THE ROLE OF OAK RIDGE IN THE MANHATTAN PROJECT [1]

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[During the Manhattan Project (from May 25, 1943) a Jr. Chemist, Tennessee Eastman Corp., Y-12 Plant]

A Paper Given Many Times Over The Years in Various Versions to Groups
and in Answer to Information Requests from Students.

I. Introduction

What a colossal accomplishment that WWII Manhattan Project was! Journalists, looking back at the end of the 20th century chose it as the most important story of that century. In an incredibly short 2½ years, it accomplished 3 missions, none of them ever before attempted: separation of the uranium isotopes (at Oak Ridge), production of the element plutonium in large nuclear reactors (at Hanford, WA), and learning how to put these materials together to make bombs (at Los Alamos, NM). Oak Ridge's was the costliest part of that Project, and by far the largest in terms of the number of people required. Sixty-three cents of every dollar of the Manhattan Project's cost through the end of 1945 was spent at Oak Ridge, 21 cents was spent at Hanford, and 4 cents at Los Alamos. In today's dollars (2008) the cost of the Oak Ridge effort would not be the 1945 total of $1.1 billion but $14.0 billion.

The scientific and engineering problems faced here were forbidding not only in number, but also in complexity, requiring inventions by scientists and engineers on a scale even now hard to believe. But if you watched the History Channel's 2003 documentary (Modern Marvels, oft re-run) on the Manhattan Project, you'd never guess at Oak Ridge's importance because most of its footage focused on the work at Los Alamos and its scientists. In WWII, over 22,400 people worked at Y-12, almost ten times the 2,500 at Los Alamos; and the cost of Oak Ridge's two U isotope separation plants was $989 million compared to the $74 million spent at Los Alamos. The disinterest in portraying Oak Ridge's efforts on video is due to our lack of drama. At Y-12 the WWII 2½ years were just a dogged effort by a brilliant and hard working team, solving one group of new problems after another with never a single day that was as exciting and could be as well-filmed for posterity as the thrilling Trinity test in the desert at Alamogordo, July 16, 1945.

So why and how did this Manhattan Project and Oak Ridge all come about? Back in 1938, a year before Hitler started WWII; two German chemists had discovered that uranium atoms when bombarded with neutrons could split into two atoms of about half the weight accompanied by a very large release of energy. [2] Soon after theoretical physicists began talking about the possibility that an atomic bomb with awesome power might be built if someone could just figure out a way to get their hands on about a hundred pounds of nearly pure uranium-235 (U-235). This is the lighter of the two forms of the heavy element uranium found in nature. The heavier form is called uranium 238 (U-238).[3] There were some physicists in 1939 that felt that separating the two isotopes, even enriching uranium a little in its U-235 content, was so difficult it might never be done.[4]

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[1] Copyright Wm. J. Wilcox Jr. 2004. Credit for quotation appreciated.
[2] Otto Hahn and Fritz Strassman.
[3] The weight difference results from there being three more neutrons in the U-238 nucleus than in the U-235 nucleus – 146 instead of 143. There are 92 protons in each, making the atomic weights 238 and 235.
[4] Harold Urey had received the Nobel Prize for separating the isotopes of hydrogen, the lightest element, but there the difference in their weight is huge, 1 vs. 2. Not so for U-235 vs. U-238, a difference ~1%.

But President Franklin Roosevelt felt it was critical that if any country could solve all the problems and make an atomic bomb, we must be the first. He was told in a letter from Albert Einstein in the fall of 1939 [5] that the Germans had discovered this possibility, that physicists all over the world knew about it, and that the Germans had already started trying to make one. Roosevelt knew Hitler, whose Blitzkrieg had just invaded Poland, would not hesitate to use such a weapon against Britain, so he ordered research to go forward and kept very secret so as not to divulge how big an effort we were making to beat Germany to the bomb.

The high priority scientific research went forward in several universities across the country, [6] and it was six months after Pearl Harbor before scientists were able to tell Roosevelt that theoretically a nuclear bomb might be built but it would require an unprecedented, large-scale industrial effort. Knowing that the university scientists could not mount such a program, Roosevelt assigned the task to the Army Corps of Engineers, and the Manhattan Project was organized June 17, 1942.

A month before the Manhattan Project was officially organized, a small government team had picked out a 15-mile long, 7-mile wide, 59,000-acre area here in East Tennessee for possible atomic use, but it was not officially designated for the purpose until September 19, 1942 when General Leslie R. Groves, Manhattan's new Commander, came here to look over the property. [7] He promptly ordered it taken over for the use of the Project. Its code name all through WWII was the Clinton Engineer Works. (The name Oak Ridge was not used except for personal mail until after the war.[8]) Colonel Kenneth D. (Nick) Nichols served as administrator for all of the Manhattan Project sites in the country and was located in Oak Ridge. He served in effect as the Project's COO, reporting to General Leslie R. Groves who maintained only a small staff in his Washington office. When appointed Groves' deputy in 1942, "Nick", a Ph.D. engineer, was 35 years old. [9]

