AFTER THE BATTLE

THE ATOMIC BOMB

Number 41

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Front Cover: The former Commercial Display Building of the city of Hiroshima, 400 feet from Ground Zero and 2,000 feet from Air Zero, has been left as it was in 1945 and renamed the Atomic Bomb Dome. (Kenneth Parkes)

Centre Pages: Ground Zero at Nagasaki is now marked by an obelisk in the memorial park located just above the stadium which was the aiming point. (Nagasaki International Cultural Hall)

Back Cover: Ground Zero in New Mexico is now located on the White Sands Missile Range. (US Army)

Acknowledgments: The Editor is indebted to the following for their generous assistance in the preparation of the feature on the atomic bomb. In America Bonifacio Basilius, Trust Territory of Saipan; Robert Galla, Wendover; J. M. Guerrero, Mariana Visitors' Bureau; J. R. Lovelady, White Sands Missile Range; Colonel Glenn E. McClure, USAF Ret. of Emerson's, Universal City, Texas; Barbara Mulkin and William L. Richmond, Los Alamos Scientific Laboratory; Wayne Range, Oak Ridge Operations; Judy L. Tokarz, Richland Operations Office; Ko Hayashida, Nagasaki International Cultural Hall, Atsushi Hirota and Kenneth Parkes in Japan not forgetting Jeff Pavey of the Imperial War Museum, London.

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War in its simplest terms is a contest. In ancient times its outcome was decided pure and simple on the battlefield. Later the victory of one side over the other became more and more dependent on invention and manufacture: from the longbow to the crossbow, from the matchlock to the flintlock, from black powder to smokeless propellant, from single shot to automatic weapon, and so on. There is nothing like a war to stretch man's ingenuity to its utmost and the Second World War was won for the Allies just as much in laboratories and factories as it was on the field of battle.

The idea that a bomb whose effect was produced by 'atomic' energy was theoretically possible came with the publication of Albert Einstein's *Annalen der Physik* in 1907 in which he showed that mass and energy are merely different aspects of the same thing. His equation proved that if any heavy nucleus breaks into two pieces (called fission), the total mass of the two parts is less than that of the original, the difference being accounted for by the release of energy. In theory any element heavier than iron is potentially able to release energy after undergoing fission although in practice the fission barrier, which causes nuclei to split at different times, is lowest in the heaviest elements.

At the beginning of the war uranium was the heaviest element then known to exist. Isolated as far back as the 1780s, and usually referred to as pitchblende, element number 92 was named uranium by Martin Klaproth, a Berlin apothecary, after the planet Uranus which had been recently discovered. Having the atomic weight of 238.08, the metal was first extracted from ore in 1841 and its radioactive properties were discovered in 1896. Comprising two parts per million of the earth's crust, it is considerably more plentiful than gold, and the world's largest producer of high-grade uranium ore in 1939 was the Union Minière du Haut-Katanga in the Belgian Congo.

In 1932 James Chadwick, working at the Cavendish Laboratory, Cambridge, had discovered the neutron — an electrically uncharged particle which could be used as a 'missile' to split an atom without being deflected. Two years later Enrico Fermi at the University of Rome used a neutron to bombard and split a uranium atom, creating in effect a mini atom bomb, although, at the time, he was unaware of what he had actually achieved — the leading scientists of the period claiming that splitting the uranium atom was impossible. It was left to three German scientists, Otto Hahn, Lise Meitner and Fritz Strassmann, to officially discover fission during their experiments in 1938. Leading physicists of the time: Niels Bohr of Denmark, Yakov Frenkel of the Soviet Union and John Wheeler in the United States, had all published papers before the outbreak of war describing what actually occurred during fission. When Fermi was awarded a Nobel Prize in 1938 for his work, he travelled to Sweden with his wife and family, seizing the

THE ATOMIC BOMB

opportunity to leave Italy and sail for America. Niels Bohr likewise had travelled to the United States to continue his work (although he later returned to Denmark and was there when his country was overrun) and the German experiment was duplicated at the University of Columbia. From this Bohr deduced that a sustained atom-splitting 'chain reaction' could be created, releasing energy which would multiply upon itself in the fraction of a second. Fermi and others were not slow to see the implications: with war now inevitable, if German scientists put two and two together and applied the principle of the chain reaction to produce a bomb, its potentially destructive force would be unlike anything known before or even conceived. A letter was therefore composed, signed by Einstein and addressed to the American President, Franklin D. Roosevelt, warning him of the danger. The Germans had already taken over Europe's richest uranium mine at Joachimsthal (now Jáchymov) in Czechoslovakia and word reached the outside world that those physicists left in Germany were feverishly at work at the Kaiser Wilhelm Institute in Berlin.

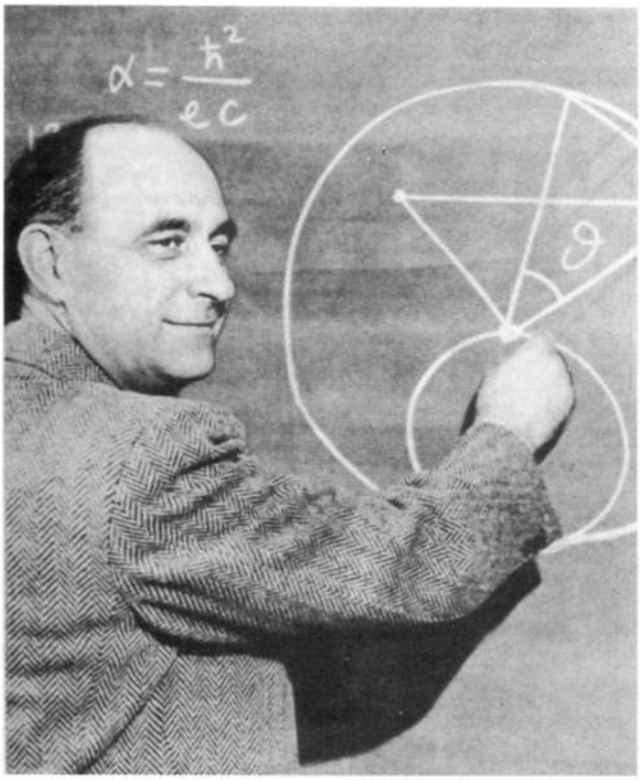
Meanwhile, in the United States, the letter had led to the President setting up an advisory committee authorising support for American universities engaged in uranium research. Some $300,000 (the exchange rate was then around $4 to £1) was allocated by the Government to sixteen research groups.

Bohr and Wheeler had already suggested that only a small part of the natural uranium was undergoing fission during the chain reaction, specifically the isotope uranium-235, differing in its atomic weight, which was only present to the extent of one part in 140. This was later confirmed by experiments at the University of Minnesota. Once having obtained enough ore in the first place, which was difficult enough, the seemingly insurmountable problem was just how to refine it to the absolute purity demanded of the end product to leave a significant quantity of the minute substance U-235. In 1939 there was only one ounce of ordinary metallic uranium in the whole of the United States and the scientists were now talking of several pounds being needed merely for experiments!

The impossibility of transforming one element into another was then an accepted principle of chemistry but this premise was to be proved wrong at the Berkeley Radiation Laboratory of the University of California. There a machine termed a 'cyclotron' had been built to accelerate nuclei to the speed required to penetrate an atom. In May 1940, after bombarding uranium, a new, yet unstable, element was produced — the first man-made element ever — which the two physicists concerned, Edwin M. McMillan and Philip H. Abelson, christened neptunium. Later that year another element was created (the 94th) by Glenn Seaborg which he later called plutonium. The amount created was infinitesimally small and invisible to the naked eye — just a trace on a measuring device — yet there were strong reasons to suspect that the new material would be fissionable like U-235. It opened up an alternative line of research and one which might lead to fission material being produced in a factory and not gleaned out of the ground.

Meanwhile, in the United Kingdom, the Committee for the Military Application of Uranium Detonation — dubbed the MAUD Committee and comprising the elite of Britain's scientists — was deliberating on its findings as to whether the construction of an atomic bomb was possible. When it reported in the late summer of 1941 that such a bomb was not only possible but that its construction should begin without delay, it galvanised forces in America to act. In the States the work of all the research laboratories was being co-ordinated by the Office of Scientific Research and Development (OSRD) under its director, Dr Vannevar Bush. On December 6, the day before America's entry into the war, the first meeting of a newly-formed atomic sub-committee, called 'S-1', was held in Washington with the brief to establish whether a bomb could be produced in America and at what cost. The committee had to submit their findings to the President within six months.

Nagasaki — blasted in the second mission of Operation Silver Plate. One support of the shrine gate amazingly still standing after the 22,000-ton explosion. (A. Hirota)



Enrico Fermi led the team at the University of Chicago which built the world's first nuclear reactor. Then termed an 'atomic pile', it was constructed in the rackets court at Stagg Field.

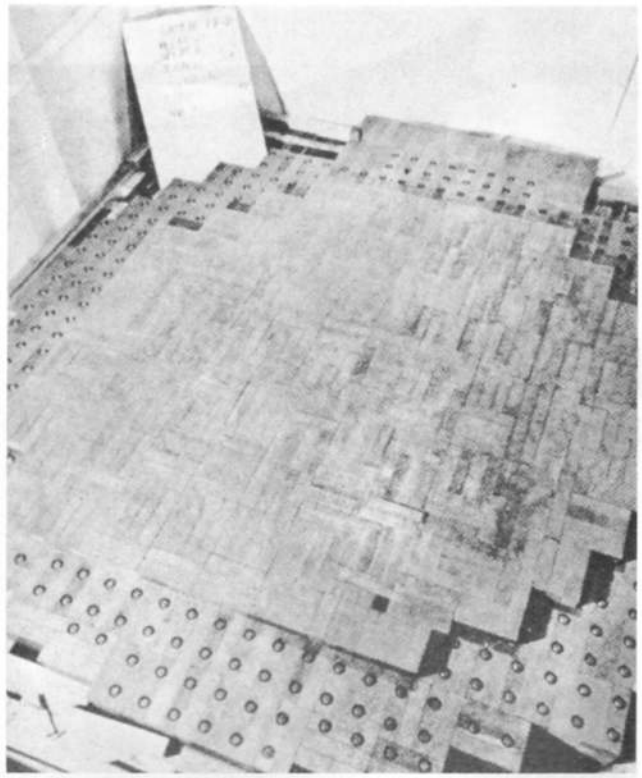
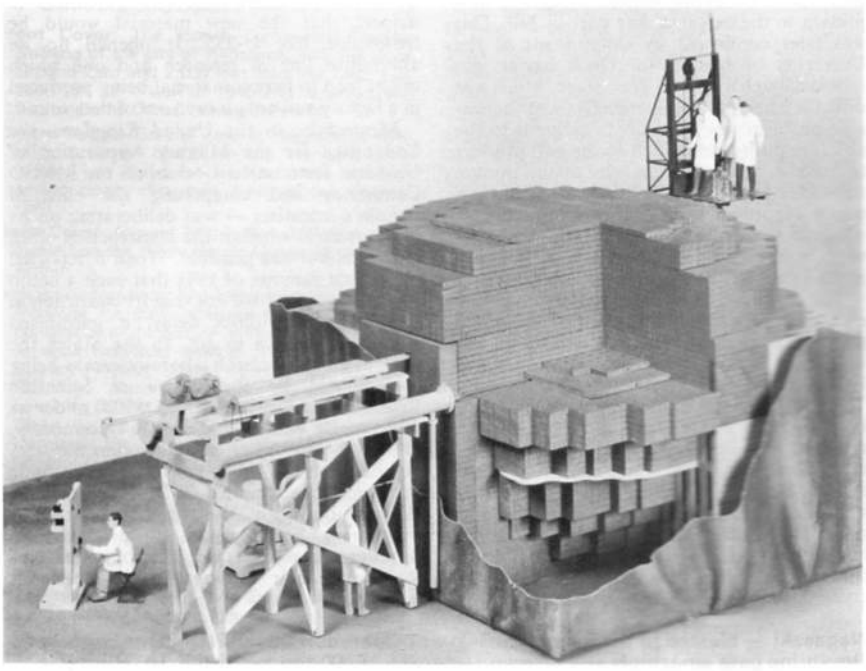


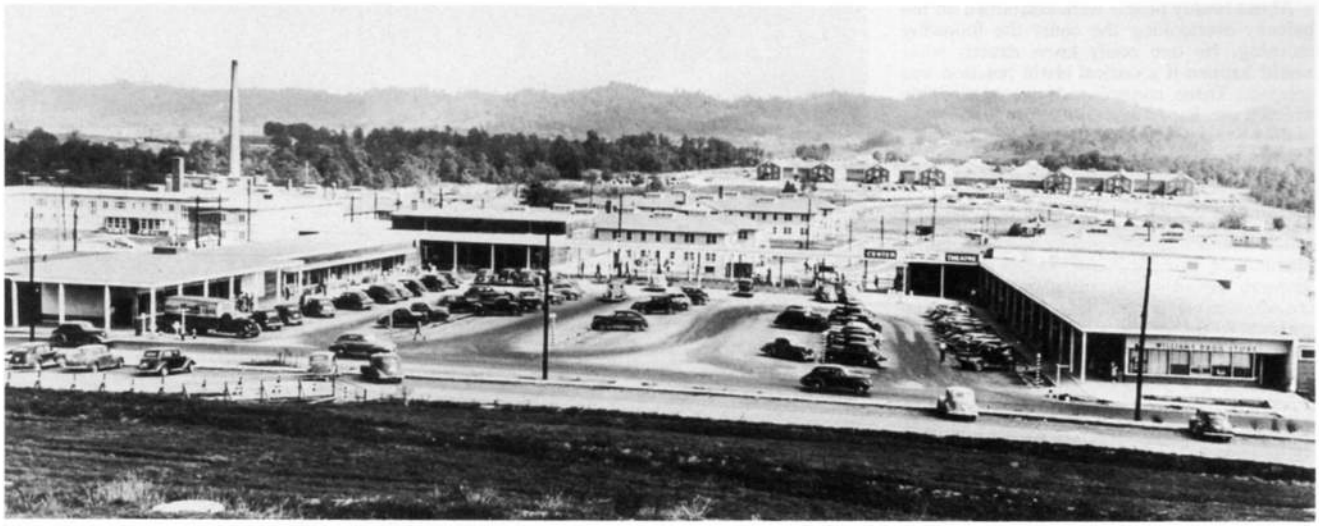
Photo shows the addition of the nineteenth layer of graphite blocks. Fifty-one layers were needed altogether, the pile becoming critical on the afternoon of December 2, 1942.

Early in 1942, Bush was able to report that production of U-235 and plutonium (P-239) was probably possible in spite of the fears of the scientists that it would take many years to refine sufficient quantity of fissionable material to make even one bomb, the physicists even holding differing opinions as to how much would actually be necessary. When the S-1 Committee reported back their conclusion was that an atomic bomb could cost upwards of $100 million (up to £764 million in today's inflated money) and might be produced by July 1944.

The MAUD Committee had already stated that no country at war could risk being without such a weapon and disturbing reports from Continental Europe indicated that the Germans had already begun work and that they most probably had an eighteen month start. Although considerable scientific research had been carried out in the United Kingdom, Britain's resources were already stretched to the utmost. With America now fully committed to the war effort and the unrivalled capacity of its industries far away from Hitler's bombers then blitzing England, the President made his decision. America would produce the bomb, whatever the cost, all research and production would be concentrated in the United States, and British scientists would continue their work in America on a combined effort. The burning question: what sort of lead might the Germans have, and could the Allies catch up in the race to produce the bomb?

No photographs exist of the completed CP-1 reactor. Drawings were made in 1946 and a model constructed of a significant portion of the West Stands at Stagg Field. This picture shows the reactor temporarily removed from the rackets court — the huge tent of balloon cloth was prepared to seal the pile and minimise the non-productive loss of neutrons although, in the event, it was not required. The stadium has since been demolished — this sculpture 'Nuclear Energy' by Henry Moore was erected near the spot on the 25th anniversary of the experiment.





The Manhattan Project

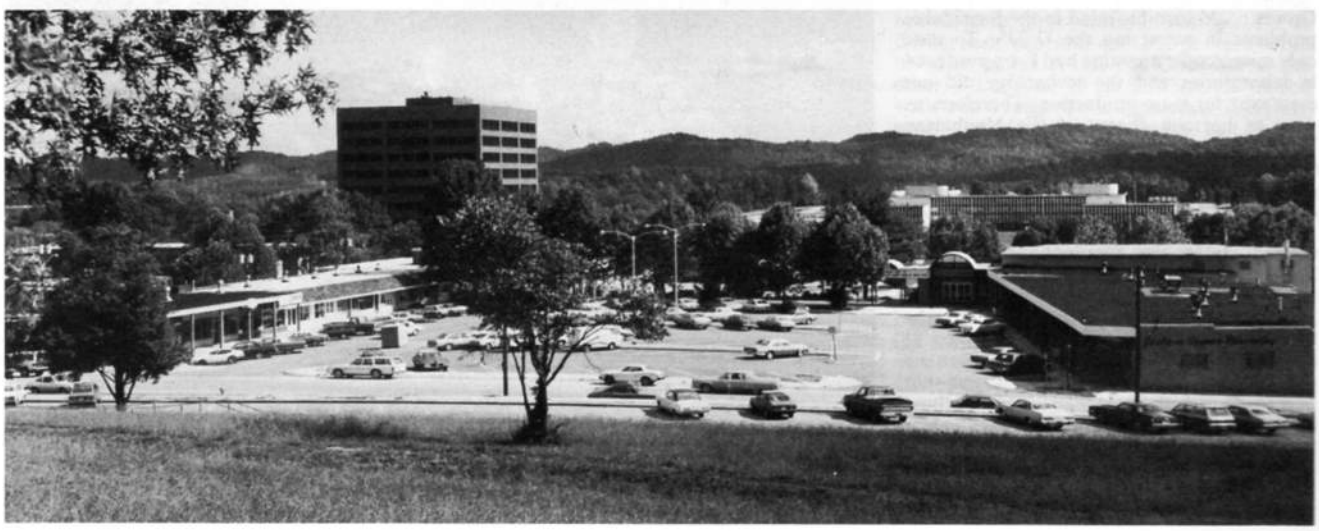
A complete government owned and operated city was built at Oak Ridge, Tennessee to manufacture fissionable material. This is the heart of that city, Jackson Square, then and now.

On the advice of Dr Bush of the OSRD, the President put the entire project in the hands of the US Army. Consequently, in June 1942, the Army formed a special unit with the Army Corps of Engineers under the command of Colonel James C. Marshall and, because his headquarters was centred on New York, the unit was code-named the 'Manhattan District'. Liaison officer between the new 'District' and the Corps of Engineers was the Army's Deputy Chief of Construction, and a scientist in his own right, Colonel Leslie R. Groves. On September 23, 1942, having been promoted to Brigadier General, Groves was appointed to head the operation, charged with every aspect concerning the atomic bomb, from initial construction to final delivery, including all the scientific, strategic and governmental aspects, with sweeping powers of requisition and appropriation and virtually a bottomless pit of money, the whole operation being termed the Manhattan Project.

When General Groves took over responsibility for production of the bomb, the viability of which depended entirely on the manufacture of sufficient fissionable material, five different production methods were under consideration. Three concerned the separation of uranium-235 from the base element uranium-238. The first envisaged the use of electromagnetic forces, while the second involved a centrifugal method. The third possibility was to use gaseous diffusion through a series of permeable membranes or filters to gradually separate out the U-235. The final two methods dealt with the possible ways of mass producing plutonium using either graphite or heavy-water 'reactors'. There was no experience to suggest which of the five possibilities would be the most successful in the long run, but the more important question was, which would be the quickest? With the over-riding knowledge that this was now 1942 and that the Germans had begun their work in 1939, the stakes against backing the wrong horse were too great a risk to take. Consequently, instead of passing through the usual experimentation, testing, analytical and reporting phases to determine the best course of development of any new product, the S-1 Committee made what was possibly the boldest decision of the entire war: to proceed with all five methods simultaneously. The expenditure would be colossal as a whole new industry was being created, not just once but five times over. It was overkill in the extreme, but it lowered the risk threshold appreciably and, it was hoped, would reduce the technological lead of Germany.

Enrico Fermi was given the task of assembling the first 'atomic pile', as the nuclear reactor was then called, to try to create a controlled chain reaction using uranium to prove if this could be self-sustaining. Construction of the test reactor called Chicago Pile 1 (CP-1) began on November 7, 1942 in a rackets court at Stagg Field, part of the University of Chicago campus. (A purpose-built building was under construction in the Argonne National Forest, twenty miles outside the city, but this had not been completed on time.) Here blocks of pure graphite, some 40,000 in all — the production of which was a feat in itself — were gradually stacked in a pile about 24 feet square, supported by wooden scaffolding. Each block was machined exactly to size — 4⅛in×4⅛in×16½in — and half were drilled with ¾in holes. The purpose of the graphite was to slow down the number of neutrons escaping from 6lb slugs of uranium inserted in the stack. It was calculated that fifty tons of uranium metal would be required before the reaction would begin — a vast amount, way beyond what had been produced to date by the Westinghouse Corporation and the Metal Hydrides Company. Fermi therefore decided that the balance could be made up from uranium oxide, putting the more efficient pure metal in the centre of the pile, with the oxide on the outside. The holes in the graphite were for the insertion of cadmium coated control rods. These would absorb the neutrons while they stayed within the core but provided a method of gradually activating the reaction as they were slowly withdrawn.

Throughout November scientists toiled under conditions of great secrecy to construct the primitive reactor. By December 1 the forty-eighth layer of blocks had been put in position and the instruments and Fermi's calculations indicated that the critical stage was about to be reached. As each metal slug was put into position, neutron activity increased. By eleven o'clock that evening with the fifty-first layer in place, all was set for the great experiment.



About twenty people were assembled on the balcony overlooking the court the following morning. No one really knew exactly what would happen if a critical chain reaction was created. Three control rods were available which it was hoped would keep the kettle from boiling over, so to speak. One could be automatically inserted by controls on the balcony; a second would be anchored by a rope which could be cut in an emergency, so dropping it back into the pile. The third was the one which was to be slowly withdrawn to start the reaction. In case the rods failed, a three-man 'fireman' squad was standing by with buckets of cadmium solution ready to throw it over the graphite to absorb the neutrons.

At 10.00 a.m. on Wednesday, December 2, Enrico Fermi gave the order to remove the emergency rod which was secured by its rope and a scientist stood by with an axe ready to drop it back if necessary. At 10.37 a.m. Fermi ordered the last rod to be withdrawn to thirteen feet. Recording instruments measured the flow of neutrons . . . the trace was steady after its initial surge. Every ten or fifteen minutes the rod would be pulled out another few inches, and each time the trace levelled off. Not until 3.20 p.m. in the afternoon was the stage reached when the readings, instead of remaining steady, continued to climb of their own accord. For twenty-eight minutes the same situation was maintained with the recorders indicating a steady upward line — a nuclear chain reaction had been produced for the first time.

The experiment not only proved that a slow chain reaction could be created by concentrating a specific quantity of uranium metal, it also indicated that U-235 (or P-239) would be required to create the instantaneous reaction necessary to produce an atomic bomb. The guesstimates of the amounts of these isotopes that would be required for one bomb varied by a factor of ten, i.e. the true amount could end up to be ten times more or less than the estimate! With only 0.7% of U-235 present in U-238, and only 6% of that present in uranium ore, thousands of tons of rock would be necessary. Thus the supply of sufficient ore was critical yet it was in extremely short supply. Fortunately Edgar Sengier, director of the Belgian mine in Katanga, acting with foresight and acumen after hearing about uranium's potential military value in 1939, had quietly shipped 1,200 tons of high-grade ore from the Congo in August 1940 packed in 2,000 steel drums. While officials of the Manhattan Project were scouring all known sources of supply, this cache was lying in a warehouse on Staten Island, New York! In September 1942 word of its existence reached the US Government and it was snapped up for $1.60 per lb. Additionally, arrangements were made to ship further stockpiled supplies direct to America from Africa.

With the supply of ore assured, General Groves could turn his mind to the formidable problems in extracting the U-235. To date only microscopic amounts had been produced in laboratories and the technology did not even exist for mass production. Therefore, as soon as he took charge of the Manhattan Project, General Groves set out on a fact-finding tour of the various research programmes to assess the potential of the three different processes being considered.

The first was the centrifuge method being worked on by the Westinghouse Research Laboratory at Pittsburg, Pennsylvania. There the basic idea was that the lighter uranium-235 isotope could be separated from the heavier U-238 in a metal drum spinning at enormous speed. So far there had been no positive results and the General was not impressed with the 'academic' pace of those involved. Success seemed very dubious and he recommended that the process be dropped in favour of all-out efforts on the other two methods which would benefit from the resources thus saved.

Brigadier General Leslie R. Groves (left), overlord of the Manhattan District Project, with his deputy, Colonel Kenneth D. Nichols.

The General's next visit was to see the gaseous-diffusion operation at New York's Columbia University. The principle involved, although barely beyond the drawing-board stage, was to convert U-238 to a gas and pass it through a filter in which the holes were so small that they would only let molecules through. The lighter U-235 would theoretically pass through quicker so that the gas on the other side would be very slightly more concentrated in U-235. If this operation was repeated again and again, this content would gradually be increased until pure fissionable material was obtained. However, the problems in so doing were in the realms of fantasy as one was building up a product molecule by molecule. First, thousands of filters would be required and none had ever been constructed with holes so small. Consistency would have to be 100 per cent — each of the billions of holes had to be just one ten-thousandth of a millimetre — otherwise precious molecules would be lost. Second, the amount of filter material required could be measured not in square inches but in acres! It hardly needs repeating that uranium is a heavy metal, not a gas, and, even if and when so converted, it would be so corrosive as to destroy any other metal, pipe or pump with which it came into contact, let alone a fragile filter. Groves and his team were hardly fired with enthusiasm for this method which seemed years away from fruition.

Next on the list was the electromagnetic process under study at Berkeley University in California. There, Professor Ernest O. Lawrence was in charge and under his direction a 'calutron' had been constructed combining a huge magnet and a crude vacuum chamber shaped like the letter 'C' inserted between the poles, the idea being to divert the lighter U-235 molecules electromagnetically. When the General asked how much U-235 had been produced so far, the answer was 225 microgrammes of a substance which was still only 30% pure! To scale up

Professor Ernest O. Lawrence (second from left) beneath the pole face of the huge 4,000-ton cyclotron magnet adapted for the experimental calutron at the University of California. Scientific project director, J. Robert Oppenheimer, touches its face.

The electromagnetic process of uranium-235 production became a reality at the Y-12 plant at Oak Ridge. The picture *above* shows the construction underway in 1943, the one *below* the same area today. Few new buildings have been added to the complex but most of the original WWII buildings have since been converted to other production and research development uses. During the war, only the Y-12 plant was able to produce weapons-level enriched material.

production to end up with pounds of pure material would require tens of thousands of magnets with thousands of scientists working round the clock in huge plants using enormous amounts of uranium — nothing more un-feasible had ever been proposed before.

Nevertheless, a manufacturing location for an, as yet, unproved process to produce the, as yet, unseen material by a production plant not yet designed had already been chosen by Colonel Marshall on a virgin site at Oak Ridge, some eighteen miles west of Knoxville, Tennessee. There an abundant water supply with the promise of plenty of electrical power from the Tennessee Valley Authority dams in an area of almost no habitation, yet having good communications by road and rail, seemed ideal, and General Groves gave his immediate approval. The task of constructing the huge complex was given to the engineers of the Stone and Webster Company with AAA priority — the highest possible — with orders to begin construction before the end of 1942 regardless of the fact that no-one knew the size, shape or specification of the plant required! The Manhattan Project was almost in the realms of fiction.

Oak Ridge

'The topography is such that a number of operations could find reasonably flat areas divided by protective hills', reported the three-man investigative team in the spring of 1942. 'The driving distance to Knoxville is less than 20 miles, and service from two important railroads is immediately available. Water from the Clinch River is regulated . . . and because of the nearby Norris Dam is relatively free of silt. A relatively small part of the land is under cultivation, indicating that a small number of families would have to be moved.'

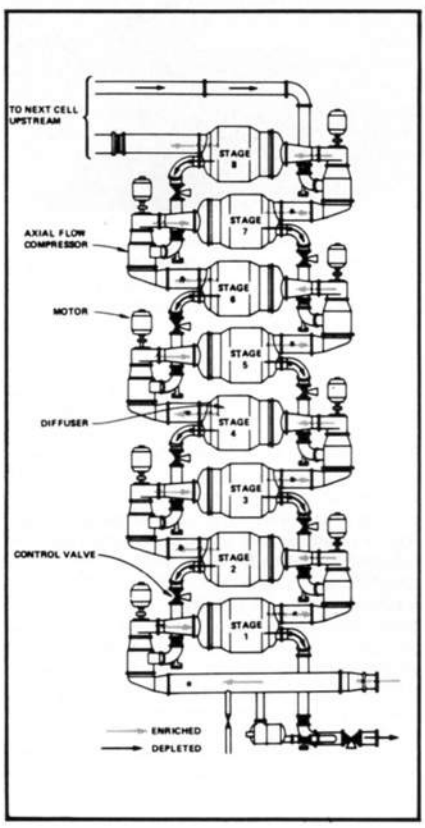
Once approval was given in September, the Manhattan District acquired the 92-square-mile site at a cost of $2,600,000. Some 1,000 families were forced to abandon their homes and the whole area was sealed off by guards, roadblocks and fences. Within a month civil engineering plant had moved in and bulldozers and steam shovels began to prepare the site. By November work had started on the first buildings which later served as headquarters for the Manhattan Engineer District and the nerve centre for the entire US nuclear war programme. Almost simultaneously work began on the huge housing and community facilities which would be needed for the vast population of engineers and scientists who eventually totalled 82,000. Accommodation in the new 'city' was so difficult that some people had to commute from up to 75 miles away.

