Every detail of the course was rehearsed —navigation, altitude , weather, where to land in emergencies. It came out that the Navy had submarines and rescue craft, known as Dumbos and Superdumbos, stationed at various strategic points in the vicinity of the targets, ready to rescue the fliers in case they were forced to bail out.

The briefing period ended with a moving prayer by the chaplain. We then proceeded to the mess hall for the traditional early morning breakfast before departure on a bombing mission.

A convoy of trucks took us to the supply building for the special equipment carried on combat missions. This included the "Mae West," a parachute, a lifeboat, an oxygen mask, a flak suit and a survival vest. We still had a few hours before take-off time, but we all went to the flying field and stood around in little groups or sat in jeeps talking rather casually about our mission to the Empire, as the Japanese home islands are known hereabouts.

In command of our mission is Maj. Charles W. Seeney, 25, of 124 Hamilton Avenue, North Quincy, Mass. His flagship, carrying the atomic bomb, is named The Great Artiste, but the name does not appear on the body of the great silver ship, with its unusually long, four-bladed, orange-tipped propellers. Instead it carried the number 77, and someone remarks that it was "Red" Grange's winning number on the gridiron.

Bombardier an 8th A. F. Veteran

Major Seeney's co-pilot is First Lieut. Charles D. Albury, 24, of 252 Northwest Fourth Street, Miami, Fla. The bombardier, upon whose shoulders rests the responsibility of depositing the atomic bomb square on its target, is Capt. Kermit K. Beahan of 1004 Telephone Road, Houston, Tex., who is celebrating his twenty-seventh birthday today.

Captain Beahan has the awards of the Distinguished Flying Cross, the Air Medal and one Silver Oak Leaf Cluster, the Purple Heart, the Western Hemisphere Ribbon, the European Theatre Ribbon and two battle stars. He participated in the first Eighth Air Force heavy bombardment mission against the Germans from England on Aug. 17, 1942, and was on the plane that transported Gen. Dwight D. Eisenhower from Gibraltar to Oran at the beginning of the North African invasion. He has had a number of hair-raising escapes in combat.

The navigator on The Great Artiste is Capt. James F. Van Pelt Jr., 27, of Oak Hill, W. Va. The flight engineer is M/Sgt. John D. Kuharek, 32, of 1054 Twenty-second Avenue, Columbus, Neb.; S/Sgt. Albert T. De Hart of Plainview, Tex., who celebrated his thirtieth birthday yesterday, is the tail gunner; the radar operator is S/Sgt. Edward K. Buckley, 32, of 529 East Washington Street, Lisbon, Ohio. The radio operator is Sgt. Abe M. Spitzer, 33, of 655 Pelham Parkway, North Bronx, N. Y.; Sgt. Raymond Gallagher, 23, of 572 South Mozart Street, Chicago, is assistant flight engineer.

The lead ship is also carrying a group of scientific personnel, headed by Comdr. Frederick L. Ashworth, USN, one of the leaders in the development of the bomb. The group includes Lieut. Jacob Beser, 24, of Baltimore, Md., an expert on airborne radar.

The other two Superfortresses in our formation are instrument planes, carrying special apparatus to measure the power of the bomb at the time of explosion, high speed cameras and other photographic equipment.

Our "Superfort" is the second in line. Its commander is Capt. Frederick C. Bock, 27, of 300 West Washington Street, Greenville, Mich. Its other officers are Second Lieut. Hugh C. Ferguson, 21, of 247 Windermere Avenue, Highland Park, Mich., pilot; Second Lieut. Leonard A. Godfrey, 24, of 72 Lincoln Street, Greenfield, Mass., navigator; and First Lieut. Charles Levy, 26, of 1954 Spencer Street, Philadelphia, bombardier.

The enlisted personnel of this "Superfort" are: T/Sgt. Roderick F. Arnold, 28, of 130 South Street, Rochester, Mich., flight engineer; Sgt. Ralph D. Curry, 20, of 1101 South Second Avenue, Hoopeston, Ill., radio operator; Sgt. William C. Barney, 22, of Columbia City, Ind., radar operator; Corp. Robert J. Stock, 21, of 415 Downing Street, Fort Wayne, Ind., assistant flight engineer, and Corp. Ralph D. Belanger, 19, of Thendara, N. Y., tail gunner.