II. Oak Ridge's Mission

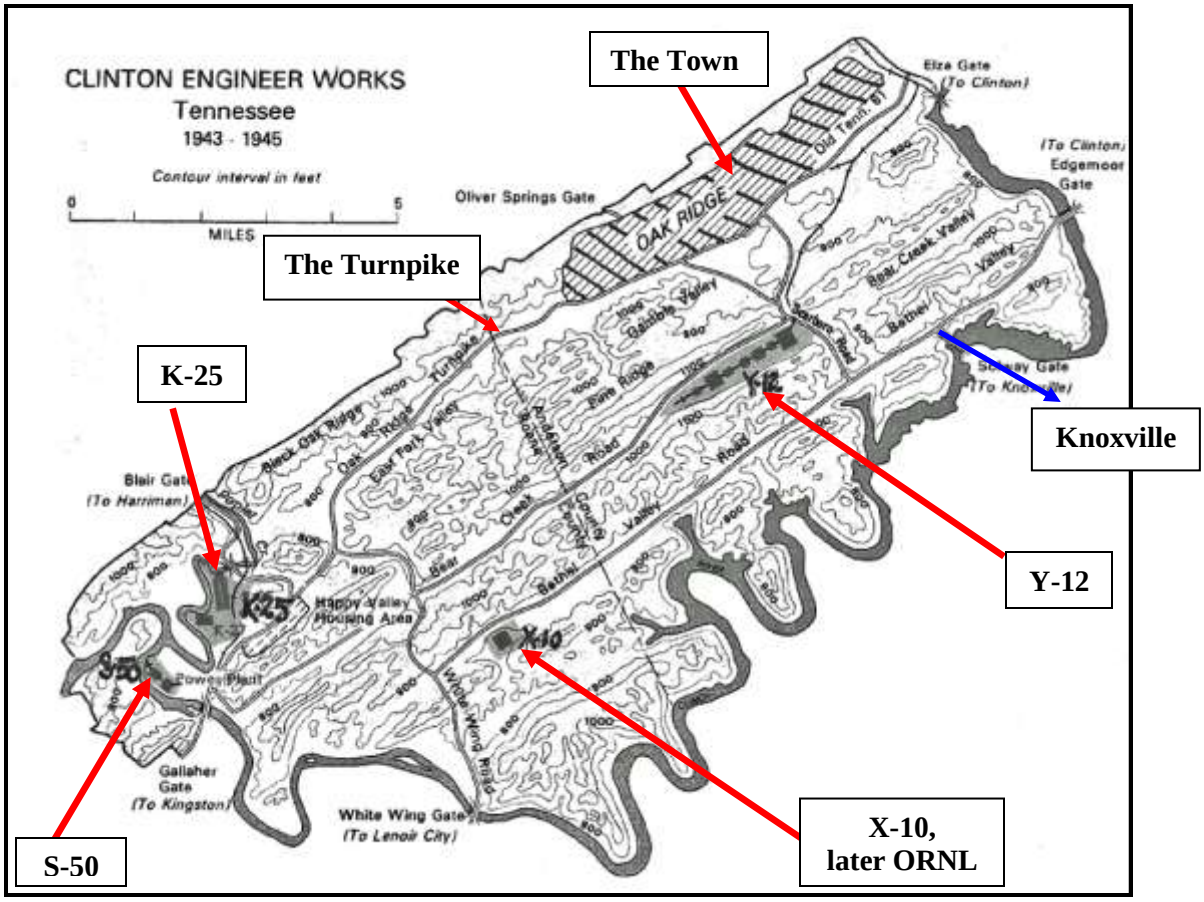
Although the first idea was that the entire Manhattan Project would be located on the East Tennessee site, General Groves right away vetoed putting the plutonium reactors here, afraid that traces of radioactivity might be picked up in Knoxville, giving away the purpose of the project. He ordered his people to find a site of ~500,000 acres the production nuclear reactors could be put in the center of, and that site turned out to be Hanford, Washington. Then Dr. Oppenheimer nixed putting his Weapons Lab in East Tennessee, wanting a more isolated and remote site. He settled on the mesa country in New Mexico at Los Alamos.

Oak Ridge's primary reason for being then became the separation or enrichment of the uranium isotopes – the two forms of the heavy element uranium having slightly different weights than occur in nature. Isotopes cannot be separated by chemical methods; they behave identically in all chemical reactions. To separate them, one must take advantage of the little difference in their weight, and that is pretty small, only a little more than a percent. And then if this isn't already hard enough, the desired U-235 is pretty rare. In every 1,000 pounds of uranium in the ground, there are only 7 lbs. of 235; all mixed intimately with 993 lbs. of U-238. The natural abundance

[5] In a letter written by Leo Szilard and Eugene Wigner in the summer, that got to him only months later.
[6] Most notably at University of Virginia (Beams), University of California (Lawrence), Columbia University (Dunning), University of Chicago (Compton), etc.
[7] Groves took over several days before from the original C.O., Col. James Marshall. His last assignment as head of Construction for the Engineers was building the Pentagon. Most historians agree he was the Project's "indispensable man."
[8] Except that during the first months it was called the "Kingston Demolition Range," a name that so upset the "locals" that it was quickly changed to CEW, a name that conjured up no images.
[9] In 1945 when Oak Ridge had a population of 75,000, the USED reported that the average age was 27 years.

of U-235 in uranium ores all over the world is this same fraction, 0.7115%. To enrich the concentration enough for use in a nuclear power plant, we learned long after the war, it only requires increasing the U-235 content from the 0.7% to 3% - 4%, but one can't make an atomic bomb out of that. The WWII objective was to get it nearly pure, say 90% U-235.

How then might this formidable job of uranium enriching be done? When General Groves and Colonel Nichols started visiting the university labs in the fall of 1942, he found four professors telling him," Well, we <u>think</u> we have a way it <u>might</u> be done." [10] A hard-boiled Army engineer, he was dismayed by their lack of certainty – none would assure him the job could be done on the scale and time he wanted. By December 1942, he and his technical advisors reduced the field of possible separation methods from four to two by stopping further work on two of the ideas: the gas centrifuge, which ironically 68 years later in 2010 is now the enriching process of choice all over the world, and the thermal diffusion process. [11] The scientists could still not assure the success of either of the two better prospects so Groves decided they would have to go ahead and build both. The fear that the Germans might succeed with their efforts was the paramount concern.



From "Manhattan: The Army and the Atomic Bomb," Vincent Jones, USGPO, 1988 page 131.

[10] Beams at University of Virginia –Gas Centrifuge; Dunning at Columbia - Gaseous Diffusion; Lawrence at California – Electromagnetic; and Abelson at Naval Research Lab – Thermal Diffusion.

[11] No more work on Thermal Diffusion was funded by the Project, but the US Navy kept supporting some effort on it throughout the war – their interest even then was in submarine propulsion reactors. In 1944 Groves brought it back in as the S-50 Plant to help in the final push for U-235. Interestingly, Japan's WWII scientists decided Thermal Diffusion was the "best" method and tried but failed to make it work.