On February 1, 1943 ground was broken on the first actual U-235 manufacturing plant building known as Y-12 which would house the electromagnetic process, and which was to be operated by Tennessee Eastman, a subsidiary of the Kodak company. Before the process had been completely developed, top Stone and Webster engineer, August C. Klein, was entrusted with the job of directing all work on the site. The Berkeley magnets had been scaled up to 250 feet long with a magnetic field so strong that ferrous tools would be pulled from the hands of workmen in the vicinity. Consequently all moveable equipment had to be made of non-ferrous metals. The magnets, weighing from 3,000 to 10,000 tons, were constructed by Allis-Chalmers and because copper could not be spared in the quantities required for the coils, silver from Fort Knox was substituted — 6,000 tons of it!

Altogether there were five 'Alpha' buildings which contained two oval-shaped 'racetracks', each track having 96 separating units — the calutrons — which could all be operated independently. The four smaller 'Beta' plants had two rectangular racetracks with 36 calutrons. Some of the calutrons had two ion guns, others four.

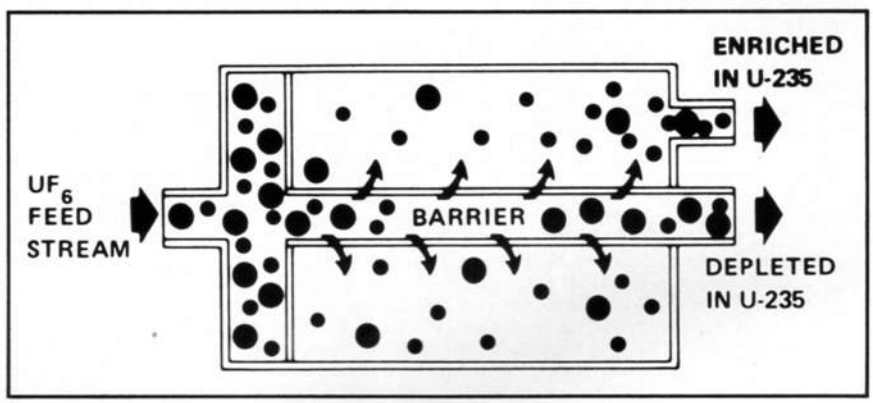
After some disastrous teething troubles, one of which involved sending all the magnets back to the manufacturers to correct the faults, the Y-12 plant came on stream on January 27, 1944 and began a round-the-clock operation in three shifts. It was found that during each 'run' only about 10 per cent of the uranium put in at one end came out at the other — the other 90 per cent was lost on the walls and linings of the apparatus. Therefore every few days each calutron had to be dismantled and completely cleaned, chemically and by other methods, to try to recover the deposits. The few grams of black powder that were the end product of the Alpha plant arrived at two collecting stations labelled U-238 and U-235. The latter was still only 13 to 15 per cent pure so that after washing it chemically, the powder was fed back through the Beta machines to improve the enrichment. In the process, 90 per cent would again be lost and the whole process started again. Some of the U-235 atoms were lost when they actually became fused into the walls of the stainless steel collecting points by the sheer power of the magnetic beam, and this was only solved by copper-plating the steel and then dissolving the copper and extracting the uranium.

The other large scale method of producing U-235 at Oak Ridge was via the gaseous-diffusion process for which the huge horseshoe-shaped K-25 plant was constructed.

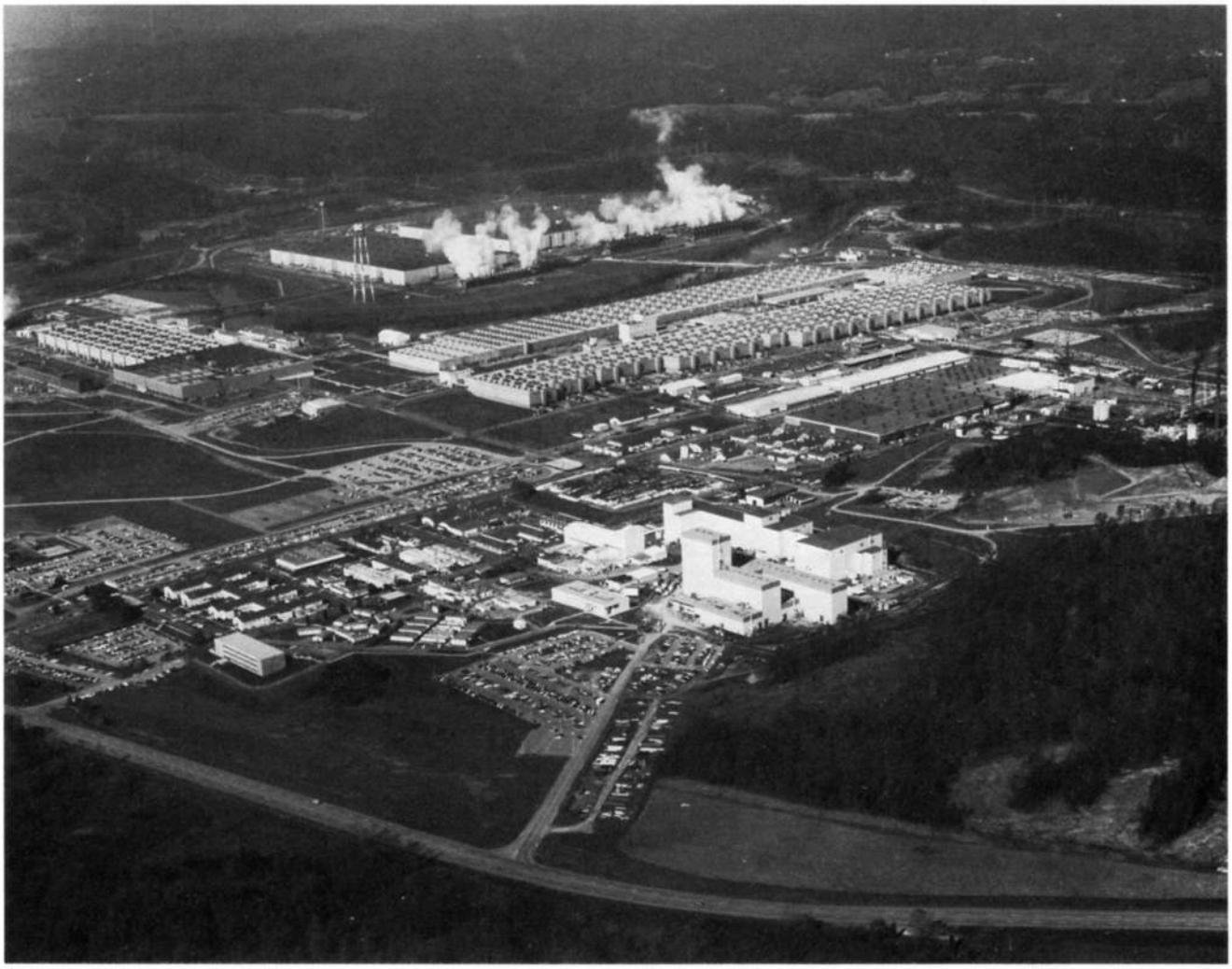


Oak Ridge was also the location of the plant to operate the second method of U-235 extraction — by gaseous diffusion. The Carbide and Carbon Chemicals Company were given operational charge of the project and work on the K-25 complex, as it was termed, began on September 10, 1943. Designed by a specially-formed subsidiary of the M. W. Kellog Corporation, the Kellax Corporation ('Kell' for Kellog and 'X' for secret), the huge U-shaped K-25 diffusion process building measured 2,450 feet long, 400 feet wide and 60 feet in height. It had a total area of 44 acres and required 350,000 cubic yards of concrete, 40,000 tons of structural steel, 15,000 tons of steel sheet and 5 million bricks.

British experts rated its success at one in a thousand as the problems were incredible. Uranium hexafluoride gas had to pass



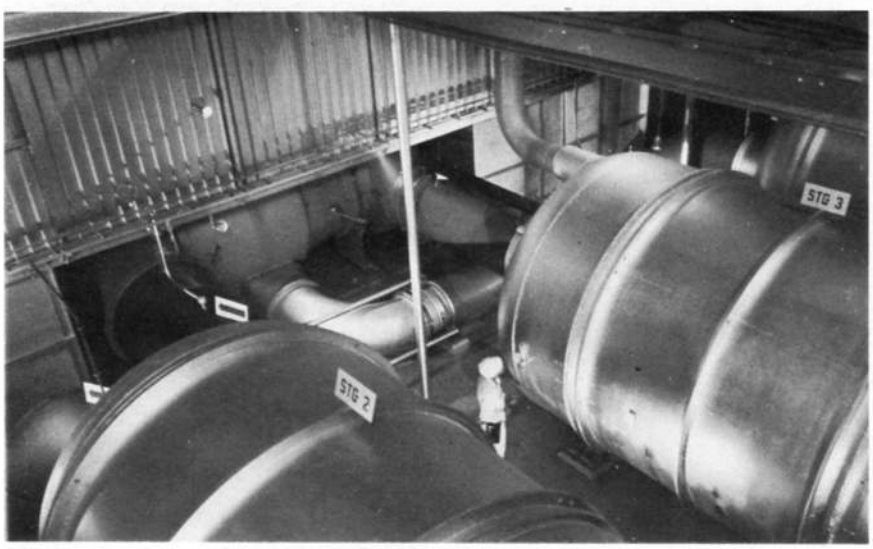
The process involves several thousand stages in what is called the 'cascade'. Uranium hexafluoride gas (UF_6) is compressed and forced against a barrier within each chamber which has a lower pressure the other side of a permeable filter with molecule-size holes. Some of the lighter U-235 molecules penetrate the filter at each stage, the impoverished gas being recycled again through the next lowest stage. (The enormity of the production problem can perhaps be best explained by its relation to today's reactors. Most of the 200-odd nuclear power plants in the world are designed to use uranium as fuel but only enriched to approximately 3 per cent, i.e. raising the level of U-235 in natural uranium of 0.711 per cent by a small amount. Weapons level enrichment on the other hand had to be 100 per cent pure.)



through three thousand stages in the 'cascade' to slowly filter out the U-235 atoms. The nickel membranes, with their holes just two millionths of an inch in diameter, were so difficult to construct that the process used is still classified. The pumps had to work at the speed of sound yet could not be lubricated in any way as the gas would cause an explosion if it came into contact with oil. Some 250,000 man-hours went into their design and development alone — equivalent to one engineer working for 100 years. Tolerances were so fine and the complexities so great that many believed the plant impossible to build and that even if built it would not work.

K-25 began operating on February 20, 1945 but the resulting U-235 only had a purity of 1.1 per cent. By then the pressure to get enough fission material for a bomb led to the decision to feed the product of the K-25 plant back through the Y-12 plant for final enrichment.

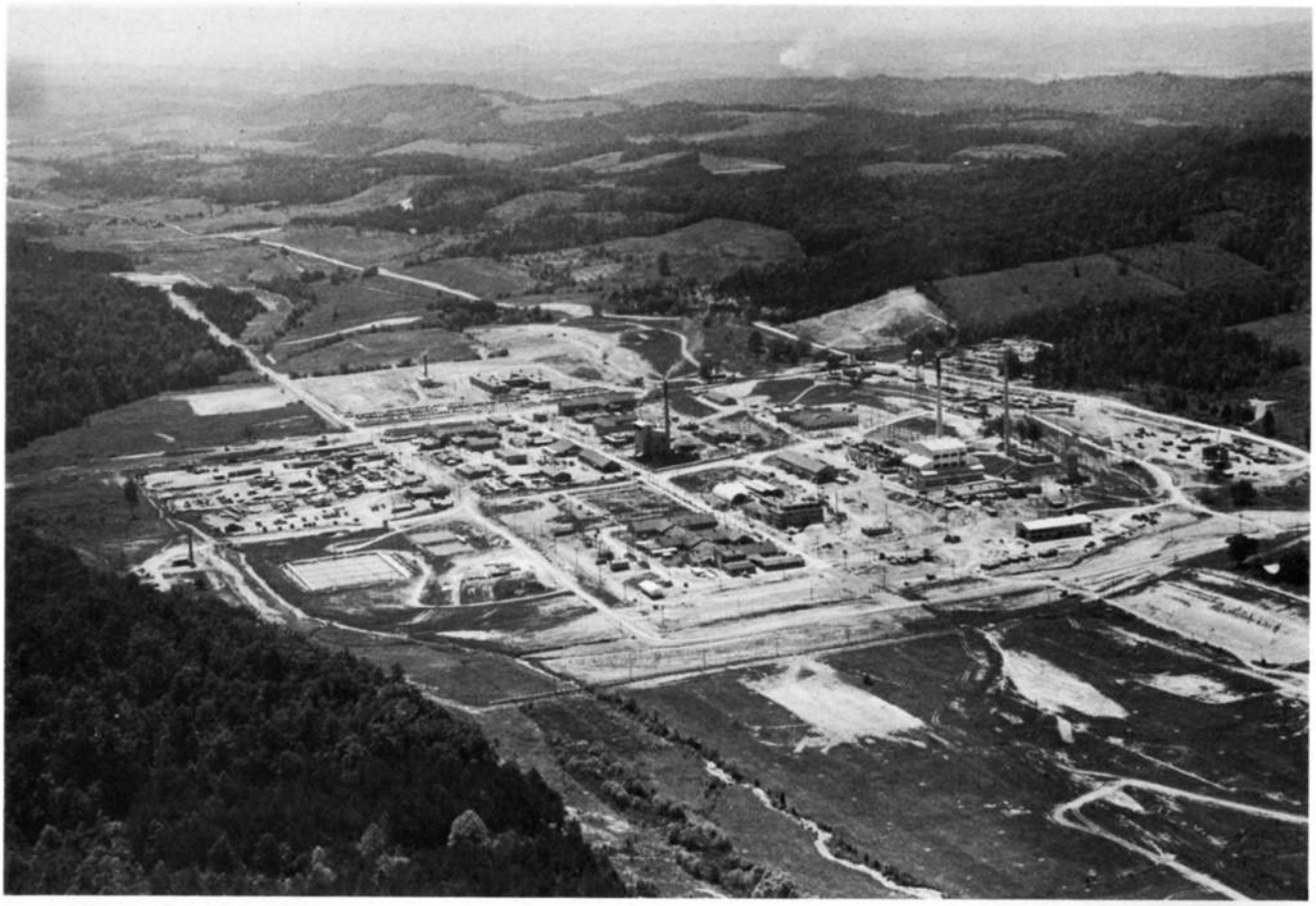
Today the K-25 building is no longer in operation. Production of enriched uranium is now achieved in the building in the left background and at the two other gaseous-diffusion plants of the US Atomic Energy Commission (which took over America's nuclear energy effort in January 1947) at Paducah, Kentucky and Portsmouth, Ohio. The community portion of Oak Ridge was opened to the public in 1949.



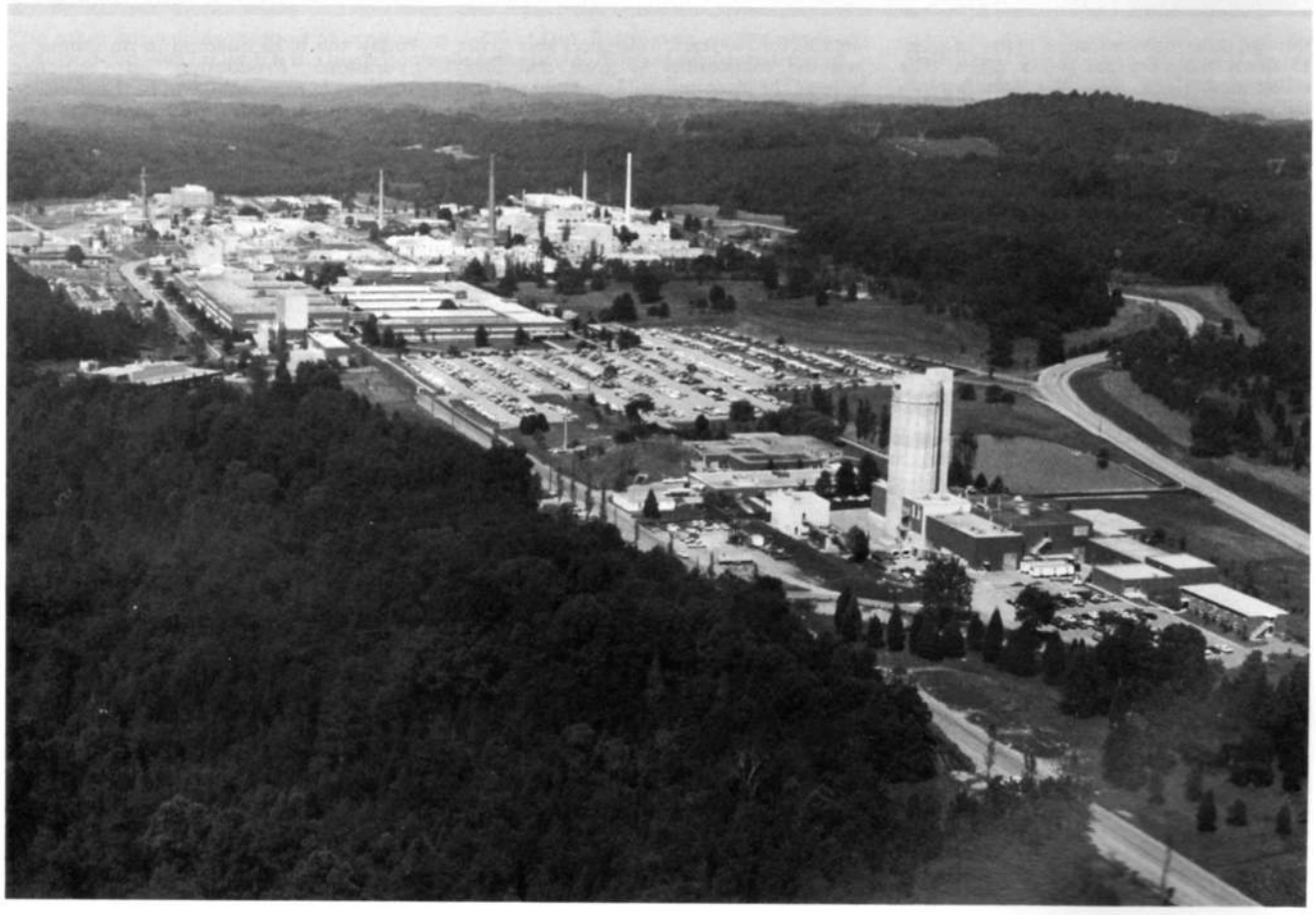
The cascade in reality. More than a million times the volume of UF_6 was reprocessed to a given volume of enriched gas produced. Even then the U-235 from K-25 was only 1.1 per cent pure necessitating feeding it through the Y-12 plant for enrichment.

Another method of U-235 production was also constructed at Oak Ridge in 1944 using a different principle entirely — thermal diffusion. This had been developed completely independently by the US Navy in their quest for an alternative form of submarine propulsion but it was adopted as a further string to the nuclear bow even though the end product was only about 1.4 per cent pure. The Ferguson Company built the plant S-50 in a record sixty-nine days and production began on September 16, 1944. Once again the impure U-235 was fed into Y-12 for final enrichment.

The fourth phase of the nuclear story at Oak Ridge was the construction of a nuclear reactor X-10, under the jurisdiction of the University of Chicago, which was to serve as a pilot plant for the large plutonium-producing reactors to be built at Hanford, in the state of Washington, on the other side of America. In this reactor it was intended to produce sufficient plutonium to provide scientists with enough material to develop a method for the chemical separation of this man-made element. Work on the X-10 plant began just two months after Dr Fermi had successfully created the first chain reaction. It was completed by November 1943.



Plutonium, the alternative fissionable material, is formed as a by-product from uranium in an atomic pile. After the success of Fermi's Chicago reactor, a pilot plant was built at Oak Ridge National Laboratory to provide the scientists with sufficient plutonium for experiments to develop the mass-production techniques to be adopted at Hanford on the far side of America. *Above:* The X-10 plant at Oak Ridge during the war and *below* today.

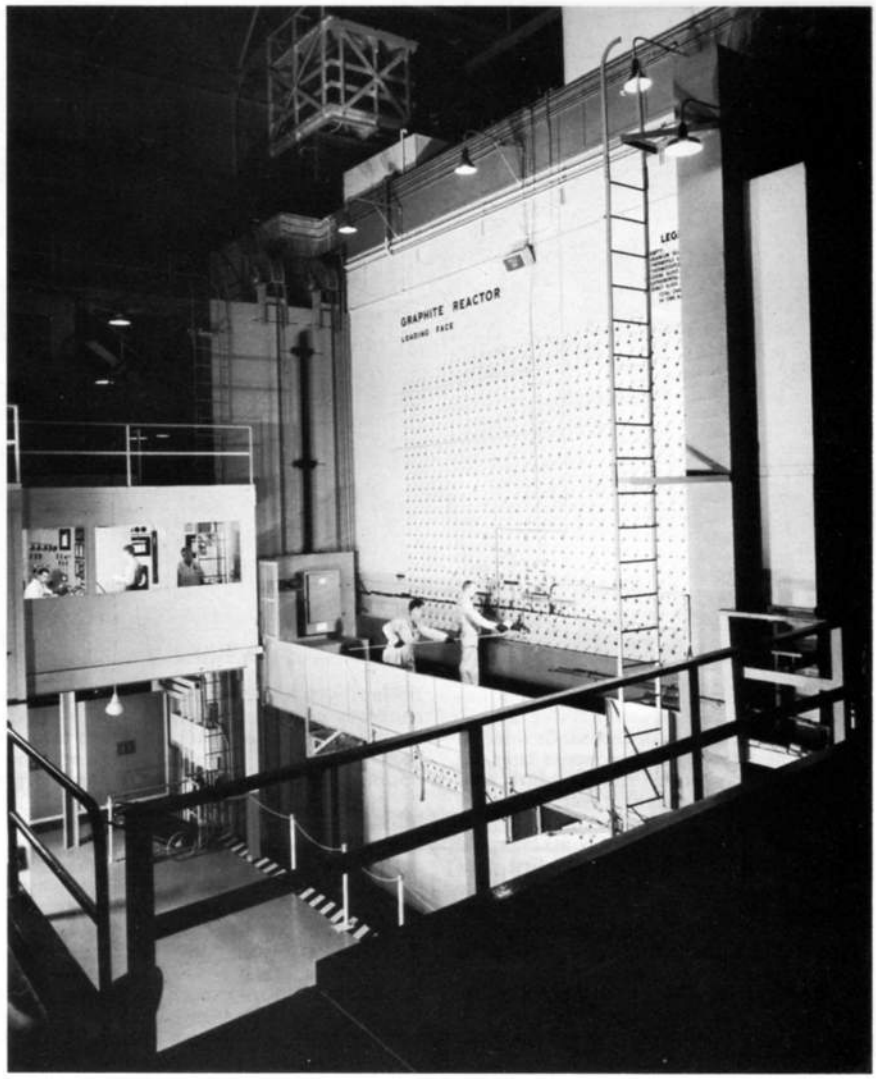


Hanford

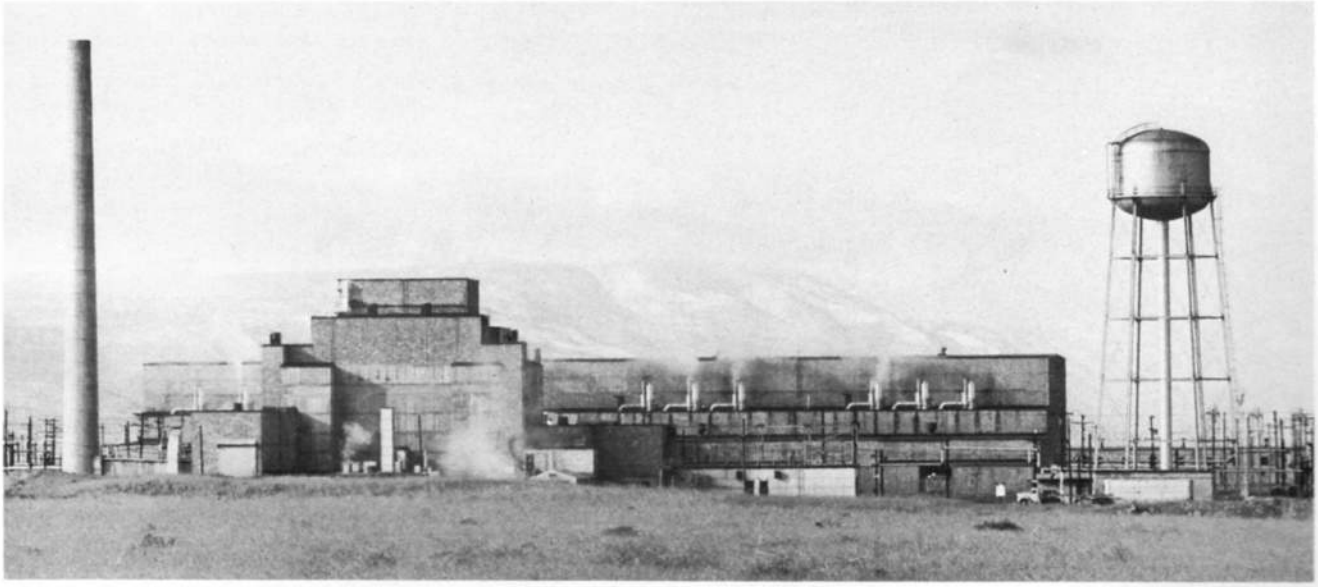
What Oak Ridge was to uranium, so Hanford in the southern central part of Washington State on the Pacific coast of the United States became to plutonium. Like Oak Ridge, Hanford was sparsely populated, had abundant water available from the Columbia River and electricity supplies from the Bonneville and Grand Coulee dam systems.

As atomic bomb material, plutonium was a more attractive investment as the critical mass of P-239 is around 11lbs (5kg) — less than a third of that required for U-235. The project was put in the hands of the Du Pont de Nemours Company but Fermi's team were obviously closely involved with the design of the reactor. Construction began on June 7, 1943 and the usual superlatives abound: 25 million cubic yards of earth excavated and 780,000 cubic yards of concrete brought in; 40,000 tons of structural steel, 158 miles of railway track laid down and 386 miles of roads constructed. Over 45,000 construction workers were employed in the building phase. The atomic pile itself, called Reactor B, contained 2,000 tons of graphite and was penetrated by 2,000 process tubes. The pile, as tall as a four-storey building, was surrounded by ten inches of cast iron and four feet of concrete.

Plutonium is produced when the uranium in the pile is subjected to the slow chain reaction. In the process some of the uranium is converted into P-239 although it remains in the uranium ingots, slugs or rods. The problem in this case was how to separate the two and, after several experiments, it was found that bismuth phosphate was a good carrier of plutonium. Thus, in addition to the reactors, separation plants had to be built and huge installations, labelled B and T Plants, were constructed in the desert some five miles south of B Reactor. For safety reasons, both were situated three miles apart and designed to be operated under remote control. Once the separation process was begun behind the eight-foot-thick walls, no human being would be able to enter the processing areas. Irradiated ingots were transported in heavily shielded casks along specially constructed railway lines between the pile and the separation buildings.



X-10 at Oak Ridge was located in a valley several miles away from the uranium plants. This picture was taken of the reactor shortly before its shutdown on November 4, 1963 — the twentieth anniversary of its start up. Now it is preserved as a National Historic landmark.