The scientific personnel of our "Superfort" includes S/Sgt. Walter Goodman, 22, of 1956 Seventy-fourth Street, Brooklyn, N. Y., and Lawrence Johnson, graduate student at the University of California, whose home is at Hollywood, Calif.

The third "Superfort" is commanded by Maj. James Hopkins, 1311 North Queen Street, Palestine, Tex. His officers are Second Lieut. John E. Cantlon, 516 North Takima Street, Tacoma, Wash., pilot; Second Lieut. Stanley C. Steinke, 604 West Chestnut Street, West Chester, Pa., navigator; and Second Lieut. Myron Faryna, 16 Elgin Street, Rochester, N. Y., bombardier.

The crew are Tech. Sgt. George L. Brabenec, 9717 South Lawndale Avenue, Evergreen, Ill.; Sgt. Francis X. Dolan, 30-60 Warren Street, Elmhurst, Queens, N. Y.; Corp. Richard F. Cannon, 160 Carmel Road, Buffalo, N. Y.; Corp. Martin G. Murray, 7356 Dexter Street, Detroit, Mich., and Corp. Sidney J. Bellamy, 529 Johnston Avenue, Trenton, N. J.

On this "Superfort" are also two distinguished observers from Britain, whose scientists played an important role in the development of the atomic bomb. One of these is Group Capt. G. Leonard Cheshire, famous Royal Air Force pilot, who is now a member of the British military mission to the United States. The other is Dr. William G. Denny, Professor of Applied Mathematics, London University, one of the group of eminent British scientists that has been working at the "Y-Site" near Santa Fe, N. M., on the enormous problems involved in taming the atom.

Group Captain Cheshire, whose rank is the equivalent to that of colonel in the United States Army Air Forces, was designated as an observer of the atomic bomb in action by Winston Churchill when he was still Prime Minister. He is now the official representative of Prime Minister Clement R. Attlee.

In Storm Soon After Take-Off

We took off at 3:50 this morning and headed northwest on a straight line for the Empire. The night was cloudy and threatening, with only a few stars here and there breaking through the overcast. The weather report had predicted storms ahead part of the way but clear sailing for the final and climactic stages of our odyssey.

We were about an hour away from our base when the storm broke. Our great ship took some heavy dips through the abysmal darkness around us but it took these dips much more gracefully than a large commercial airliner, producing a sensation more in the nature of a glide than a "bump," like a great ocean liner riding the waves, except that in this case the air waves were much higher and the rhythmic tempo of the glide much faster.

I noticed a strange eerie light coming through the window high above the navigator's cabin and as I peered through the dark all around us I saw a startling phenomenon. The whirling giant propellers had somehow became great luminous disks of blue flame. The same luminous blue flame appeared on the plexiglass windows in the nose of the ship, and on the tips of the giant wings it looked as though we were riding the whirlwind through space on a chariot of blue fire.

William L. Laurence of The New York Times (left) and Maj. John F. Moynahan of West Orange, N. J., public relations officer, at an airfield in the Pacific before taking off on mission over Japan.

The New York Times (U. S. Army Air Forces)

It was, I surmised, a surcharge of static electricity that had accumulated on the tips of the propellers and on the di-electric material in the plastic windows. One's thoughts dwelt anxiously on the precious cargo in the invisible ship ahead of us. Was there any likelihood of danger that this heavy electric tension in the atmosphere all about us might set it off?

I expressed my fears to Captain Bock, who seems nonchalant and imperturbed at the controls. He quickly reassures me:

"It is a familiar phenomenon seen often on ships. I have seen it many times on bombing missions. It is known as St. Elmo's Fire."

On we went through the night. We soon rode out the storm and our ship was once again sailing on a smooth course straight ahead, on a direct line to the Empire.

Our altimeter showed that we were traveling through space at a height of 17,000 feet. The thermometer registered an outside temperature of 33 degrees below zero centigrade, about 30 below Fahrenheit. Inside our pressurized cabin the temperature was that of a comfortable air-conditioned room, and a pressure corresponding to an altitude of 8,000 feet. Captain Bock cautioned me, however, to keep my oxygen mask handy in case of emergency. This, he explained, might mean either something going wrong with the pressure equipment inside the ship or a hole through the cabin by flak.