The Y-12 Plant

Ground breaking for the world's first U-235 separation plant code named "Y-12" was in February 1943, and, almost incredibly, this never before conceived of, $478 million, industrial plant started running in January 1944.

Y-12 used over a thousand big devices called Calutrons in nine big brick buildings that produced separation when the uranium isotope mixture was driven through a very strong electromagnetic field. After each had run a few days it ran out of feed and had to be stopped, the "tiny" little bit of product removed, recharged, and restarted. The product from the first pass – the Alpha calutrons - was only partly enriched (~12-15%), so it had to be put through the process again to produce bomb grade fuel. Recovering the product from the Alpha Calutrons and preparing it for feeding to the smaller Beta Calutrons was a complex process called Beta Recycle or Beta Chemistry. These operations required hundreds of chemists like the author.

Copy of a post WWII colored post card, about 1947.

Those calutron electromagnets were enormous, the biggest ever built. Alpha magnets were over eight feet tall, and copper to wind around their iron cores was in very short supply because of the war effort, so Y-12 borrowed silver from the U.S. Treasury to use instead of copper. The amount borrowed was impressive, 14,000 tons of silver worth more than $300 million. All shipments, the processing into strips and winding into the huge coils by different contractors were kept secret and the silver very carefully accounted for. After the war it was stripped out and sent back to the Treasury with almost no loss.

The magnetic field the big magnets produced was so strong it would jerk an ordinary wrench right out of your hand if you walked inside that red line painted on the floor. 30 Beta calutrons are shown in the photo above.

The K-25 Plant

Because the success of Y-12 was not a sure-fire bet, Groves kept the heat on for the construction of a back up plant called K-25 that employed a very different process called gaseous diffusion and eventually cost $512 million – Oak Ridge's second half billion dollar plant. Compared to the complex physics machines at Y-12, this process in principle sounded easy: all one needed to do was to make some gaseous form of uranium diffuse or flow through a porous membrane (code named and still today called "barrier," and because U-235 molecules are a little lighter, they move a little faster than the U-238s. But the secret of how to make a really workable porous barrier had eluded scientists at Columbia University who started working on the problem in 1941. For one thing, all the holes in the membrane had to be microscopically small, so small there could be hundreds of millions of holes in a square centimeter- the size of your thumbnail - and they had to be all the same size, none too big, and none too small. But even if you can make the perfect barrier, you get such a little separation each time it diffuses that you have to re-compress the gas and pass it through another barrier then repeat this 3,000 times to obtain the enrichment of U-235 you need for a bomb. That means the plant is going to be huge. The gigantic K-25 building was 400 feet wide, a mile long, with 44 acres under roof, at that time probably the largest process building in the world. Because the entire mile long process of 3,000 diffusion stages had to be all on the same level, the engineers folded it into the shape of a giant letter "U"(as seen from the sky). It was packed full of vacuum-tight pipes, pumps and tanks to hold the barrier, and located out in the western end of the Clinton Engineer Works reservation.

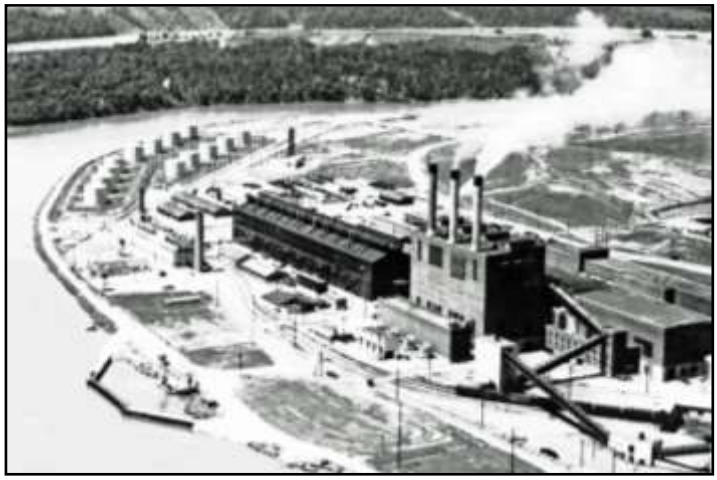
The just-finished K-25 Gaseous Diffusion Plant in 1945.
There are no steam clouds from the cooling towers in the foreground, showing it is not yet in operation.
12,000 construction workers lived in a temporary city at the top left that they called Happy Valley.

K-25 started production in January 1945, a full year after Y-12, so K-25 contributed only in a small way to Y-12's furnishing the highly enriched uranium for the first atomic bomb. But during the postwar arms race the K-25 plant was expanded again and again and it produced the majority of the highly enriched uranium for the nation's nuclear defense during the Cold War– many thousands of times what was produced during WWII. Inside the mile long "U" building were 3,000 gaseous diffusion stages like the four shown on the left.

This "U" shaped building operated superbly until the President and Department of Defense felt they had sufficient highly enriched uranium and shut it down in 1964.

The S-50 Plant

In addition to the two big uranium enriching plants at Y-12 and K-25 which together cost just a little short of a billion 1945 dollars, there was a third, far smaller uranium enriching plant, S-50, added in late summer of 1944 in a great hurry to speed up delivery of the desperately needed U-235. It cost only $16 million, and used a third enriching process called liquid thermal diffusion. It was built next to the K-25 plant's coal fired powerhouse on the Clinch River to use its superheated steam until K-25's "U" building had to have its steam for producing electricity. S-50 is the long black building in the photo to the left. It operated for only about a year from Sept. 1944 to Sept. 1945. It was shut down as soon as possible because it was a very difficult process to operate, and then was demolished leaving only its concrete pad to mark its location.