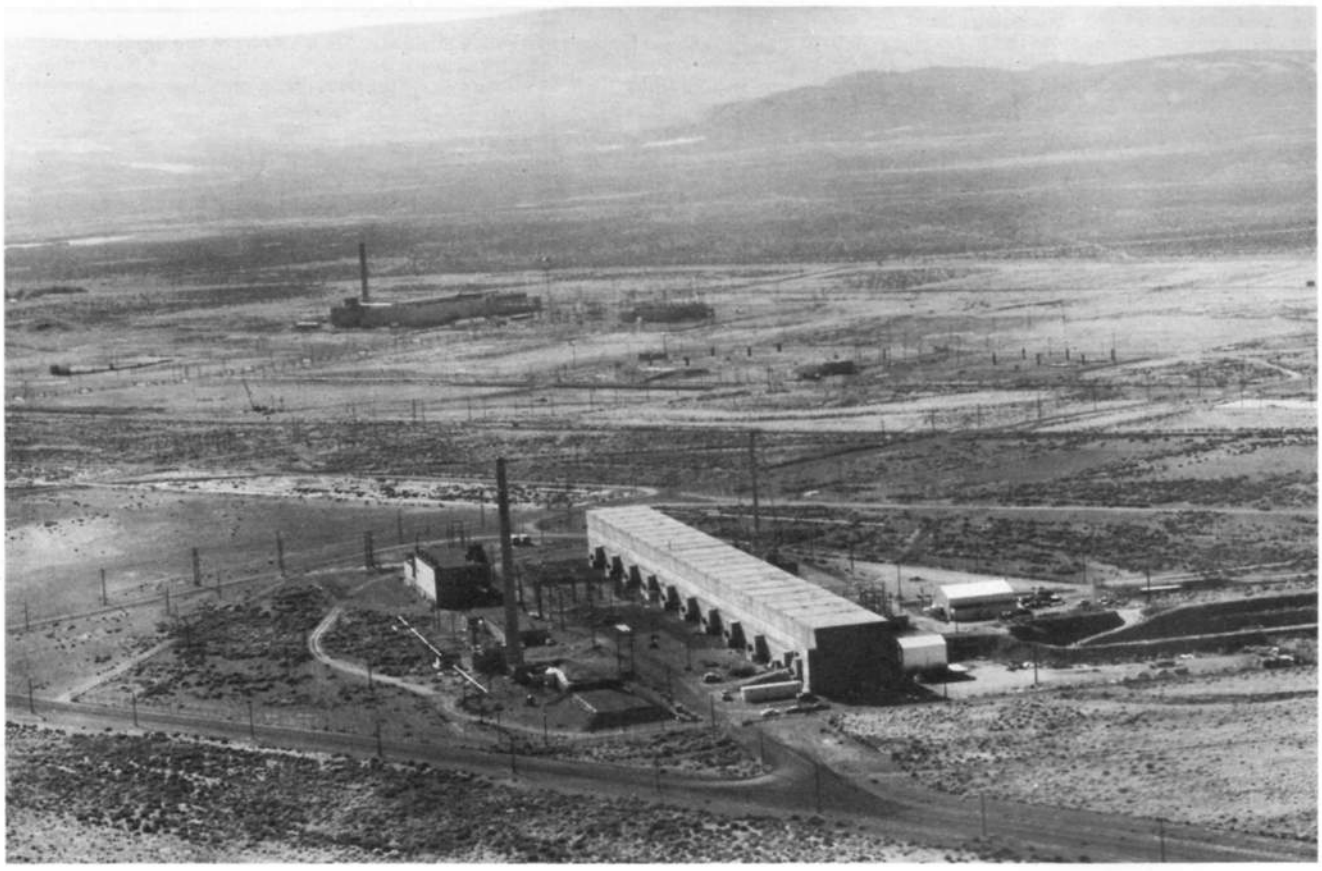
B Reactor, the world's first plutonium production reactor, was constructed on the Hanford site near Richland in Washington State. After producing the fission material for the wartime bombs, it was shut down shortly after the end of the war. It was reactivated in 1948 and operated almost continually until its retirement in February 1968. In 1976 it was named a national landmark by the American Society of Mechanical Engineers and is maintained for the US Department of Energy as a shutdown facility by UNC Nuclear Industries. Altogether there have been nine government production reactors at Hanford. Eight have been deactivated, the ninth — N Reactor — completed in 1963 is expected to continue to operate into the 1990s.

B Plant was one of the original two chemical processing facilities built at Hanford to separate plutonium from irradiated uranium. In the mid-1960s, the plant was converted to remove cesium-137 and strontium-90 from the waste stream — two high heat producing isotopes which are then converted to solid form, and sealed in double-walled Hastelloy containers by remote control in the building alongside.

On September 13, 1944, Enrico Fermi was on hand to load the first uranium slug into the graphite pile, the first of thousands inserted over the next few days. Two weeks later the critical point was reached and the control rods withdrawn to begin the chain reaction. Power began to build up nicely, sustaining the reaction, until suddenly, three hours later, the gauges began to fall. Slowly at first, but inexorably lower and lower until finally the pile shut itself down completely. The failure was baffling and many different possibilities were put forward as to the cause. Then on the evening of September 27, almost like a sleeping monster, the pile suddenly came to life again. Power was raised to 9,000 kilowatts — the same level reached the day previously — before once again the chain reaction died away. The problem was eventually diagnosed as the production of a gas (called xenon-135) as a by-product of the fission process which was absorbing neutrons and 'poisoning' the reactor. The cure was to load an additional 504 uranium-bearing tubes (a 25 per cent increase) to boost capacity and overcome the neutrons lost.

By December 25, 1944, B Reactor had turned out its first irradiated slugs and, after separation in T Plant, the first plutonium was ready for shipment by the end of January 1945.

T Plant in the foreground, the other WWII processing plant, produced the plutonium for the Hiroshima bomb. In 1957 the building was converted to handle the decontamination of radioactive equipment by Rockwell Hanford Operations.



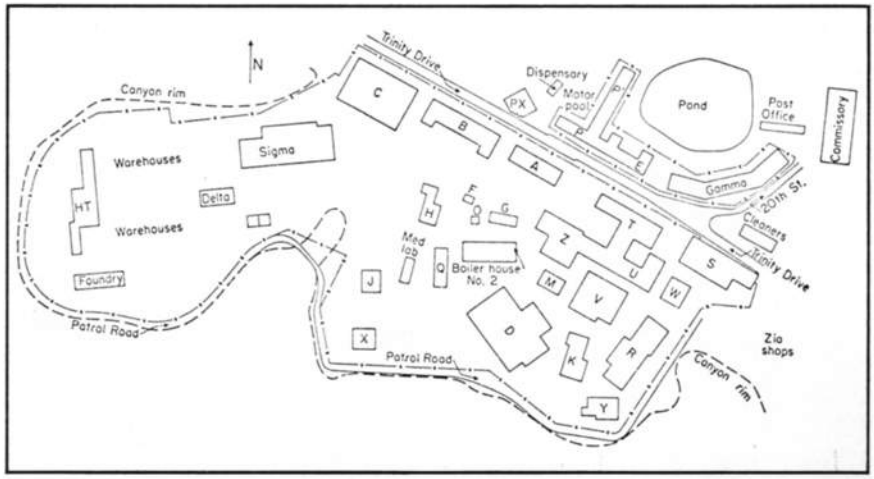
Los Alamos

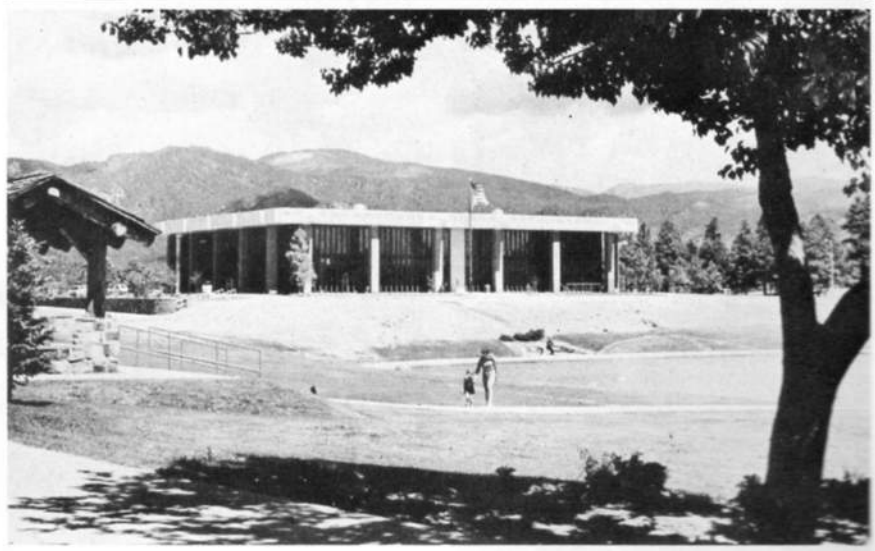
Above: **The original administration building T-1 at Los Alamos (see the wartime layout plan *below*) lay south of the pond.** *Bottom:* **Now the Los Alamos County Municipal Building, dedicated in 1967, overlooks Ashley Pond.**

At this stage in the story we must go back to October 1942 when it was becoming increasingly evident that the Manhattan Project would need a specific research site to design and manufacture the bomb itself. Because of its crucial importance it was given a separate title — Project Y — and a search began in sparsely-populated New Mexico for a safe and secure location for this most secret of all installations. After examining several possibilities, General Groves settled on one that encompassed the existing buildings of the Ranch School at Los Alamos, a 7,300-foot pine-forested plateau in the Jemez Mountains, twenty miles north-west of Santa Fe. The General appointed Dr J. Robert Oppenheimer to be project director against the advice of security chiefs who considered that his political background made him an unacceptable risk.

On November 25 the go-ahead was given to take over nearly 50,000 acres including the 50 school buildings at a total cost of $414,971 — a low figure in view of the fact that over three-quarters of the area was already held by the US Forest Service. Administration of Los Alamos was to be under the jurisdiction of the University of California.

Huts and buildings of every description soon spawned across the site, but until sufficient housing had been constructed, the

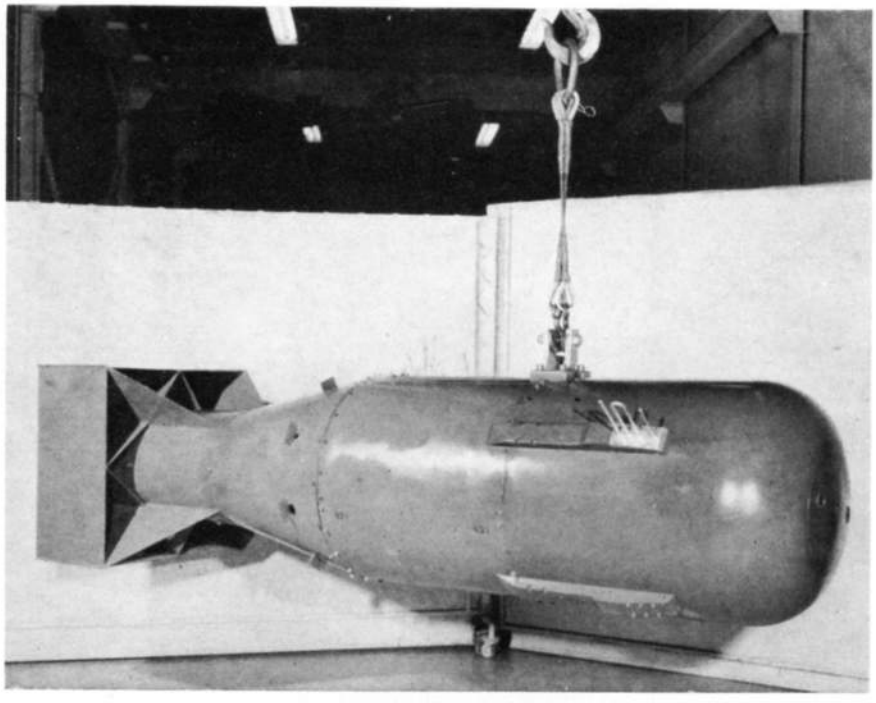




The structure on the left marks the site of the old Ice House *(left)* where the nuclear components for the first bomb were assembled.

scientists (or 'engineers' as they were termed for security reasons) were billeted in ranches and private homes throughout the surrounding area. Oppenheimer personally recruited most of the scientists he required and he arrived at Los Alamos in March 1943. Security was extremely tight — all the top men had cover names (Oppenheimer was Mr Bradley), driving licences had numbers instead of names and were not signed, and all mail in and out was censored (the postal address was simply PO Box 1663, Santa Fe). The whole site was ringed with barbed wire patrolled by military police and a pass system regulated who was able to go where.

The problem central to the Los Alamos scientists was the method of assembly of the atomic bomb. Where in a reactor the criticality could be controlled by moving neutron-absorbing rods, a nuclear bomb would have to be sub-critical in the aircraft delivering it, but somehow be made instantly critical at the point of impact on the target. Additionally, the scientists were dealing with two completely different explosive elements, U-235 and P-239. Work initially centred around the idea of using an artillery gun barrel to fire one piece of fission material at the other: separated they were insufficient to go critical but as soon as they hit each other the chain reaction would begin, 'fast' neutrons would be released and the explosion would follow — all in a split second. The method was simple and radar timing devices could be used to fire the gun at an appropriate point above the target to avoid the possibility of the bomb hitting the ground before detonation. However, there was one snag. When the P-239 is manufactured in a reactor from U-238, some of the plutonium absorbs a neutron and is transformed into P-240. This material undergoes spontaneous fission and this would cause a plutonium bomb to begin the chain reaction before reaching supercriticality. The result would be a premature explosion producing little energy just like a damp squib. This problem did not occur with uranium, only plutonium, and by July 1944 it was evident that a plutonium bomb could not be assembled fast enough by the gun method to overcome this effect. It was all the more frustrating as it appeared likely that plutonium would be the first material available and in greater quantity than uranium produced by the painfully slow processes at Oak Ridge. Therefore, while the gun was adopted for the uranium bomb, and a suitable



The 4-ton uranium gun bomb, dubbed 'Little Boy'. The cases enclosing the uranium 'target' were made of high-alloy steel, and were so sturdy that they could be repeatedly re-used. The first one was tested four times before being used in the actual bomb dropped on Hiroshima. The gun itself was six feet long with a threaded muzzle and weighed about half a ton.

After the war, the wartime director of the Los Alamos Scientific Laboratory, Dr J. Robert Oppenheimer was awarded the Medal of Merit and credited 'more than any other man' with the creation of the atomic bomb. Having received the nation's accolade, ten years later he was a rejected man when his top 'Q' security status was revoked after a soul-searching inquiry into his political motivation. Ten years on all was forgiven when President Lyndon Johnson presented him with the Atomic Energy Commission's highest honour — the $50,000 Enrico Fermi Award.

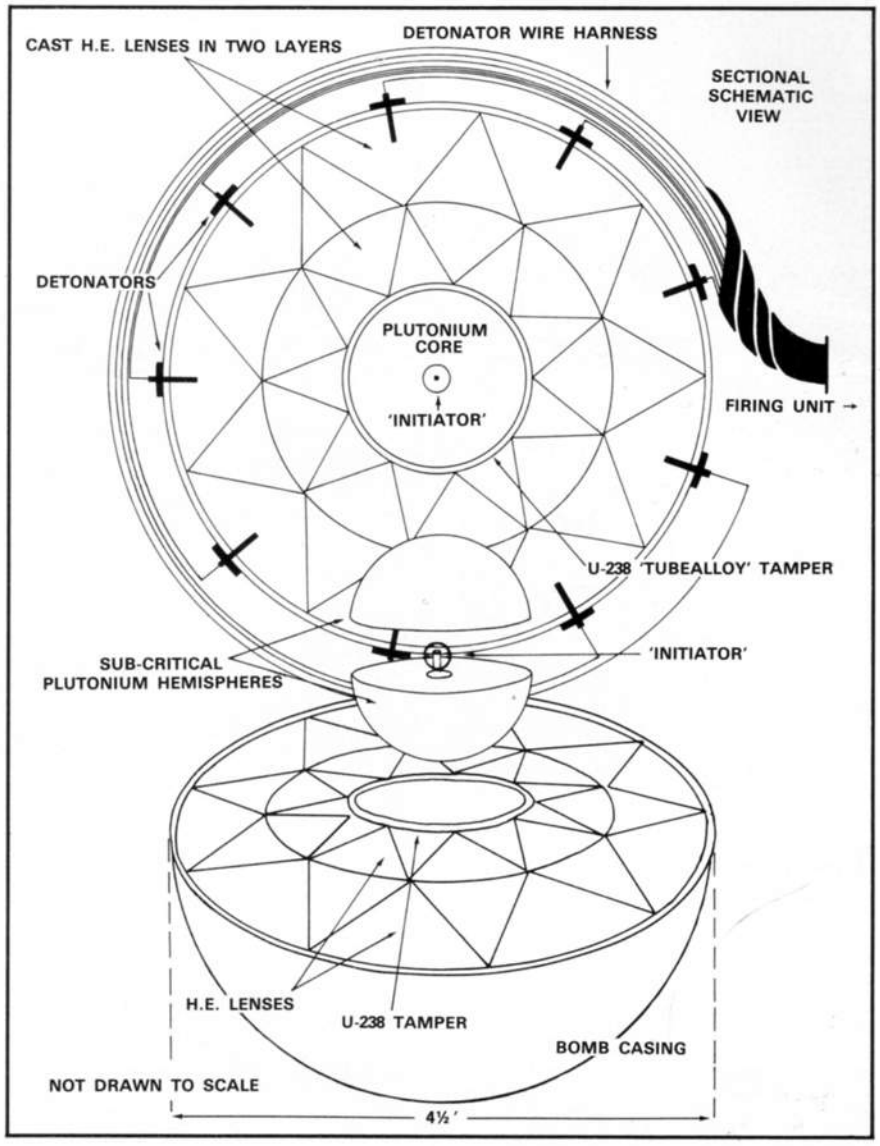
Identical ballistic cases for both WWII atomic bombs ('Fat Man' which weighed 4½ tons is on right) are displayed, with other post-war nuclear weaponry, outside the Bradbury Science Hall and Museum opened in August 1965 at Los Alamos.

barrel ordered from the Naval Gun Factory in Washington, DC, an alternative design was sought for the plutonium.

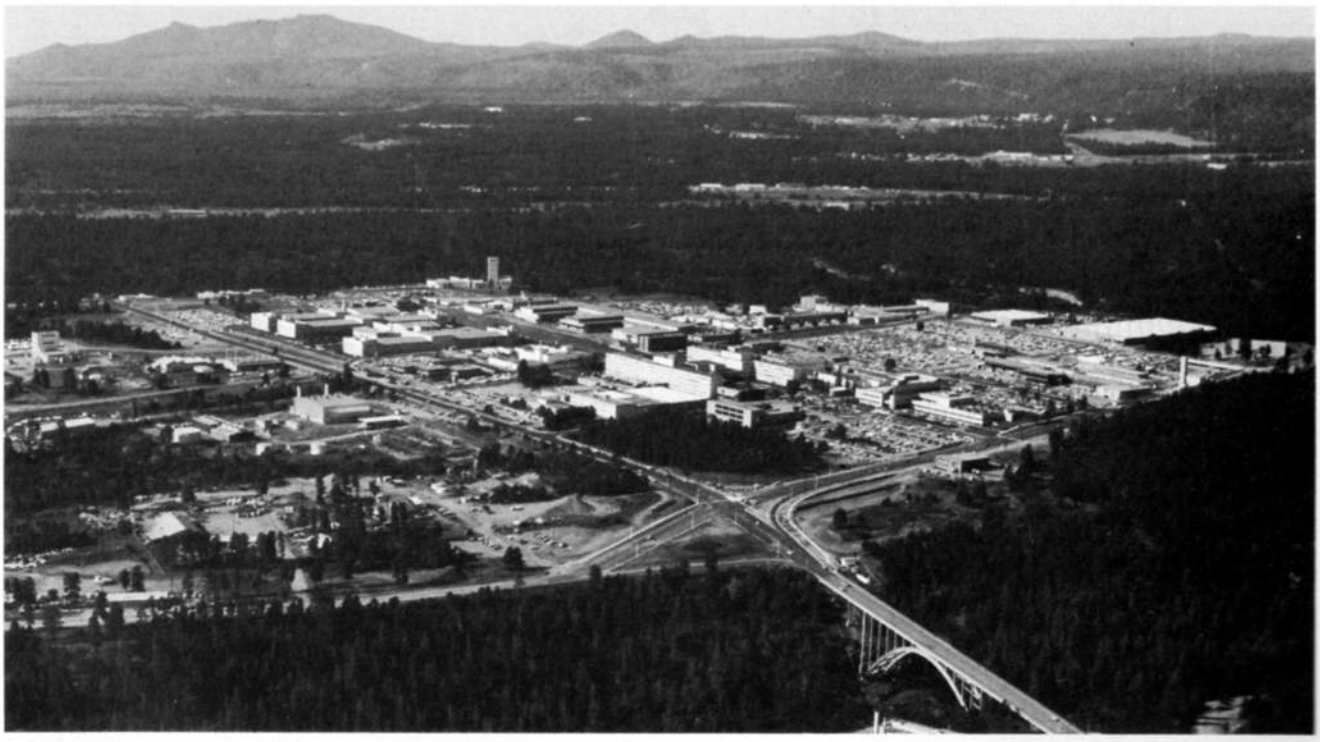
It was one of Project Y's physicists, Seth Neddermeyer, that proposed a revolutionary idea of assembling a supercritical mass from every direction at once. His answer to the seemingly impossible was to surround a sphere of P-239 by shaped explosive charges which would blow inwards many other pieces of P-239 to smash into the centre core at a speed of millionths of a second which would overcome the problem of premature criticality. The idea was enthusiastically taken up by another scientist who believed that the resulting compression of the P-239 might even mean that less plutonium would be required to create an atomic explosion. Neddermeyer called his method 'implosion'.

No one knew if the fantastic tolerances of instantly detonating the explosive from every point of the compass at once could be achieved. On the other hand it was still doubtful if Oak Ridge could produce enough uranium for the gun bomb. The news from Germany was equally disturbing, for reports of the increased production of 'heavy water' (an alternative to graphite in a reactor) indicated that production of plutonium might not be far away.

Although spontaneous fission was likely with the implosion method, a safeguard to ensure that there was no doubt was to design an 'initiator' which could be placed in the very centre of the plutonium core and produce enough neutrons at the right moment to start the chain reaction of its own accord. This object, the size of a nut, was developed by Dr Charles Critchfield using separate pieces of beryllium and polonium. These two metals, when combined, give off neutrons and his idea was that when the implosion shock wave hit the initiator (inserted in the plutonium by casting the core in two hemispheres), the two metals would combine producing the spark to light the fire.



Artist's impression of the plutonium bomb showing the shaped TNT 'lenses' to direct the implosion onto the nuclear core. The U-238 'tubealloy' tamper was to contain the neutrons for a split second to enable the chain reaction to build up.



A new laboratory complex (not open to the public) now sprawls across South Mesa at Los Alamos replacing the wartime camp.

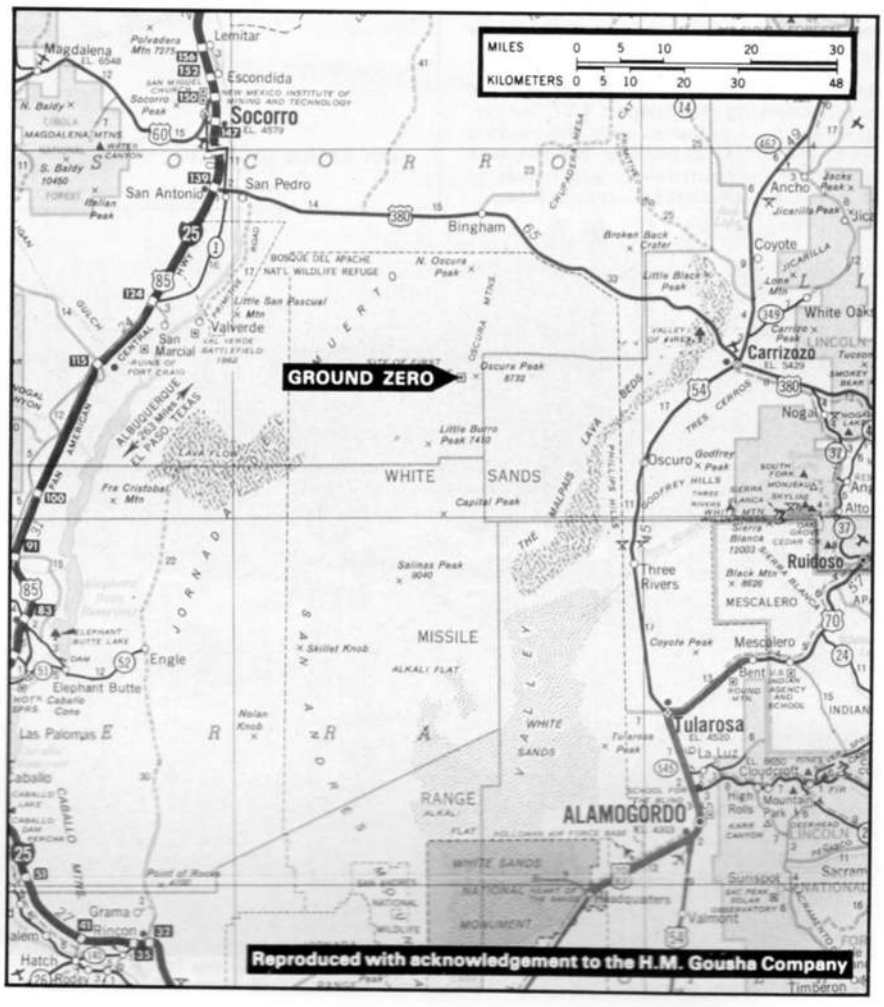
Trinity

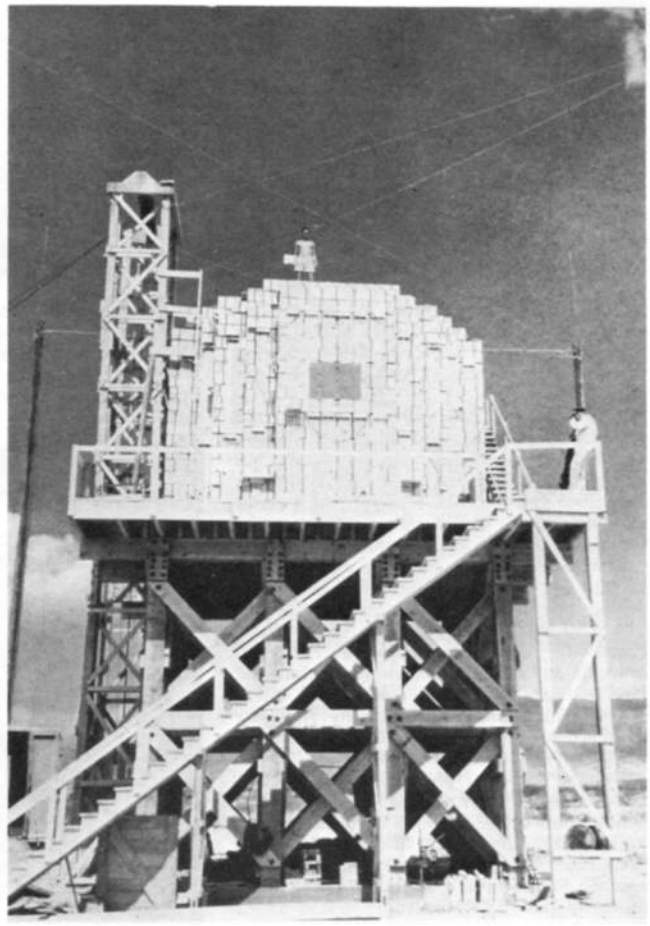
A site for Trinity — the test of the plutonium bomb — was found sixty miles northwest of Alamogordo in southern New Mexico. A base camp *(above)* was set up during the winter of 1944-45 while a detonation point was established ten miles to the north.

It was pretty certain that the uranium gun bomb, based on proven ballistic principles, would work first time and as it would take months to produce enough U-235 for just one device, there seemed no point in wasting this on a test explosion. The plutonium bomb with its untried implosion technique of assembly was another matter and a test firing was considered essential to prove whether it would work.

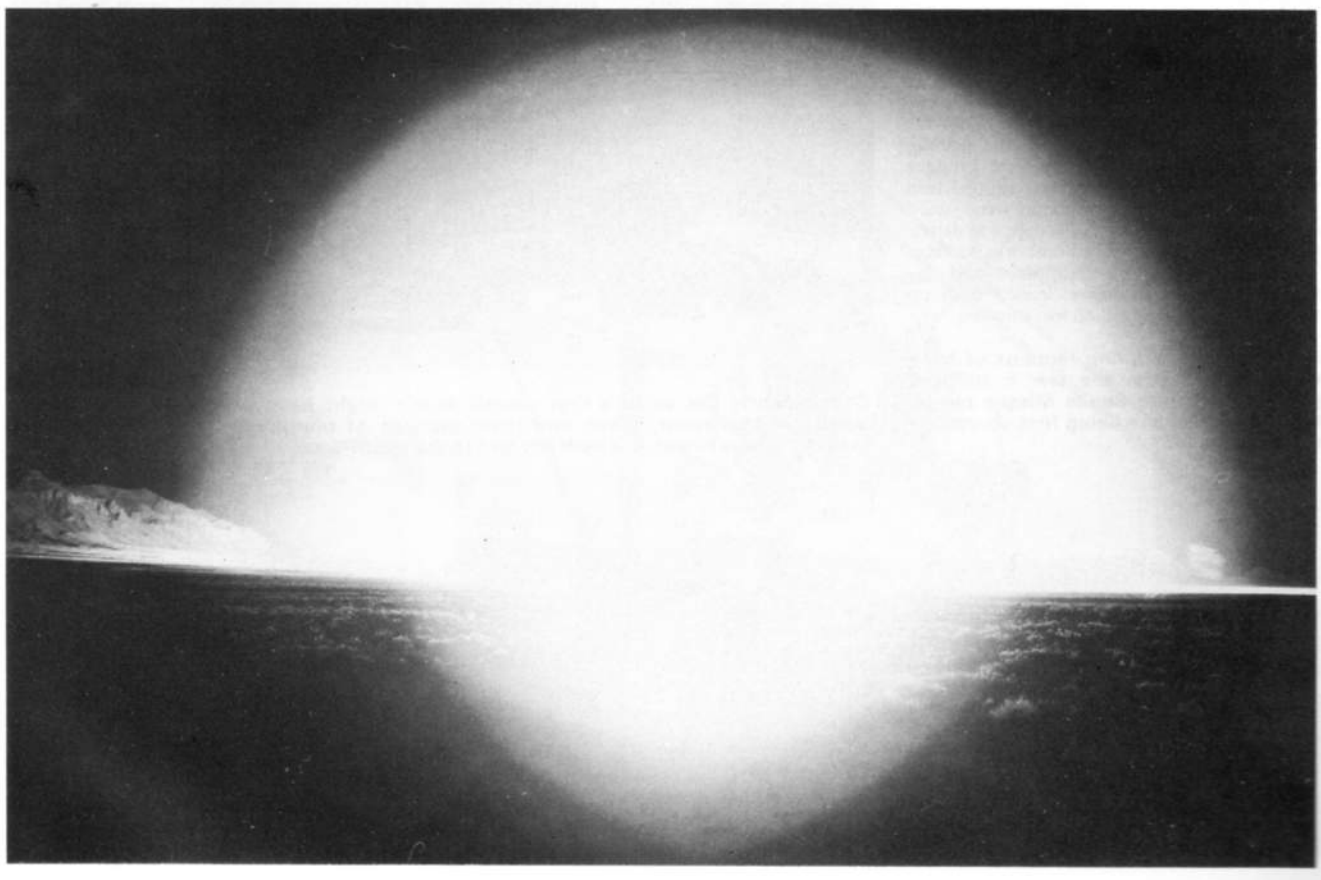
The Los Alamos area itself could not be used and a short list of eight possible locations, from Texas to California, was drawn up early in 1944. By the summer all had been surveyed and the choice narrowed to an 18 by 24 mile section of the US Air Force bombing range in southern New Mexico — the Jornada del Muerto (Journey of Death) — cupped between two mountain ranges. It was also conveniently just 160 miles south of Los Alamos. The code name they gave it was Trinity.

