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WAS FOUND TO BE ONLY AN ISOTOPE OF URANIUM WITH WEIGHT OF 235- OR URANIUM 235. MOST URANIUM IN NATURE HAS WEIGHT 238--99.3%- SO TO BUILD AN ATOM BOMB THE JOB WAS TO SEPARATE THE TINY 0.7 % U235 FROM NATURAL URANIUM.

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FROM HERE ON, WE'LL TELL THE BOMB STORY FROM A PERSONAL EXPERIENCE POINT OF VIEW. MY FIRST JOB

AFTER GRADUATING CHEM E IN 1940 WAS WITH DUPONT IN CHARLESTON, WVA. IT WAS HERE THAT I FIRST CAME IN TOUCH WITH ASPECTS OF THE MANHATTAN PROJECT, THOUGH I KNEW NOTHING OF IT. THERE WERE A NUMBER OF INCIDENTS LEAD TO A GROWING AWARENESS THAT THE USA WAS INVOLVED IN AN ATOM BOMB PROGRAM OF SOME SORT.

1- IN EARLY 1941, WELL BEFORE PEARL HARBOR, MY BACHELOR ROOMMATE ACCEPTED A DUPONT TRANSFER TO CHICAGO. HE WAS FORBIDDEN TO TALK ABOUT THE LOCATION OR NATURE OF THE ASSIGNMENT. WE KEPT IN TOUCH BY MAIL, AND IN AN EARLY LETTER, HE SAID "I USED TO KID YOU ABOUT YOUR ADDICTION TO SCIENCE FICTION— NEVER AGAIN"

2- IN EARLY ' 42, NOW AT WAR, I WAS TRANSFERRED TO A NEW PLANT IN MORGANTOWN, WV.

WITHIN THE PLANT GATES, A NEW AREA WAS UNDER CONSTRUCTION CONSISTING OF WHAT ANY CHEM ENGINEER WOULD THINK DISTILLATION TOWERS. NO ANNOUNCEMENT WAS MADE OF ITS PURPOSE AND A FENCE WITHIN OUR

FENCE WAS UNDER CONSTRUCTION. CURIOUSLY, THERE WAS NO PRODUCT EXIT RAIL LINE. IT WAS JOKINGLY CALLED "THE BUBBLE GUM" PLANT.

MORE SERIOUSLY FROM A SECRECY POINT OF VIEW, THERE WAS OPEN SPECULATION AMONG THE YOUNG ENGINEERS THAT IT MIGHT BE A PLANT TO MAKE HEAVY WATER, WHICH TEXTBOOKS RECOGNIZED AS A POTENTIAL NEED IF ONE WERE TO BUILD AN ATOMIC REACTOR. I HAD BEEN GUESSING ON THIS WITH ONE OF MY CLOSE FRIENDS BUT ONE DAY HE BECAME CLOSMOUTHED. YEARS LATER, AFTER THE BOMB SECRET WAS OUT, HE TOLD ME THAT THE FBI HAD TOLD HIM IN STRONG TERMS TO SHUT UP. TO ME, HIS STRANGE SILENCE WAS ALMOST CONFIRMATION THAT WE HAD BEEN RIGHT.

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BEFORE DISCUSSING WHAT THOSE THREE APPROACHES WERE, LET'S DISCUSS THE ROLE OF HEAVY WATER IN THE PROGRAM. A WHILE AGO I SAID THE FISSION OF U-235 WORKED BETTER IF NEUTRONS WERE SLOWED. LIKE POOL BALLS ARE WHEN BOUNCING ON A TABLE. TWO WAYS WERE KNOWN OF DOING THIS. ORDINARY CARBON AND HEAVY WATER WOULD BOTH SLOW DOWN NEUTRONS WITHOUT ABSORBING THEM AND BOTH GERMANY AND USA WERE LOOKING AT WAYS OF EXTRACTING HEAVY WATER FROM REGULAR WATER WHERE IT IS 140 PPM. BECAUSE THAT IS HARD TO DO, ALL EARLY REACTORS WERE CARBON MODERATED- LITERALLY A PILE OF CARBON BLOCKS IN A CONTAINMENT COVER.

