

WHICH BRINGS US BACK TO NUCLEAR FUSION WHICH OCCURS MOST READILY OR EASILY ONLY IN CERTAIN ISOTOPES OF THE HEAVY METALS SUCH AS URANIUM AND THORIUM IN WHICH IT HAS BEEN OBSERVED. THE NUCLEAR FUSION OBSERVED IN URANIUM IN THE 1930S, WAS FOUND TO BE ONLY AN ISOTOPE OF URANIUM WITH WEIGHT OF 235- OR URANIUM 235. MOST URANIUM IN NATURE HAS WEIGHT 238 -- 9.3% - SO TO BUILD AN ATOM BOMB, THE JOB WAS TO SEPARATE THE TINY 0.7% U-235 FROM NATURAL URANIUM.

SO LET'S TALK ABOUT HOW THE UNITED STATES GOT IN THE BOMB BUILDING BUSINESS. IN THE EARLY 40S, SCIENTISTS THAT WERE CONCERNED THAT HITLER WOULD DEVELOP AN ATOM BOMB - A LOGICAL ASSUMPTION SINCE THE MAJOR DISCOVERIES HAD BEEN MADE BY GERMANS - PERSUADED ALBERT EINSTEIN TO WRITE DIRECTLY TO PRESIDENT FRANKLIN ROOSEVELT URGING A U.S. PROGRAM. ROOSEVELT ACTED BY CREATING WHAT WAS KNOWN AS THE MANHATTAN PROJECT UNDER DIRECTION OF THE U.S. ARMY CORPS OF ENGINEERS AND BOSSED BY GENERAL LESLIE GROVES. WE WERE NOT YET IN THE WAR, BUT THE PROGRAM WAS WELL UNDERWAY BY PEARL HARBOR.

FROM HERE ON, WE'LL TELL THE BOMB STORY FROM A PERSONAL EXPERIENCE POINT OF VIEW. MY FIRST JOB AFTER GRADUATING WITH A CHEMICAL ENGINEERING DEGREE IN 1940 WAS WITH DUPONT IN CHARLESTON, W.VA. 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, W.VA. WITHIN THE PLANT GATES, A NEW AREA WAS UNDER CONSTRUCTION CONSISTING OF WHAT ANY CHEM ENGINEER WOULD THINK WERE 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 POSSIBLE 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 CLOSEMOUTHED. 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.

3. ONE DAY, BEN, ONE OF THE ENGINEERS IN OUR SHARED OFFICE, CAME IN AND PUT ON HIS HARD HAT SAYING - “COME ON, THEY ARE CLOSING THE FENCE ON THE BUBBLE GUM AREA. IT’S OUR LAST CHANCE TO FIND OUT WHAT IT’S ABOUT”. WARILY, I DECLINED. AN HOUR LATER, THERE WERE A SERIES OF INCREASINGLY FRANTIC TELEPHONE CALLS FOR THE ABSENT BEN

WITH THE FINAL ORDER TO REPORT TO THE BOSS IN THE SEPARATE MAIN OFFICE. WHEN HE CAME IN, HE TURNED WHITE AND LEFT. WHEN OUR CARPOOL LEFT THE PARKING LOT AT 5:30 THAT DARK WINTER EVENING, BEN'S WAS STILL WAITING FOR HIM. NEXT DAY, MEMBERS TOLD US THAT HE DIDN'T SHOW UP UNTIL AFTER SIX AND WOULD GIVE NO REASON FOR BEING LATE.

I TELL THIS STORY -- OF WHICH I GOT THE DETAILS MUCH LATER FROM THE SAME BOSS WE HAD THEN - BECAUSE IT HAS A HUMOROUS SIDE AS WELL AS A PRACTICAL ASPECT THAT FITTED THE FBI ABILITY TO INVESTIGATE WHICH TOOK ABOUT 90 DAYS. 90 DAYS WAS TOO LONG TO WAIT SO THE FBI ACCEPTED THE CERTIFICATION OF THE PRIVATE COMPANY - IN THIS CASE DUPONT - AND CONDUCTED THE INVESTIGATION LATER.

