THOSE WONDERFUL MEN WITH THEIR WELDING MACHINES

INTRODUCTION

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There are only a few men in this world who have earned the right to act as spokesman for any group of people. One of these is, I believe, Leon D. Richardson, (Don, to all who know him).

Don Richardson, author of "THOSE WONDERFUL MEN AND THEIR WELDING MACHINES", is, foremost, a welder. He has been a welder for more than half a century. He knows and counts many welders as his closest friends.

He has personally known, and been a part of those important few men, who have contributed much to the advancement of welding during the last fifty years.

Don has long held the belief that welders have not received the recognition that they justly deserve. In short, he believes that welders have made considerable contributions to the advancement of man's living standards. The newspapers repeatedly publish articles about lawyers who brilliantly convince or confuse; of glamourous racing drivers who win prestigeous races; of accountants who juggle figures to reduce their clients' taxes; of chefs who prepare splendid gourmet foods; of tennis stars who win Wimbledon; and yet ..... of the welder, they say little. The welder who salvages a huge piece of equipment, or repaired a dangerous girder on a bridge (which would otherwise have cost lives), or repaired a pump housing at an electric station, or who simply put together again a child's school chair that had broken ------ this man remains largely unknown and unheralded.

These men, Don calls the "forgotten welders". These same men have, over the decades, made tremendous sacrifices and improved man's lot are all but forgotten.

Has Don earned the right to be spokesman for this group of forgotten people ? You be the judge .....

Don has welded galvanized iron in the double-bottom of large ships --- and had to drink milk for days on end to clear his system of the harmful zinc fumes ingested. He's welded ship plating through more than 20 coats of paint. In the Arctic, he has welded steel pipe while the heat of the torch rapidly melted the "permafrost" and gradually caused him to sink 25 feet lower into the ground than from the level at which he began.

Don has been down coal mines in Pennsylvania, West Virginia, and Canada and welded in these bowels of the earth. He's welded a few miles into the earth's crust in the South African gold mines. He has welded three miles and up to seven miles out ---- under the seabed in Newfoundland.

He's repaired broken diesel engines for the U.S. Air Force at Thule --- just a stone's throw from the North Pole ! "The temperature," quipped he,"was about a hundred degrees below zero!"

He's welded pipe in Oklahoma that had oil and gasoline running through it ! Over a period of time, he was called on to complete welding operations at no less than 32 U.S. Air Force bases. He also did welding work at the S.H.A.P.E. (Supreme Headquarters, Allied Powers in Europe) in Paris. Once, during the war, he welded 60-hours non-stop to get the damaged hospital ship "Martinique" repaired and back into service.

Don was called to the White Sands Proving Grounds in New Mexico where he helped put leftover German V-2 rockets into space (see also Chapter Eight). He welded at Los Alamos, New Mexico, where the first atomic bomb was exploded. He went to the Wright Aeronautical Center on countless occasions to help design future aircraft welds.

Somewhere in-between all these historical and monumental firsts, he found time to write the Air Force Manual on Tool and Die Welding.

During the latter stages of the Second World War, he welded the porous nickel barriers on the converters that separated Uranium 235 at Oak Ridge Tennessee. These converters were ultimately used to extract the U-235 to make the two bombs that ended World War Two. Don had solved problems that had never been attempted before and worked at Oak Ridges' all-important K25 and Y10 Plants.

He welded the famous atomic "cyclotron" magnets that had enough strength to literally yank an automobile off the road ---- from six blocks away !!! For the U.S. Navy, Don welded at the ocean's bottom, off Puerto Rico. He welded beryllium (formerly said to be impossible to weld), in the famous wind tunnel in Tennessee. At the Y10 plant, Don performed welding work on the U.S. Navy's "heavy water" atomic plant. Similar work was also performed in Washington.

It was said that Don's welding prowess was so great that he could weld cracked church bells .... and still retain their original timbre and tone !!!

Don wrote the manual for welding leg and spine braces from spring steel (for polio victims). And he's conducted hundreds of seminars - teaching farm youth to weld.

Back in the "good ole days", he arc welded with a welding machine that simply consisted of a barrel of salt water with the current running through it. When he needed more amperage, he added more salt. When he needed less, he simply added more water !!!

Many years later, he welded at NASA and was linked with research for the U.S. space program.

In Bolivia, some 17,500 feet up, he conducted enthusiastic welding demonstations (while taking occasional "swigs" from an oxygen mask !) Don mentioned in passing that there was very little of himself that doesn't show scars caused by molten weld metal burns. He also lost count, years ago, of how many times he had suffered electric arc eye burns.

Indeed, Don's involvement in welding has taken him to just about every country in the world there is. He is truly, the welder's friend. He, of all people, knows welders, and their problems first-hand. He knows and understands how difficult it is to weld without a helmet in "tight" areas. He knows what it is like to use three sticks of electrodes - welded together end-on-end, to reach that vital, distant and almost inaccessible point.

Perhaps, most of all, Don knows and understand the accomplishments of welders.

This series of mini-manuscripts are not really about one man - it is an ode to the intrepid ranks of welders worldwide - who remain the unsung heroes of industry and of mankind's progress.

Robert E. Castilho
Editor

IN HOMAGE TO WELDERS

In this world of great mechanics, there is something out of place ..
And it is the lack of recognition - a fact we all must face.
Among the various tradesmen who have moved our world ahead,
There is a missing praise - to welders - a credit left unsaid.

Through the pace of ancient legend. Through the space of time and age,
There is, to me, an admiration - on the ancient, historied page.
Though the welder's trade be ancient, and the welder's art be old,
The fullest fame that is fully deserved, is omitted --- and untold.