Like all the other Oak Ridge wartime facilities, the liquid thermal diffusion project, whose research and development was supported by the U.S. Navy, was given a meaningless code name, S-50. The code name list – Y-12, K-25, S-50, X-10 – suggests map coordinates, and many folks have searched for a "Secret" map and puzzled over their connection in vain. The only one of the four that has any rational basis is K-25. It was used by a Columbia University engineering contractor, the M. W. Kellogg Company in NYC, in 1942. The K stands for Kellogg or according to some authorities for Kellex, the Kellogg subsidiary that did the detailed plant design during 1943. The 25 was a thinly disguised symbol for U-235, put into use before the Army took over. By the time the Army engineers intelligence folks became aware of it, it had been in such long and widespread use by engineers and draftsmen in NYC that the Army decided more

attention would be drawn to it and harm done by trying to change it than by letting it continue to be used.

The X-10 Facility or Clinton Labs (Years Later the Oak Ridge National Laboratory)

Though 97% of Oak Ridge's effort was spent on enriching U-235, it does a have a very important connection to the second, Nagasaki, plutonium bomb code named "Fat Man." That connection is through the Graphite Reactor, the world's first production nuclear reactor built out in Bethel Valley about 13 miles from Townsite, at the site code-named X-10. This was the world's second nuclear reactor, and its first-ever production nuclear reactor. It was the first Oak Ridge facility to "get into business," with its ground breaking in February 1943, and its start up, that is "went critical," on November 4, 1943.

The X-10 facility with the tall white Graphite Reactor building, post war.

Its mission was to make gram quantities of the element plutonium so that chemists could work out ways to separate it from uranium and fission products when they started up the big production reactors at Hanford, WA. By spring 1945, the Clinton Labs had made about three quarters of a pound of plutonium, fulfilling its mission, and then they turned their interests to nuclear science and technology. Since 1947 it has been known to the world as the Oak Ridge National Laboratory.

III. Life in the "Secret City"

One of the site selection criteria for the Manhattan District area was that it be sparsely settled.[12] There were only about 1,000 farming families living on these 59,000 acres, perhaps 3,000 people to be moved out. Many of them moved to new homes nearby and came back to work on the Project. But the Army needed a city to house the thousands of scientists, engineers, managers,

[12] The others were: that it had adequate power (TVA), an adequate labor supply (Knoxville), good rail service (Southern and L&N), good cooling water (Clinch River), good typography (ridge and valley geology), and be a good distance from the Coast (concern for attack from German U-Boats).

and other professionals being brought in from university towns and big cities all over the country like Rochester, New York; Chicago, Illinois and Berkeley, California, as well as for the many tens of thousands more people needed for the operating and support staffs. The latter came from Tennessee and surrounding states.

The new city grew in leaps and bounds after the evictions that took place over the winter and spring of 1943. The Army's first order in the fall of 1942 to their construction contractor was to build a new town for 13,000 people, but by 1944 they changed this to 44,000 and a year later to 61,000. The actual peak population of 75,000 was reached in May 1945! Oak Ridge was then the 5th largest city in the State after Memphis, Nashville, Chattanooga, and Knoxville, yet it was a "Secret City" not shown on any maps.

The center of the original town, 1944, looking north toward the Cumberland Mountains. In the left foreground is the Central Cafeteria and across the street the first of the Women's Dormitories for 150 singles. In the center is the first shopping center in a "U" shaped area containing the Post Office, bowling alley, movie theater, bank, men's store, drug store, grocery, etc. On top of the hill beyond is the new High School, overlooking its still unfinished football stadium.

Everyone in Oak Ridge of working age had a job and a security pass,. There were no homeless, no salesmen, no poverty. Oak Ridge was like a gated community with a real sense of security and the camaraderie of fellow travelers. It was, most of all, a wartime culture. Everyone knew why everyone else was there – to do his or her part in winning the terrible war the country was fighting. Everyone had family members or knew soldiers fighting in harm's way in Europe or in the Pacific and felt the sacrifices we had to make here in East Tennessee (food shortages, being

away from home, tire and gas rationing, no booze in these "dry" counties, and yes, the mud) were far less than those being asked of our troops. It was an entirely different culture than today. The culture in town was pleasant for the 13,000 singles because the locked gates gave the recreation halls where they congregated the feeling not unlike a freshman class in college – everyone might be a stranger, but all knew why all the others were there; everyone had passed security clearance checks, making it a lot easier to meet others.

Oak Ridge in WWII looked entirely different than it does now. Today the green-lawned, tree-lined city of 27,000 is a sleepy little town compared to the bustling city of 75,000, much of it built on cultivated fields in the East Fork Valley floor. And then it ran full-throttle all night as well as all day. The town then looked like what it was – a sprawling, brand-new army base, built fast to do a particular job, not intended to last long after the war. There was one exception to the Army base "look," there were only a very few soldiers in view – none marching around anywhere. In the city of 75,000, there were maybe 2,500 in uniform, many of them officers running the Manhattan Project all over the country!

Between 1943 and 1945 the farmland of the East Fork Valley between Black Oak Ridge and Pine Ridge had been transformed into the new city. It was always referred to as a "Town" to keep outsiders from guessing how big it was. The Army engineers had quickly built miles of roads, fences, guard posts, and in a remarkably short period of time built nearly 10,000 homes for families, 90 two-story dormitories for 13,000 singles, 5,000 trailers for families, 16,000 hutments and barracks spaces for construction workers and soldiers, three non-denominational chapels, nine neighborhood schools and a High School, a full-service hospital ($4/month for a family's insurance that paid for everything), five huge cafeterias to serve meals to the singles in different parts of town, four recreation (Rec) halls for dancing, reading, table games, and listening to music (records)

A vital organization the Army set up at the beginning to try to keep folks from "getting the blues" back here in the hills was their Recreation Department that organized and furnished facilities and equipment for bowling leagues, all manner of ball leagues, and even a legitimate theater and a symphony orchestra that is still in operation today – the oldest in the State of Tennessee.

For those who moved here with families living in the houses up on the still-wooded sides of Black Oak Ridge, there were a dozen neighborhood shopping centers with nine elementary schools that moms and kids *could walk to.* Serving everyone was the ninth largest bus system *in the U.S.,* taking folks around town and to the plants to work. In addition to the 75,000 residents that made us the fifth largest city in Tennessee, thousands of workers and construction workers commuted in every day for their three shifts from all around East Tennessee.