WHAT BEN HAD DONE - WHICH CAUSED SUCH AN UPROAR IN THE FRONT OFFICE - WAS TO WANDER INTO THE ALREADY ACTIVE ANALYTICAL LABORATORY AND READ PROCEDURES FOR DETERMINING THE % HEAVY WATER IN SAMPLES. HE HAD BEEN CHALLENGED, AND HIS BADGE NUMBER REPORTED TO THE FRONT OFFICE. THE ARMY INTELLIGENCE PEOPLE WERE OUTRAGED AND

WANTED TO LOCK HIM UP FOR THE DURATION - MY BOSS, HIS ALSO, ARGUED HE WAS ONLY NAÏVE AND HARMLESS - LEAVE HIM ALONE BUT INVESTIGATE HIM ANYWAY. THAT COMPROMISE ALMOST FAILED IN A FEW DAYS WHEN THE FBI FOUND THAT BEN WAS A HAM RADIO OPERATOR. THE SOLUTION WAS TO TRANSFER BEN INTO THE SECRET PROGRAM -- A MOVE FOR HIM THAT PUT HIM IN ATOMIC ENERGY ACTIVITIES FOR MOST OF THE REST OF HIS DUPONT CAREER.

4. I GOT MARRIED TO A SENIOR IN WVU -- A SCIENCE MAJOR - AND DISCOVERED THAT SHE WAS FAR AHEAD OF ME IN SCUTTLEBUTT ABOUT ATOMIC ENERGY AND ATOM BOMBS. WE SPECULATED THAT FRIENDS WHO WERE TRANSFERRED TO THE STATE OF WASHINGTON TO A SECRET PROJECT WERE SO INVOLVED.

5. TALKING TO ONE SUCH FRIEND WHEN HE CAME BACK TO GET HIS FAMILY, I HEARD HIS COMPLAINT ABOUT THE LONG DRIVE FROM TOWN TO WORK -- 40 MILES, HE SAID. I SAID - WELL, E EQUALS MC SQUARED - HIS RESPONSE "RIGHT" WAS PERFECT CONFIRMATION THAT MARY AND I HAD BEEN GUESSING RIGHT.

FINALLY, IN JULY 1944, MY CALL CAME. A FELLOW EMPLOYEE WHO GOT THE SAME SUMMONS TRIED TO AVOID IT, SAYING HE HAD ILL PARENTS HE COULDN'T LEAVE. THE STRONG ARM RESPONSE WAS -- YOUR JOB HERE HAS BEEN ELIMINATED -- YOU MUST GO.

MY INSTRUCTIONS WERE TO REPORT TO AN ADDRESS IN KNOXVILLE, TENNESSEE WHICH TURNED OUT TO BE AN OLD AUTO SHOWROOM FUNCTIONING AS A VERY BUSY EMPLOYMENT OFFICE FILLED WITH SCHOOL DESKS AND PEOPLE FILLING OUT FORMS. I WAS GIVEN A PACKAGE ALSO AND DIRECTED TO SIT IN A CERTAIN PART OF THE ROOM. I SOON DISCOVERED MY NEIGHBORS WERE DUPONTERS ALSO FROM OTHER LOCATIONS THOUGH I KNEW NONE OF THEM. A QUESTION ON MY FORM INQUIRED REGARDING GERMAN RELATIVES AND VISITS. WHEN I TURNED IN MY FORMS THAT PRODUCED A PACK OF MORE DETAILED QUESTIONS. FINALLY, WITH LUNCHTIME APPROACHING, WE WERE TRANSFERRED TO A CORPS OF ENGINEERS STRETCH-OUT 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 U-235 FROM THE REST OF NATURAL URANIUM.

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

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

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 NATIONAL WEALTH TO DEFEATING HITLER'S GANG.