..... But t'was not always so .....

The saga of this legend, gathered the people all around
And there arose contention, whether one man could be found....
To whom the coat of honour .... on whose shoulder should it rest ?
Which of all ye gather'd tradesmen. One who's art was deemed the best.

Then they pass'd a solemn judgement, and all pointed to one man
Who with anvil, arc and torch had sculptured progress with his hand.
Thus the progress of all mankind was a fact --- could never be !
If t'were not for the welder man, who made it certainty.

And upon a stone of honour, he was crowned the leading man.
All to him gave praise and homage, and proclaim'd him "Artisan".
Just a simple crown they gave him yet, vast homage did they pay
And the prestige of that judgement MUST be resumed now, this day !

The wisdom of pronouncement seems to hold -- for me -- no doubt.
I often think and wonder how the welder, did he come about.
One must look with closer view to the welder of today,
And see him with new honour, and to that honour pay.

The electrician waits on circuits, till the welder joins the wire.
The pilot remains grounded, till the welder uses fire.
Can mechanic start his engine ? Not till the welder workd his art.
Without power through the systems -- when the pieces left apart.

Can the chauffeur drive his truck ? Not till the baseplate has been seal'd.
And can the miner mine for ore ..... not with his equipment yet anneal'd.

And the answer, the answer MUST be NO.

The welder is a quiet man who asks for nothing more
Than to shield behind his mask to knock - on progress' door.
Come -let us praise our modern welders ! And silent homage to their trade.
For without this man so basic, tomorrow's world .... unmade.

Without his art --- and his industry, with his strong hands and his heart
Our dependency on iron and steel, t'would surely fall apart.....

by Leon D. Richardson

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THOSE WONDERFUL MEN WITH THEIR WELDING MACHINES

PART ONE

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THE HISTORY OF WELDING

Most people think of welding as relatively new. They classify it along with electronics and ultrasonic devices such as radio and television and as something modern --- of the 20th Century.

Actually welding is an ancient art. Man learned to weld metals many centuries before the time of Jesus Christ. There are numerous welding references in the Old Testament of the Bible, one even in the Book of Genesis, and one in the second Book of the Bible.

I believe gold was the first metal welded for two reasons. Firstly gold is the only metal that is found in its natural state. And ancient man found nuggets of gold in a pure state which did not occur with any other metal. Secondly, gold does not tarnish. It is the easiest of all metals to weld. A simple experiment to prove this is to take 2 pieces of goldleaf. They will weld themselves together at ambient temperature with only contact pressure. All you really have to do to weld two pieces of gold together is to bang them and they will stick to each other. Ancient man, no doubt, welded gold using only a stone as an anvil, and another stone as a hammer.

Silver may have also came to man in its natural state. In the early 1950's, I was working as a consultant for a short time for the mines at Cobalt, Ontario. (In addition to minerals, Cobalt, they also mined very pure silver). In most of the world'silver is a by-product of mining other materials, such as copper. The silver is never actually seen until the ore is smelted.

At Cobalt, Canada, I found by experience that I could pick up a piece of stone and rub my fingers on the stone and tell if it had silver in it or not. I further found that I could put this same stone on an anvil and,

with a hammer, pulverize the stone. However the high content and nearly pure silver would hang together, and the rock dust could therefore be discarded as waste.

Many years later, I also found in Broken Hill, Australia, that I could determine just by my blind feel of the rocks, those which contained silver. Again, if pulverized with a hammer the rock would end up as pulverized dust but the silver would hang together. I found the same results in the State of Pachuca in Mexico, whilst visiting the many silver mines in that area.

While it has never been recorded in any text book I have read, I do believe it is possible that ancient man learned to tell stones which contained silver, just as I had, by the feel. They could then extract the silver from the rock with nothing more than a hammer. I believe they then, with low heat, forged the silver and gold together, welding it by hammering it, at a plastic state, into an alloy.

This belief is reinforced by reports that in the royal tombs at Byblos, archaeologists have found axes made from electrum, statuettes of gold, and fine gold and silver Phonenician Jewelry. These items date back nearly 40 centuries.

There is also a remarkable collection of electrum tools and axes in the National Museum of Archaeology in Beirut, Lebanon, which have been dated about 1800 B.C.

Electrum is an alloy which is 75% gold and 25% silver. The silver hardened the gold to a point that it made a satisfactory tool. In seeing these axes of electrum, it does not appear that they were cast. It appears the two metals, gold and silver, were welded together with the Forge Welding Process. I believe they heated the two metals over coal or charcoal,

perhaps fanning the flame with air, and they became hot enough to forge together with repeated hammer blows until the two metals became one --- in other words they were alloyed by welding, rather than being alloyed by melting which is the normal process today. It proves once again, that welding is a very ancient art.

Before we get too far into this subject of welding we had better define what welding is. I define welding as "the joining of 2 or more pieces of metal with or without heat and pressure". Of course, most welding requires one or the other - heat or pressure - and usually both. How does this phenomena occur?

When metals are placed close enough together and heated, under certain conditions they form intimate atomic linkages that bind each other together --- across the joint.

Why does a plate of unwelded steel hang together in one piece? Because of the inter-atomic forces --- one atom pulling at another atom in the metal. Welding is the same except that the inter-atomic forces have to come into play across a joint. The blacksmith achieved his weld with a combination of heat and pressure. He heated steel parts until they were malleable and then pressed them together and the inter-atomic forces held them together. The two parts each had particles of metal that intermingled across the joint. Particles of matter, so to speak, shook hands across a frontier.