One thing about WWII life in Oak Ridge that all survivors remember is what happened when it rained. Almost any rain turned the thinly graveled roads into seas of sticky, slimy, slippery, mud. But that gave rise to one nice feature of town – its 163 miles of boardwalks instead of sidewalks, built using boards from trees that had to be cut down in building the town. Many workers kept clean pairs of shoes at the plants and would change from whatever they wore getting to work because most of the plant areas had to be kept very clean.

Another memorable feature for many survivors was the fact that the land the Army moved into lay in two Tennessee counties, Anderson and Roane, each having "bone-dry" laws, meaning it was against the law to have <u>any</u> booze here. Administered by the Army, it was possible to buy 3.2% "near-beer," the brand sold in the Rec Halls was "Barbarossa Beer." It was a poor excuse. Any real booze had to be smuggled in under the knowing eyes of the guards at the gates who knew most of the tricks and never looked the other way.

There were wartime shortages of lots of things like sugar, butter, meat, cigarettes, candy, gasoline and tires. There were long lines for everything; a common saying was, "If you see a long line get in it – bound to be for something good." The thousands of singles went to all the movies at the Center Theatre where the Oak Ridge Playhouse now calls home. Going to the movies meant four to five times a week (that's how often they showed a new flick). After the show, we went to the bowling alleys or to a Rec Hall to dance to Big Band music, then in its prime. Jitterbugging was the in-thing.

And always, at the plants and in town, there was an ever-present insistence on very tight security – don't talk about what you do, don't ask what someone else does. The enemy is listening. Keeping a secrecy rein on the people here was a real challenge. There were frequent security briefings at the plants and big security billboards leaving the area, "What You See Here, What You Do Here, When You Leave Here, Let It Stay Here." But aggravating the problem of keeping tight security was the short 13 miles to Knoxville where Ridgers bussed in to shop and eat as often as they could. Ridgers travelling outside the CEW reservation could be easily spotted because of their muddy shoes and "foreign" (damn-Yankee) accents. Friendly, but so curious Knoxvillians in stores or on the street might come up with questions like, "Gosh, that Project out there must be huge, how many folks are working out there?" After soon getting tired of the proper, "I can't say" responses, Ridgers tended to get a little creative in answering. To the question of how many are working out there, the answer could be, "Oh, I'd guess about half of them!" And to the frequent, "Say, whatever are you all making out there?" "Oh, we're just building lots of homes for all the Army and Navy officers to come retire in after the war." Or "Oh, we're just making 4th term campaign buttons for FDR and luggage for his globe-trotting Eleanor." And one worker said, "Well I don't mind telling you what I'm making out there – it's 78¢/hour." And a local maintenance man at Y-12 said, "Well, I'll be honest with you, I don't know what they'se makin' out there, but I'll tell you this much – the govmint could sure as hell go buy it somm'ers else a whole lot cheaper!"

IV. Mission Success

Not many people working at any of the four plants and none of the townspeople at all would have judged the huge Y-12 plant much of a success if they had been told the truth - that the product of all of that cost and effort of 22,000+ workers was being carried out in a briefcase each week! That highly pure, very precious U-235, did not take up much space.

We made none of the bomb parts here. All of Y-12's wartime U-235 product was shipped out to Los Alamos in the form of fine crystals of U-235 tetrafluoride, a pretty blue-green powder. It does not glow in the dark. Its radioactivity will not penetrate the skin, so several pounds can safely be held in one's hand, but it was far too precious to allow that, having cost well over $200,000 an ounce to make. It was packed into a container about the size of a coffee cup made out of nickel and heavily plated with gold on the inside so the costly green powder would not get contaminated and then have to be re-purified in Los Alamos. Time was urgent. Two of these cans were packed in a wooden frame in a very ordinary looking leather briefcase like lots of businessmen carried in 1945. This super valuable briefcase was then chained to the wrist of a 1st Lieutenant in Military Security wearing civilian clothes and off he went with armed escorts by train to Chicago where they then took the Santa-Fe Chief out to Lamy, New Mexico, the railroad stop nearest Los Alamos.

In the early spring of 1945 Y-12 was finally operating smoothly as everyone had hoped it could, finally sending nearly pure U-235 to Los Alamos week after week. And over the next months, Y-

12, with a little boost from both S-50 and K-25, had sent enough so that Los Alamos could finally turn out the uranium metal parts for the first gun-type atomic bomb. In this type, a uranium 235 bullet was fired down a gun barrel into a uranium 235 target, very rapidly creating a supercritical mass that resulted in the chain reaction and atomic explosion. The last metal parts were finished in July and carried out to Tinian Island in the Pacific, mostly by the USS Indianapolis. The final parts were flown in by three C-54 aircraft. [13] There a team from Los Alamos assembled the bomb by August 1st, meeting General Groves' near impossible target. Weather kept it from being dropped until August 6th, 1945.

V. Why Did the Manhattan Project Succeed?

The Y-12 and K-25 ventures at Oak Ridge represented the first-ever production-scale separation of the isotopes of any heavy element anywhere in the world. [14] The Graphite Reactor at Clinton Labs was the first-ever nuclear reactor to produce plutonium on a gram scale. The Hanford production reactors were the first-ever built that produced large quantities of the heavy element plutonium that had once been present on the earth but had all decayed away. Los Alamos worked out the physics theory and then implemented it in producing both a gun-type U-235 bomb and an implosion type plutonium bomb. All this helped bring peace and an end to WWII.

As singular as these never before attempted scientific and engineering achievements were, the most amazing thing is that they were all accomplished in 2½ years from ground breaking! The first time anything is done is the hardest for any such achievement, because you never know what will and what won't work.

Here's one way to gauge that accomplishment. The British physicist and spy at Los Alamos, Klaus Fuchs, gave the Russians the design of the plutonium implosion weapon successfully tested at Alamogordo in July 1945, and under orders from Stalin's KGB boss Lavrenti Beria that their scientists not to try to improve on the U.S. design but just produce an exact duplicate, it took the very able Russians four years to do what we did in 2.5 years! [15] Yes, the Manhattan Project accomplished its mission in an unbelievably short time.