The first signs of dawn came shortly after 5 o'clock. Sergeant Curry, who had been listening steadily on his earphones for radio reports, while maintaining a strict radio silence himself, greeted it by rising to his feet and gazing out the window.

"It's good to see the day," he told me. "I get a feeling of claustrophobia hemmed in in this cabin at night."

He is a typical American youth, looking even younger than his 20 years. It takes no mind-reader to read his thoughts.

"It's a long way from Hoopeston, Ill.," I find myself remarking.

"Yep," he replies, as he busies himself decoding a message from outer space.

"Think this atomic bomb will end The war?" he asks hopefully.

"There is a very good chance that this one may do the trick," I assure him, "but if not, then the next one or two surely will. Its power is such that no nation can stand up against it very long."

This was not my own view. I had heard it expressed all around a few hours earlier, before we took off. To anyone who had seen this man-made fireball in action, as I had less than a month ago in the desert of New Mexico, this view did not sound overoptimistic.

By 5:50 it was real light outside. We had lost our lead ship, but Lieutenant Godfrey, our navigator, informs me that we had arranged for that contingency. We have an assembly point in the sky above the little island of Yakoshima, southeast of Kyushu, at 9:10. We are to circle there and wait for the rest of our formation.

Our genial bombardier, Lieutenant Levy, comes over to invite me to take his front-row seat in the transparent nose of the ship and I accept eagerly. From that vantage point in space, 17,000 feet above the Pacific, one gets a view of hundreds of miles on all sides, horizontally and vertically. At that height the vast ocean below and the sky above seem to merge into one great sphere.

I was on the inside of that firmament, riding above the giant mountains of white cumulous clouds, letting myself be suspended in infinite space. One hears the whirl of the motors behind one, but it soon becomes insignificant against the immensity all around and is before long swallowed by it. There comes a point where space also swallows time and one lives through eternal moments filled with an oppressive loneliness, as though all life had suddenly vanished from the earth and you are the only one left, a lone survivor traveling endlessly through interplanetary space.

My mind soon returns to the mission I am on. Somewhere beyond these vast mountains of white clouds ahead of me there lies Japan, the land of our enemy. In about four hours from now one of its cities, making weapons of war for use against us, will be wiped off the map by the greatest weapon ever made by man. In one-tenth of a millionth of a second, a fraction of time immeasurable by any clock, a whirlwind from the skies will pulverize thousands of its buildings and tens of thousands of its inhabitants.

Our weather planes ahead of us are on their way to find out where the wind blows. Half an hour before target time we will know what the winds have decided.

Does one feel any pity or compassion for the poor devils about to die? Not when one thinks of Pearl Harbor and of the Death March on Bataan.

Captain Bock informs me that we are about to start our climb to bombing altitude.

He manipulates a few knobs on his control panel to the right of him and I alternately watch the white clouds and ocean below me and the altimeter on the bombardier's panel. We reached our altitude at 9 o'clock. We were then over Japanese waters, close to their mainland. Lieutenant Godfrey motioned to me to look through his radar scope. Before me was the outline of our assembly point. We shall soon meet our lead ship and proceed to the final stage of our journey.

We reached Yakoshima at 9:12 and there, about 4,000 feet ahead of us, was The Great Artiste with its precious load. I saw Lieutenant Godfrey and Sergeant Curry strap on their parachutes and I decided to do likewise.

We started circling. We saw little towns on the coastline, heedless of our presence. We kept on circling, waiting for the third ship in our formation.

It was 9:56 when we began heading for the coastline. Our weather scouts had sent us code messages, deciphered by Sergeant Curry, informing us that both the primary target as well as the secondary were clearly visible.

The winds of destiny seemed to favor certain Japanese cities that must remain nameless. We circled about them again and again and found no opening in the thick umbrella of clouds that covered them. Destiny chose Nagasaki as the ultimate target.

We had been circling for some time when we noticed black puffs of smoke coming through the white clouds directly at us. There were fifteen bursts of flak in rapid succession, all too low. Captain Bock changed his course. There soon followed eight more bursts of flak, right up to our altitude, but by this time were too far to the left.

We flew southward down the channel and at 11:33 crossed the coastline and headed straight for Nagasaki about 100 miles to the west. Here again we circled until we found an opening in the clouds. It was 12:01 and the goal of our mission had arrived.