The principal occupier at the proposed site was the McDonald ranch which was retained as a final assembly point for the bomb which was to be detonated a mile away at a point termed Ground Zero. By October plans for the construction of the base camp, ten miles further away to the south, were drawn up and two months later the construction was completed and the permanent MP guard detachment increased. Shelters were built 10,000 yards north, south and west of Ground Zero. The bomb itself was to be mounted on a high tower to lessen the chance of sucking up too much earth which would subsequently descend as radioactive debris. Escape routes were planned and an enormous 214-ton steel container, 25 feet long, 12 feet in diameter with walls more than 14 inches thick, dubbed Jumbo, was fabricated with great difficulty in Ohio and transported to the site. The initial idea was to explode the bomb inside it, so that in the event of a misfire or a partial explosion of the TNT only, it was hoped that the plutonium would be trapped in the bottle





A trial run was conducted on May 7, 1945 with the explosion of 100 tons of TNT. A sturdy 20-foot tower was built about 10,000 feet south from Ground Zero and the boxes of explosive brought in from Fort Wingate. Fission products from Hanford were inserted in the stack to simulate, at a low level, the radioactive products which could be expected from a nuclear blast. *Below:* The brilliant orange fireball from the 100-ton explosion, photographed here from sixty miles away, would have been an unforgettable sight, witnesses say, had it not been upstaged by the atomic test a few weeks later.



where it could be recovered for another attempt. When a regular supply of plutonium from Hanford was assured, the precaution was deemed unnecessary and Jumbo was not used.

As a dress rehearsal in order to calibrate the scientific instruments and gain some advance knowledge of the sort of explosion which could be expected, a hundred tons of TNT were set off before dawn on May 7, 1945. As a result additional roads were constructed around the site to facilitate quicker communications.

Several press releases were prepared to explain away the nuclear blast to the media should it be successful, one of which said that a remote ammunition dump had accidentally exploded. Should it become necessary to evacuate any area, the news would include the fact that gas shells had gone off. A more sinister communique was ready to report the strange deaths of many famous scientists in an accidental explosion in New Mexico.

By now sufficient plutonium had reached Los Alamos to fabricate sections for the two hemispheres of P-239 which were transported to the Trinity site on July 12 on the back seat of an ordinary army staff car. When the core reached Alamogordo it was taken to one of the rooms in the McDonald ranch house which had been prepared for its reception. The following day a convoy arrived with the main explosive assembly of the bomb, driving straight to the tower where it was unloaded into a canvas tent erected at the base. There it was partially dismantled ready for the core to be inserted.

Meanwhile back at the ranch the nuclear assembly team were preparing to bring together for the first time an amount of plutonium never before concentrated in one piece. In case anything should go wrong, jeeps were stationed outside, engines running, for immediate getaway. Slowly the pieces forming the two halves of the sphere were brought together, then the initiator was slipped into place before the two hemispheres were joined together. Once assembled, the core was driven to the test tower where the bomb was waiting. There it was inserted into place and the remainder of the explosive 'lenses' built up around it. By 10.00 p.m. all was finished.

Jumbo weighs in across the desert at 214 tons. One of the early fears was that, should only the TNT explosive go off without initiating a chain reaction, the precious plutonium would be scattered far and wide. One rather bizarre solution to avoid this was to explode the bomb inside Jumbo which had been built strong enough, it was hoped, to withstand the non-nuclear blast. The plutonium could then be retrieved for another try.

Consequently the world's first atomic bomb might have been detonated in this bottle! In the event, when sufficient supplies of plutonium from Hanford were assured, a new tower was built 800 feet to the south-west.

Below: **The mouldering remains of base camp today. After the war it became part of the White Sands Missile range, the atomic test site being first opened to the public in 1953.**

Above: **The plutonium arrives at the McDonald ranch. The weight of this, the heaviest of metals, can be appreciated from the two men lifting the small box.** *Right:* **The initiator, the precise nature of which is still classified, is brought in for insertion in the core.**

At 8.00 a.m. on July 14 the bomb began its journey to the top of the tower. Mattresses were piled twelve feet high to break its fall if anything should go wrong with the electric hoist or the cable should break. Gently it was eased up through the trap door in the floor of the firing chamber 100 feet above the surrounding desert. Once in position the detonators were inserted in the bomb casing leaving only a final connection to arm the device.

The test was scheduled for early morning on Monday, July 16 and during Sunday all the leading scientists and observers began to assemble at Trinity. General Groves arrived at base camp during the afternoon just as it began to rain. The weather forecast was bad with the chance of thunderstorms. The steel test tower, the tallest structure for miles, was a veritable lightning conductor; not only might freak lightning set the bomb off prematurely, but moisture could cause short-circuits on the intricate wiring to the detonators. Then wind and rain could precipitate fall-out over a wide area.

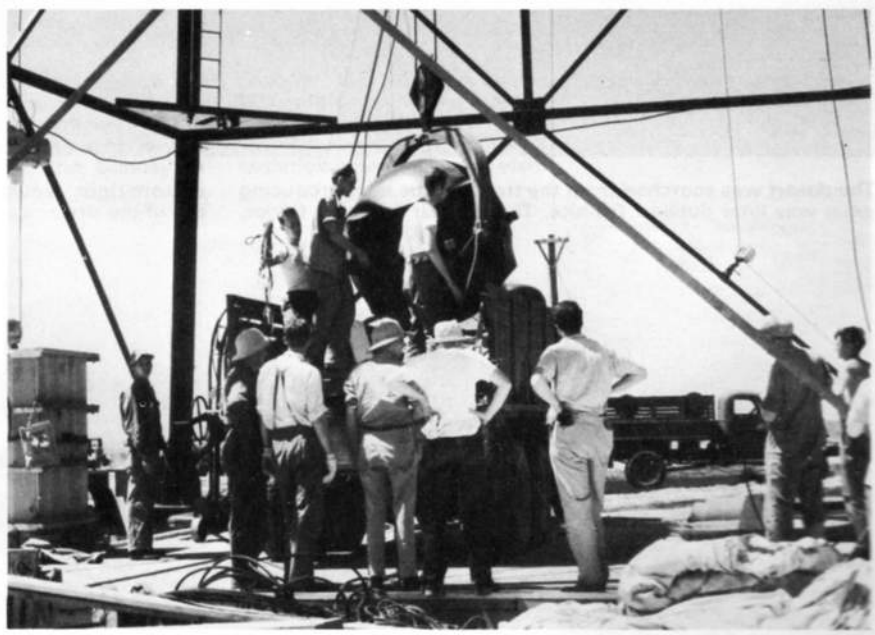
However, were the test to be delayed, this could result in even wider implications. Six thousand miles away in Berlin, President Truman and Prime Minister Winston Churchill were attending the Potsdam Conference with Russian premier Josef Stalin. At that very moment they were waiting for word from Alamogordo as to the success or otherwise of the test, hoping this would come before they met with Stalin again. With Germany out of the war the intended target for the bomb had switched to Japan, against which Stalin was poised to declare war. The Allies were hoping they had an ace card, but it was a card which might easily turn out to be a joker.

Shortly after midnight General Groves, accompanied by Robert Oppenheimer, left base camp for the main VIP control centre at the southern bunker, six miles from the bomb. By 2.00 a.m. the weather began to improve and two hours later the wind had dropped and the rain had stopped. With the promise of stable conditions for the next two hours, General Groves made the decision to go at 5.30 a.m. Mountain War Time.

The final stages of the arming procedure began. Searchlights were switched on to guide the two B-29 observation aircraft, and thirty minutes before zero hour the five-man team guarding the tower retreated. General Groves returned to base camp which was the nearest point where observers could remain out in the open. Even then everyone was instructed to lay face down and cover their eyes with their hands.

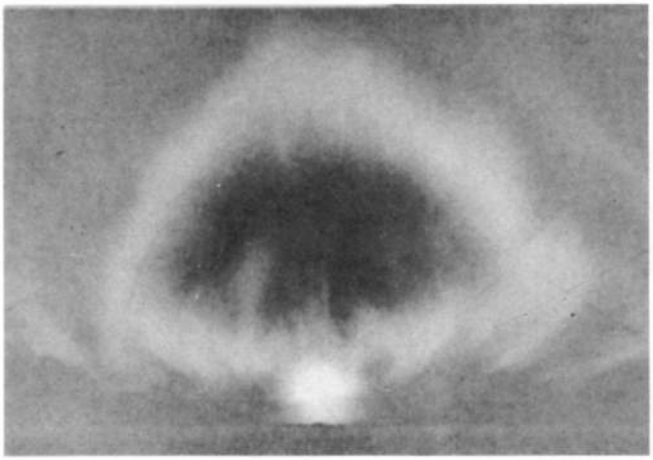
At 5.10 a.m. the countdown began and at D minus 45 seconds a switch was thrown to activate an automatic firing timer. At 29 minutes and 45 seconds past the hour the bomb exploded.

The blast was felt throughout the southern portion of New Mexico and into Arizona in the west and Texas in the east. Windows were blown out up to 200 miles to the north-west and 150 miles away people reported the sun coming up and going down again. Many of the measuring devices and instruments which had been set up in the surrounding desert were swept away and most of the film in the cameras was completely fogged by radiation.

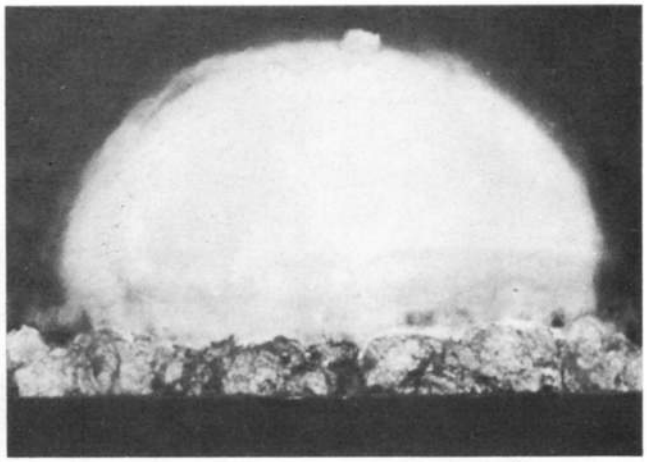


Left: **It was hoped to avoid sucking up too much of the desert, which would later fall to earth as radioactive dust, by detonating the bomb at the top of a 100-foot tower.**

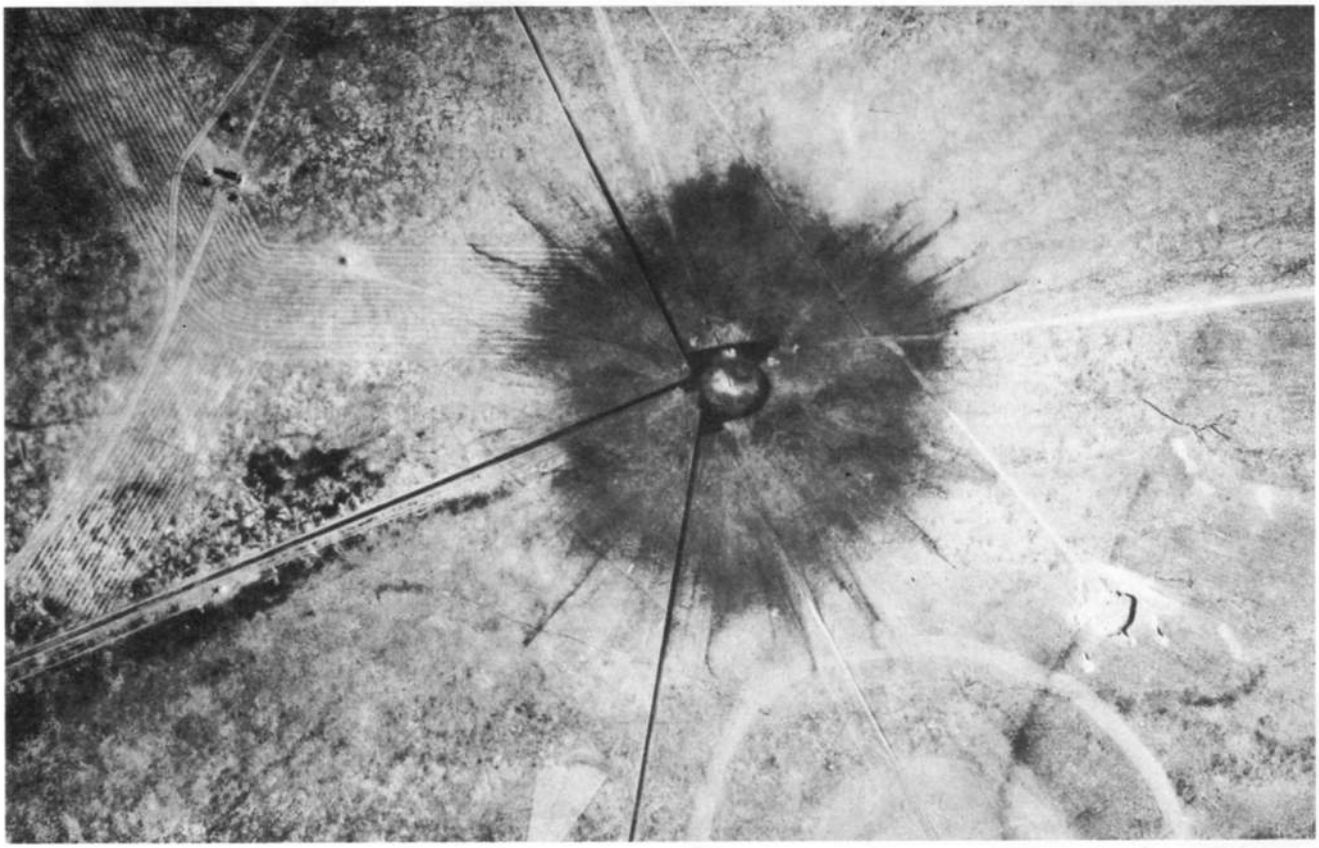
Right: **Fat Man Mk I is slowly eased off the back of a truck. This was identical in size to the Hiroshima bomb minus the ballistic trimmings.**



Photographed from six miles away, the explosion began with a brilliant flash . . . the shot tower still appears to be intact.

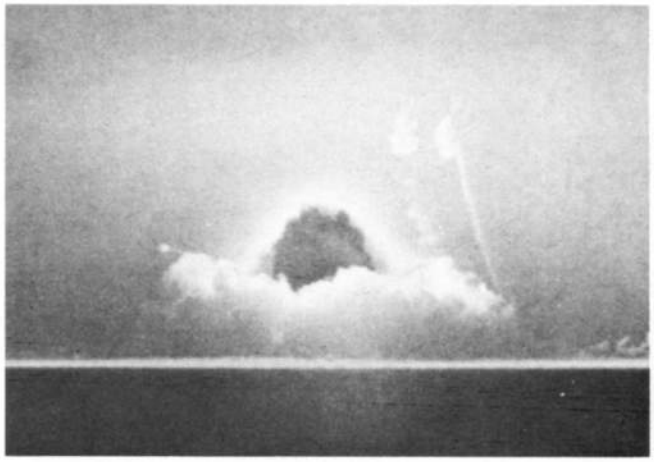


Just 0.34 seconds later the tower has vapourised as the blast sears across the desert rolling a cloud of dust before it.

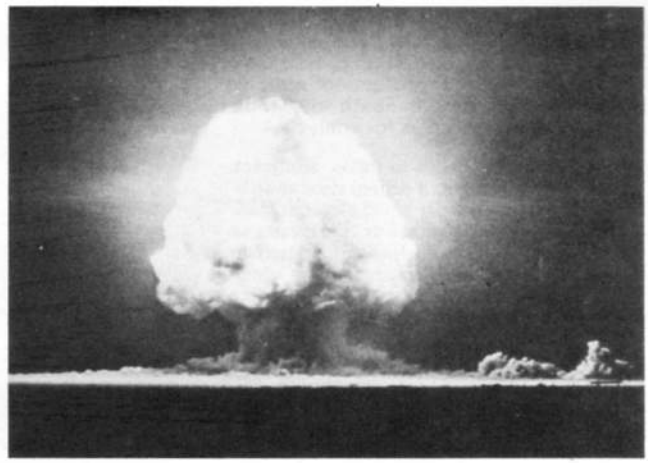


The desert was scorched from the tremendous heat producing what was later dubbed Trinitite. The circular bombing target, bottom right, would seem a left over from the former air force use of the site as a conventional bombing range.

The instrument shelter damaged at North 1000 (1,000 yards from the tower). Jumbo can be seen intact in the background.



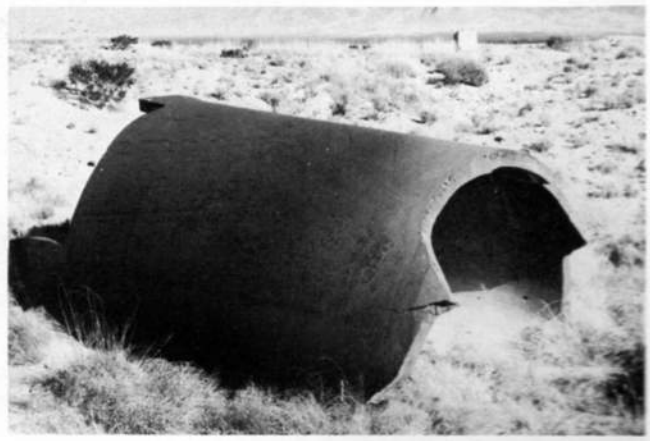
Two seconds later the curtain begins to rise as the boiling debris are carried aloft.



Within seconds a massive fireball belches into the sky . . . 'beautiful, magnificent, terrifying' . . . the birth of a new age.

The Trinitite was dozed into the crater and buried, and the whole area fenced off. In 1965 a monument was erected near the centre (see back cover) and the Alamogordo branch of the New Mexico Chamber of Commerce conducts a public tour to Ground Zero once each year, usually the first Sunday in October. It is not open at any other time. There is still detectable radioactivity in the area but according to a Health Physics Survey of Trinity Site, conducted in 1967 by Los Alamos scientists, 'it does not appear that anyone could receive any radiation injury through a visit.'

Jumbo's tower was swept away, dropping the monster without damage. After the war a series of unrelated experiments were conducted resulting in blowing the ends from the



huge casing. Still standing higher than a man, the fragments still lie where they were bulldozed into an arroyo. One of the concrete footings can be seen in the background.

Enrico Fermi's special Sherman driven by Sergeant Bill Smith, was lined with two inches of lead and had a pressurised oxygen supply for protection against radiation. A device beneath the tank scooped up soil samples for analysis.

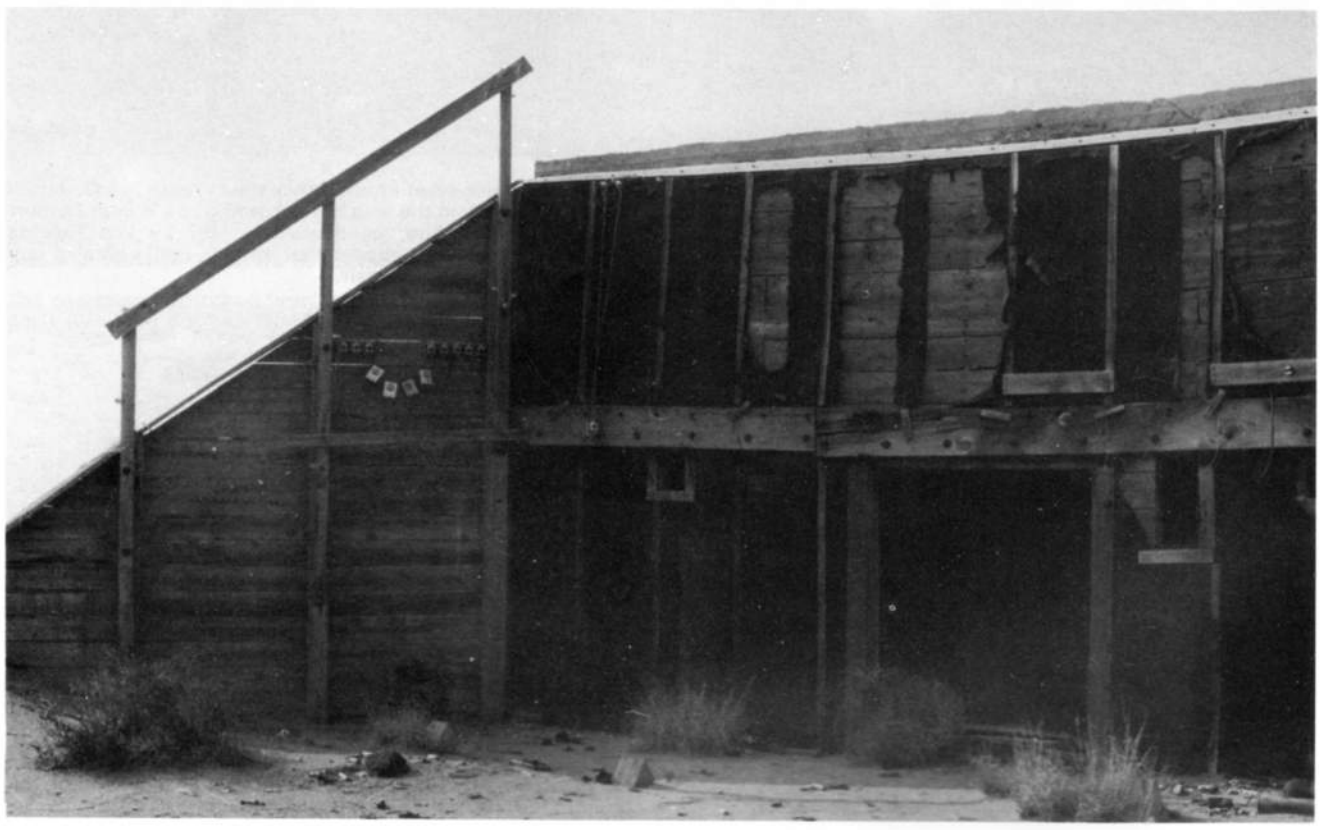
As monitor teams began to follow and track the radioactive cloud as it drifted slowly north-eastward at ten miles per hour, a special lead-lined Sherman tank with Enrico Fermi and Herbert Anderson clanked over the desert to Ground Zero across an expanse from which all vegetation had disappeared. A saucer-like depression 1,200 feet in diameter and 25 feet deep surrounded Ground Zero but of the test tower there was no sign. It had been completely vapourised and its foundations were subsequently discovered seven feet beneath the crater floor. The whole area was coated with a jade-green opaque glass where the desert sand had been melted and fused into what was later called Trinitite. Jumbo, 800 feet beyond the detonation point, had survived intact but its surrounding steel girder tower had been snapped clean. As the Sherman approached Ground Zero, the geiger counter aboard went berserk.

The monitoring teams following the fall-out cloud were also detecting heavy amounts of radiation in a band thirty miles wide and a hundred miles in depth and some radioactivity was detected 120 miles from the test site.

In Berlin the news was reported to the President enigmatically:

'Operated on this morning. Diagnosis not yet complete but results seem satisfactory and already exceed expectations. Local press release necessary as interest extends great distance . . . '

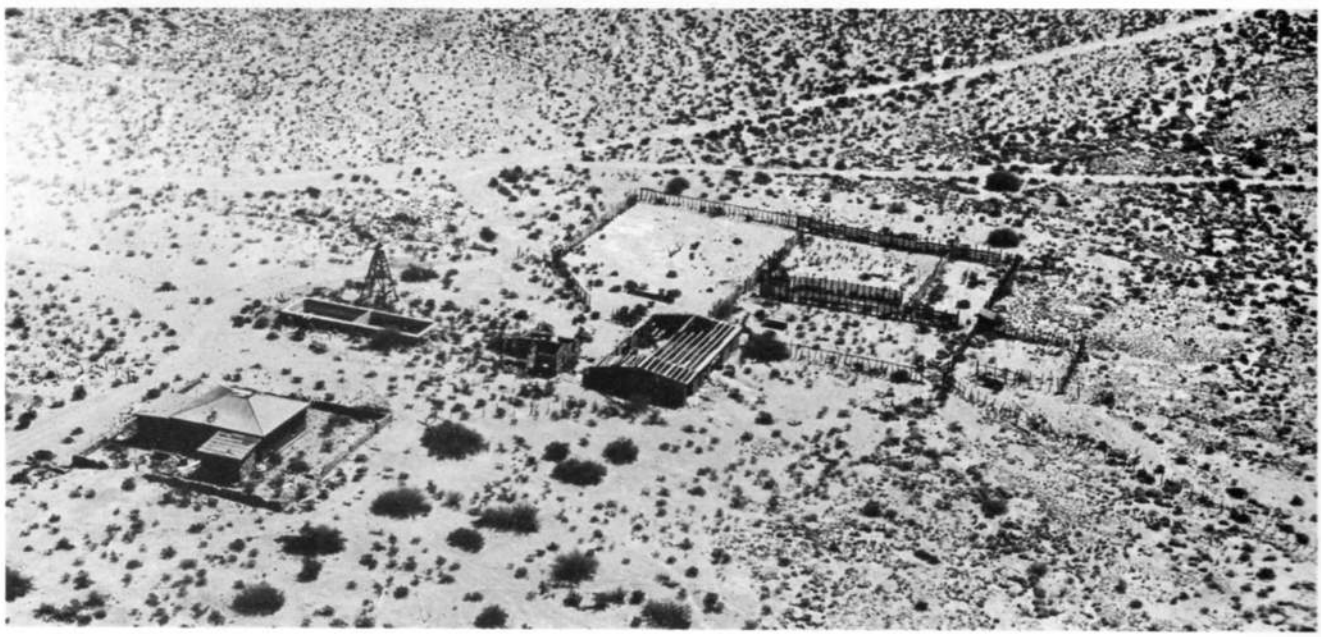
Right: **The most historic of the three bunker sites was S-10000 where General Groves, Oppenheimer and the other VIPs were stationed. This was the control centre where Joe McKibben threw the switch which began the automatic firing timer as Ernest Titterton, an Englishman, activated the detonators. Since the photo *below* was taken in 1965, all the main bunkers have been destroyed.**

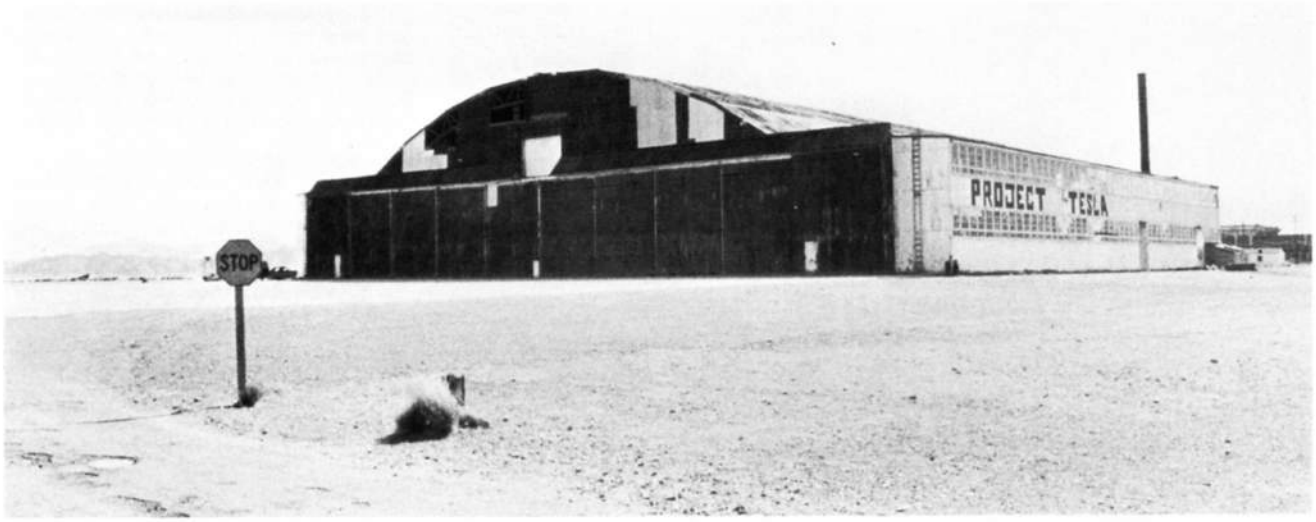


The McDonald ranch, where the final fission assembly took place, still stands . . . abandoned, vandalised and mouldering.

Above: **Deterioration inside the west room.** *Below:* **The corral still stands.**

The east room.