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SO THE GERMAN BOMB CRIOWD ARRANGED TO BUILD A SECRET FENCED OFF HEAVY WATER FACILITY – EXACTLY WHAT HAPPENED IN THE U.S. WITH EVEN THE LOCALS NOT BEING TOLD WHAT IT WAS ABOUT.

BUT U.S INTELLIGENCE KNEW, THOUGH THEY DID NOT KNOW THE LOW PRIORITY OF THE GERMAN ATOMIC BOMB PROJECT. AS WE FOUND OUT LATER, HITLER HAD PUT MOST OF HIS SPACE AGE MONEY INTO ROCKETS—THE VI AND V2. AS A RESULT, THE ALLIERS MOUNTED A FURIOUS EFFORT TO SHUT DOWN THE HEAVY WATER EFFORT.

SABOTAGE WAS TRIED AND A DISASTROUS RAID BY BRITISH COMMANDOES. THIS MADE THE NEWS BUT NOT THE REASON. THERE WAS ALSO A DESPERATE ATTEMPT TO BOMB THE PLANT, SENDING B-24 BOMBERS ACROSS THE NORTH SEA WITH BARELY ENOUGH GAS. BY THEN, WE CONTROLLED THE NORTH SEA, SO THEIR INSTRUCTIONS WERE WERE TO CRASH LAND IN THE WATER TO GET PICKED UP.

THROUGHOUT, THE GERMAN MUNITIONS ADMIN WERE BAFFLED- WHY WAS THIS AMMONIA PLANT GETTING SUCH ATTENTION WHEN ALLIED BOMBERS OVER GERMANY IGNORED SUCH PLANTS AND CONCENTRATED ON BALL BEARING FACTORIES, ETC.FINALLY, THEY FIGURED IT OUT AND GOT PERMISSION TO THROW THEM OUT. THAT WAS THE

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FINALLY, WITH LUNCHTIME APPROACHING, WE WERE TRANSFERRED TO A CORPS OF ENGINEERS STRETCHOUT LIMO- AND TAKEN TO LUNCH AND THEN ON A RIDE THRU THE COUNTRY SIDE TO WHAT WAS OAK RIDGE, THE HUGE LOCATION WHERE TWO FACILITIES WERE BUILT TO SEPARATE FISSIONABLE

U235 FROM THE REST OF NATURAL URANIUM.

LET'S TAKE TIME HERE TO COMMENT ON THE TWO --TO ME-- MOST REMARCABLE LESSONS FROM THOSE TIMES.

1- AN ATOMIC ENERGY FACILITY CAN BE BUILT VERY RAPIDLY TODAY IF THE BUILDERS ARE NOT STOPPED BY THE NEED FOR APPROVALS. THERE IS NOTHING INHERENTLY MORE DIFFICULT ABOUT ATOMIC REACTORS TOUGH THEY ARE COMPLICATED, BUT SO ARE OIL REFINERIES. ATER.

2- HOW THE INDUSTRIAL MIGHT OF THE USA DOOMED THE AXIS POWERS. AT THE TIME I WAS IN THE PROGRAM, THE VARIOUS APPROACHES TO A BOMB WERE UNDER QUESTION. THE ANSWER WAS "SINCE WE'RE NOT SURE, LET'S DO THEM ALL.it WAS, TO ME, AN ASTOUNDING DEDICATION OF OUR

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BOMB

BUILDING THE BOMB

FOR THE NEXT FEW WEEKS, THE NUMBER
DEPENDING ON HOW MUCH

DISCUSSION WE HAVE, ~~I WILL BE TALKING ABOUT MY~~ ^{→ This is for}
WARTIME

EXPERIENCES IN PART OF THE USA EFFORT TO BEAT THE
GERMANS

IN DEVELOPING THE ATOM BOMB. WE'LL TALK ABOUT
LIVING IN A NEARLY

DESERT COMMUNITY ON THE COLUMBIA RIVER IN
WASHINGTON STATE-- 4

INCHES OF RAIN PER YEAR-- AN ENVIRONMENT OF SAGE
BRUSH, CACTUS,

AND COYOTES HOWLING AT NIGHT. WE LIVED IN RICHLAND,
WASHINGTON,

A GREATLY EXPANDED COMPANY VILLAGE THAT HAD ONCE
BEEN A FRUIT

GROWING TOWN IRRIGATED BY THE YAKIMA
RIVER--SHOWMAP.