BEFORE DISCUSSING WHAT THOSE THREE APPROACHES WERE, LET'S DISCUSS THE ROLE OF HEAVY WATER IN THE PROGRAM. AWHILE 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 OF U-OXIDE. TODAY, NONE ARE, BECAUSE OVERHEATING CAN CAUSE A FIRE, WITH DISASTROUS RESULTS AS AT CHERNOBYL IN RUSSIA WHERE THE REACTOR WAS ALSO NOT ENCLOSED IN A CONTAINMENT VESSEL.

LET'S TAKE A BREAK FROM SCIENCE TO TELL A TRAGIC THOUGH HUMOROUS STORY ABOUT GERMANY ATTEMPTS TO GET HEAVY WATER.

EARLY IN THE WAR, GERMANY INVADED NORWAY. AT A PLACE CALLED TRONDHEIM WAS A UNIQUE PLANT FOR MAKING AMMONIA, AN ESSENTIAL STARTING POINT IN MAKING ANY EXPLOSIVES. THE PLANT WAS UNIQUE BECAUSE IT USED CHEAP NORWAY HYDRO POWER TO ELECTROLYZE WATER TO GET HYDROGEN AND OXYGEN. IF YOU ELECTROLYZE WATER UNTIL IT IS ALMOST GONE, YOU'LL FIND THE RESIDUE HAS A HIGHER HEAVY



WATER CONTENT. SAVE THOSE RESIDUES AND ELECTROLYZE AGAIN, AND YOU'LL GET EVEN HIGHER CONTENT UNTIL EVENTUALLY YOU'LL GET PURE HEAVY WATER. AMERICAN ATTEMPTS TO ISOLATE HEAVY WATER USED A COMBINATION OF DISTILLATION AND ELECTROLYSIS - HUGE FACILITIES AT THREE DIFFERENT LOCATIONS THAT, IN THE END, PLAYED NO PART IN THE U-235 PROGRAM.

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

BUT U.S. INTELLIGENCE KNEW, THOUGH WE DID NOT KNOW, THE LOW PRIORITY OF THE GERMAN ATOMIC BOMB PROJECT. AS WE FOUND OUT LATER, HITLER HAD PUT MOST OF HIS "HI TECH" SPACE AGE MONEY INTO ROCKETS - THE V1 AND V2. AS A RESULT, THE ALLIES MOUNTED A FURIOUS EFFORT TO SHUT DOWN THE HEAVY WATER EFFORT.

SABOTAGE WAS TRIED, AND A DISASTROUS FAILED 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 TO CRASH LAND IN THE WATER TO GET PICKED UP.

THROUGHOUT, THE GERMAN MUNITIONS ADMIN WERE BAFFLED - WHY WAS THIS AMMONIA PLANT WAS 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 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 GASEOUS 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 SEPARATE 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-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, FURNITURE AND CAR. SO I CONTACTED UNCLE JOEL BOONE, WHO WAS HEAD OF THE NAVAL HOSPITAL IN SEATTLE, AND HE FOUND MARY A PLACE TO STAY WITH BABY JOHN. IT TURNED OUT THAT ALTHOUGH WE GOT TO TRAVEL TOGETHER ON THE LONG TRAIN TRIP, I NEVER SAW MARY UNTIL WE GOT HOUSING BECAUSE I WAS WORKING A SIX AND LATER SEVEN DAY WEEK AND SEATTLE WAS 300 MILES WEST.

SO WE TRAVELED OUT TOGETHER TAKING AN OVERNIGHT TRAIN TO CHICAGO WHERE DUPONT HAD A FULLY EQUIPPED

TRANSIT CENTER WITH COTS, BABYSITTERS AND FOOD FOR FAMILIES WAITING TO CATCH THE NIGHT 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, IN KEEPING WITH A PREFERENCE FOR FREE FLOW OF INFORMATION, WE 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 NIGHT.