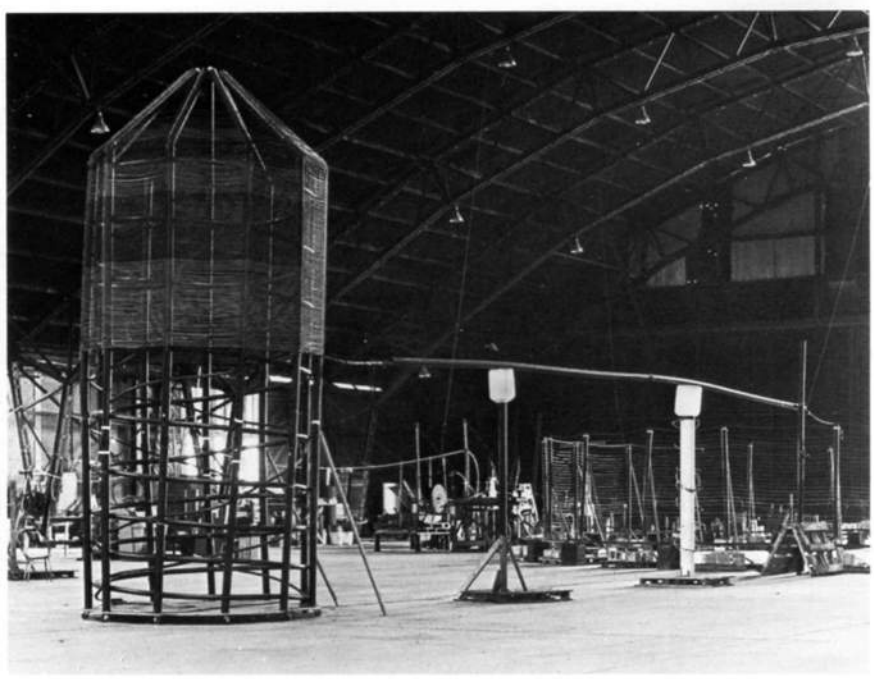
Wendover

Wendover Field is no longer an active base. The State of Utah have campaigned for it to be used as an alternative civilian airport when Salt Lake International is closed, although it is over 100 miles away.

At the same time that scientific and manufacturing effort was being expended in untold amounts to produce a bomb, the USAAF had activated a special unit to carry it into action — the 509th Composite Group commanded by Colonel Paul W. Tibbets, a superb pilot with a distinguished record with the 97th Bomb Group in Europe and North Africa. Colonel Tibbets had been given the job of choosing a suitable Stateside training base and he decided on Wendover Army Air Field west of the Great Salt Lake on the Utah-Nevada border. The area could guarantee more than 300 sunny days per year which was an important prerequisite for developing the bombing techniques required as it had already been laid down that the bomb would be dropped only in a daylight operation under visual aiming conditions.

The Group was assembled on December 17, 1944 equipped with the B-29 Superfortress and began to practise dropping single 10,000lb bombs from 20,000 to 30,000 feet. The dummy bombs were fatter than normal, simulating the 'Fat Man' plutonium bomb — so called because of its similarity with Winston Churchill's physique! (The slimline uranium bomb was named 'Little Boy' after President Roosevelt.) Immediately the bomb was released the aircraft had to make steep 158-degree turns, diving to gain speed to outrun the shock-wave. At the outset, only Colonel Tibbets knew the precise nature of the new weapon, the crews merely being informed that it was a special sort of new bomb.

By the end of May 1945, the Group had been equipped with nine new, specially modified B-29s and on June 5 the first crew left Wendover for their forward base at Tinian.



The main hangar is currently used by Robert Golka, who is credited with generating the most powerful lightning bolts ever created by man. Flashes of 25 million volts send off 50-foot sparks in the experiments using coils in the 20-foot tower and 51-foot diameter ring in the photo *right*. The inventor hopes to develop a system of cheap energy from a device he calls a pyrosphere. His proposal, yet to receive official backing, is based on creating thermonuclear fusion from five laser beams using deuterium, a hydrogen isotope, as a fuel. Other work, which has resulted in government grants, involves the testing of military aircraft against the vulnerability of their highly-sophisticated computer systems to lightning strikes.

Tinian

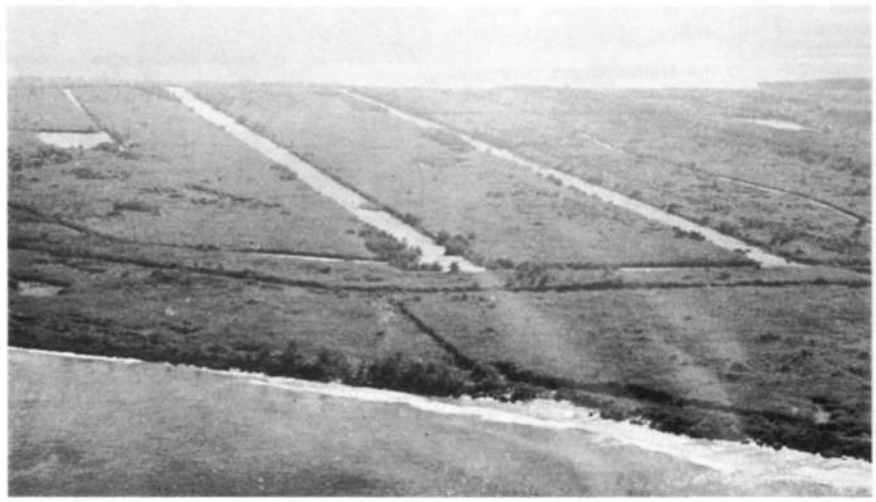
Tinian lies three miles off the southern coast of Saipan in the Mariana group of islands in the north-west Pacific. After a tremendous pre-invasion bombardment, Task Force 52 had landed General Schmidt's V Amphibious Corps, comprising the 2nd and 4th Marine Divisions, on Tinian on July 24, 1944. The battle was noted for the first use of napalm in the Pacific; ironically just over a year later it was to be host to yet another new weapon. The island was finally secured on August 1 with over 6,000 Japanese dead, and the Americans immediately set about converting it into an advanced base for the eventual invasion of Japan. Seabees bulldozed four 8,500-foot parallel runways on the northern tip of the island, aptly named North Field airstrip, while another aerodrome sited on the western side became West Field. Roads were laid down and, because Tinian resembles Manhattan in shape, they were given names such as Eighth Avenue and Park, Grand Avenue, Fifth, 42nd and 110th Streets, and Broadway.

On July 14, 1945, just as the Trinity test was nearing its climax, the components for Little Boy — the uranium bomb — left Los Alamos. First deliveries of U-235 from Oak Ridge had begun in March 1945, and the gun parts were readied by the spring, yet it was not until July that enough fissionable material had been produced to make one core. On July 16 the bomb and half the uranium, the latter sealed in a lead-lined container, were loaded aboard the cruiser *Indianapolis* for the journey to Tinian where it arrived ten days later. The remainder of the uranium was flown in direct by C–54 transport a few days later.

Waiting for it on the island was a detachment of Los Alamos scientists who were to assemble the bomb and the 509th who were to drop it. Colonel Tibbets and the crew of his aircraft *Enola Gay* had been earmarked to carry out the first mission. Captain William S. Parsons of the US Naval Ordnance Division, who had led the development of the uranium gun, would be aboard the B–29 to load the U-235 projectile once in the air.

Meanwhile Hanford had supplied Los Alamos with sufficient material to fabricate a second plutonium bomb with a promise of more in the pipeline to make a third Fat Man. The P-239, consigned under the code-name 'Bronx', was already en route to Tinian by air. Whereas the uranium from the K-25 plant had taken months to produce, plutonium was now coming on stream and, with the proven success of the implosion method of ignition, a sustained campaign of atomic bombing with P-239 seemed more viable.

On August 4, seven crews of the 509th were finally briefed on the true nature of their mission. They were shown a film of the Trinity explosion and, although the word 'atomic' was not mentioned, the reason for the tight turns after dropping the practice bombs was now only too clear. Because of the large amount of



Above: **North Field was constructed on the site of a temporary US Navy airfield which in turn had utilised the original Japanese Ushi Point aerodrome. With four parallel E-W runways, it became WWII's largest and busiest airfield.** *Below:* **Abandoned and now overtaken by the prolific growth of the tangan-tangan jungle. (Glen McClure)**

Nominally the base of Brigadier General John C. Davies' 313th Bomb Wing, his Superforts made their initial combat strike on February 4, 1945. The airfield was ideally situated for Operation Silver Plate — the atomic attack against Japan.

radioactive debris sucked up on the static test firing in the desert, the Manhattan Project scientists had decided to try to avoid this in future by detonating the air-dropped bomb several thousand feet above the ground. However the blast effect would thereby be increased and the danger to the aircraft might well be more severe and crews were especially warned not to fly near the smoke rising from the explosion.

The following day, General Groves' deputy on Tinian, Brigadier General Thomas F. Farrell, reported that the weather conditions over Japan were finally suitable for a visual mission and *Enola Gay* was prepared for a take-off early the next morning. At North Field Loading Pit No. 1, the black and orange-painted Little Boy was winched into the belly of the B-29 while the two escorting observation aircraft were made ready for the 13-hour return flight. The target for the first bomb had been specified as Hiroshima, located in the south-west of the principal Japanese island of Honshu. It was the seventh largest city in Japan with a wartime peak population of 380,000 but five completed evacuations had reduced this figure to an estimated 245,000. It was a modern administrative, communications and military centre built primarily on the fan-shaped alluvial deposits of the Ota River which flows through the city.

According to the United States Strategic Bombing Survey conducted after the raid, published under the 'Secret' classification in 1947, the reasons for selecting Hiroshima as the target for the first bomb were as follows:

a. The city of Hiroshima had received only an insignificant amount of prior damage; therefore, what damage resulted could be attributed to the atomic bomb.

b. Being built on a deltaic formation, it was nearly flat for a distance of 6,000 feet in all directions from the aiming point, and for more than 15,000 feet in the southerly quadrant.

c. At various intervals within a 6,000-foot radius from the aiming point there were enough substantially constructed, multistory, commercial buildings of representative structural types to allow comparative study of the effects.

d. Because of the prevalence of wood construction throughout the city, and the pattern of the water courses which formed natural firebreaks, the incendiary effects of the bomb could be analyzed.

e. Within the area were representative types of short-span, fixed bridges in sufficient numbers to permit a relative study of the effectiveness of the weapon against them.

f. Hiroshima was well equipped with public utilities (water, gas, electricity, sewers) and inter-urban transportation so that conclusions could be drawn regarding the relative vulnerability of these facilities.

g. The principal feature which detracted from the target value was the remoteness of the industrial concentration from the center of the city.

The secondary target was Kokura, a hundred miles to the south-west on the southernmost Japanese island of Kyushu, with the third choice, Nagasaki, another hundred miles south-west.

At 2.45 a.m. on Monday, August 6 *Enola Gay* lifted off the runway in the company of the instrument aircraft, *The Great Artiste*, piloted by Major Chuck Sweeney, and a third B-29 commanded by George Marquardt, equipped with photographic equipment. A quarter of an hour later, once course for Japan, 1,700 miles away, had been set, Captain Parsons began the final loading of the

Members of the 509th Composite Group at a briefing session on Tinian. (US Air Force)

Captain William Parsons, weaponeer on Enola Gay.

Above: **The building where the atomic bomb was assembled.** *Right:* **The nearby loading pit No. 1 is now suitably marked and a tourist attraction. (Glenn McClure)**

At 2.45 a.m. on August 6 Enola Gay taxied out for take off. (US Air Force)

uranium gun which was completed within fifteen minutes. At five minutes past six, having reached Iwo Jima, the formation altered course for Hiroshima. The Japanese coastline was sighted at 8.30 a.m. (Tinian time) whereupon Captain Parsons made a final check on the radar fuses which were set to explode the bomb at 2,000 feet. Eleven minutes later the reconnaissance aircraft, sent ahead to check each target, reported weather fine with few high clouds and a visibility of 10-15 miles over the primary target. Wind was from the south about 5 mph.

The appearance of the weather 'plane had caused the Hiroshima Chugoko Regional Military Headquarters to sound the air raid sirens at 7.09 a.m. (Japanese time was one hour behind). As the aircraft left the area the all-clear was given at 7.31 a.m. when most Japanese who worked in the city were on their way to their offices or factories. At 8.06 a.m. the Matsunaga lookout station reported two aircraft proceeding north-west, corrected to three aircraft three minutes later. The sound of aircraft engines was picked up by the Nakano searchlight battery at 8.14 a.m. yet no further air raid warning was sounded.

Captain Parsons logged the *Enola Gay* as levelling out at 32,000 feet at 8.38 a.m. (7.38 a.m. on the ground). At 9.09 a.m. the target was in sight and at 9.15½ a.m. Tinian time the bomb aimer, Major Tom Ferebee, announced: 'Bombs away!'

'It was hard to believe what we saw,' wrote Captain Parsons later. 'We dropped the bomb at exactly 9.15 a.m. Japanese time (sic) and got out of the target area as quickly as possible to avoid the full effect of the explosion. A tremendous cloud of smoke arose which completely blotted out Hiroshima. When we felt the explosion it was like flak bursting close by. We stayed over the target area for two minutes.

'The whole thing was tremendous and awe-inspiring. After the missile had been released I sighed and stood back for the shock. When it came, the men aboard with me gasped "My God!" and what had been Hiroshima was a mountain of smoke like a giant mushroom. A thousand feet above the ground was a great mass of dust, boiling, swirling, and extending over most of the city. We watched it for several minutes, and when the tip of the mushroom broke off there was evidence of fires.'

Above: **Aboard, the crew were: L to R kneeling: Staff Sergeant George R. Caron, Sergeant Joe S. Stiborik, Staff Sergeant Wyatt E. Duzenbury, Private First Class Richard H. Nelson, Sergeant Robert H. Shumad. L to R standing: Major Thomas W. Ferebee, group bombardier; Captain Theodore J. Van Kirk, navigator; Colonel Paul W. Tibbets, Group CO and pilot; Captain Robert A. Lewis, Aircraft Commander.**

Below: **Mission accomplished.**

Hiroshima

The Chiyoda Life Insurance building (No. 6 in the Strategic Bombing Report), in the centre of the photo *above*, was the nearest one to Ground Zero, 600 feet away, which did not suffer major damage from blast. (IWM)

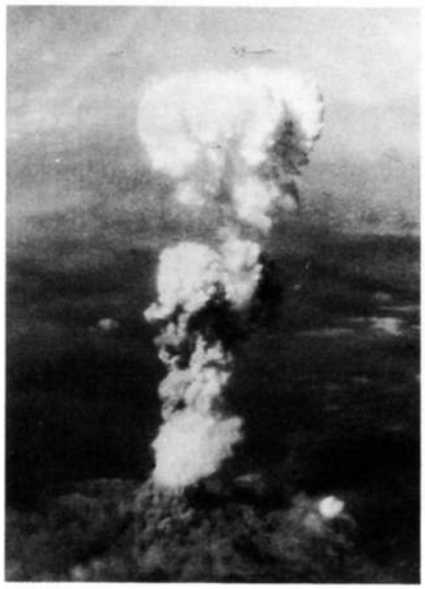
Post-war research has indicated that the bomb exploded at 580 metres (1,903 feet) ±15 metres directly above a point (also referred to as Ground Zero) in the grounds of the Shima Hospital. The power of the bomb has been assessed at 12,500 tons of TNT of which 35 per cent was released as thermal radiation, 17 per cent as radioactive radiation, and the remainder as blast energy. Within a millionth of a second the nuclear chain reaction built up a temperature in the core of several million degrees Centigrade. In 0.1 millisecond a fireball of 300,000°C was created which expanded to 250 metres in diameter one second after detonation.

Survivors stated that the explosion seemed like a vast combustion of magnesium filling the entire sky. Its reported colour was greenish-white and yellowish-red, lasting for two to four seconds. At the same time an overpowering heat wave emanated from the source of the flash. The entire city was darkened by a dense pall of smoke and dust which limited visibility to a few feet. From a distance, a grey-coloured, mushroom-shaped cloud was seen expanding and covering the whole area, reaching a height of 23,000 feet within four minutes. This column began to disintegrate within eight minutes, the top becoming detached.

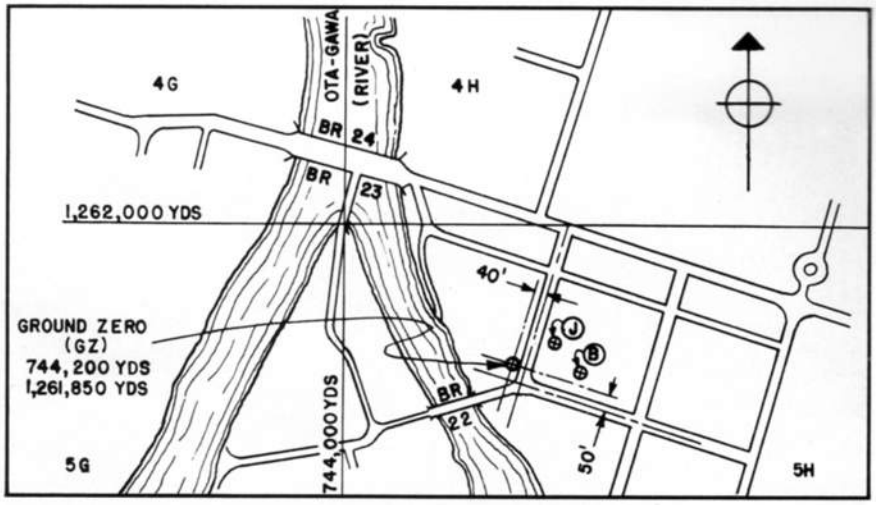
In the centre of Hiroshima, a violent blast of air immediately followed the flash, knocking down trees and poles, tearing sheets of galvanised metal from buildings and squashing or knocking over houses. The temperature of the ground beneath the burst reached an estimated 3,000 to 4,000°C and the heat rays caused flash burns up to 13,000 feet away.

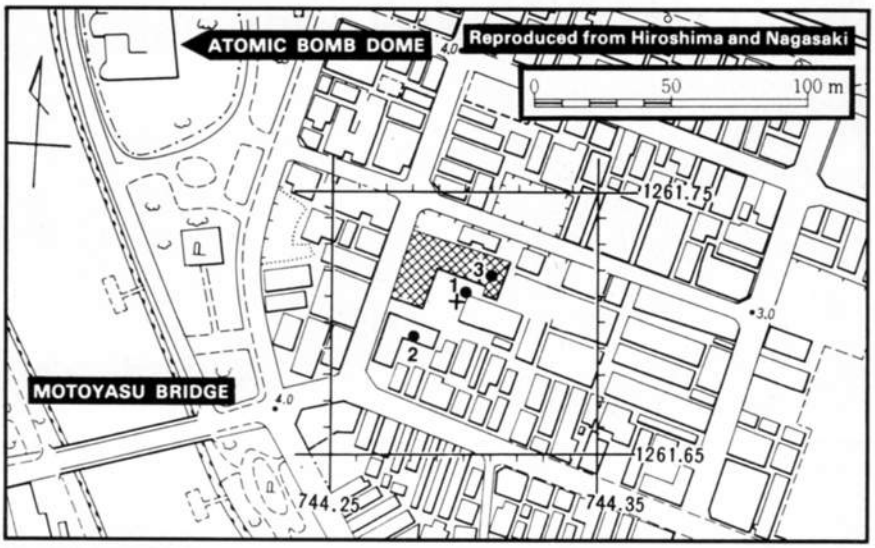
The US aerial photograph on page 33 indicates the aiming point as being the Motoyasu Bridge in the foreground of the photo *below*. The actual detonation point was 500 feet away to the north-west. (See plans opposite.)

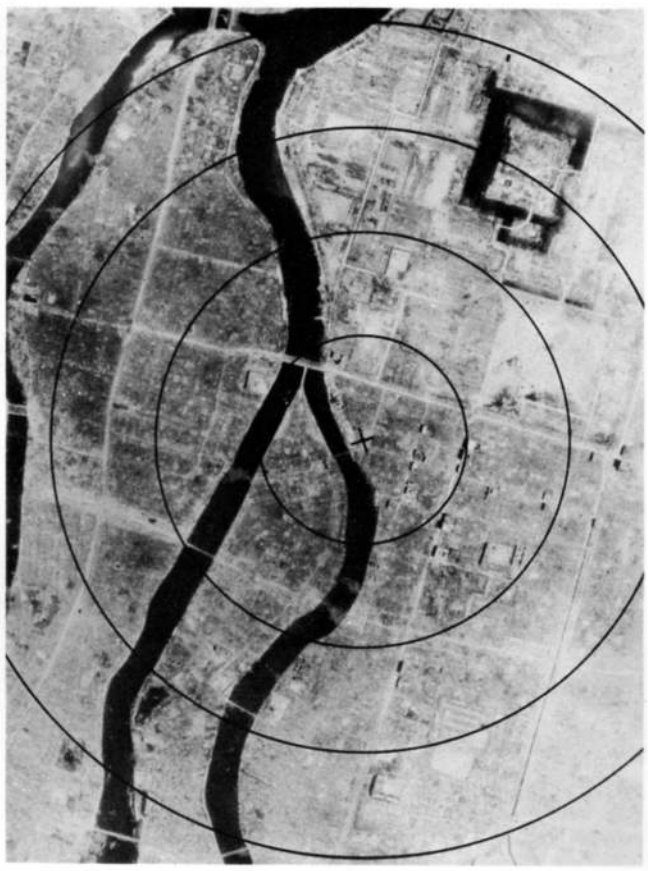
Several bodies have endeavoured to determine the actual position of Ground Zero (now referred to by the Japanese as the Hypocentre). The Chugoku Electric Company and the city architect (J), the British Mission (B) and the US Bombing Survey all disagreed in 1945 as to the precise spot (see drawing *right*). *Centre:* In 1953, Kimura and Tajima gave GZ as position 1; Arakawa and Nagaoka said position 2 in 1959 and Woodbury and Mizuki position 3 in 1961. Further research in 1969 by Hubbell, Jones and Cheka gave position +. All basically try to compute the location by triangulation from scorch marks burnt when the bomb exploded. Distances quoted in captions are from US Ground Zero.



Hiroshima before and after. Circles at 1,000 foot intervals from GZ.







Whichever way one works it out, the Shima Hospital was almost directly beneath the bomb when it exploded. The building was totally destroyed but a new hospital has risen out of the ashes of the old. (Kikuchi/Hirota)

Left: **Marks such as these provide the evidence for the position of GZ although the lack of a sharp edge to the shadow explains the discrepancies between the various authorities. The bridge is the Yokozuyo and the building the Hiroshima City Hall, 3,300 feet from Ground Zero. (IWM)** *Right:* **Our photographer, Jeff Pavey, could not resist this artistic recreation using the sun as his point light source although the actual comparison is on the old bridge to the left.**

Above: **The Fukuya department store, 2,500 feet from Ground Zero, was another reinforced-concrete structure which outwardly survived the blast. However direct radiated heat spontaneously ignited the interior and the fire had spread to the entire building by 10.00 a.m. (IWM)** *Right:* **Subsequently demolished, it has since been rebuilt in modern style. The reconstruction of Hiroshima has been almost total, leaving few of the former buildings. (J. Pavey)**

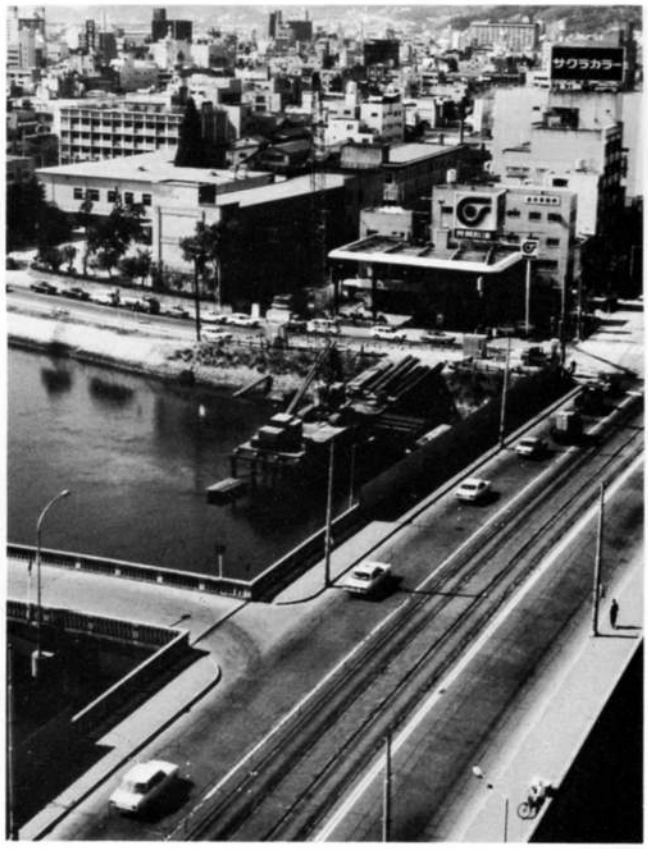
Left: The view southwards from Yokogawa Station. The bridge in the background crosses the River Tenma. (Y. Hirayama)

Above: The original building still standing on the left is now a bank.

Left: The tower of the Shimomura Clock Company building leans at a drunken angle some 2,000 feet from American Ground Zero. (Y. Hirayama) *Above:* Hondori is now a prosperous covered shopping precinct.

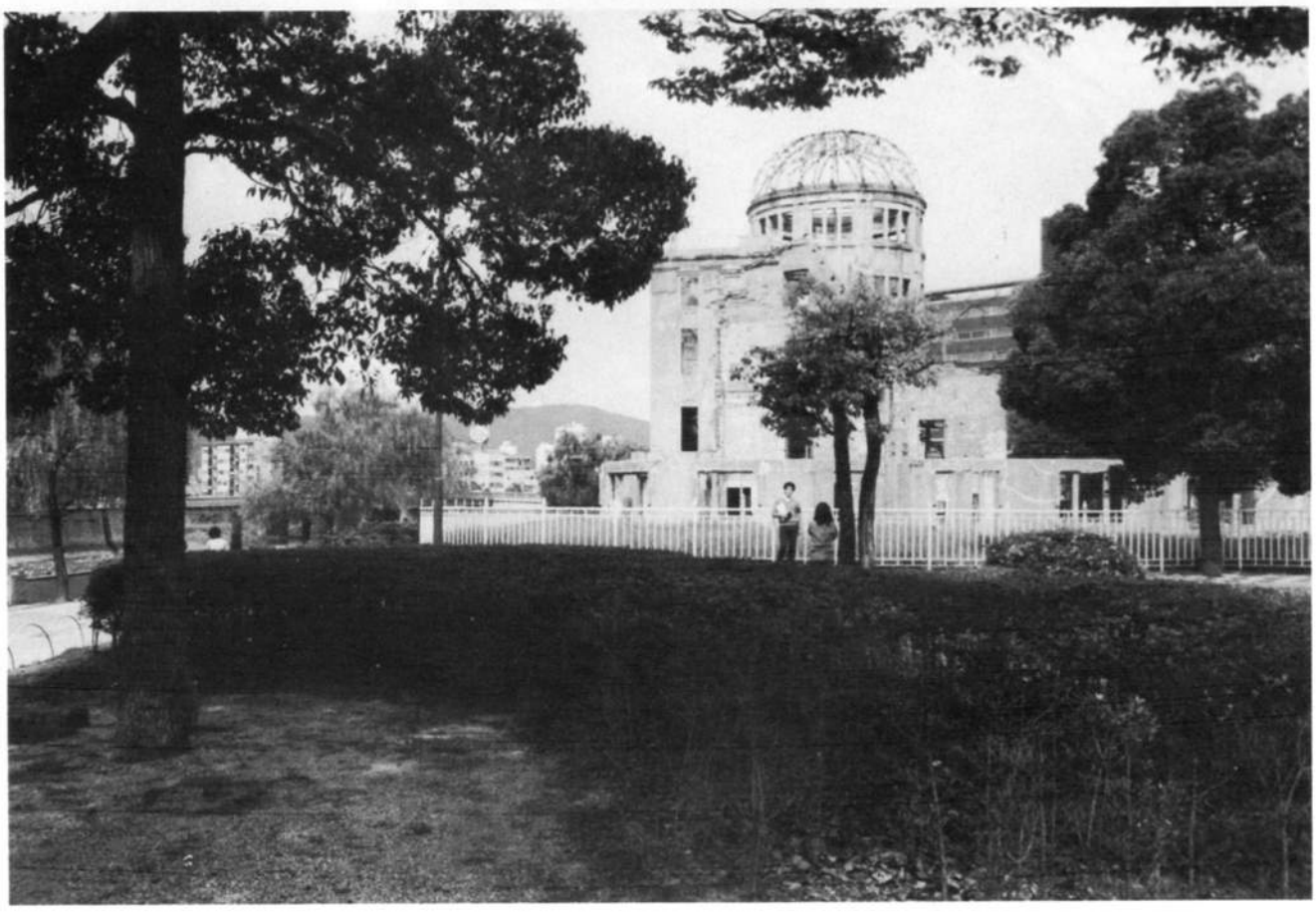
The Hiroshima branch of the Geibi Bank on Kamiya-Cho stands 1,000 feet from GZ. Although it appears here to be little damaged, structurally roof beams were cracked and it was gutted by fire. (Kikuchi/Hirota)

Although the whole area has been reconstructed, the Bank of Japan building further along still remains. It was only superficially damaged as the fire was restricted to one room on the south-west corner. (Kikuchi/Hirota)



Above: **The Aioi T-bridge (No. 22 on the US Air Intelligence Report photo *below*) spanning the confluence of the Honkawa and Motoyasu rivers. In the background stands Honkawa Grammar School, a reinforced-concrete three storey building 1,200 feet from GZ and 2,300 feet from Air Zero. Walls facing the blast as seen in the corridor (right) were buckled while the interior was totally destroyed by fire. Today the building still stands and cracks are evident in some outer walls. (J. Pavey)**

The most famous building associated with the atomic bomb is the City of Hiroshima Commercial Display Building designed in 1925 — now termed the 'Atomic Bomb Dome'. It lay 400 feet north-west of GZ (see plans page 29) and has been left in its ruined state as a symbol of the destruction. It is now fenced off with no admittance signs. (Kikuchi/Hirota)



Hundreds of fires were reported to have started within ten minutes, spreading in all directions aided by the large proportion of highly-combustible materials which are used in the majority of Japanese housing. A fire storm began to develop, a wind of 30 to 40 mph blowing continuously in towards the burning area for two or three hours after the explosion. This was followed by rain contaminated with radioactive fall-out. All wooden buildings within half a mile of Ground Zero collapsed and were burned down. Most concrete buildings escaped complete destruction but were badly damaged and gutted by fire. Broken windows were found up to ten miles away.