How was that possible and could such an effort ever be done again are questions we are often asked. Here are some reasons I give, having read a number of different accounts and discussed them with others:

First. One big reason for its success was the choice of General Leslie R. Groves to head the effort, not only because of his intelligence and personal skills, but because he was given and then assumed full responsibility for the entire Project. The decision to put the entire U.S program under him with full support from our top government was a major difference between our atomic program and the WWII atomic programs in Germany, Japan, and Russia, in addition to the reality that none of them had the resources they could make available in the midst of fighting the war.

Groves had great skill and insight in selecting outstanding performers, contractors and individuals like his superb second-in-command, Colonel Kenneth D. Nichols, who has never, in this writer's view, received all the credit he deserves. Nichols effectively served as Groves' COO and administered the far-flung Manhattan Project from his offices in the "Castle on the Hill" in Oak

[13] Oak Ridger Lt. Nicholas Del Genio carried one of these last parts by C-54 to Tinian Island. "From Us to Tojo" tells that story by Wm. J. Wilcox Jr., written for the AMSE, Oak Ridge, 2000.
[14] Harold Urey had earlier received the Nobel Prize for discovering and separating the isotopes of hydrogen.
[15] Saying that they started in July 1945 to August 1949. We know they started well before that, so it really took them more than four years.

Ridge. He knew the detailed problems faced by the Manhattan Project better than anyone else. Sometime after the war at a National War College conference, Nichols was pressed for his opinion of Groves, and though he had dodged the question often, he finally responded,

> *"General Groves is the biggest S.O.B. I have ever worked for. He is most demanding. He is most critical. He is always a driver, never a praiser. He is abrasive and sarcastic. He disregards all normal organizational channels . . . he constantly meddled with my subordinates. He ruthlessly protected the overall project from other government agency interference, which made my task easier . . . He is extremely intelligent and he has the guts to make timely, difficult decisions."*
>
> (Nichols went on with more details for about twice this length, then concluded)*:*
> *" if I had to do my part of the atomic bomb project over again and had the privilege of picking my boss, I would pick General Groves."*

Second. Masterful corporate recruitment and delegation. In his first four months on the job (Sept, Oct, Nov, Dec. 1942) General Groves against strong objections talked the top U.S. corporations with strength in chemistry and chemical engineering to sign on as their patriotic duty to operate the plants, partnering each of them with the top university scientists that had been doing the research and development (R&D). To build and run Y-12's electromagnetic separation plant he enlisted Tennessee Eastman (a subsidiary of Eastman Kodak) to implement the R&D done by Prof. E. O. Lawrence and his team at California. He enlisted Stone & Webster of Boston to do the demanding Architecture/Engineering work for Y-12. For K-25 he enlisted Union Carbide to work with Prof. J. R. Dunning's team of scientists at Columbia along with M.W. Kellogg (Kellex Corp.) to do K-25's awesomely difficult engineering design. And for the Plutonium Project at Hanford (including their pilot graphite reactor in Oak Ridge) Groves twisted the reluctant arms of E.I. DuPont to work with Prof. Arthur Holly Compton's team at the University of Chicago.

What these partnerships meant was the immediate injection into the Manhattan Project of a huge cadre of senior professionals of all the needed disciplines with their support infrastructure into the Project. These were people who knew how to get things done in high technology fields and who were already organized to work together. It was far faster and far more productive than putting everyone in the Army. By summer 1943, only six months into the project, Groves had many thousands of people security-cleared and already hard at work – scientists, engineers, and architects designing exotic equipment, and construction workers already building plants and towns. It was an extraordinarily fast ramp-up that could not have been achieved another way.

Third, not in importance, but in timing, was the availability of almost new building sites for the needed Manhattan facilities at Oak Ridge, Hanford, and Los Alamos. One thing the Army Engineers were experts at doing was what then most needed to be done: building roads, guard fences, putting up towns, living quarters, and all the infrastructures required in a big hurry. The fact that these were new sites made everything move a lot faster than if they had to deal with tearing down communities or existing facilities first.

Fourth. A major reason things got done much faster than usual was because of the secrecy this wartime Project demanded. Groves decided early on to compartmentalize every part of what would become an over $2 billion dollar Project. No one – even the various corporate top managers – was told any more than he or she needed to know to do the job. As a Jr. Chemist at Y-12, for example, I knew everything about what my job was in the chemistry building 9203, but nothing about what was going on in all those other buildings, let alone what was going on in the other plants in Oak Ridge.

This secrecy worked to a great advantage in saving time. A very small top policy group made decisions on the crucial questions, but there was no need for the different plants or segments across the country to get "buy-in" from the Administration, from Congress, the public, or to gather other stakeholder input and agreement. Much time was saved in not having to "sell" plans or decisions, report progress or problems to others. Also your boss knew everything he needed to know about his responsibility, so you could almost always count on getting "yes or no" answers to your questions right away, not, "Well I'll think about it," or "I'll run it up the line." Decisions were made very quickly.

Fifth. General Groves virtually had a blank check, almost unlimited funding. If anything was wanted to keep the program on schedule or might speed things it up; it was bought, not studied. Laboratory workers wrote up their progress in standard Lab Notebooks for progress and patent reviews by the bosses, but spent no time on budget presentations, writing project proposals, or getting bids on purchases. The only forms that had to be filled out were time cards and forms to account for every milligram of U-235. Having all the money the Manhattan Project needed made a big difference in the time things took and as well as in how much was accomplished.

Sixth. Another factor of real importance was the Project's top wartime priority ranking. Throughout WWII, every business with a wartime contract clamored for their basic materials – almost everything was in short supply. The priority system was the tool government officials used to get things done in the right order, and when push came to shove, the Manhattan Project had that over-riding AAA priority, a big club they did not use often, but could when it really counted.