I have always felt the latins have a better view of welding than we English-speaking people. When we think of welding, we think of the act of joining metals together. In other words, we have the process in mind. We even say 'weld', 'braze', or 'solder', and if we say: "we solder something", we imagine the process of joining metals with a third metal, melting below 1,000^{o}F.

When a Frenchman refers to welding he 'souder' the two pieces. The Frenchman does not refer to the process, as the English-speaking person does. He refers to the objective, the end result, which is to "solidify". To a Frenchman the objective is to make something solid. The same with a Spaniard with the verb "soldar" meaning "to weld" and also to solidify.

The English word "weld" comes from a modern corruption of the word 'well'. This means to 'boil', to well out of the earth, to bubble. This corruption. of the word 'well' into 'welding' occurred about the 15th Century and it conveys the meaning; 'to liquefy' while the French word for welding conveys the meaning 'to solidify'.

The Frenchman is trying to make something solid. The Englishman is trying to make something liquid. I believe the French are right. We should never forget that we really are trying to make something solid --- not liquid.

Welding, as I stated earlier, is a very ancient process. One of the best examples of ancient welding is the famous iron column at Delhi, India. The weight of the column is about 6 tons, but it was made by welding small casts of only a few hundred pounds each, together. This column still stands today yet the column was erected about the time that Christ lived. The welded pieces form a column 24 feet high and the welds have held for many centuries. The iron column has pillars 62 feet long by 16 inches in diameter, made from individual bars about 20 lbs each.

HISTORICAL SIGNIFICANCE

A little epileptic camel driver who led the faith of Allah --- a little horse with the stamina of a Sherman tank and the fleetness of an arrow --- and knowledge of metallurgy, welding and blacksmithing (almost equal to our 20th Century Knowledge), all combined to change the history of the world five centuries after the crucifixion of Christ.

The camel driver's name was Mohammed. He devoutly prayed for countless hours in the unrelenting desert heat and he often suffered epileptic seizures which were accompanied by the "sound of bells". He was convinced that the great God Allah was revealing to him the ultimate truth. Mohammed was transformed and strengthened by these divine revelations. He lectured a new Faith, which was to one day be embraced by one-eigth of the world's people.

Mohammed preached, "There is no God but Allah and Mohammed is his prophet". The Word spread like wildfire and organized the fierce, illiterate, tough Bedouin tribes into a united group for the first time. The "Praised One" in his brief lifetime, originated the Koran which promised instant paradise to any warrior who was killed in battle on behalf of the Faith.

Arabic nations, under their unified faith of Islam, became the greatest welders --- the greatest blacksmiths --- the greatest scientists that ever lived.

Allah himself created the Arabian horse with 'a handful of the Southwind', and stated "I create thee, oh Arabian, I give thee flight without wings". Anyone who knows horses must realize that the blood of this divine horse is like the rare elements of fine steel. The Arabian horse became a "Daughter of the Southwind" which was a whirling dervish in battle against the unbeliever --- wheeling, reeling, dodging, starting and charging a wall of steel and, to their very death .... always obedient.

THE SWORD OF DAMASCUS

The Faith, however, needed more than Mohammed, more than a Pegasus without wings. It needed a weapon.

The 'Sword of Damascus' was magical. It made the Islamic warrior invincible. Allah, himself, must have inspired a new type of blacksmith who could mould steel, forge it, and weld it as had not been done before.

The Arab Poet AUR B. Hajor, said of this first truly great welded piece: "It has water whose many gleaming streaks are glistening --- It is like a pond over whose surface the wind is gliding --- The smith has worked out in it a grain as if it were the trail of small black ants that had travelled over it while it was still soft".

The Damascus Sword was not made of female iron, which, as everyone knew was too soft and could not be hardened. It was made of fashioned male iron.

The Egyptians had placed a taboo on iron but the Arabians knew from Mohammed's teachings that iron was the gift of Allah and was meant to be used. The Islam people did use it.

The Sword of Damascus was perhaps the greatest welding work of all time. They were supple enough to be bent from tip to hilt without fracturing. They were sharp enough to cut through a silk handkerchief and strong enough to cut through armour. Damascus is the oldest city in the world and it is perhaps only proper that it should make such a great contribution to man's knowledge of welding.

The Damascus Sword steel was a closely guarded secret for many centuries.

Before 1300 B.C., the great "crucible process" for steelmaking was invented in Western India in Hyberdad. This great steel had unrivaled competence because it was made of carburized iron. This unique steel was subsequently shipped to ancient Syria where craftsmen hammered, welded, and tempered the steel and formed it into the great Sword of Damascus.

The Sword of Damascus was made from "KUS cakes", which was steel produced on a fired charcoal hearth, from about one half kilo of malleable iron, cut into small pieces. The fire contained about 10% of dried wood in clay crucibles, and the covers were looted with clay. The Kus cakes

were made from black magnetite sand (ore) thoroughly crushed, and the small pieces were first washed. In Damascus they used a small oven less than five feet in height into which clay tubes had been inserted at the lower area to benefit from and air blast from two or more sheep skin bellows.

When the furnace was hot, they sprinkled the ore onto the charcoal. No flux was used. The melted "bloom" of the iron was removed from the furnace and then hammered continuously for a long period of time into bars approximately 3½ inches thick, 12 inches in length, and 1½ inches wide.