Several bodies have carried out research since the end of the war to try to determine the total number of casualties. Because of the large-scale destruction of local society and the disorganisation which followed, probably the most accurate is that compiled by the Hiroshima City Survey Section (see table) which recorded the number of casualties up until August 10, 1946. (Ironically its report was subsequently lost for twenty years.)

TOTAL NUMBER OF CASUALTIES AT HIROSHIMA, UP TO AUGUST 10, 1946 NOT INCLUDING MILITARY PERSONNEL

Distance from Ground Zero (km)	Killed	Severely Injured	Slightly Injured	Missing	Not Injured	Total
Under 0.5	19,329	478	338	593	924	21,662
0.5–1.0	42,271	3,046	1,919	1,366	4,434	53,036
1.0–1.5	37,689	7,732	9,522	1,188	9,140	65,271
1.5–2.0	13,422	7,627	11,516	227	11,698	44,490
2.0–2.5	4,513	7,830	14,149	98	26,096	52,686
2.5–3.0	1,139	2,923	6,795	32	19,907	30,796
3.0–3.5	117	474	1,934	2	10,250	12,777
3.5–4.0	100	295	1,768	3	13,513	15,679
4.0–4.5	8	64	373		4,260	4,705
4.5–5.0	31	36	156	1	6,593	6,817
Over 5.0	42	19	136	167	11,798	12,162
Total	118,661	30,524	48,606	3,677	118,613	320,081

Hiroshima's present war museum was opened in 1955 although this is called the Peace Memorial Museum. The anachronism is compounded by it being located in Peace Park across the river from the Commercial Display building on Nakajimacho, the island below the spur of bridge 22 (see page 33). Displays in the museum are supported by the provision of portable cassette recorders giving commentaries in five languages although some visitors have noted that the English version cleverly masks the acts of the aggressor in the 'Pacific War' (as Japan refers to WWII) and the events which led up to the bombing.

The Memorial Cenotaph houses the Books of the Past recording the names of the victims. Survivors who die of any cancer-related diseases are automatically added each year. Behind cenotaph stands the Memorial Pool and the Flame of Peace.

Bockscar was flown to the US Air Force Museum at Wright-Patterson Air Force Base on September 26, 1961. It is now displayed out of the elements inside the huge museum building.

Nagasaki

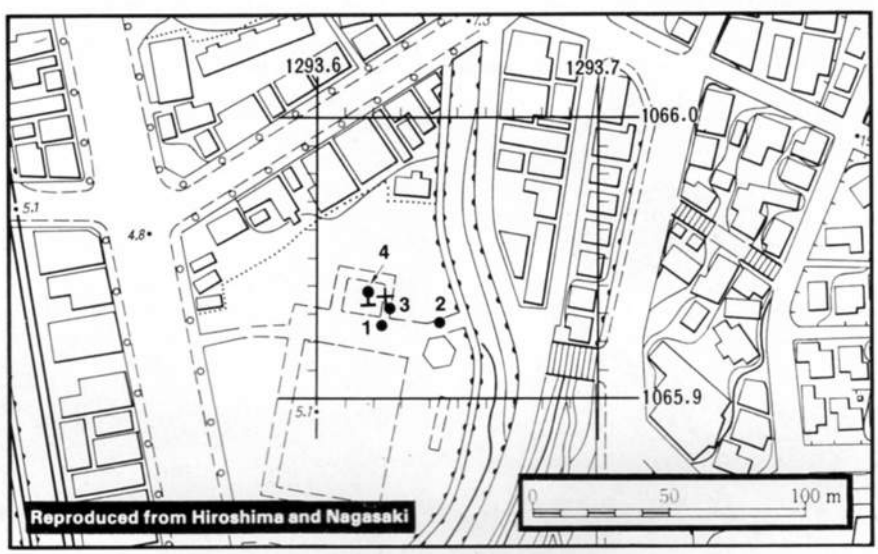
Prior to the dropping of the first bomb, a declaration of the terms under which the surrender of Japan would be accepted had been transmitted to the Japanese Government on July 27 following the conference of the Big Three powers at Potsdam. The final sentence read: 'The alternative for Japan is prompt and utter destruction', a rather oblique and vague reference to the impending use of the atomic bomb, about whose existence the Japanese were left in ignorance. The lack of a positive response led to the Allied decision to embark on a series of knock-out blows to force a submission.

With the forecast of approaching unsettled weather over Japan, the second plutonium bomb was quickly being made ready on Tinian. This time Major Chuck Sweeney's crew were detailed to carry the bomb and they had already carried out a dummy run, dropping a Fat Man without the nuclear core into the sea to test the fusing and detonators. As *The Great Artiste*, their aircraft on the Hiroshima run, was one of the instrument 'planes, they switched machines and borrowed *Bockscar*. Commander Fred Ashworth was in charge of fusing the weapon, with Captain Kermit Beahan as bombardier. The target would be the number two on the first raid, Kokura, with the alternative choice of Nagasaki in case Kokura was obscured by cloud.

Shortly before take-off the first problem to befall the flight became apparent when the engineer reported the fuel valve which controlled the reserve tank was inoperative. At this late stage the implications of an aborted mission were too great and as Iwo Jima had a suitable runway, there was the possibility of landing there on the return flight should fuel run low.

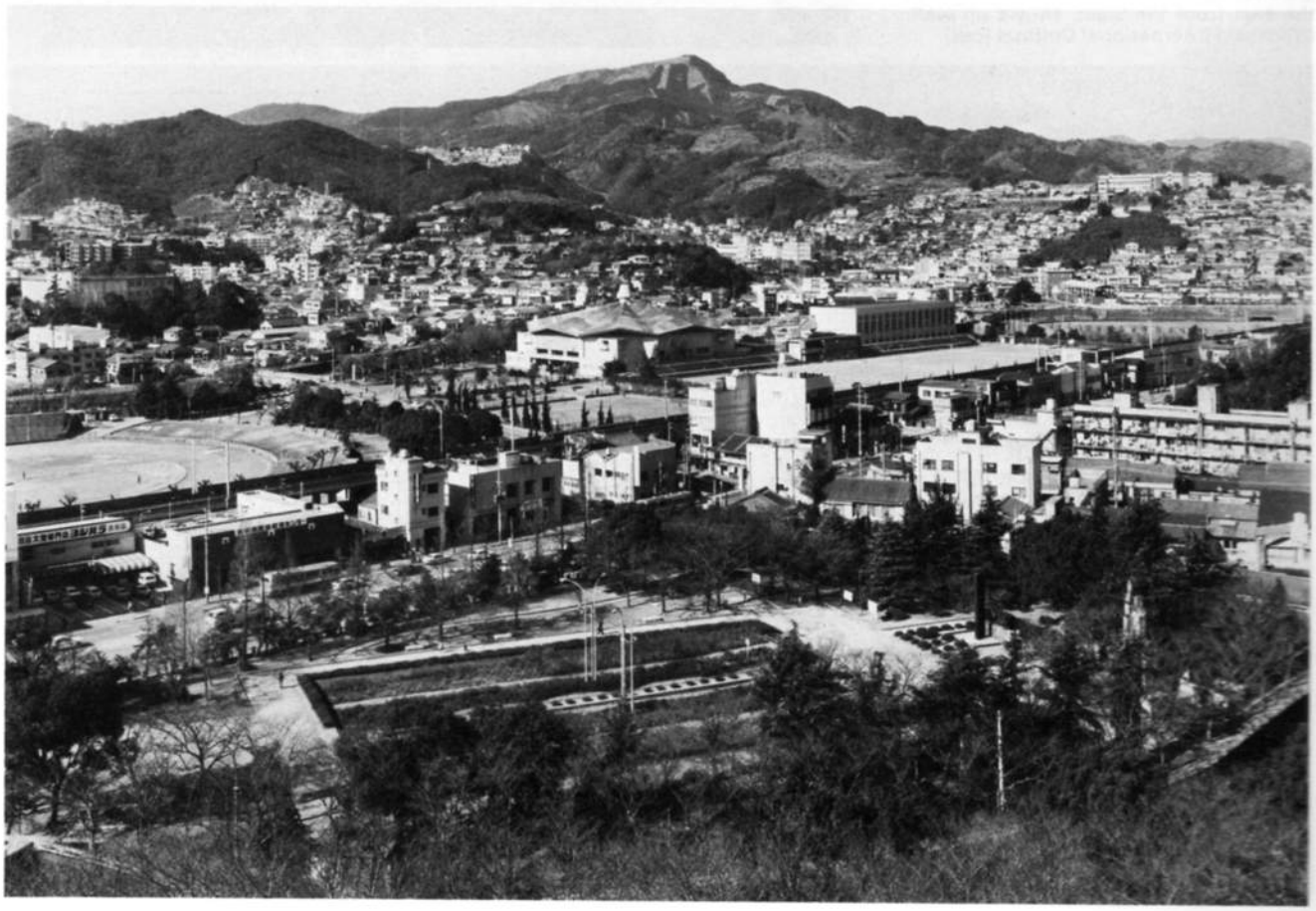
At 1.56 a.m. Japanese time on August 9 *Bockscar* took off followed later by the photographic and instrument-carrying B-29s. Slowly climbing out over the Pacific, Major Sweeney set course for Iwo, passing the island at 5.04 a.m. Making landfall at the Yakoshima rendezvous, the second problem arose with the non-arrival of the photographic aircraft. Major Sweeney circled, waiting for the missing B-29 which was carrying the British scientist Dr William Penny and Group Captain Leonard Cheshire as observers. With the fuel shortage exacerbating the situation, after forty minutes Major Sweeney gave up and headed in to Kokura. Although the weather aircraft had earlier advised that both targets were clear, by the time they reached the city it was mid morning and industrial haze obscured the arsenal which was the aiming point. Frustrated, Major Sweeney tried a second run over the target. Still invisible, the B-29 was now attracting anti-aircraft fire and Japanese fighters were heard scrambling on the radio. To linger over the target was to invite trouble, yet Major Sweeney swung *Bockscar* round for yet

L to R standing: Captain Kermit K. Beahan, bombardier; Captain James F. Van Pelt, navigator; Lieutenant Charles D. Albury, Aircraft Commander; Lieutenant Fred J. Olivi, co-pilot; Major Charles W. Sweeney, CO. L to R kneeling: Staff Sergeant John D. Kuharek, Sergeant Ray G. Gallagher, Staff Sergeant Albert T. DeHart, Sergeant Abe M. Spitzer.



Like Hiroshima, similar discrepancies exist as to the precise location of Ground Zero at Nagasaki. 1 indicates the spot computed by Kimura and Tajima in 1953, 2 the position plotted by H. H. Hubbell, T. D. Jones and J. S. Cheka in 1969 and 3 the revised location by Mr Hubbell in conjunction with others the following year. The evidence was re-analysed in 1976 by G. D. Kerr and D. L. Solomon giving a new point +. By then, an obelisk, 4, supposedly marking the precise point had already been erected some thirty feet or so to the west in what had become Nagasaki's Peace Park opened in 1955.

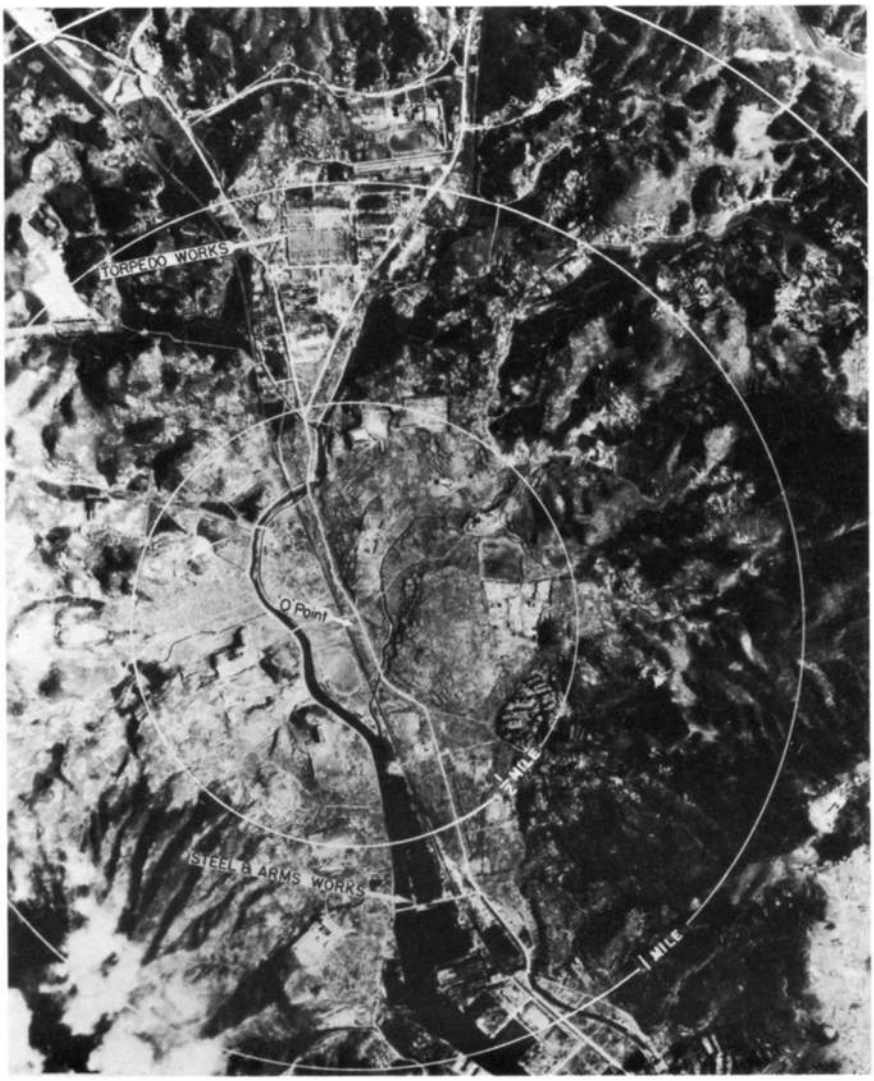
Above: The view of the north-west district of the city photographed by Shigeo Hayashi in September 1945. Photography of atomic bomb devastation was prohibited by Allied GHQ in October that year. *Below:* Comparison by the Nagasaki Photo Service — the Ground Zero monument can be seen in the right foreground.



another pass. Nevertheless his orders were specific: the bomb was only to be dropped visually. With the warning of fighters approaching from below, there was no other choice but to set course for the alternate target of Nagasaki. With fuel running short they would have to take the direct route which led right over the Japanese fighter airfields on Kyushu, make one pass over the city and then try to make Okinawa, the mainland island wrested from Japan at the end of June. As *Bockscar* approached Nagasaki, the two-tenths cloud cover reported by the reconnaissance aircraft now appeared to be nearer nine-tenths. Responsibility for choosing between jettisoning the bomb and three years tremendous effort into the sea or going against orders and dropping it by radar rested with Commander Ashworth. Time was running out and a decision had to be made if the aircraft was not to ditch or even crash-land in Japan.

'Go ahead and drop it by radar, if you can't do it visually,' he told Sweeney, only too aware of the fact that he was countermanding explicit orders. Fortunately for him, twenty-five seconds before release, a hole appeared in the clouds and the bombardier took over visually. At 11.02 a.m. — just over nine hours after leaving Tinian — the bomb was released.

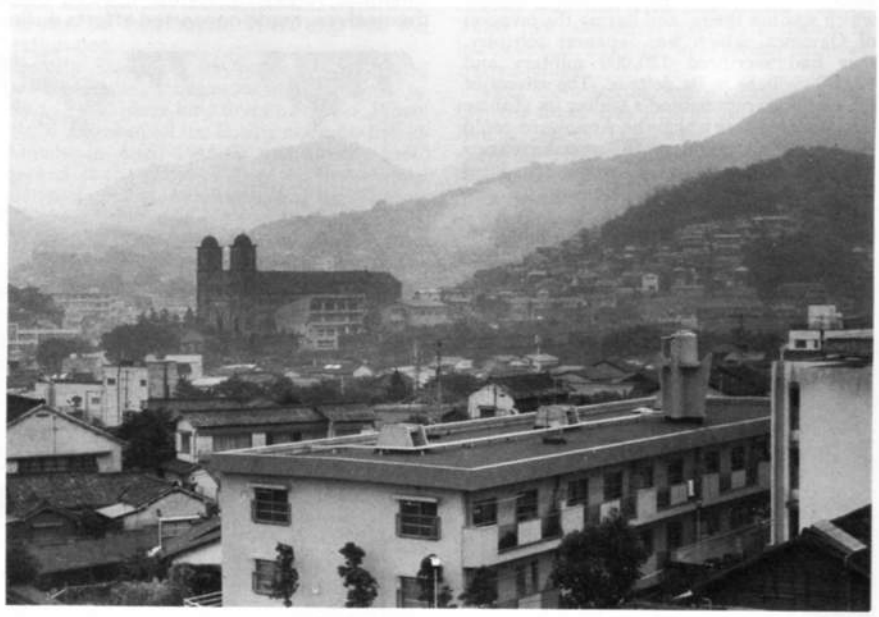
The plutonium bomb exploded at 1,650 feet (±32 feet) above the Urakami district of Nagasaki, post-war researchers having pinpointed the position of Ground Zero to within 20 feet. Although its explosive power has been estimated at 22,000 tons of TNT, the magnitude of its effect was deflected by the hills which divide the city, and the Nakashima river district escaped with lesser damage.



Right: **This would have been Captain Beahan's view of Nagasaki except that this reconnaissance photo was taken after he dropped Fat Man Mk II. (US Air Force)** *Below:* **Present day Nagasaki looking north — the stadium which was the aiming point can be seen in the centre of this oblique shot. The high ground, which protected the suburb to the east from the blast, shows up well. (Nagasaki International Cultural Hall)**

In after years

Above: **The ruin of the Urakami Cathedral formerly the largest Christian church in eastern Asia located 1,900 feet east-north-east from Ground Zero.** *Below:* **The rebuilt cathedral was inaugurated by Pope John Paul in 1981. (A. Hirota)**



Within hours of the news of the second bomb reaching Tokyo, the Japanese heirarchy were meeting with the Emperor to thrash out once again the pros and cons of accepting the terms of the Potsdam Declaration. The arguments for and against continued but, with the entry of the Soviet Union into the Far Eastern war the previous day with decisive effect, on August 15 the Emperor broadcast his acceptance.

As soon as it was considered safe to do so, numerous teams entered the cities of Hiroshima and Nagasaki to begin investigations into the effects wrought by the bombs. While assessments were prepared by the individual town civilian administrations, the United States Strategic Bombing Survey, established by the Secretary of War on November 3, 1944 to prepare detailed technical reports on the effects of Allied bombing on German, French and Belgian targets, had its brief widened on August 15, 1945 to encompass Japanese targets. President Truman requested that the Survey conduct a study into all types of air attack in the war against Japan, not just the atomic ones. A complement of 350 officers, 500 enlisted men (the military personnel comprising 60 per cent from the Army and 40 per cent Navy) and 300 civilians were detailed for the task, operating from a headquarters established in Tokyo early in September 1945, with sub-headquarters in Nagoya, Osaka, Hiroshima and Nagasaki. Mobile teams operated in other parts of Japan, the islands of the Pacific and the Asiatic mainland.

The survey interrogated more than 700 Japanese military, government and industrial officials and recovered and translated many documents to build up a picture of the Japanese economy and war production, factory by factory, industry by industry. As far as Hiroshima and Nagasaki were concerned, the teams began their studies in October and were joined for the month of November by a 16-man mission from Britain. The short report of the latter was published by His Majesty's Stationery Office in 1946. The US Survey, on the other hand, ran to several volumes. Report No. 3 from the Office of the Chairman, Nos. 5 and 9 on Air Raid Protection from the Civil Defense Division, and No. 13 from the Medical Division were all published by the US Government Printing Office, while the more interesting Physical Damage Division reports (Nos. 92 and 93) and the Urban Areas Division reports (Nos. 59 and 60) were classified as secret.

Volume 1 of Report No. 92, completed in May 1947, explained that no attempt had been made to pass judgment on the overall effectiveness of the atomic bomb, the purpose of the Survey being only to tell as complete a story as possible of the physical damage suffered by the stricken cities as a result of both the direct and indirect effects of the explosions. Reports of damage to buildings of all existing types — industrial, commercial, and residential — were included, together with some conclusions concerning the relative degrees of resistance inherent in the several types to the direct and indirect results of the atomic bomb forces. Likewise, there was considerable discussion regarding building contents' vulnerability and degree of damage in relation to the types of construction. Fire also was reported on at length since it resulted from both direct and indirect causes and was

Yamade primary school — then and now.

responsible for a large proportion of the physical damage. Other subjects studied and reported on were: damage to machine tools, bridges, chimney stacks, services, and utilities.

Since then countless books, articles and papers have been written and published covering every aspect of the bombings. Memories of what total war really meant in 1945 have faded and the passage of time has seen the armchair critics of another age bring into question the 'morality' of the construction and use of the atomic bomb. It is not the Editor's intention to enter into the argument. Our role is merely to state the facts and let every reader decide for himself or herself what he or she would have done had they been in President Truman's shoes.

Firstly, the President inherited a fact of life: the decision to develop the bomb had already been taken by Britain and America early in the war in the light of the knowledge that German scientists were already at work on nuclear research.

When a national army is fighting on its own territory to defend its own capital city, the resistance is bound to be bitter. Churchill stated that the Battle of London, were it to be fought street by street, could devour an entire enemy army. After the invasion of Europe, the Western Allies refrained from a drive to capture Berlin, which General Omar N. Bradley, commander of the US 12th Army Group, warned Eisenhower could result in 100,000 casualties, and the Russians later stated that they had suffered that many men killed during its capture.

Although Germany was knocked out long before the atomic bomb was even tested, the war in the East was expected at the time to last well into 1946. In the island-hopping campaign across the Pacific the Japanese had already fought tenaciously to hold territory which was not theirs, and during the invasion of Okinawa, which was Japanese territory, they had sacrificed 120,000 military and 42,000 civilians in its defence. The advent of the kamikazi represented a scaling up of these 'do or die' tactics which the Americans could expect to encounter in ever-increasing numbers in the invasion of Kyushu, scheduled for November 1, 1945, and Honshu, planned for March 1, 1946.

The success of the Trinity test on July 16, with the guarantee of further regular supplies from Hanford, offered the possibility of launching a series of hammer blows which might force an early surrender and avoid the necessity for the long and costly campaign which would have inevitably resulted, like Germany, in the total destruction of Japan by conventional bombing.

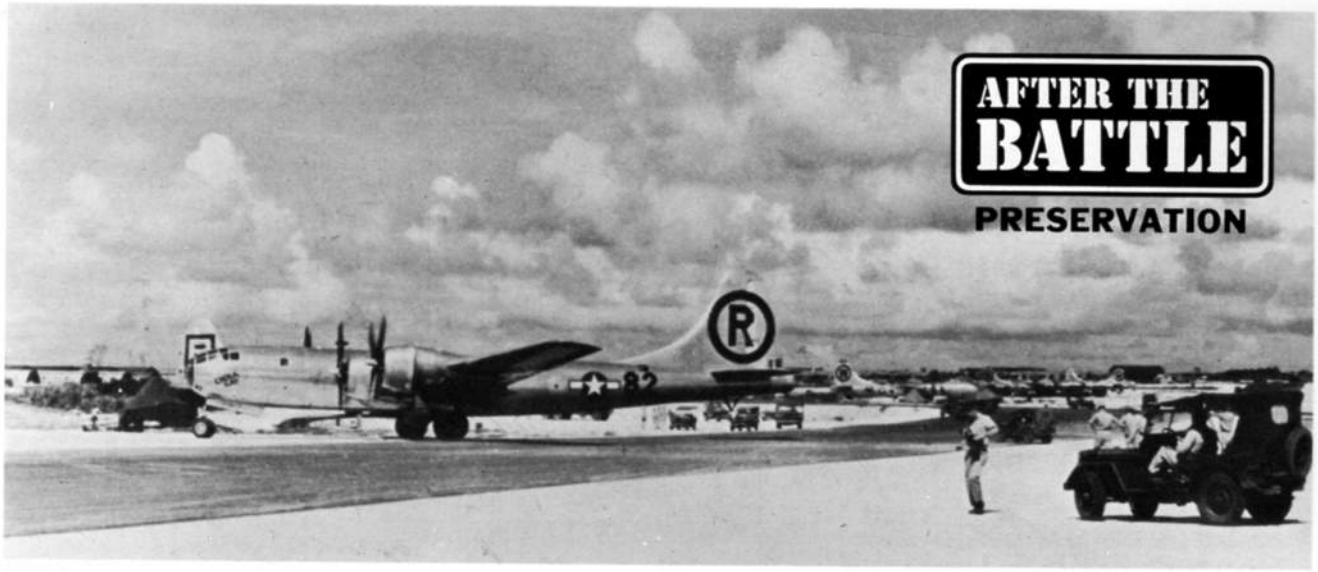
For nearly twenty years after the end of the Pacific war, Harry Truman refrained from public comment while his critics became more noisy in their condemnation of his decision to use the weapon. His answer came in February 1965 during a television interview:

'It was a question of saving hundreds of thousands of American lives. I don't mind telling you that you don't feel normal when you have to plan hundreds of thousands of complete, final deaths of American boys who are alive and joking and having fun while you are doing your planning. You break your heart and your head trying to figure out a way to save one life.

'The name given to our invasion plan was OLYMPIC, but I saw nothing godly about the killing of all the people that would be necessary to make that invasion. The casualty estimates called for 750,000 Americans — 250,000 killed; 500,000 maimed for life.

'I could not worry about what history would say about my personal morality,' concluded the former President. 'I made the only decision I ever knew how to make. I did what I thought was right.'

Casualties in Nagasaki reported in December 1945 amounted to 73,884 killed and 74,909 injured although it is not known if military personnel are included in these totals. Understandably, a catastrophe such as this had a profound effect on the people of Japan and memorial services were held in both cities on the first anniversary of the bombing. Over the years, these annual services became transformed into 'Peace Festivals' with a strong anti-nuclear theme leading to a ban being imposed by the Allied GHQ in 1950. With the signing of the San Francisco Peace Treaty in September 1951, the occupation of Japan was formally ended and thereafter the annual 'festivals' became more demonstrations of a national resolve against the nuclear weapons which were then being increasingly test fired by the major powers. The expansion of the peace movement, with some more radical groups defining Russian weapons as 'peaceful', has, as one observer commented, 'paradoxically earned Japan growing criticism overseas . . . while shielded by the nuclear umbrella of the security treaty with the United States, her miniscule defence spending is accurately singled out as a major reason for Japan's enormous industrial success'. In 1978 the Japanese government was the first to defy a US anti-proliferation ban on the use of plutonium in nuclear power stations which now only costs around £100 per gram to produce. (Note: Japanese physicists at the Institute of Physical and Chemical Research, Kyoto Imperial University and Osaka Imperial University had, themselves, made concerted efforts during the war to crack the nuclear nutshell.)



THE ENOLA GAY

Enola Gay taxies to dispersal having landed back at North Field, Tinian, after dropping the uranium bomb. (US Air Force)

BY LARRY SUID

Next to the Wright Brothers' plane and Lindbergh's *Spirit of St Louis*, the *Enola Gay* has probably had the greatest impact on civilization of any aircraft ever to have flown. The first two planes hang majestically in the central bay of the Air and Space Museum on the Mall in Washington while the B–29 which dropped the first atomic bomb sits disassembled in a warehouse in Silver Hill, Maryland.

The plane's pilot, Paul Tibbets, believes that the controversy surrounding the plane's mission over Hiroshima has prevented the *Enola Gay* from assuming a position of honour in the new Smithsonian Museum. For his part, General Tibbets believes the bomb 'should have been dropped. It never occurred to me in 1944 and 1945 that you would even think if you had a weapon of that type that you wouldn't use it. We were out to win a war, not to prolong it or stall it or fight with one hand'. Tibbets, now the president of an air charter service, has expressed disappointment that 'the government and quasi parts of it are ashamed of the *Enola Gay* and what she did during the war. I think they would all like to play ostrich, i.e. "put their heads in the sand" and hope the problem [use of the A-bomb] would disappear.'

In a 1965 article, *Life* magazine noted that some Smithsonian officials did 'worry that the plane would be out of place alongside objects intended to engender pride.' However, in discussing plans for the new Air and Space Museum that was then on the drawing boards, other officials pointed out that because the plane 'figured so prominently in history it is a legitimate subject for display.'