We heard the prearranged signal on our radio, put on our arc-welder's glasses and watched tensely the maneuverings of the strike ship about half a mile in front of us.

"There she goes!" someone said.

Out of the belly of The Great Artiste what looked like a black object went downward.

Captain Bock swung around to get out of range; but even though we were turning away in the opposite direction, and despite the fact that it was broad daylight in our cabin, all of us became aware of a giant flash that broke through the dark barrier of our arc-welder's lenses and flooded our cabin with intense light.

We removed our glasses after the first flash, but the light still lingered on, a bluish-green light that illuminated the entire sky all around. A tremendous blast wave struck our ship and made it tremble from nose to tail. This was followed by four more blasts in rapid succession, each resounding like the boom of cannon fire hitting our plane from all directions.

Observers in the tail of our ship saw a giant ball of fire rise as though from the bowels of the earth, belching forth enormous white smoke rings. Next they saw a giant pillar of purple fire, 10,000 feet high, shooting skyward with enormous speed.

By the time our ship had made another turn in the direction of the atomic explosion the pillar of purple fire had reached the level of our altitude. Only about forty-five seconds had passed. Awe-struck, we watched it shoot upward like a meteor coming from the earth instead of from outer space, becoming ever more alive as it climbed skyward through the white clouds. It was no longer smoke, or dust, or even a cloud of fire. It was a living thing, a new species of being, born right before our incredulous eyes.

At one stage of its evolution, covering millions of years in terms of seconds, the entity assumed the form of a giant square totem pole, with its base about three miles long, tapering off to about a mile at the top. Its bottom was brown, its center was amber, its top white. But it was a living totem pole, carved with many grotesque masks grimacing at the earth.

Then, just when it appeared as though the thing has settled down into a state of permanence, there came shooting out of the top a giant mushroom that increased the height of the pillar to a total of 45,000 feet. The mushroom top was even more alive than the pillar, seething and boiling in a white fury of creamy foam, sizzling upward and then descending earthward, a thousand Old Faithful geysers rolled into one.

It kept struggling in an elemental fury, like a creature in the act of breaking the bonds that held it down. In a few seconds it had freed itself from its gigantic stem and floated upward with tremendous speed, its momentum carrying into the stratosphere to a height of about 60,000 feet.

But no sooner did this happen when another mushroom, smaller in size than the first one, began emerging out of the pillar. It was as though the decapitated monster was growing a new head.

As the first mushroom floated off into the blue it changed its shape into a flowerlike form, its giant petal curving downward, creamy white outside, rose-colored inside. It still retained that shape when we last gazed at it from a distance of about 200 miles.

William Laurence Of The Times Dies

Special to The New York Times

MAJORCA, Spain, Saturday, March 19 —William L. Laurence, a science reporter who was the only journalist to witness the historic nuclear blast at Alamogordo, N. M., in 1945 and later the only newspaperman permitted to fly on the atomic-bomb mission over Nagasaki, Japan, died here today of complications from a blood clot in the brain. He was 89 years old.

Mr. Laurence won two Pulitzer Prizes as a reporter for The New York Times. He was a member of The Times staff for 34 years, first as a reporter and later as an editor, and retired in 1964. He is survived by his wife, Florence.

Mr. Laurence was one of the country's first full-time science reporters, and his biggest exclusive was the dawn of the nuclear age. With a style that often relied on vivid, but simple, imagery, he put technical subjects into terms that a lay-

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WILLIAM L. LAURENCE OF THE TIMES IS DEAD

Continued From Page 1

man could understand.

He never wrote "down." But by combining the significance and the drama of his subject with an insistent talent for clarity, he made his readers meet him half way.

Called 'Atomic Bill'

Mr. Laurence was a science reporter who conceived of his beat as the universe.

Besides his two Pulitzer Prizes, he won many other professional awards and held two honorary doctorates. But perhaps the accolade of which he was fondest was the nickname "Atomic Bill." This served to distinguish him at The New York Times from W. H. (Bill) Laurence, then a political writer for the paper. But it also tended to identify Mr. Laurence, warmly and constantly, with the subject of his biggest story.