These bars were then cut into smaller pieces weighing about one kilo, and then packed in clay, inside bamboo shoots. The top was sealed with fresh clay. These were then placed in a charcoal furnace for 20 or more hours. The iron absorbed enough carbon from the bamboo to become fluid. The crucibles were then removed from the furnace and broken open not unlike 'piggy' banks. The precious high carbon steel now existed. These cakes were then hammered into discs about six inches in diameter by Aryan Indians.

The "Damascus Sword" was then welded by hammering a pile of alternate bars of steel and iron, then reheating and hammering time and again until the desired thickness had been reached.

About 25 alternate bars of iron and steel about 2 feet long were welded into ingots. These were about five feet long and 3/8 inch square. Each piece was then heated to a cherry red, and one end twisted while the other end was held rigidly in a vise. The twisting made it cylindrical and shortened it to about a meter in length. Two pieces were then turned in diverse positions (one to the left and one to the right) and laid parallel and flattened and welded with heat and the hammer. With these

operations the alternations of steel and iron would change places at each half revolution of the square rod. The 25 laminates formed a mass in which the external layers were wound around the internal ones and thus forming, after being flattened into a ribbon, regular eccentric ovals or circles.

This great welding feat united the fanaticism of the Faith. The fierce nomads charged out of the desert like a whirlwind reincarnated, with the aid of the fleet-footed Arabian horses. With their deadly Saracen blade they conquered and converted all of Arabia.

Mohammed did not live long. When he passed away, his followers used their welded Damascus Swords and their Arabian horses to cut a swathe through Portugal,Spain, North Africa, the Byzantium Empire, Persia, Egypt and Syria and on even to the Isle of Cyprus in the Mediterranean. In less than a century, the Flag of Islam reigned from the gates of China and India to the Pyrenees on the Atlantic. They then tried to conquer Europe, but in 732, Charles the Hammer crushed their hopes at the Battle of Tours.

THE CRUSADERS BLADE

The next adventure in metallurgy came with the Crusades. Pope Urban the Second's (1042-1099) declaration of the defence of Christ against the "Turkish Infidel" set afire the imagination, zeal and loyalty of Knights, Serfs, Kings, Counts, Barons Knaves and even convicts and criminals, all over Europe. Even the dreaded Vikings, or Norsemen, were converted to the holy cause defending christianity against the savage and barbaric Moors.

The necessity of proper metallurgy, blacksmithing and welding (I personally consider the three as being only one art --- one cannot function without

the other two) was thoroughly proven in the first of the Ten Crusades. This occurred in about 1000A.D., when King Clovis was converted to Christianity, and he crowned Charlemagne Emperor of the Holy Roman Empire.

This first Crusade freed Jerusalem from the 'Infidel'. It succeeded because of Metallurgy (and its twin brothers, 'welding' and 'smithing'). This Crusade was led by iron men with Hudge horses and Knights mailed with armor weighing more than they did. They used heavy welded, broad swords. The Moslem light sword could not overpower the heavy swords. The Arabian horses were fleet but could not maneuver when the Islamic Warrior started carrying armor that weighed as much as 400 lbs. The metallurgy and horse that brought victory to the Moslems for a century was outmaneuvered by the metallurgy and horses of the Christians during the Crusades.

The Arabians (and Moslems as a group) had made a great contribution to science in many important ways without which modern science, as we know it, could not exist. They borrowed numerals from the Indians but it was the Arabs who put the cipher in and simplified it. The Arabs were great metal workers and scientists.

They gave symbols to hundreds of metals and chemicals. It is interesting to note that even in the early centuries, the Arabs had identified and used glass, hydrochloric acid, borax, mercury, amalgam, ammoniac salts, iron vitriol, iron fillings, gravel, lead sulphate, brimstone, magnesia, lime, metal lime, minium, nickel, arsenic, sulphur, antimony, gold, and acid. Even more interesting, they had symbols 15 centuries ago for hundreds of elements and combinations of elements.

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WELDING BY FORGE

Forge welding was the "modern" means of welding, and was practiced as far back as 30 Centuries ago and may have been in use 50 Centuries ago! Forging was so important to the ancients that one Roman god "Vulcan", god of all fire, was attributed great ability at the Forge. The Greek god Hephaestos was also of great importance as a blacksmith. I visited the tomb of Tutankhamen at the Cairo Museum nearly 20 years ago, and from his tomb and on display was an iron head-rest which had been welded. This must have been welded about 1350 years B.C. I am also told that the framework for the Collossus of Rhodes contains about 135 iron bars welded together, and weighs about 7 metric tons. This is probably the first large welded structure and was welded about 280 B.C.

When I was a boy and also later as a young man, every industry had a blacksmith and a forge. Today the forge is practically non-existent, except at race tracks and occasionally one is to be seen at an isolated workshop, (generally in a rural area). To me, seeing the forge I know so well become a collectors' item is like a part of my life disappearing. Something is missing.

WELDING PROCESSES

Soldering and brazing widely used by the ancients in many parts of the world including North Africa, China, Japan and Southern Europe and were well known arts by the time of the Roman Empire. Just for the record let me explain these three processes as it is strange how many people do not know the difference between the basic 3 welding processes:-

Soldering: Joining of two or more parts with a dissimilar filler metal having melting temperature below 1,000°F.

Brazing : Joining of two or more parts with a dissimilar filler metal having a melting temperature above 1,000°F.

Welding : Fusion joining two or more similar metals with or without a filler metal and with or without heat and pressure.