While the plane still remains controversial for those people who see it as a symbol of the evils of nuclear war, its size rather than any efforts to keep it hidden remains the basic reason why the Smithsonian has not restored the *Enola Gay* to exhibition condition. The *Life* article pointed out that the plane's 141-foot wing span and 99-foot length made it too large for any then-existing museum. Even the new Air and Space Museum does not contain an exhibit area large enough to hold the assembled plane.

Walter Boyne, the museum's curator, conceded that it would be possible to place only the fuselage in one of the bays. However, he points out that even this section of the plane would displace several other aircraft and would probably engender criticism for not having restored the entire plane. As an alternative to keeping the *Enola Gay* in storage, Boyne says he has hopes that the plane can be sent to some other air museum where it can be reassembled and exhibited indoors. To further this goal, the curator indicates that tentative negotiations have taken place with a museum 'in a most appropriate location' and if an agreement is reached, he says the Smithsonian would help with the restoration.

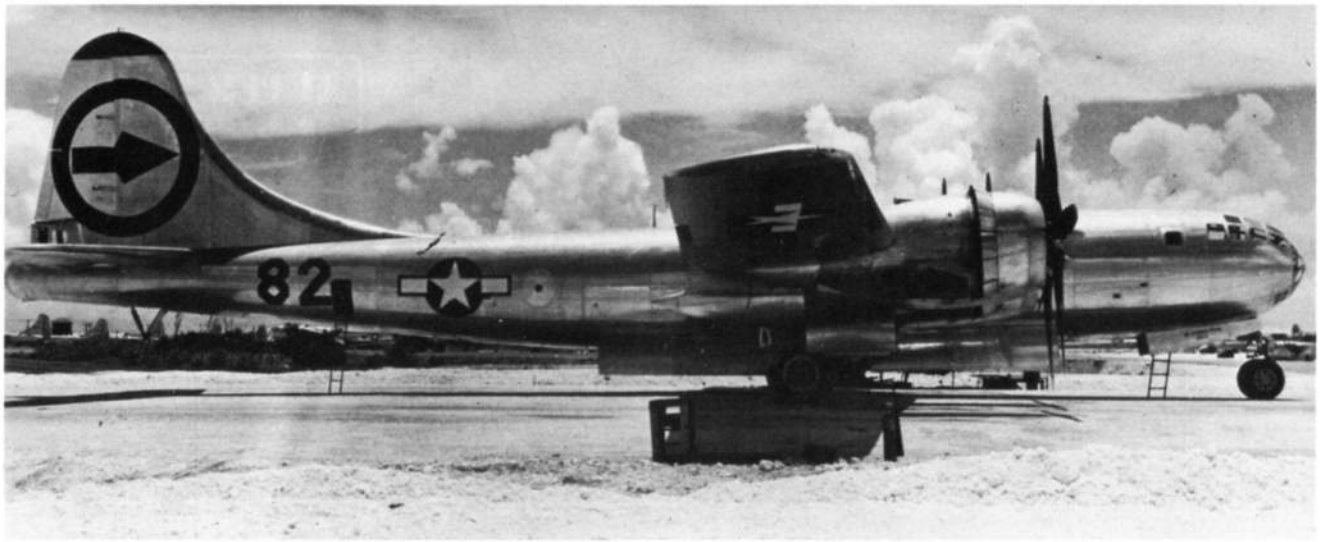
If the *Enola Gay* has not yet found a permanent home, it began its life designated to be a special plane for a unique mission. When the B–29 rolled off the Boeing assembly line in Omaha in April 1945, it had already been picked as the plane to drop the first atomic bomb in combat. While directing the training for the mission at Wendover, Utah, the then-Colonel Tibbets ordered the B–29 to be modified as it was being built.

Wanting the fastest possible aircraft, he had the *Enola Gay* stripped of all heavy turrets and the central fire control system in order to make the plane 7,700lbs lighter. He also had the B–29 specially equipped with electric, reversible pitch propellers which had originally been designed for use on Consolidated Aircraft's B–32 bomber, the unsuccessful challenger to Boeing's Superfortress. Explaining his requisition of the props, Tibbets said, 'We couldn't afford to pile up at the end of a runway with that load [the atomic bomb]. These [the propellers] gave us a chance to backwater if anything went wrong once we started rolling.'

After flight testing and preliminary training, the *Enola Gay* flew to the Marianas on June 29, 1945. On Tinian, it began flying warm-up missions against Japan and on August 6, with Colonel Tibbets at the controls, the plane dropped the first atomic bomb on Hiroshima at 9.15 a.m., ushering in the nuclear age.

Despite the long-running debate over whether the United States should have dropped the bomb, Tibbets himself has never

Victory smiles from both the flight and ground crew. Colonel Paul Tibbets in the centre in front of the prop blade. In 1979 he gave the aircraft's flight manual together with his pre-war log book to the Montessori School in County Wicklow, Ireland, for a celebrities' auction to raise money for new classrooms. (US Air Force)



Note the change of tail markings from the Circle R — the 313th Bomb Wing code adopted for deception purposes — to the official 509th Composite Group marking.

seen the plane's mission as anything which should have caused controversy. He saw it as 'a military assignment and I did what I was told to do'. Thomas Ferebee, the bombardier on the Hiroshima flight, verbalised the same thoughts: 'I've always felt compassion for those at Hiroshima that day, but I never got a guilt complex over it. It was just like any other mission military people are asked to do.'

In any case, following the bombing mission, the *Enola Gay* stayed in the south Pacific until November, when Robert Lewis, the plane's regular pilot, flew it from Tinian to the Air Force Base at Roswell, New Mexico. Even though it had established its claim to fame, the B-29's flying career was not over. At Roswell, Tibbets flew the plane in routine training exercises. He later recalled, 'The *Enola*'s really a very boring airplane. Nothing ever happens to her, not even vibrations.' Describing a series of three high altitude missions in one day, Tibbets remembered, 'All the sceptics said we'd lose an engine. *Enola* didn't even cough.'

Because the plane was one of the very few B-29s that had been modified to carry an atomic bomb, Tibbets flew the *Enola Gay* back to the Pacific in July 1946 to take part in the Bikini bomb tests *(see After the Battle No. 28)*. The plane did not drop any of the bombs, however, and it returned to the United States after the operation.

On orders of General Carl Spaatz, the Air Force's Commanding General, the *Enola Gay* was then placed in mothballs at Davis-Monthan Air Force Base in Arizona to preserve it until a decision was made about its ultimate disposition. In June 1949 it was taken out of its protective cocoon and, on July 3, Tibbets with his former bombardier, Major Ferebee, aboard, flew the plane to Chicago where he formally turned it over to the Smithsonian Institution. After being exhibited at the National Air Fair then being held concurrently with the third Air Force Association Convention, the Smithsonian placed the plane inside the former Douglas aircraft plant at Orchard Place, now the site of O'Hare Airport.

Plans called for the *Enola Gay* to remain indoors until the Smithsonian could build its Air Museum in Washington. With the outbreak of the Korean War, however, Douglas reactivated its assembly line and on short notice, Smithsonian officials had to move the B-29 and other planes being stored in the plant outdoors and to the mercy of the harsh Chicago-area weather. Finally, on August 31, 1951, the *Enola Gay* was flown from Orchard Place to Andrews Air Force Base to await a permanent home.

At least throughout the 1950s, the plane and her mission remained a source of pride to the nation. In 1952, MGM released *Above and Beyond* which told the story of Colonel Tibbets, his training of the 509th Bomb Group for its nuclear missions, and the actual dropping of the bomb on Hiroshima. While Tibbets said he had already had more than enough publicity, he felt that he was 'public property' and the American people were entitled to know what had happened to their property during the war. With the assistance of the Air Force, MGM was able to tell a story that Tibbets felt was 'so close to realism that really we would have to be very, very nit-picking to separate what was on the screen from reality'.

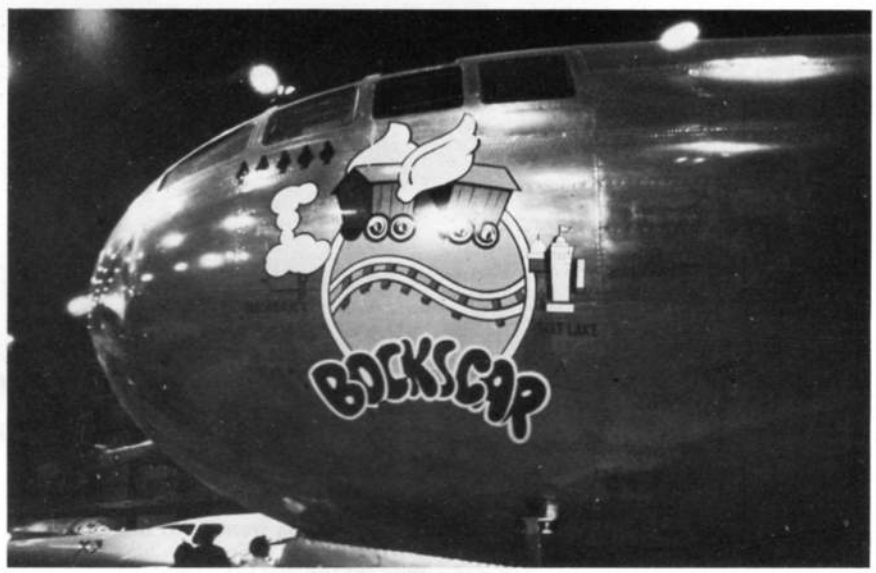
Hollywood followed *Above and Beyond* with a series of movies made in co-operation with the Air Force which portrayed the activities of the Strategic Air Command during the Cold War. *Strategic Air Command* (1955), *Bombers B-52* (1957), and *Gathering of Eagles* (1963) pictured the bomb as a necessary deterrent to Soviet aggression, with the clear implication that Hiroshima and Nagasaki had been necessary military actions.

Meanwhile, the *Enola Gay* herself sat outdoors at Andrews Air Force Base unattended, collecting birds' nests, suffering weathering to her unprotected body and even being vandalized by servicemen stationed on the base. In contrast, *Bockscar*, the B-29 which dropped the bomb on Nagasaki, remained on display at the Davis-Monthan Air Force Museum in Arizona from September 1946 to September 1961. It then made the last known Air Force B-29 flight when it flew to Wright-Patterson Air Force Base in Dayton, Ohio, where it has been on permanent indoor display ever since.

(The Confederate Air Force in Texas has a B-29 which it flies — *see After the Battle No. 8*. Now Brigadier General (Retired), Tibbets flew the plane in 1976 in a simulation of his Hiroshima mission and promptly stirred up a rash of protests both in the United States and Japan.)

In the summer of 1960 the Smithsonian began dismantling the *Enola Gay* and moved the pieces to its 'preservation headquarters' at Silver Hill, Maryland. When a storage facility was completed in the summer of 1961, the plane was moved out of the elements for the first time and it remains dismantled in Building 21. Initially, officials indicated the plane would not be exhibited until it could be placed in the new air museum. Responding to an inquiry about the *Enola Gay* in 1967, the museum's director, S. Paul Johnston, explained that there were 'no immediate plans to re-assemble the airplane, largely because we do not have any display space large enough to house it.'

In fact, during the 1960s, plans to build a national air museum on the Mall in Washington remained stalled. The original



Bockscar assured of a permanent future at the US Air Force Museum. (G. Riley)

concept for a museum as part of the Smithsonian complex dated from August 1946. At that time, the few planes on exhibit such as the *Spirit of St Louis* were in the Smithsonian's original red brick building. The Wright Brothers' plane had not yet been returned to the United States from England where the brothers had sent it in reaction to the Smithsonian's label saying Samuel Langley's plane was the first aircraft capable of flight.

With the rapid growth of aviation after World War II, however, the need for a museum dedicated solely to flight became obvious and Congress finally authorised the Mall site in 1958. Nevertheless, it did not appropriate $2 million for architectural design and layout until 1965, and did not change the name of the museum to the National Air and Space Museum until 1966. The Vietnam War provided a further delay in construction because of the reordering of budgetary priorities during the conflict. As a result, the museum did not finally open until July 4, 1976.

By that time, however, the nation's attitude toward nuclear warfare had undergone a decided change. At least part of the disenchantment with the use of atomic weapons came from Hollywood's changing portrayal of the military in general and of the atomic bomb in particular. Following the example of Stanley Kramer's bleak vision of the aftermath of nuclear holocaust in *On the Beach* (1959), film makers produced such anti-bomb movies as *Dr Strangelove* and *Fail Safe* in 1964 and *The Bedford Incident* in 1965, all picturing the dangers of accidental nuclear warfare. In addition, such books as John Hershey's *Hiroshima* and Robert Lifton's *Death in Life* had described in graphic detail the results of the *Enola Gay*'s mission on the Japanese people. Consequently, the plane had become a symbol of the horrors of nuclear warfare.

When asked shortly after the Air and Space Museum opened why the *Enola Gay* was not on exhibit, a museum offical explained that the plane was simply too large to fit inside the building. At the same time, he conceded that even if the Museum had sufficient room, the plane might not have been displayed because of potential criticism by anti-bomb people.

Walter Boyne, the museum's curator, recognised the significance of the *Enola Gay* both as a milestone in aeronautical design and in altering political thinking on the nature of warfare. Consequently, he said that if there was a 'legitimate requirement to have an exhibit concerning nuclear warfare, then certainly the B-29 would come in and there would be no apologies for it. Nobody can say that the *Enola Gay* is intrinsically bad. It is simply an instrument of history.'

Despite Boyne's personal desire to have the B-29 exhibited, however, he remained sensitive to the emotions the plane engenders from those who see it as a symbol of the evils of nuclear war. As a result, the Smithsonian staff would prefer that the plane receive no undue publicity. Boyne explained that if the plane got unwarranted attention, it might cause protests which could reach into Congress. According to Boyne, such protests were 'not profitable to anybody. We don't satisfy the people who protest because basically we can't alter history. We don't satisfy ourselves because we know that we're spending energy answering their questions that could be better spent doing something else.'

The *Enola Gay* itself remains out of sight for most tourists at the Silver Hill facility although the museum does permit an occasional Japanese visitor to photograph the plane and legitimate researchers examine it. In addition, some restoration work has been done on the plane. In 1970, Vince LoPrinzi, a pilot for Allegheny Airlines then based in Washington, visited the storage area as a result of his volunteer work in the Air Museum's library. When he first saw the B-29, he recalled, 'It looked pretty forlorn with its wings off and sitting in a wooden cradle. It just didn't seem right to me that such an historic airplane should be allowed to deteriorate so I asked if I could try to restore it.'

The rough and ready inscription and stencilled aircraft number have both been repainted since its Tinian days. It is a pity the typeface has been altered — look at the new style E and G on the fuselage pictured by Gordon Riley in store at Silver Hill.

Restoring an historic aircraft to the Smithsonian standards involves much more than repainting and fixing broken windows. While not committed to putting a plane in flyable condition, Smithsonian curators use authentic parts wherever possible. In replacing the broken plexiglass in the *Enola Gay*'s nose, for example, LoPrinzi found the bolts were stripped and had to be replaced. Since he couldn't 'just go to the hardware store and buy new bolts' LoPrinzi said he had 'to scrounge around. I found some parts that were taken from scrapped B-29s; others from old airplane graveyards; and still others in the Smithsonian's shop.'

Despite its years outdoors in the elements, LoPrinzi found the *Enola Gay* in pretty good condition. Before being transferred to another home base, the pilot worked first in the cockpit area and then began moving back through the engineer, navigator, and bombardier panels. According to Lo Prinzi, the bomb bay sections, one of which was modified to handle the 'Fat Man' bomb, were in excellent condition. The tail gunner's compartment, however, required work. While the pilot said he would like to see the *Enola Gay* put on display, such a decision had no bearing on his restoration work: 'It's a matter of personal satisfaction and I would do it even if the airplane never gets outside the warehouse!'

When LoPrinzi was transferred, all restoration work on the B-29 came to a halt. Given the Smithsonian's priorities for restoration of other planes also in storage at Silver Hill and the museum's budgetary limitations, it is unlikely that more work will be done in the near future unless another air museum can be found in which the reassembled B-29 can be exhibited. If such negotiations are unsuccessful, however, Walter Boyne has indicated that facilities will be improved at Silver Hill so that people can view the *Enola Gay* at close range in Building 21.

The plane they see may not be one of the most significant aircraft in the development of aviation. But next to the Wright Brothers' *Kitty Hawk flyer* and Lindbergh's *The Spirit of St Louis*, the *Enola Gay* has undoubtedly affected the course of civilization and of international politics more than any other aircraft.

ONE NIGHT...ONE LANCASTER

BY J. C. MAARSCHALKERWEERD

June 1943 . . . war in Europe. The Netherlands had been occupied since May 1940 when German armed forces invaded its neutrality. Inadequately armed Dutch forces had fought against a modern, highly-trained and equipped army and air force. After five days of hopeless struggle, Holland surrendered. There was some consolation for the Dutch people to know that the Queen and many able men had succeeded in escaping to England to carry on the fight. To those of us left behind all we could do was wait and hope that one day she would return, throw the Germans out and liberate us.

By 1943 we had been occupied by the Germans for more than three years, and at that time I was living with my parents and a younger brother in the city of Utrecht, right in the centre of Holland. Born in March 1938, I was still very young and to me the situation in Holland seemed quite normal as I had seen

Salvaged furniture lies on a street in Utrecht on the morning of June 23, 1943. This is Goedestraat 61 where the starboard wing of ED928 and inboard engine, part of the fuselage and bomb bay (Nos. 6 and 7 on drawing) landed in the back garden.

nothing else but German soldiers for as long as I could remember. But, was it really normal?

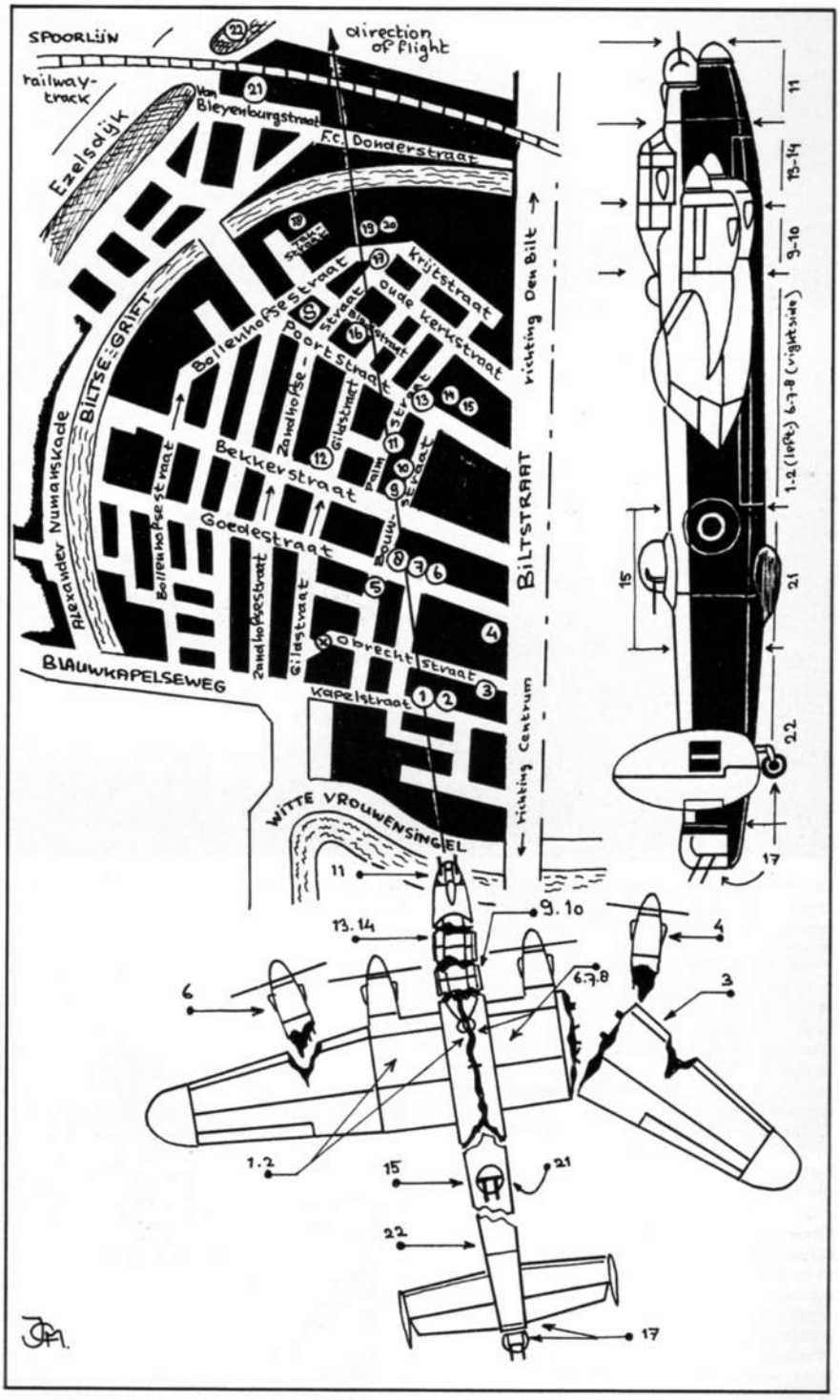
Well, at least at night it was not! Then, we were often awakened by the alarming sound of the air raid warning system and, soon after that, we would hear the monotone sound of thousands of aero engines coming from the hundreds of British bombers passing through the dark sky above our city. We knew they were on their way to bomb targets somewhere in Germany, but we also heard the shooting of the German anti-aircraft guns and we knew anything could happen from then on. Sometimes we heard the screaming noise of a German night fighter flying low over the rooftops. To me, a five-year-old boy, and no doubt to anyone else, this was a very frightening experience and one I don't think I shall ever be able to forget. Often we were taken from our beds in panic and brought downstairs for shelter until we got the signal 'all clear' again.

June 1943 brought a lot of air activity over Holland as RAF Bomber Command increased their air attacks on targets in the German Rühr area. The most important raids of that month were:

June 11/12 860 aircraft to Düsseldorf/Münster
June 12/13 503 aircraft to Bochum
June 14/15 205 aircraft to Oberhausen
June 16/17 215 aircraft to Cologne
June 21/22 706 aircraft to Krefeld
June 22/23 557 aircraft to Mülheim
June 24/25 634 aircraft to Wuppertal/Elberfeld
June 25/26 473 aircraft to Gelsenkirchen/Bochum
June 28/29 612 aircraft to Cologne

On their way to Germany, the British bombers usually had to fly across the Netherlands, and our country took a heavy toll from these men who were risking their lives night after night. In one week, from June 21 to June 29, the RAF lost a total of 157 aircraft over Holland, 134 of them during the above mentioned raids. In the heaviest of them — the one against Düsseldorf/Münster on the night of June 11/12 — 43 of the 860 aircraft that took part failed to return to their bases. Out of those 43 aircraft, 31 of them came down in Holland. One of these raids, the attack on Mülheim on the night of June 22/23, was of great significance to me as this one brought the war in the air for the very first time only a few steps outside our front door.

Earlier that day in England, forecasters had completed their estimates of the weather which could be expected over Europe. The route to the Rühr was stated as: 'Patches of low cloud and layers of medium and high cloud breaking eastwards and thinning appreciably over the Continent'. Over the target itself, crews could expect 'small amounts of very thin medium cloud between 15,000 and



1/2. Kapelstraat 47 & 49 — Left wing with inboard engine plus part of the fuselage with bomb bay and incendiaries. Houses completely burnt out. Four victims. 3. Obrechtstraat 20 — Part of wing with fuel tanks through roof killing Mr. Van Heelsum. Unidentified part on number 3, and part of landing gear on the pavement in front of No. 96 (marked X). 4. Biltstraat 74 — Right inboard engine (?). 5. Bouwstraat — Left outboard engine in the centre of the street. 6/7/8/9/10. Bouwstraat (corner) 37 and Goedestraat 61/63 — Right wing with inboard engine plus part of fuselage and bomb containers. Unidentified part on Goedestraat 59, accumulator on Bouwstraat 49, plus radar/radio equipment on Bouwstraat 48. 11. Palmstraat 38 — Complete nose section with turret through bedroom ceiling. 12. Gildstraat — One dead crewman on the pavement in front of No. 94. 13/14. Poortstraat — Part of flight deck with control column and the pilot seat on the pavement in front of No. 35A. One crew member in back garden of No. 29, and part of fuselage with mid-upper turret through the roof of No. 25. 16. Bladstraat — Several houses damaged. 17. Zandhofsestraat/Bollenhofsestraat (corner) — Tail wheel plus tail turret (?) in front of No. 174. 18. Takstraat — One airman landed safely but wounded in the back garden of No. 8. 19. Bollenhofsestraat 192 — One crewman (dead) through roof and onto the bed of Mr and Mrs Tomassen. 20. Bollenhofsestraat 198 — Parachute found in back garden. 21. Van Blyenburgstraat — Part of fuselage with radio, radar and/or bomb aiming equipment alongside railway track. 22. Ezelsdijk — Tail section, plus some radio, radar and/or bomb aiming equipment in ditch beside dike. S. Crisis and evacuation centre in Poorstraat School.

Bouwstraat (No. 5 on drawing). The left outboard Merlin half buried in the roadway. Today the surface has been repaved showing no sign of the damage.

18,000ft' although there was a warning that seven-tenths thin cloud might drift over the target at the time of the attack. Visibility would be moderate apart from haze.

Bomber Command's night operational plan that day consisted of four separate missions: a major attack on the steelworks at Mülheim including that of August Thyssen Hutte; pinprick bombing raids on Cologne and Berlin by Mosquitoes; minelaying off the Frisian Islands and leaflet dropping over northern France.

The main operation was timed for 1.17 a.m. to 1.59 a.m. and during these concentrated forty-two minutes, 557 aircraft would be over the target area. Zero hour (Z) would be 1.20 a.m. At Z−3 to Z+36 Mosquitoes using the Oboe navigational device were to drop red 1lb target indicators in salvos on the aiming point to be renewed every five to six minutes. At one minute intervals, 29 back-up Lancasters would drop green 2lb TIs. The main force, comprising Lancaster, Halifax, Stirling and Wellington aircraft, divided into eight sections, would then come in with the best crews of the Lancasters and Halifaxes in the first half to try to ensure accurate bombing for the rest to follow.

That afternoon in England, aircraft were brought to readiness in 1, 3, 4, 5, 6, and 8 Groups. At Bourn in Cambridgeshire, home of No. 97 Squadron, stood Lancaster Mk III ED928 (only delivered three weeks earlier) bearing the squadron's code letters OF with the personal letter B Baker. The seven-man crew for the Mülheim operation were: Pilot Officer George Armstrong, RCAF, (pilot), Flight Sergeant John Mansfield (navigator), Sergeant David Williams (wireless operator/air gunner), Sergeant Joseph David (air bomber), and Flying Officer Sydney Blackhurst, Warrant Officer A. R. Laing and Sergeant E. Bellis gunners. They were just one crew . . . of one aircraft . . . on one operation . . . on one night of the war.

In Utrecht on the 22nd, people had watched high-flying American bombers on their way to targets in Germany but by midnight all was quiet. My family had all gone to bed hoping to get a good night's rest, for British bombers had crossed the city almost every night for the previous two weeks.

Around thirty minutes after midnight the first British aircraft arrived above our city. Down below on the ground, in the quarter called 'Witte Vrouwen' (White Women) where I was living with my parents and younger brother at the corner of the Zandhofsestraat and Bollenhofsestraat, most of the inhabitants did not try sleep anymore after the air raid siren had sounded. Some of them took shelter right away but others were watching the dark sky above them, now illuminated by the German searchlights. High up in the air, they heard the intriguing drone of hundreds of aircraft flying towards Germany. Of course, according to German regulations one was not allowed to go out into the streets at night so people watched the British bombers from their blacked-out bedroom windows or the small garret-windows in the roofs of their houses. They could see the ghostly outlines of the planes when caught by the beams from the searchlights.