WE'LL NOT ONLY TALK ABOUT THE BOMB PROGRAM
ITSELF BUT

ALSO ABOUT THE GOVERNMENT IMPOSED RESTRICTIONS ON
MANY

ACTIVITIES--FOOD AND GASOLINE RATIONING, THE DRAFT,
RESTRICTIONS

BOMB

ON CHANGING JOBS, ETC. MANY OF YOU ARE TOO YOUNG TO REMEMBER THR

DETAILS AND I THINK IT IMPORTANT TO SEE THAT WE SURVIVED THESE

RESTRICTIONS AND WON THE WAR. IT WILL GIVE PERSPECTIVE NOW WHEN

THERE IS MUCH DISCUSSION ABOUT ^{restrictions imposed} THE PATRIOT ACT.

^{to} HOW WILL WE RUN THIS COURSE? IT WILL BE A DISCUSSION

RATHER THAN A LECTURE, SO IF YOU HAVE A QUESTION, RAISE YOUR

HAND AND ASK IT. IF THE ANSWER IS COMING UP SOON IN MY NOTES,

I'LL ASK YOU TO WAIT--OTHERWISE, WE'LL DEAL WITH IT THEN.

SO LET'S GO BY STARTING WITH A BIT OF NOT TOO TECHNICAL

INFO ON HOW THE BOMB AND NUCLEAR ENERGY ^{program} STARTED. IN 1906 OR SO,

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MOON, THE

STARS, THE ROCKS IN OUR GARDEN, E, OR ENERGY, IS LIGHT AND HEAT.

C IS THE VELOCITY OF LIGHT--186,000 MILES PER SECOND--A BIG

NUMBER. EINSTEIN WAS TELLING US THAT IF WE KNEW HOW TO DESTROY

MASS WE'D GET LOTS OF ENERGY.

ALTHOUGH NO ONE KNEW HOW TO DO THAT HERE ON EARTH,

PHYSICIST SOON FIGURED OUT THAT THE SUN AND STARS DO THAT BY

CONVERTING HYDROGEN--THE LIGHTEST OF THE 92 KNOWN ELEMENTS

TO HELIUM- THE NEXT LIGHTEST. BUT HELIUM ISN'T TWICE AS HEAVY AS

THE TWO HYDROGEN ATOMS FROM WHICH IT IS MADE--IT, S SLIGHTLY

LESS- AND THAT LOSS OF MASS SHOWS UP AS THE HEAT AND LIGHT OF

THAT PROCESS IS CALLED FISSION

OUR SUN AND THE STARS. ~~OK??~~

THE NEXT BREAKTHRU TOOK ABOUT 25 YEARS. IN THE 30S, TWO

GERMAN SCIENTISTS- HAHN AND STRASSMAN-DISCOVERED THAT SOME OF

BOMB

ADD THURIN

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HEAVIEST OF ALL KNOWN ELEMENTS- UNDERGO WHAT WE NOW CALL

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HYDROGEN WITH ITS ELECTRONS ~~WHICH MAKE~~

~~STRIPPED OR~~

~~IT WAS ALSO LEARNED~~

~~FIRST TIME~~

- ① FISSION, IT TURNS OUT, RANDOM - SPLIT INTO TWO PIECES NOT ALWAYS THE SAME + ~~FREE~~ ALSO RADIOACTIVE
- ② ALSO PRODUCES MORE NEUTRONS THAN THE ONE CAUSED THE (2.3 AVERAGE)

~~ALSO LEARNED~~

THEORETICALLY, AN ATOM BOMB WAS NOW POSSIBLE OR POSSIBLY NUCLEAR POWER. THE KEY + LATER WAS LOW SPEED NEUTRONS - HAD MULT > probability OR

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WANTED TO LOCK HIM UP FOR THE DURATION- MY BOSS, HIS

END OF THE HEAVY WATER OPERATION.

I MENTIONED EARLIER THAT THE USA PROGRAM PUT MAJOR EFFORT INTO THREE DIFFERENT WAYS OF GETTING FISSIONABLE MATERIAL. TWO OF THESE WERE AT OAK RIDGE, AND SEPARATED U-235 FROM U-238...IT'S ONLY 0.7% UNION CARBIDE, THEN A MAJOR CHEMICAL COMPANY, OPERATED A THERMAL DIFFUSION PLANT USING A GASEUOS URANIUM COMPOUND.