Thus it may be seen that the three methods of joining are quite distinct from each other. Some marketing companies have used the term "Low Temperature Welding" but this is, in reality, only a sales gimmick because actual welding, as it is defined, cannot exist but is merely an unsupported claim. There is, of course, "Low Temperature Brazing" and "Low Temperature Soldering" but "Low Temperature Welding" is a misleading marketing claim that tends to confuse more than clarify.

Most people think of platinum as a metal akin to gold. However, while gold was probably the first metal to be welded, platinum was one of the last. I have never welded gold in my entire life, but I have welded platinum many times in glass factories and other industries where it is used. I have found platinum to be the easiest of all metals to weld. Actually gold and platinum are not closely related except that their specific gravities are about the same. Platinum is closely related to rhodium, ruthenium, palladium, osmium, and indium. Until the 18th Century, platinum could not be welded because there was no way to melt it, due to its high melting point.

While the ancients may have known of platinum, this metal was probably discovered (as far as history knows) by Central American Indians. It was found in considerable quantities in Honduras, Panama, and Colombia. When the Spaniards came, in the 16th Century, they found the Indians making Jewelry from it. The Spaniards named the metal "Platina del Pinto" meaning "Silver from the Pinto River". Later the latin and English changed the name to "Platinum" and Germans changed to "das Platin".

Casanova, whom history records as a great lover, was actually a scholar of considerable note. In his, "Memoirs of Casanova" he records that shortly after he escaped from prison in Venice, he went to Paris. In 1757 he had an affair with a wealthy woman, the "Marquise I'Urfe" who was interested in alchemy and who claimed she could transmute base metals into stone. She demonstrated to Casanova the melting and welding of Platinum by means of a concave "burning mirror". Casanova also reported that platinum is precipitated from solution by ammonium chloride, whereas gold is not, and that Platinum is not attacked by sulfuric, nitric, or hydrochloric acid.

This brief resume' brings us to the Modern Times, the 19th Century where welding, as we know it today, started.

MODERN WELDING

My earliest memories go back to 1921. My uncle, Ed Richardson, was Chief Engineer of the National Refinery Company in Coffeyville, Kansas. My father, Paul Richardson, was "Master Crude Stillman" in the same oil refinery. It was the custom in those days for the operating executives to live on the premises of the Industry. We lived in a huge, red, brick house located inside the Oil Refinery. My uncle's family lived downstairs and my father's family lived upstairs.

As a child I would stroll through the refinery. It was my playground. The Maintenance Department was like a magnet to me and I would often visit the workshop and watch the blacksmiths hammer white hot iron. I was hypnotized as the sparks flew everywhere and I would watch him for hours. The blacksmith's name was "Uncle Mert" MacDonald. He taught me to weld two hot pieces of metal together on the anvil with a hammer when I was 6 or 7 years old.

The first item I tried it, the steel would not weld. Uncle Mert taught me that it was most important to have the coals heaped up over the iron to allow the coals themselves to eliminate the oxygen. In this way the bars were deoxidized and welded. He taught me not to overheat the bars or I would have surface deterioration. However, he also taught me that they must be hot enough to be malleable when brought into intimate contact.

Before I was 8 years old, he had taught me how to heat-treat and harden steel by wrapping leather around it, and to put steel on white hot coals until the leather put enough carbon into the steel to make the surface liquid, and then quenching the steel in Salt Water.

Even as a child I learnt early how to tell the temperature of metal by its colour, how to make fluxes from borax and brown oxide and other chemicals. Uncle Mert even taught me how to form steel into different shapes.

I believe today just as strongly as I have believed all my life, that no man is a good welder if he has not first been a blacksmith. There are things about metal and its reaction to pressure and heat that cannot be learned from a book. There is a "feel", an inner sense of knowing, just what effect 10 more degrees of temperature and one ounce more of pressure will do to a given size and shape of steel. You can only learn this as a "Smithy". Until you learn this art (it isn't a science), you haven't learned anything about the science of welding.

Welding involves more sciences than most other arts. Welding involves the five sciences of Chemistry, Metallurgy, Electrical Engineering, Physics, and Engineering. One without the other four will fail. All five will fail without one of "Those Wonderful Men With Their Welding Machines".

In future chapters I hope to tell you what welding was like in each decade from 1920 to 1980. There were a few amusing, as well tense moments that occurred during my long relationships with welding during this half century of close contact with the art.

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THOSE WONDERFUL MEN WITH THEIR WELDING MACHINES

PART TWO

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WELDING FIRSTS

The first really great welding development was of course the forge as I already mentioned in the previous chapter. The other two processes (gas and arc welding) were evolving at about the same time. Arc welding --- strange as it may sound --- was actually discovered first, but gas welding was more readily accepted by metal workers. In fact, gas welding overshadowed arc welding to such an extent that the latter didn't achieve acceptance until many years after it was discovered.

The history books tell us Priestly discovered oxygen in 1777. Personally, I don't agree. The Chinese manufactured oxygen from burning saltpeter as early as the 8th century! They knew it was a component of the natural air even then. It was Leo Chatier who invented the process whereby oxygen was separated from hydrogen (in water) by electrolysis and that was only in 1895.

The use of oxygen as the second gas in oxyacetylene welding was established in the mid-1880's. It was however delayed in use because, at that time, no one saw any real commercial future in the production of oxygen and subsequently, no one wanted to manufacture it. Since there was no commercial demand for oxygen, it took another twenty years or so before the need came about.

In the year 1900, a liquification process was developed that economically produced oxygen. It was remarkably low-cost and, as a result, heralded the age of gas welding. This process was described by a scientific journal of the day thus:

> "The process is based on the concept that oxygen boils at minus 269^{o}F. Nitrogen boils at about minus 320^{o}F. It's a simple job of boiling the nitrogen off first and leaving the oxygen behind. The raw material is of course plentiful and free."