He was born in Salantai, Lithuania, on March 7, 1888. He came to this country in 1905 and studied at Harvard College, the Harvard Law School and Boston University. He was naturalized in 1913, served with the Army Signal Corps in World War I and pursued his education at the University of Besançon in France in 1919.

Mr. Laurence entered journalism with The World in New York in 1926 and moved to The Times in 1930. In those days, there was more of a premium on the top-level general-assignment reporter than on the specialist. Mr. Laurence combined the technique of general reporting with specialized knowledge of science.

Used Vivid Imagery

In 1936, Mr. Laurence covered the Harvard Tercentenary Conference of Arts and Sciences at Cambridge, Mass. For this he shared a Pulitzer Prize with four other science reporters. In the prewar years, he kept abreast of medicine and physics, chemistry and astronomy.

Mr. Laurence told an interviewer that in the early days his mission had been highly suspect among men of science. He recalled visiting the Massachusetts Institute of Technology about 1940 and hearing a young scientist, Dr. J. Robert Oppenheimer, give an abstruse lecture on higher mathematics.

Afterward, the reporter sought out the scientist and asked him to explain some aspect of his talk. Dr. Oppenheimer recoiled and declared flatly and firmly that his subject was "not for the lay public."

Mr. Laurence remarked that he would just have to go ahead and write it as he saw it. "And what is that?" Dr. Oppenheimer asked. Mr. Laurence then gave him portions of his lecture back in simplified laymen's terms. "I never thought of it that way," Dr. Oppenheimer said, obviously rather pleased.

"We never had trouble again," Mr. Laurence told the interviewer.

Formed Writers' Group

In 1934, Mr. Laurence and David Deitz of the Scripps-Howard newspapers were covering a science meeting in Philadelphia when they decided to form the National Association of Science Writers. There were 12 charter members. The membership is now in the hundreds.

A few lines in a 1940 issue of The Physical Review told Mr. Laurence of successful efforts to isolate uranium 235. Not many journalists at the time would have known the significance of those lines. But Mr. Laurence did. In The Times of May 5, 1940, he had a front-page exclusive that began:

"A natural substance found abundantly in many parts of the earth, now separated for the first time in pure form, has been found in pioneer experiments at the Physics Department of Columbia University to be capable of yielding such energy that one pound of it is equal in power output to 5,000,000 pounds of coal or 3,000,000 pounds of gasoline. . . ."

Illustratively, he incorporated the prediction that "a chunk of five to ten pounds of the new substance, a close relative of uranium and known as U-235, would drive an ocean liner for an indefinite period around the ocean without refueling."

There is no doubt that at least some of Mr. Laurence's colleagues, reading his story that morning, felt that this was one time he had gone off the deep end. Yet, within two years and eight months—on Dec. 2, 1942—the first sustained controlled production of atomic energy had been achieved at the University of Chicago. And within a little more than five years—on Aug. 6 and Aug. 9, 1945—the accuracy of his work was to be stunningly demonstrated by the demolition of two Japanese cities by a single bomb each, and the swift ending of the resistance of an empire.

And as postwar nuclear development produced the atomic submarines, and the great cruises under the polar ice cap, it became apparent that Mr. Laurence had known what he was writing about in terms of both the destructive and constructive potential of nuclear energy.

Outlined Atomic Race

A few months after his first story in The Times, Mr. Laurence wrote a magazine piece that outlined the crucial nature of the race for an atomic breakthrough. He mentioned the physicists Enrico Fermi and Niels Bohr, then unknown to the general public. It became obvious to United States authorities familiar with the building of the atomic bomb, called the Manhattan Project, that when the time came to explain the bomb to the world, Mr. Laurence was the best man to do so.

So one day, in the spring of 1945, The Times's science reporter simply didn't show up at work. Only the then managing editor of The Times, Edwin L. James, and Mrs. Laurence knew—and only in general terms—where he was.

He had been made a party to the secret bomb project, and on July 16, 1945, he witnessed the Alamogordo test that proved the atomic bomb was ready. He was an eyewitness to the dropping of the bomb that ravaged Nagasaki and knocked Japan out of the war. And he won the 1946 Pulitzer Prize for his account of the Nagasaki bomb and for a subsequent series in The Times on the development, production and significance of the bomb.