TENNESSEE EASTMAN, A DIVISION OF KODAK, RAN AN ELECTROMAGNETIC SEPARATION PROCESS THAT REQUIRED HUGE AMOUNTS OF ELECTRIC POWER. THE OAK RIDGE LOCATION WAS CHOSEN BECAUSE IT COULD DRAW POWER FROM GOVERNMENT CONTROLLED TVA.

THE THIRD APPROACH, IN WHICH I WAS INVOLVED, REQUIRED A NUCLEAR REACTOR TO PRODUCE PLUTONIUM, A NEW FISSIONABLE MATERIAL – ELEMENT 94, THAT DOES NOT OCCUR IN NATURE. ALSO REQUIRED WAS A CHEMICAL PLANT TO SEPAR ATE THE PLUTONIUM FROM THE DEPLETED URANIUM AND THE DANGEROUS RADIOACTIVE FISSION PRODUCTS, WHICH HAD TO BE STORED. IN UNDERGROUND

TANKS COVERED BY ABOUT 10 FEET OF DIRT. THE MAIN FACILITY WAS IN WASHINGTON STATE ABOUT 300 MILES EAST OF SEATTLE. AT OAK RIDGE, AT A FACILITY CALLED CLINTON ENGINEER WORKS, WAS A PILOT PLANT FOR ALL THIS AND A TRAINING SCHOOL FOR ABOUT 150 YOUNG ENGINEERS WHO WOULD OPERATE THE WASHINGTON-CALLED HANFORD PLANT.

ALL THREE SYSTEMS ULTIMATELY WORKED!! OF THE TWO BOMBS DROPPED ON JAPAN, ONE WAS U-235, THE OTHER PLUTONIUM. THE THERMAL DIFFUSION PROCESS IS STILL USED TO ENRICH URANIUM. A CENTRIFUGE PROCESS WAS ALSO CONSIDERED BUT NOT PURSUED BUT TODAY IS COMMERCIAL

Insert description of arrival , and life at oak ridge

THE DAY CAME TO HEAD WEST TO RICHLAND BUT I DIDN'T CARE FOR THE RULES. NO FAMILIES WERE TO GO UNTIL HOUSING WAS AVAILABLE, WHICH MEANT MARY AND A BABY WOULD HAVE TO TAKE THE LONG TRAIN TRIP ALONE. DRIVING WAS OUT OF THE QUESTION BECAUSE OF GAS

RATIONING AND TIRES. THE COMPANY PLAN CALLED FOR EVERYTHING TO GO BY RAIL FAMILY, AND CAR. SO I CONTACTED MY UNCLE JOEL BOONE WHO WAS HEAD OF THE NAVAL HOSPITAL IN SEATTLE AND HE FOUND MARY A PLACE SAW MARY UNTIL WE GOT HOUSING BECAUSE I WAS WORKING A SIX AND LATER SEVEN DAY WEEK AND SEATTLE WAS 300 MILES AWAY.

SO WE TRAVELLED OUT TOGETHER TAKING AN OVERNITE TRAIN TO CHICAGO WHERE DUPONT HAD A FULLY EQUIPPED TRANSIT CENTER WITH COTS, BABY SITTERS AND FOOD FOR FAMILIES WAITING TO CATCH THE NITE TRAIN FOR A 52 HOUR RIDE TO SEATTLE.. THE TRAIN ONLY SERVED 2 MEALS A DAY BUT MARY WAS NURSING THE BABY SO WE HAD NO PROBLEMS WITH FORMULA .AND WERE IN A COMFORTABLE COMPARTMENT.

AFTER GETTING MARY SETTLED I TOOK THE TRAIN BACK TO RICHLAND WHERE I GOT MY FIRST TASTE OF THE CONFLICTING RULES GOVERNING SECURITY. AT OAK RIDGE, AND IN KEEPING WITH A PREFERENCE FOR FREE FLOW OF

INFORMATION, WERE TOLD EVERYTHING . WE EVEN HAD
WEEKLY BRIEFINGS ON THE LATEST INTELLIGENCE \\
REPORTS. ANY NOTES WERE WRITTEN IN A BOUND
CLASSIFIED SECRET NOTEBOOK WHICH WAS LOCKED IN A
SAFE EVERY NITE..