OXYGEN .... LITERALLY PAYING THROUGH THE NOSE!!!

On the question of oxygen being plentiful --- and free, one wonders how the producers of this gas have the gall to charge the "way out" prices that they often do. As long as I can remember, oxygen has been sold at a glutinous profit by the oxygen companies in every country. I would go so far as to say that in most countries, the oxygen companies have only achieved their unrealistic 'price' for this gas (taken from the air we breathe) by using cartels and monopolistic trading practises.

The fact is that most industrial gas supply companies practically give their welding rods and equipment away at cost or less --- in order to hold on to the oxygen business. In order to use gas welding rods, you, off course, have to purchase oxygen and acetylene gas cylinders! This is naturally extremely lucrative because the price of oxygen is exorbitantly high!

The market price of oxygen, in industry today, has become an insult to one's intelligence. Anyone who knows the low cost of making oxygen cannot believe that the prices being charged are realistic.

It is however thankfully true that the hospitals get low cost oxygen supplies --- (and focus of attention is shifted away from government scrutiny). However, there are many cases where industry, in the same country, has to pay up to ten times the price that the government hospital pays!

ACETYLENE

Oxy-hydrogen was the first of the high temperature flames. Man's ancient dream of a flame with sufficient heat to melt steel had to wait until the discovery of acetylene. The first step towards discovery began in 1836

when Edward Davey, a British chemist heated a mixture of calcined tartar and charcoal. He obtained a black substance (subsequently identified as potassium carbonate). He experimented with it and found that when this substance was placed in water, it decomposed, giving off a gas which would burn with intense brilliance.

Acetylene!

(We read that Robert Hare made calcium carbide from mecuric cyanide in 1840 but he was unable to identify it, and so we accept that Edward Davey was the inventor of acetylene).

Editor's Note: The process of making acetylene was refined by many men. Henri Moissan, Turner Morehead, Tomas Wilson and others.

It's ironic to think that the development of oxygen and acetylene was in fact perpetrated by the criminal mind. The 'safe-crackers' of 1895 (especially in France) did more for the development of flame cutting than any scientist! They refined the process by criminal safe-cracking activities.

The first safe ever 'cracked' was actually in England in 1887. However, it was the French who made the biggest 'contribution'. The incidents were of course unfortunate, but, safe-cracking was a well 'paid' occupation, and did a great deal to advertise the efficiency of oxyacetylene as a cutting process.

In 1898 the 'Acetylene Journal', which was a monthly magazine, began publication. This was later merged with the "Welding Engineer" (to which I regularly contributed many papers and articles). I believe them to be the finest welding magazine ever published. It's owner/publisher, for over a third of a century is Ted Jefferson. He is now the Dean of Welding in

the USA. We've been good friends for many many years and a recent letter from him confined that both of us are still "weld crazy"!!! He's a man for whom I have immense admiration and respect and holds some kind of record for having attended 49 Consecutive U.S. Welding Shows without a single break!! And that was at last count!!!

GAS WELDING COMES OF AGE

From 1895 on, there was no stopping oxy-acetylene welding. By 1910, practically every industry had an oxyacetylene welding and cutting rig.

As early as the early years of the 20th century, practically all common metals could be welded or brazed with the torch. By 1930, when I was 12 years old, even the smallest workshop had an oxyacetylene torch. This rig appealed to the common man. It was self-sufficient and could be used where there was no electricity. It wasn't terribly bulky - one man could move it. It cut, it welded, it heated, it soldered, it brazed, and in many a workshop it even made the coffee! I know this to be true because I have enjoyed many a can of "Mocca Java" cooked in a tin can with a welding torch. You have to have some respect for a moderately low priced rig that will do all these things.

As for me, I am mad about gas welding. Just as many men can relax whistling, or doing woodwork, and women relax sewing or embroidering, I relax best with a welding torch. I love to pick up a torch, make it "pop" real loud when I light it, and write my name with a brazing rod on a piece of steel.

I can get the same satisfaction from gas welding that many men get from catching a bass or playing golf. I have, I suppose, arc welded 100,000 hours, more or less.

To me arc welding isn't nearly as much fun. It is work. It happens so fast that it loses the fun that gas welding has.

With gas I can make beads so perfect they look machine made and it is fun to be an artist with metals (which many of Those Wonderful Men With Their Welding Machines are).

But Arc welding is sometimes fun. I love to get underneath a ship on the ways and weld shell-butt overhead in the summertime. You are outdoors, out of the heat, where it is cool, the helmet is over your head cutting out all outside influences, and the skill it requires to lay in a good weld overhead is a thrill I can't described.

It is you --- and the arc at that moment. There is no one else on this planet for a few minutes until the electrode burns down and you raise your helmet to insert a new electrode. Only then you realise there is another bloke 10 feet from you and another 20 feet, etc. But, for those few minutes, it is just you and the arc - and seeing that beautiful faultless weld go on overhead to close the ship shell-butt must give one the same feeling Michelangelo had painting the Cistine Chapel. When a welder takes pride in his work, it is an art not beneath sculpturing, painting, or the potters wheel.

As I remember Ted Jefferson saying as late as 1978: "Leon, you are just as crazy about welding as I am". Ted is right - I don't think a welder, with his helmet down, shut completely away from the rest of the world and only watching that 5000^{o}F arc melting the steel and healing it together, could ever have an evil thought in his mind. His total attention is focused on that magic arc - the flame that heals.