Seventh. But in my mind one of the most important reasons so much got done so fast was that everyone from General Groves on down to the operators on all three shifts had a common purpose – to do whatever they could seven days a week to help the country win the war. Nobody ordered us to work extra long and extra hard. We motivated ourselves by reading the morning and evening newspapers each day and by hearing on the radio every night of the atrocities and the killing of our countrymen and its Allies in North Africa, on the beaches in Normandy, on the infamous Bataan Death march in the Philippines, in the jungles of Burma, and on islands in the Pacific whose names we had never heard of before, and now can never forget. This is what is so hard to get across to the next generations. It was a deeply felt patriotic spirit that made everyone work so long and hard, keep secrets, put up with the shortages, and live with rules we often did not understand. It was all "to help win the war."

The country glimpsed a kindred spirit in a few weeks following the horrific attacks of September 11, 2001, an outpouring of that patriotic feeling: "What can I do to help?" But during WWII workers on the home front read about awful horrors somewhere week after week after week for six long years (1939 to 1945). A million American boys were killed or wounded in the three years and nine months the U.S. was at war. [16] I lost my best friend from 1st grade on who was piloting a bomber over Germany. Almost everyone knew someone who had lost family members.

So how did we Ridgers react to the atomic bombings on August 6th and 9th? Because about 73,000 of the 75,000 did not even know that they had a major role in building such a bomb, they reacted just like everyone else in the country – that is with incredible surprise and relief. No one felt any pride or gloried in the deaths of the 100,000 Japanese at Hiroshima any more than they

[16] For the 1,342 days from Dec. 7, 1941 to Aug 14, 1945, the average was 745 men/day, killed or wounded, (using 400M killed and 600 wounded). Truman told a joint session of Congress in 1948, that the cost to the US was $341B, or $245 M/day.

gloried in the deaths of about that same number in the fire-bombing of Tokyo a few months before on the night of March 9/10 - a bombing that burned out 16 square miles of Tokyo, 4 times the area burned out at Hiroshima. [17] Nor have they gloried in the firebombing of Dresden, Germany in February of 1945 by the British and Americans with about the same loss of life. What Oak Ridgers did take pride in was that the shock of the Manhattan Project's success finally caused Japan's reluctant Emperor Hirohito to stand up to his die-hard militarists and insist on bringing the war to an end. It was a dreadful war they started against us at Pearl Harbor; one that had earlier seen their savage attacks on China that resulted in a now all but forgotten 14 million Chinese dead. That six year World War that Oak Ridge helped end involved a nearly incomprehensible total of 54 million people killed by other humans. [18]

It was that role in ending the war that caused Oak Ridgers waking up on the morning of August 14th, 1945 to rejoice when they saw a special edition of The Knoxville Journal. That newspaper, printed on the very special red paper used only for the most important editions carried an 8-inch tall banner headline PEACE. The peace we had worked so long for and prayed so earnestly for, was at last a reality.

The author with a favorite souvenir, August 14, 1945

VI. Post-War Oak Ridge

After the war, Oak Ridge scientists and engineers eagerly went to work applying this newly understood nuclear science and technology to peaceful applications. The first was using Calutrons and the Graphite Reactor to produce stable and radioactive isotopes for use in medical diagnoses and therapy, applications that even today help millions around the world through nuclear medicine. Then these isotopes of other elements were put to work in agriculture and industry in so many applications that affect our daily lives. Oak Ridge's ORNL led the way in giving to the world nuclear research reactors in the 1950s. In the 1960s, civilian nuclear power plants using light water moderated reactors with low enriched U-235 fuels were

[17] 140,000 were killed or seriously wounded by the firestorm caused by 334 B-29s from Tinian each carrying six tons of incendiaries. 1,000,000 were wounded. 16 sq. miles of the city were burned out. Night 3/9-10/45.
Tibbets, Return of the Enola Gay, page 195. Rhodes, Making the Atomic Bomb, page 597-600.
[18] From Gil Elliot, The Twentieth Century Book of the Dead, Chas. Scribner's & Sons, NY, 1972.

produced at K-25. These reactors, whose clean electric power though not yet accepted widely by the public in this country, have been welcomed and beneficial to so many countries of the world including Japan, our war-time enemy but for a half century since, such good friends. These and many other peaceful uses of atomic energy, together with the blessed freedom from WWIII for well over half a century of Cold War that our nuclear defense (in part due to Y-12) has brought us, – these are rich legacies of the Manhattan Project in which Oak Ridge played such a vital and successful role.

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Photographs, except as noted otherwise in captions, are by the WWII official photographer of the Army Engineers, J. Ed Westcott, taken from the Westcott collection in the Oak Ridge Public Library.

Appendix

Was the Manhattan Project A Triumph or a Tragedy?

Triumph?

1. It brought peace to a world aching from a war that had devastated Europe, Asia, and involved countries all over the world for six long years – a war in which 54,000,000 humans were killed by others – Russia lost the most people 20,000,000 followed by China who lost an all but forgotten 14,000,000, many of them civilians, at the hands of the Japanese.

	Deaths	Ref. Page
Russia	20,000,000	227
China	14,000,000	230
Jews (Ger.,Polish, Russ.,etc.	5,000,000	231
Germany(excl. Jews)	5,000,000	83
Poland (excl. Jews)	3,000,000	83
Japan	2,500,000	83
Yugoslavia	1,700,000	83
France	570,000	86
Britain & Commonwealth	460,000	86
Italy	450,000	86
United States	400,000	86
Greece	360,000	86
Rumania	350,000	86
Czechoslovakia	160,000	87
Netherlands	145,000	87
Hungary	100,000	87
Norway	10,000	87
Bulgaria	10,000	87
Belgium	10,000	87
Denmark	5,000	87
TOTAL	54,230,000	

Complied by the author from *The Twentieth Century Book of the Dead* by Gil Elliot, Charles Scribner's & Sons, NY, 1972

2. It saved <u>millions</u> of lives of Japanese civilian women, children, men, and soldiers and the lives of 250,000 Allied soldiers (estimate by Admiral Wm. Leahy) or 200,000 (estimate by Winston

Churchill) in the already planned invasion of Japan in November, 1945 called *Operation Olympic*. Every time I have spoken to visiting groups (a number of service reunions) about Oak Ridge's role, one or more veterans afterwards told me they were on their way to prepare for the invasion and thanked Oak Ridge for saving their lives. Some say Japan was already defeated, but their militarists were not about to surrender. (See for a detailed account "The Last Days of Japan." They and their government did not give up after the Hiroshima A-Bomb. It took the second bomb to convince Emperor Hirohito to insist his Supreme Command surrender unconditionally.