For another decade Mr. Laurence continued to range across the country, and away from it, in search of science news. He covered the major scientific meetings —and was often as much a subject for the respectful questions of scientists interested in atomic energy as they were for his.

In May 1956 he flew to the Pacific for the explosion of a hydrogen bomb.

The New York Times, 1963
William L. Laurence

His 3,500-word piece had not only the impact of an account by an eager—and properly respectful—witness. It was based on more continuous, intimate background in nuclear physics than that of any other journalist on the story.

Named Science Editor

Later that year, upon the death of Waldemar Kaempffert, Mr. Laurence became science editor of The Times. He moved from the third to the 10th floor; but his technique was the same. He pored over the most advanced of the technical journals; and his Sunday column related what he had discovered and developed to the needs and hopes and day-to-day routines of hundreds of thousands of readers.

Mr. Laurence retired as science editor of The Times on Jan. 1, 1964, and became science editor emeritus. His last regular bylined story ran in the paper that morning on page 8.

In 16 paragraphs, the 75-year-old writer told of the discovery by two Columbia University physicians of a "dual hormone" in the human placenta that helped promote the growth of the fetus and also helped to stimulate lactation in the mother.

On Jan. 20 of that year, 300 friends gathered for a dinner in honor of Mr. Laurence at the Statler Hilton Hotel to pay tribute to him for nearly 34 years of "distinguished science reporting."

Mr. Laurence had come a long way from the days when scientists had viewed him with suspicion as a newspaperman. The dinner was sponsored by 27 eminent societies and institutions of science, including the American Association for the Advancement of Science, the American Medical Association and Harvard University.

Address by Bronk

Dr. Detlev W. Bronk, a former president of the National Academy of Sciences, addressed the dinner.

Once, several years before, a young reporter had been assigned to write a biographical sketch of Dr. Bronk and he had gone instinctively to Mr. Laurence to ask him to assess Dr. Bronk.

"Why," Mr. Laurence said earnestly, "he's the pooh-bah of American science!"

If Dr. Bronk was indeed that, Mr. Laurence was its Boswell.

In retirement, Mr. Laurence served as science consultant to the 1964-65 New York World's Fair and as scientific consultant to the National Foundation-March of Dimes.

He occupied honored places on daises at major affairs of scientific and other organizations, and his short, chunky frame frequently stood on the lecture platform.

His gnome-like appearance was accentuated by a flattened nose and a flowing head of hair. His nose had been mashed, he said, by the butt of a Cossack rifle when he was a youth in Lithuania (then, as now, a part of Russia). Later, hidden in a hogshead, he escaped to Berlin and finally made his way to this country.

Tutored Harvard Students

Mr. Laurence displayed his intellectual prowess at an early age. He was a highly successful tutor of less gifted Harvard students, working for a time at an establishment run by a man known as "the widow" Nolan. On the eve of an examination, a derby hat stood on a table in the lobby. Students who deposited therein a $5 bill were permitted to hear Mr. Laurence and others outline answers to anticipated questions.

His virtuoso performance in a word game at the home of Herbert Bayard Swope, executive editor of The New York World, is said to have led to his being hired as a reporter on that paper.

Mr. Laurence's original family name had been Siew. He chose Laurence in affectionate tribute to elm-shaded Laurence Street, where he lived in Cambridge. In 1931, he married Florence Davidow; they had no children.

Early in his career, Mr. Laurence adapted three dramatic works, from the Russian. He was a frequent contributor to national magazines.

Among his books were "Dawn Over Zero—the Story of the Atomic Bomb," published in 1946; "The Hell Bomb," 1951, and "Men and Atoms," 1959.

Mr. Laurence belonged to the Players, the Harvard, the Lotos, the Dutch Treat, the National Press and the Overseas Press Clubs and to the Society of the Silurians.

The Laurences moved to Majorica in 1968.

In July 1965, Mr. Laurence reviewed "Day of Trinity" by Lansing Lamont for The Times Book Review, and he began with these words:

"In the predawn darkness of Monday, July 16, 1945, a small group of men, including this writer, stood in the primeval desert near Alamogordo, N. M., and watched the birth of a new age. On that morning, when the first atomic bomb sent up a mountain of cosmic fire . . . the world we lived in came to an end, though few of us realize it even now. The new world that was born is still in the making, and no one yet knows what kind of world it will finally be."