WELDING GOES TO WAR

The oxyacetylene process moved rapidly ahead between 1900 and World War I. It was very much more an amateurs game than arc welding and every shade tree mechanic had an oxyacetylene torch. However, it took a World War to firmly establish both processes. Up until that time there was a great deal of prejudice against welding and ignorance of metallurgy. Many engineers said, "the high heat of the arc will burn the life out of steel!"

Most of the men who marched to fight in World War I from several continents had never heard of welding. Nonetheless welding played an important role in the war. Some examples:-

(1) There was a hugh demand for steel scrap. The oxyacetylene process made it possible to segment heavy scrap used subsequently in melting pots to eventually be used for ships, guns, and tanks.

(2) When the U.S.A. declared war on 6th April, 1917, the U.S. Government seized all German ships in U.S. ports at the time. The German crews had anticipated this and had damaged as much vital machinery on the ships as possible. It was estimated that it would require over 2 years to replace the machinery. Examples are:-

* The USS Huron (formerly SS Freidrich des Grosse) had broken steam nozzles.

* The Moccasin (formerly Prinz Joachim) had a badly broken cylinder head.

* The Agamemnon (formerly the Kaiser Wilhelm II) had a break and split in machinery.

* The Ostewgo (formerly Prinz Eitel Freidrich) had a broken valve chest and piston rods.

* The George Washington, Pocahontas (formerly Prinzess Irene), and over 100 other German ships had extensive sabotage damage.

Those Wonderful Men With Their Welding Machines came to the rescue. In 8 months all 109 German ships had been repaired by welding and these weld-repaired ships carried fully one quarter of the total A.E.F. (Allied Expeditionary Force) to France (500,000 troops). This saved the U.S. countless millions of dollars and well over one full year of time.

A German and British naval battle off the Falkland islands left many British Ships damaged and these were towed to a South American port for repairs. A marine electric welding unit was commandeered and the ships quickly repaired and put back into service at a time when every minute counted.

The war effort required 2,000 welders in the U.S. alone but there was nothing like 2,000 welders available in 1917. The U.S. Army set up schools in Cleveland, Schenectady, Brooklyn, Philadelphia, Clintonville, Peoria and the Rock Island arsenal. Perhaps the man who made the greatest contribution to training welders in the U.S. was Lieutenant Cyrus K. Rickel, who was already a skilled welder when the war started.

Cy Rickel and I became good friends in the early 1940's and we often did much business together from then until his death in the late 1960's. He was one of the founders of The Big Three Welding Equipment Co. of Fort Worth and Houston. Cy and I have whiled away pleasant hours talking about the early days of welding at many times and in many places before his death.

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In Britain the need for more trained welders was recognized early in the war. At least 1,500 women welders were trained and in Britain, women accomplished heavy welding work, although in the U.S., in World War I, women only welded light structures such as aircraft tubing. After World War I and until World War II, there were no major revolutionary changes in welding. It was a period of consolidation.

ELECTRODES DEVELOPMENT

One of the outstanding improvements was in electrode coatings. A piano maker in England named Strohmenger and a Swedish marine engineer named Klellberg, and the General Electric Company in the U.S., made the first coated electrodes. These however, didn't actually produce protecting gases, although they did make all position welding easier.

The first real improvement was an organic coated type made by the A.O. Smith Company of Milwaukee. Their electrodes were baked 12 hours and this was the first electrode to produce a ductility of 25% elongation in 2" and was a great improvement. This was achieved in 1918.

The next great improvement in electrodes was made again by A.O. Smith in 1927, when the first extruded cellulosic-coated electrodes were invented by a young chemist named John Chyle. His electrodes are essentially the same as the mild steel electrodes still used widely today.

In fact some of the marketing companies around the world still sell this 50-year-old product and have the audacity to call them "Maintenance Welding Rods".

John Chyle's Electrode was made of cellulose flour, ferro manganese, titanium oxide and sodium silicate. Today A.O. Smith Co. no longer make electrodes, having failed in the business along with Westinghouse, General Electric, Page Steel, Harnisfegar, and so many others.

To give credit to all of the many welding electrode developments during the 30's and 40's would be impossible because each development was shrouded in secrecy. It was generally accepted that no electrode coating was patentable. This belief still exists today and details of nearly all electrode coatings are kept secret and not patented.

This came about because of an early lawsuit wherein A.O. Smith Company sued Lincoln Electric Co. for infringement of its first electrode patent. Lincoln, it was believed, had clearly infringed the patent, but the court ruled in favour of Lincoln. Ever since, electrode coatings have been protected by their inventors by secrecy in nearly all cases, rather than patents.

This brings us up to the advent of World War II which we will discuss in later writings. It was in this era that welding started to find its true indispensible place in industry.

WELDING EQUIPMENT KEEPS PACE

The first attempts to electric weld were a direct adaptation from carbon arc lighting which was then in use. Carbon electrodes were used to provide the heat and a filler rod was applied to provide the metal to fill up the joint.

The electric arc jumped between the two carbon rods creating an energy source. But, it was clumsy and difficult because the arc didn't concentrate its energy on heating the steel and there was no way of directing it. It was an unobliging arc that wavered.

Some time later the magnetic circuit was developed. This consisted of a magnetic coil which surrounded the electrode. And, as is well known, the arc is subject to deflection by a magnetic field, the effect it had was to force the arc down, towards the workpiece.

The first patent granted for arc welding was in 1865 to a man named Wilde, an Englishman. Wilde worked on the established theories of Volta and Davey, combined with the crude power sources available at that time.