3. The Manhattan Project unlocked the secrets of harnessing nuclear energy, the energy of our sun and the entire universe since its beginning, whereas we have been burning our planet's irreplaceable oil, gas, and coal deposits which cause global warming and do other damage. From the standpoint of safety, saving lives, and being environmentally benign, nuclear is much to be preferred over coal for large power stations. A 1,000 MW coal fired plant requires more than one 110-car trains of coal *every day*, each car carrying 100 tons. A 1,000 MW nuclear plant has to be refueled about every year and a half by a fuel re-load carried by an eighteen-wheel truck. Oak Ridge's biggest user of our K-25 Plants peacetime (1960-1980) low enriched uranium for nuclear power plants was Japan. There are now over 400 nuclear reactors in the world, only 104 in the U.S. In 2009 the U.S. has only 1 under construction, Russia-7, China- 6, India- 6, South Korea-3.

4. Russia would have won the Cold War, not us, if it had not been for our Manhattan Project. In the same way and at the same time as we learned from the Germans in 1939 what the possibilities were, so did the Russian physicists. Their brilliant Igor Kurchatov (their Robt. Oppenheimer) led their program since 1943 and right after the war they went all-out to build nuclear weapons, actually beating the U.S. to a first type of hydrogen bomb. And they beat us in the satellite race with their Sputniks. If we had not had the Manhattan Project, Stalin might well have succeeded in his global communism threats.

5. Manhattan Project scientists used the wartime equipment at X-10 and Y-12 to make the first radioactive and stable isotopes [a] for nuclear medicine that has revolutionized disease diagnosis and therapy to the benefit of millions of people all over the world. [b] For industrial uses, other radioisotopes have increased industrial productivity (e.g. radioactive thickness control gauges.) And [c] for agriculture, researching fertilizer uptakes has increased productivity and radiation has been used to sterilize foods and kill insects in grains to be planted.

6. Freedom from WW III at least for the past 60 years. The 20th century saw two world wars just 20 years apart in the world without nuclear weapons and with real yearnings for peace.

Tragedy?

1. Loss of life at Hiroshima and Nagasaki. Awful. As was the killing of almost the same number in Dresden, Germany by British fire bombing in February 1945, the same number in the U.S. firebombing of Tokyo the night of Mar 9/10 1945, and in their killing of far more civilians in the Rape of Nanking, China in 1937. Yes, war is terrible. Some assert the killing by one plane is morally worse that if by hundreds. Both these cities would have been destroyed by firebombing as Tokyo and dozens of other Japanese cities were except for being placed on the atomic bomb target short list. The answers to Hiroshima cannot be found in its ashes, one must look in all those grave yards at Pearl Harbor, Anzio, Normandy, Auschwitz, Bataan Peninsula, Tarawa, the ocean floors, and so many other battlefields. The horrifying photographs of victims and the destroyed city of Hiroshima turned so many Americans against Nuclear Weapons and

have tainted the Manhattan Project even 60 years after. Some people feel far more antipathy toward nuclear weapons than against Napalm in part due to the fact that no comparable photographs have ever been shown nor have journalists or commissions reported in detail on victims stories and the aftermath of the killing and wounding by Napalm burning of similar cities.

2. Cold War. The U.S. led idealistic efforts right after the war (Baruch Plan) to turn all control of nuclear materials and technology over to an International Authority. They failed immediately because countries like Russia wanted their own supply of bombs to control. All through the last 50 years, what peace we have had was the result of a stalemate, both USSR and U.S. matching each other's building of huge stockpiles of nuclear weapons of every imaginable sort – air dropped, cruise missiles, ICBMs, submarine launched, etc.

Right after the Cold War was won, President Geo. H. W. Bush 1991 decided unilaterally to cut our nuclear stockpile to 6,000; lately Pres G.W. Bush announced a new target of 2,200, and Pres. Obama has called for a max. of 1,700 operational nuclear weapons. Y-12 is busy dismantling weapons, and the U.S. Enrichment Corporation (USEC) is busy turning Russian warhead U-235 (90% U-235) into Low Enriched Uranium (LEU – <5% U-235). The U.S. has already "neutralized" over 10,000 Russian warheads.

3. Now nine countries have nuclear weapons with most having no intention of using them. Today the problem is terrorists and rogue states that want one or a few to use as nuclear blackmail or to create panic or surrender. Those with nuclear weapons are: U.S., Russia, Britain, France, China, Israel, India, Pakistan, North Korea.

4. Radioactive waste disposal – it's not a technical problem (we know how to safely store it or recycle it) but it is a real political problem. Nobody wants it. NIMBY = Not in my back yard.

5. Frequently heard comment right after the war: "You can't put the Genie back in the bottle." There is no way you can take back all the "secrets' of enriching or bomb physics.

Is it a curse or a blessing? Nuclear energy, just like the other energy sources like fire, electricity, solar, and hydro can be both a blessing to mankind and a curse. Fire warms the hearth, cooks people's food, but when you hear the sirens of the fire engines during the night or see the raging wild-fires on TV, you are reminded it can be a curse. Electricity also can so easily kill as most parents teach their children, but they also have learned how it can safely serve us in so many ways. The sun's nuclear reactions produce radiation that sustains our planet and human life, but its radiation can burn and cause melanomas. Dams can break with awful results. Mankind has found ways to conquer fear of each of these energy sources and not be paralyzed into rejecting the benefits of fire, solar, electricity, and water power. And so must we with nuclear, the energy source of the entire universe.

wjw/revision of 2013.