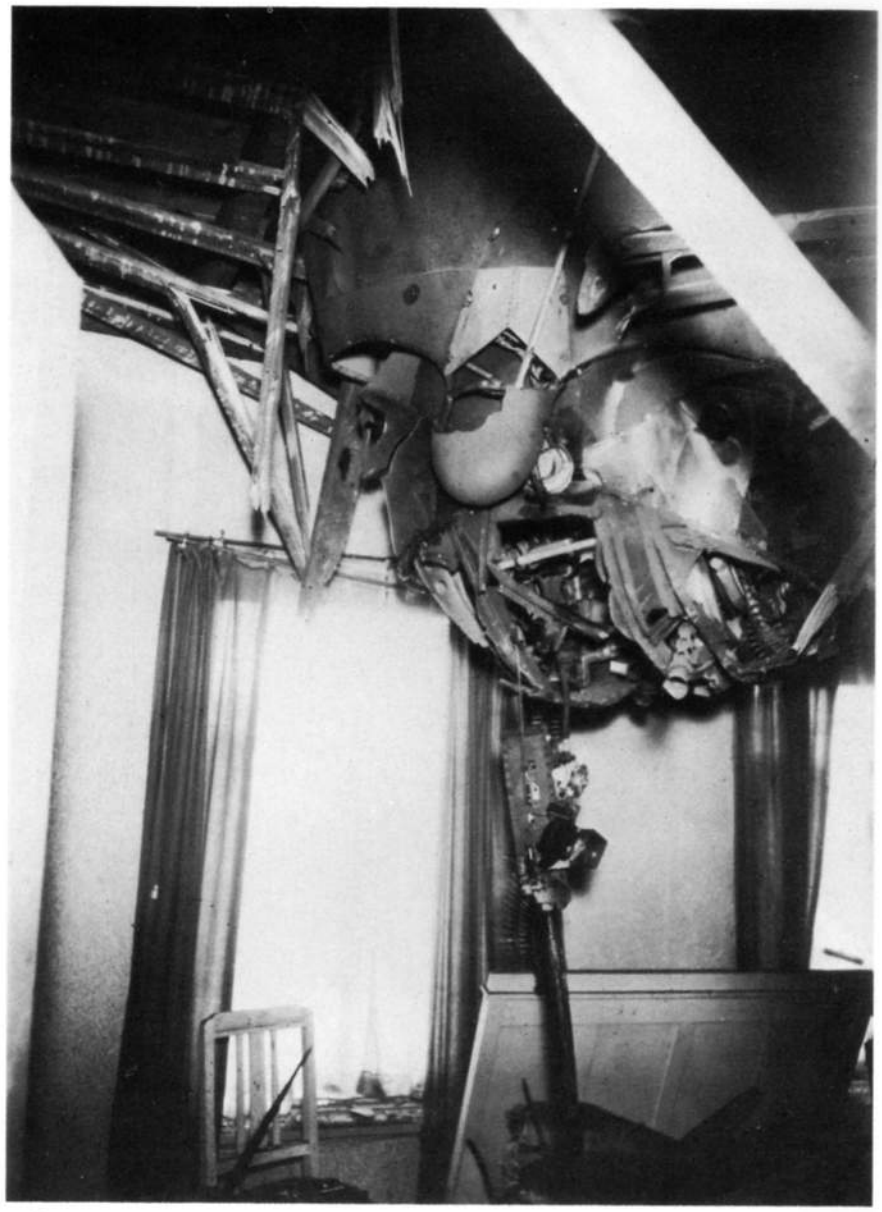
Among those who were watching the planes that night, were Mr and Mrs Tomassen living at No. 192 Bollenhofsestraat, sitting at the

end of their bed near the upstairs window of their bedroom. At No. 20 Obrechtstraat, also in the neighbourhood, 79-year-old Mr Cornelis van Heelsum was sound asleep and completely ignorant as to what was going on above and around him. When he finally woke up, it was too late and he never really realised what was happening. Neither did Mr and Mrs Boer and their 12-year-old son Johan living at No. 49 Kapelstraat, nor the four-year-old son Aart of Mr and Mrs Stravers living next door at No. 47. Within a few minutes they all would be dead.

By now the German defences were well awake. At one of their airfields, either Gilze-Rijen, Twenthe, Deelen or Venlo, night fighters stood at readiness, awaiting the signal to scramble. Once airborne the pilots were guided by information and instructions issued by radio from the Jägerleitoffizier on the ground. The Germans were operating Me 110Cs, Ju 88Cs, Do 217Js and Do 217Ns at this time but had also just introduced the Heinkel He 219, an advanced night fighter which had had its operational debut only eleven days earlier from Venlo when Major Werner Streib shot down five Lancasters in one single flight. Major Streib was one of the most famous and well known of the German night fighter aces stationed in Holland and was Gruppenkommandeur of IV/NJG 1 at the time.

It is not known which fighter latched onto Lancaster ED928 but four of the British bombers were attacked over the city. At 0.56 a.m., an air raid observer on top of the 380-foot-high 15th Century Dom tower, in the centre of Utrecht, reported a burning aircraft falling in an easterly direction. Suddenly, in one consuming blast, the bomber disintegrated and burning fragments from the unlucky aircraft tumbled down towards the earth.

When the bomber exploded in mid-air, the burning debris from the plane fell down onto the streets and houses of the area where we were living. Five minutes later several fires had started in the neighbourhood. The largest part of the Lancaster, the left inboard wing with the engine plus part of the fuselage with bomb bay and incendiary bombs, came down on the houses of Kapelstraat behind Nos. 47 and 49. The houses were set on fire by the incendiaries and the burning petrol from the bomber, and No. 49 was destroyed completely. Little Aart Stravers and Johan Boer, as well as Mr and Mrs Boer died in the flames. Their bodies were to be found later in the afternoon of June 23 inside the ruins of the house.



The complete nose of OF-B with the turret spewing out Brownings hanging precariously above the bed of Mr and Mrs van Montfoort at No. 38 Palmstraat.

Large sections of the Lancaster including its load of incendaries fell on Nos. 47, 49 and 51 Kapelstraat causing the greatest loss of life (1 and 2 on drawing). As rescue workers toiled through the burned out shell they came across the pitiful remains of the victims: Aart Stravers aged four in No. 47 and Johan de Boer aged twelve and his parents in No. 49.

There was severe damage all over the neighbourhood, and there was panic among those who lived there. Despite German regulations, everyone ran outside their houses and into the streets, grabbing items that seemed to be valuable enough to be saved.

Mrs Stravers was running around in the street, screaming hysterically that Aart was still inside the burning house after the rest of the family had been rescued. Little Aart did not make it, despite some effort made by neighbours trying to go inside and rescue him. Her 13-year-old daughter Johanna was taken to a hospital with severe burns and in critical condition, as were two other persons.

Nearby, at No. 20 Obrechtstraat, poor old Mr Cornelis van Heelsum was sleeping like a child until suddenly a piece of the wing fell on the roof of his house and through his bedroom ceiling and straight down through the floor, barely missing the sleeping man and his bed. Awakened by the terrible noise, Mr van Heelsum jumped out of his bed and fell into the hole made by the falling wreckage from the bomber. He died from his injuries.

At our house, No. 174 Zandhofsestraat, at first there was some panic too. Mother ran outside the house carrying me and my brother Gerard, one under each arm, not really knowing in which direction she should go as long as it was as far away from the house as was possible. Just a few steps from our front door the tailwheel of the Lancaster was lying on the street and, according to what my father told me, also the tail turret of the bomber.

A neighbour opposite, Mr Klaassen, called my father in panic and asked him for help as there was a bomb inside his house. 'Well', my father answered him, 'if that's true what you're telling me, I certainly won't go in and get it out for you!' But then, after a short interval when nothing happened, he decided otherwise and took a quick look inside. On the floor he saw a cylindrical thing that sizzled which was identified as an oxygen cylinder.

In the roof of a house across the street, and left from where we were living, there was a hole in the roof. One crew member, whose parachute obviously had not opened, had fallen through the roof and straight onto the bed of Mr and Mrs Tomassen who were sitting on the other end. The British flyer was already dead, probably killed when the bomber exploded. Next morning he was lowered outside the bedroom window with a rope around his feet by the Germans and dumped in the back of a truck.

A second airman landed safely but wounded in the back garden of a house in a nearby street, No. 8 Takstraat, and a third at the premises of the Veterinary College between Biltstraat and Krijtstraat. His parachute still hung in a tree and some people kept themselves busy by tearing off large pieces of the silk, a very useful and valuable material during the war.

In a back garden in Bollenhofsestraat another parachute was found, and in front of No. 94 a dead crewman was lying on the pavement. According to my parents who both saw this man, he did not have his head anymore which had smashed against the wall of the house when landing. They told me how they saw the remains of his head and brains stuck onto the wall.

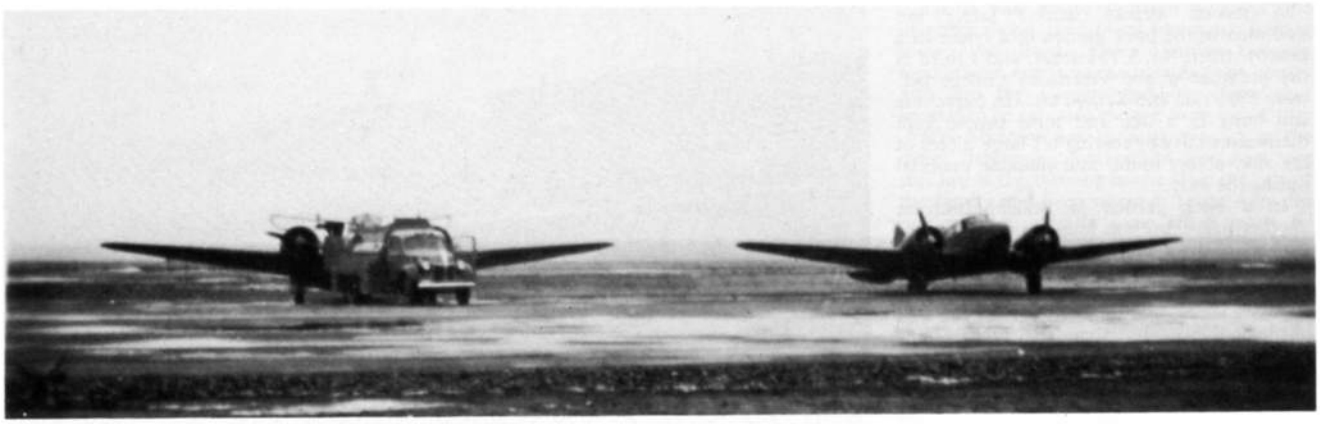
The two airmen who safely landed by parachute and survived the crash of the bomber, were Warrant Officer Laing and Sergeant Bellis, and one of them got medical attention from Dr Nieuwenhuizen, our family doctor, while sitting on the street and against the wall of a house around the corner of Bollenhofsestraat and Zandhofsestraat. They were soon taken prisoner.

In the garden of No. 29 Poortstraat a third dead flyer was found. My parents do not remember where the remaining British airman came down. Altogether five of them died and some days later they all were buried at the Eerste Algemene Begraafplaats 'Soestbergen', near the Gansstraat in Utrecht.

In total, thirty-five aircraft failed to return from the operation, some 6.3 per cent of the force involved. Another 18.1 per cent were damaged by flak or fighters including one hit by incendiaries dropped by another aircraft. Reconnaissance photographs of Mülheim indicated that the Vereinigte Stahlwerke, Friedrich Wilhelmshutte, Siemens-Schuckertwerke, and the Rheinische Filz und Wappenfabrik sustained major damage. Fifteen other factories were hit, eight of which were completely destroyed. The main railway station was almost completely demolished as were two other stations and railway workshops. Widespread damage was also caused to business and residential property, chiefly by fire. A total of 1,414 tons of high explosive bombs were dropped and 28,531 incendiaries.

Mr Maarschalkerweerd's father points to the roof of No. 192 Bollenhofsestraat where one of the crew, his parachute unopened, crashed through to fall onto the bed as Mr and Mrs Tomassen watched the raid through the window (19 on drawing).

I am indebted to Mr A. Cocural (and Mr L. Zwaaf, Jnr.), who lived in Utrecht at the time and who has conducted considerable research into the crash, publishing articles in Bulletin 1939–1945, the magazine of the air war study group in Holland. Also to the monthly magazine, Oud Utrecht and the local newspaper Utrechts Nieuwsblad. The contemporary photographs are from the Gemeentelijke Archiefdienst, Utrecht. Comparison photographs were taken by Mr D. Sleurink, of Gemeentelijke Archiefdienst of Utrecht to whom I am most appreciative for his professional help.



FORTY YEARS ON

Investigation No. 4

BY DONALD RUSSELL

Airspeed Oxford 2 trainers on the tarmac of No. 39 Service Flying Training School at Swift Current aerodrome in 1943 have given wing to a weed-strewn apron and blustery prairie in 1983.

For many wartime RAF pilots the name Swift Current and No. 39 Service Flying Training School holds a very special place in their memories, for there, amid the prairie lands of southern Saskatchewan in Canada, they gained their coveted 'wings'. For my part it is a name from my childhood, a place to where a much missed father had been sent in 1943 and from where on birthdays and at Christmas, parcels of 'candy' and other goodies arrived to gladden the heart of a wartime schoolboy. In 1945 the name manifested itself in the form of a photograph album and mementos brought home by my father, LAC Les Russell, Accounts Clerk, SHQ, at the end of the war.

There the matter rested until the death of my mother in 1980 when I inherited, amongst other things, the album together with RAF station magazines, and letters etc., which rekindled my interest and imagination to the extent that I decided that at the first opportunity I would visit Swift Current to find out what, if anything, remained. A visit would also provide the opportunity to visit the grave of my cousin, LAC Norman Russell, killed in December 1943 whilst pilot training at No. 34 Elementary Flying Training School at nearby Assiniboia, Saskatchewan.

The opportunity presented itself in the summer of 1982 and having written to the Swift Current *Sun* newspaper advising them of my visit, I took the Wardair DC 10 flight out of Gatwick which flew me to Saskatoon, from where a four-and-a-half hour bus ride brought me to Swift Current. On arrival, my spirits heightened when my cab driver informed me that the old RAF station was still in existence but long since converted to public use.

An initial call at the *Sun* offices revealed that on receipt of my letter they had run an article appealing for anyone with any contact with the RAF station during the war, but unfortunately nobody had come forward. However, as luck would have it, a waitress at my motel suggested that I should look in at the Royal Canadian Legion in the town, and this proved to be the key to what turned out to be a hectic but very rewarding four days. I was welcomed in a way that only those who have experienced Canadian hospitality will appreciate and straightaway the telephone wires were buzzing to members who remembered those times and to some who were ex-RAF and who had returned to Britain in 1945 only to emigrate to Canada and settle in Swift Current in later years.

From father to son. Main Street Swift Current in 1943 — just a snapshot from an album which led to this photo being taken in 1983.

First I was driven out to the local high school by an American schoolteacher, Clint Schryver, who informed me that the janitor at their school, Eric Ward, had been stationed at the airfield. He turned out to be an ex-cook in the Airmen's Mess, and in the February 1944 edition of *Swift*, the station magazine, which I had with me, he was delighted to see himself in a group photograph and was amazed that I should have come 5,000 miles to show it to him. My father, who had always sung at home, had joined the entertainment staff at the camp and Eric confirmed that he had seen all the theatrical productions in which dad had appeared and I was able to make his memory clearer by showing him the original programmes. Eric also picked out a Jim Bailey in the *Swift* photograph of the Motor Transport Section and told me that Jim was a despatcher at the local Royal Canadian Mounted Police depot in Swift Current and no doubt would like to see me.

Clint then offered to drive me out to the airfield, which was about three miles east of the town, isolated on the prairie which stretched out in all directions as far as the eye could see, and I called to mind my father's words 'you can see for four days'! From the road you could see two of the original hangers. This was the place that I had come a long way to visit and I needed to be alone with unlimited time so I decided I would return on the following day.

Back at the Legion, Shirley, the secretary, had been busy in my absence trying to locate a house and family depicted in my photographs without success but had arranged two more meetings with members who might have useful information. On the way out we looked up Jim Bailey at the RCMP who on seeing his photograph in the *Swift* said it brought back many memories which probably would have remained forgotten, but neither he nor his police colleagues could shed any light on this particular house.

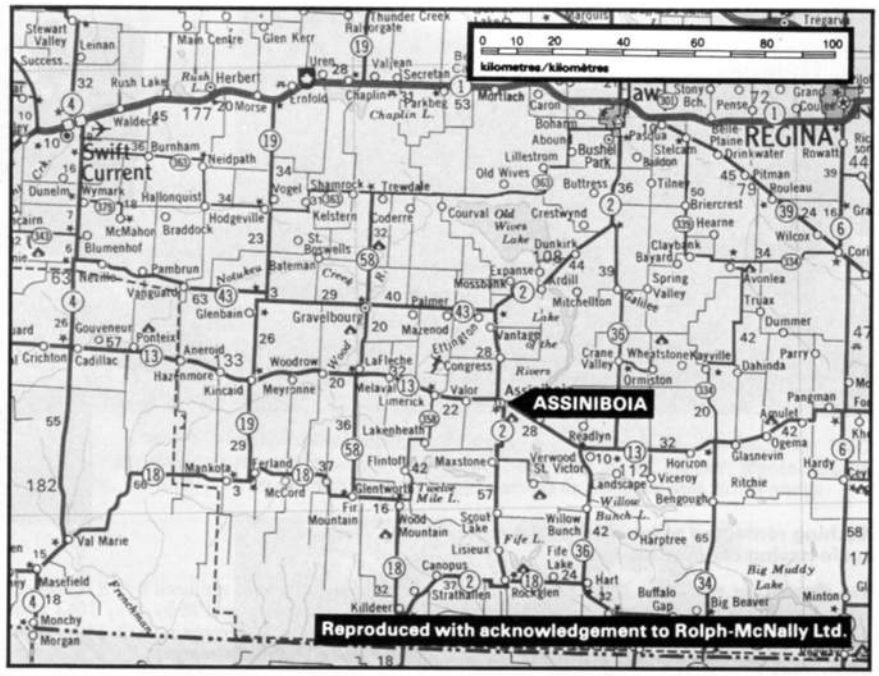
The following day dawned bright and sunny and I decided that before concentrating on the Swift Current airfield I would make the journey to Assiniboia to see my cousin's grave, last visited by my father in January 1944. I breakfasted early and set out to drive the 120 miles south-east across the prairie. For those who like me had not experienced this boundless landscape the size was awe inspiring. After about thirty miles I stopped the car and got out. The road was dead straight and narrowed to a dot on the horizon. Not a sound came across the flat treeless panorama and the sense of isolation was complete. It was easy to appreciate why this desolate part of the world had been selected for the Empire Air Training Scheme, nowhere else on earth could have been more suitable.

Assiniboia is a small town built around a railhead for the transportation of grain and has not changed much in its 100-year history and still lacks a paved mainstreet. I stopped at the bank to change some money and explained to the cashier in answer to her question as to why I was in town. She asked if I would wait a few moments and straight away telephoned a Mr Everett Klein, a senior Legion officer and Dunkirk veteran. Within minutes he arrived and drove me out to the Mount Hope Cemetery just outside town. The RAF graves were just as in my father's photographs save that the white wooden crosses had been replaced by granite headstones with RAF crests. I found my cousin's and took a series of photographs. Forty years had brought change to that hallowed place and the trees, just saplings in 1943, were now well established. On seeing the original photographs Everett told me he recognised the Minister as a Dr Henn of the United Church who died about ten years ago. Later I looked in my father's diary and found the entry 'Dr Henn — Assiniboia'.

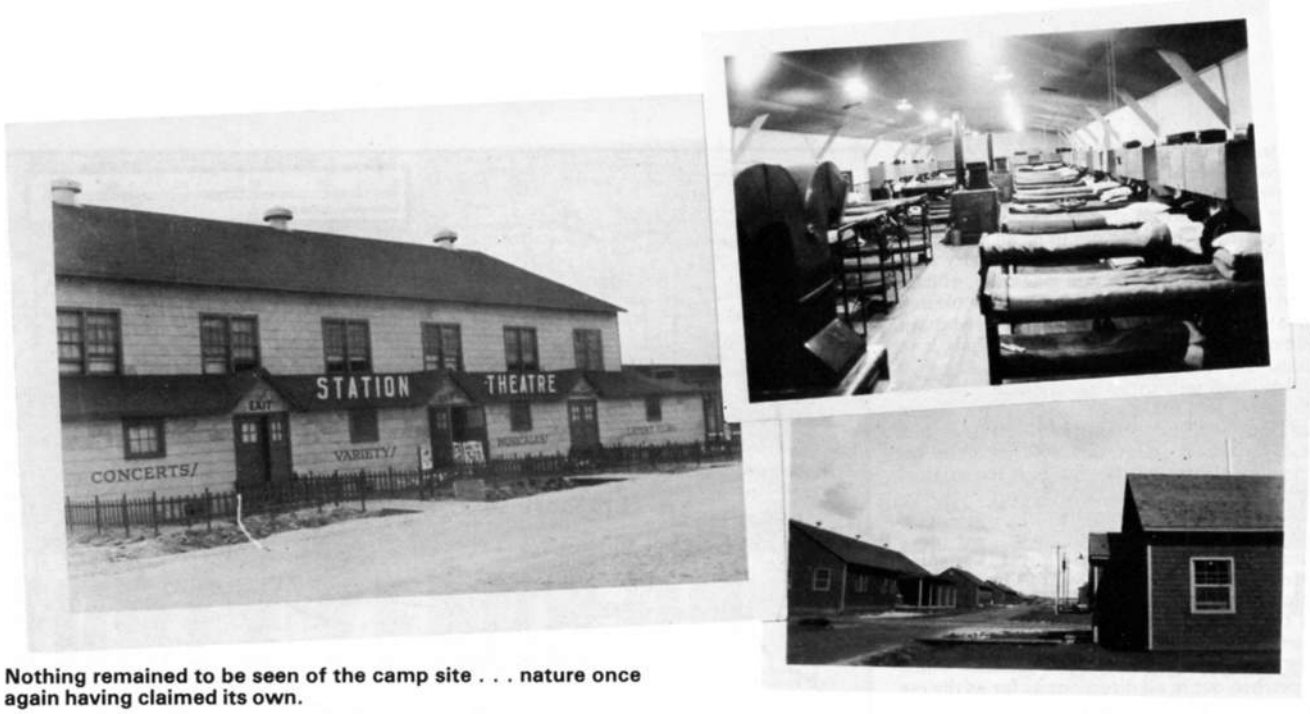
The entrance to the cemetery had been resited but Everett informed me that the old gateway, although no longer used, still existed, and I was able to take a comparison photograph. The official record states that my cousin's Fairchild Cornell aircraft had crashed six miles west of a place called Congress and Everett told me that RAF Assiniboia had been sited just outside Congress and the runways and perimeter track still existed although all station buildings barring the butts had long since disappeared. I thanked Everett for his kindness and decided I would drive up to the airfield before returning to Swift Current.

Paint was flaking off the rough wooden sign on the main highway indicating the location of the airfield and on arrival the site looked derelict. Closer examination revealed a small blister hangar and office and a small private Cessna on the tarmac, no doubt the property of a local farmer. I drove a little way along the perimeter track and took a few photographs for the record. The scene was deserted and the original windsock blowing in the prairie wind was all that served as a reminder of the once busy No. 34 Elementary Flying Training School.

My drive back to Swift Current was uneventful and by mid afternoon, after turning right off the main Route 4 highway and following the undulating road climbing a gradual incline in the prairie for about a mile, once again I reached '39 SFTS'. At first glance the sight of the old multi-windowed main hangars gave rise to my hope that much



Harvard 2 outside flying control in 1942. The watch office tower was removed in 1960.



Nothing remained to be seen of the camp site . . . nature once again having claimed its own.

had survived of this large RAF station which once had been home to some 700 officers, NCOs and airmen, but I was soon to realise that this was not so. From the site of the main gate to the hangars was a distance of about 300 yards, and the area along the road for about half a mile (forming I suppose, more than fifty acres) had once housed all the administrative and domestic buildings. Now this whole area was covered in sun-bleached prairie grass. Disappointed, I drove the 300 yards to the car park alongside one of the hangars. The building in front of me looked reasonably modern yet strangely familiar and I examined my 1943 photographs. Clearly this was the original flying control building but minus its tall watch office tower. I went over to the entrance to seek permission to browse around and photograph. The young man in control was most interested in my purpose and my wartime photographs and confirmed that the tower had been dismantled and removed along with all the old camp buildings in the 1960s. The aerodrome was now principally used by an aviation services company to maintain light aircraft and crop sprayers owned by local farmers, and to house a small flying club with training facilities for instrument ratings. The airfield also contained a radio communication transmitting station.

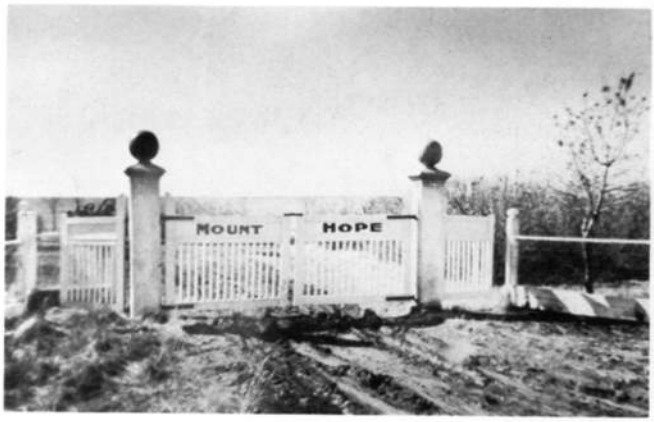
It was obvious from the far distant boundaries that in its operational days this had been a very large airfield. In November 1941 the station, which was attached to No. 4 Training Command at Calgary, Alberta, and commenced under the command of Group Captain D'Arcy Grieg (ex-RAF High Speed Flight and British air speed record holder in the Supermarine S.5 in 1927 at 319.57 mph) with 88 Harvard 2 Trainers on charge. Later in September 1942 the Harvards, then numbering 100, were replaced by 78 Airspeed Oxfords, increasing to 108 by May 1943 and continuing at that strength until May 1944 when the SFTS was disbanded.

The original surface of the hard standing in front of flying control had suffered over the years and tufts of grass had spread over the tarmac. The perimeter track had fared better and I walked round to the threshold of the main runway. Surely at any moment the air would be filled with the harsh reverberating note of Harvards in a formation take off but nothing broke the silence save the wind coming strong across the prairie from the far distant horizon. The ceaseless day and night flying schedules designed to turn out aircrew urgently required in a wartorn Europe was now just a part of history which for a short time had occupied this peaceful landscape.

Before returning to my car I walked over the barren area that had once been the camp. Here and there worn patches in the grass indicated the site of a building or the course of a road but the uninformed would never appreciate that here for two and a half years 700 personnel had lived and operated this once highly active station. Near the path to the main gate an evergreen hedge now overgrown but clearly once cultivated formed a large rectangle and I later learned that this had enclosed the station headquarters building where my father had worked. I returned to the car and turned out into the Swift Current road. From this higher point on the prairie you could make out the town some three miles distant which had provided the only organised civilisation within a radius of 100 miles.

On reaching my motel room, a message left requested that I should telephone a Mr Roy Spence, now the manager of the local Co-op but then a corporal in station headquarters. This was the sort of contact I had hoped for as he would have worked in close proximity to my father. He told me over the telephone that he had been contacted by the Canadian Legion of which he was a member and he would like to come over that evening and bring a colleague, Art Gibbs. They brought with them photographs and material and Roy, now 60, told me he had known my father well and remembered much of the events and happenings dad had described in his letters. Art had been on the airfield maintenance and the three of us spent a very interesting evening covering as much ground as possible prompted by the surviving material. The *Swift* magazine contained two references to Roy, one his appearance in the SHQ group photograph and a further piece regarding his prowess on the then newly constructed open air winter skating rink within the camp confines.

There was one more journey I had promised myself before leaving Swift Current. In a surviving letter my father had graphically described a visit to a weekend camp that had been organised by the RAF to provide relaxation in the summer of '43 for airmen on 48-hour passes. Any reader stationed at Swift Current at that time will no doubt recall the 'Chalet' at Lac Pelletier some thirty-six miles from the camp. This lake was about four miles long and one mile wide and set amongst the 'Coules' (low prairie hills) and provided swimming, fishing and boating as well as walking and general relaxation 'far away from the hustle and bustle of station life'. For a dollar in advance for cooking, and taking their own blankets and sheets, a party of thirty or so would leave the camp by RCAF transport on a Friday evening to be collected again on Sunday night. Described now as a



Last visited by Donald Russell's father in 1944, Mount Hope Cemetery is the last resting place of his cousin Norman killed while pilot training at No. 34 EFTS at Assiniboia. Here, at 10.30 a.m. on December 31, 1943, a joint funeral was held for LAC Russell and his instructor, Sergeant A. W. Davey. Senior NCOs and airmen of their flight served as bearers and firing party.

'Regional Park' I anticipated that there would be much development and, following the directions accurately described in my father's letter, I arrived in the lake area an hour later. The approach road had been rerouted since dad's day but apart from there being many more bungalows and holiday chalets the scene was very much as he had described it. The strange 'Coules' which surrounded the lake were about 60 feet high and I could appreciate his words in one letter: 'the only way I can give you any impression of them is by saying that at night as it is getting dark they look like a row of pyramids all around the lake'. I stopped the car and climbed one. The view from the top took in the whole lake, which looking downsun was a deep blue contrasting with the long golden prairie grass. I took a series of photographs and then called in at the provision store. The young couple behind the counter were very interested to see my old photographs and told me that the Darling family, who owned most of the surrounding land and who had developed the area, were there in the '40s and doubtless were the family mentioned in my father's letter. Unfortunately the surviving daughters who, the letter explained, acted as waitresses and with whom it would have been interesting to talk were not at the lake that day. I drove as far as the road round the lake would allow, the day was warming up and one or two families were arriving no doubt for the weekend. For me time was limited and reluctantly I made the journey back to Swift Current.

Over the three days my plans for the most part had been achieved and the inability to trace civilians had been more than compensated by my meetings with the ex-servicemen and I had made many new friends. Unbeknown to me that afternoon, the evening and following day were to include speech-making and a presentation to me of a Royal Canadian Legion engraved tankard as a memento of my visit and a fishing trip to Lake Deifenbaker as the guest of the Vice-President of the Swift Current Branch, Charlie Low. Forty years had brought changes and that was to be expected but there had been no change in one area experienced by both me and my father, that which no period of time is likely to change — the 'good old Canadian hospitality'.

Forty years on and Lake Pelletier caters for a different generation of tourists.


TRINITY SITE
WHERE
THE WORLD'S FIRST
NUCLEAR DEVICE
WAS EXPLODED ON
JULY 16. 1945
ERECTED 1965
WHITE SANDS MISSILE RANGE
J FREDERICK THORLIN
MAJOR GENERAL U.S. ARMY
COMMANDING