J.P. Joule, a brewer by trade but keen on welding, worked out the relationship for electrical resistance heating, and ironically, it's the same one we use today, $H = I^2R + K$. Heat, time and pressure.

Patents were deemed important, and in 1885, the first electic arc welding patents were granted to two Russians, Bernado and Olszewski for straight carbon electrodes. And, fortunately for them, their patents contained details of two later developments. One was the use of metal electrodes, and the other magnetic deflection. When the patents were granted, they were the substance of an idea --- a dream from Bernado's mind. Bernado also filed for a patent on a carbon arc process whereby the work was negative and electrode was positive. Today we call this 'reverse polarity'.

The brilliance of Bernado's work was in his patent. For the first time the carbon arc was not fixed and could be moved and manipulated by hand. I accept that Bernado was the 'pioneer' of welding and the inventor of practical, electrical arc welding, as we know it.

A few years later, another Russian called Slavianoff experimented by using bare wire as both the electrode and the filler metal. However, in 1889, some two years after the experiment, Charles Coffin in the U.S. patented the process. Apparently both Slavianoof and Coffin had been independantly working on the same idea. I think, however that Slavianoff was first.

'Bare wire' welding brings back many memories. In fact if you talk to any 'Old Timer Welder' and mention 'bare wire' welding, he'll get that glazed expression and a look of melancholy as he casts his mind back to the 'good old days'.

When I was first learning about welding I used to practise for many,many hours with the bare wire rod. I never gave up until I had mastered the technique --- in all positions --- thoroughly. I wonder if there are any 'bare wire' welders left today? If there are, they'll remember the unbelievably difficult problem they posed. The sticking, no force and getting red-hot its full length. It's one of those processes you really have to practise before getting the 'hang of it'!

Of course there were flaws in both bare wire and carbon arc welding. With the carbon arc, a large percentage of carbon got deposited into the weld and made the steel brittle and hard. With the bare wire process, nitrogen from the atmosphere caused untold problems. But, time was to iron out these problems.

Along came the coated electrode which, as we all know, consists of steel wire with a coating wrapped around it. However, the coating then, was made of asbestos and paper (as well as other materials) which vapourized as it melted and formed a shield across the molten weld metal.

This was achieved in about 1907 in both the U.S.A. and Europe. Today this same form is still in use. The only difference being evolutionary --- and not revolutionary.

I used these 'wrapped' electrodes (as they were then known) in the later 1930's and early 1940's. By then, they had gone out of use, but during the war there was a severe shortage of electrodes. Everything possible --- old

and new --- was rounded up and put to use for the war effort. In retrospect it's little wonder that lung cancer was rife considering the wide usage of asbestos-wrapped electrodes.

Ironically, even though arc welding was 'complete' by the year 1907, it didn't take 'off' for a long time thereafter. The world wasn't ready to provide the ancilliary equipment and in 1907 you couldn't walk up to the nearest wall and take 240 volts out of a wall plug! When the Bernado's and the Slavianoff's were pioneering the welding process they had to generate their own electricity with a large and cumbersome steam engine --- right on the spot. Welding was not a small man's job it was limited to the strong and those who could afford large capital installations.

It's little wonder tha arc welding was slow to get into industry. Arc welding was far surpassed in popularity by the oxyacetylene process up until the 1940's. But, arc welding is actually the earlier of the two processes.

DSA 054

THOSE WONDERFUL MEN WITH THEIR WELDING MACHINES

(PART THREE)

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During the sunset years of the Great Depression, times were incredibly hard. My family was no exception. During the early 1930's, my father's health failed and I found myself, a mere youngster --- bread-winner for the family. I worked late at night and early morning -- before and after school. I remember being paid about 15 U.S. cents an hour --- and was glad to get it.

At the age of seven, I was going to school and working. I managed to compact the twelve-year course into seven years, and graduated when I was fourteen. I went on to University when I was fifteen.

To improve my finances, I joined the 114th Cavalry, National Guard. I was there for 2½ years, after which I left with an honourable discharge. The National Guard during peacetime is a 'week-end warrior' type of army. We joined ranks for a few hours each week and spent two weeks each year at Summer Camp.

I suppose there are not too many men alive today who were in the Cavalry when it was still 100% horse cavalry. I was tall for my age, looked older than I really was, and therefore got away with it. The legal age was 18. A few years later the horse cavalry was disbanded in favour of mechanised and motorised transport.

I could shoe a horse when I was 12 years old, having learnt the basic trade as a child. I was made army 'blacksmith' where I shod horses and welded on the forge. When I wasn't too busy, I made 'fire dogs' and other fireplace equipment. I used to sell them to the officers and anyone who wanted to buy them. It was an interesting time of my life.

I attended the University in Kansas and later the Santa Monica City College, in California. Ironically, my brother is today a professor at this same college (Industrial Engineering), and has been a professor at two colleges for 25 years.

In the army I learnt to ride horses using the 4 pound McClellan saddle. I carried a sword, a rifle and saddle bags. The exercise was tough and I well remember the 8-minute gallop, followed by the 8-minute trot and finally the 8-minute walk. We often rode for more than 50 miles at a time, on bivouac. This, combined with being the army Blacksmith, hardened me up physically as a youngster.

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I have already mentioned that I was working during my spare time while going to University. The job most suited to late night or early morning hours was book-keeping. So, I became a Book Keeper for a beauty shop. This led me to work with an accountant in Los Angeles by the name of Baron Luttermoser. The 'Baron' --- as he was known --- dropped the hint that one of his clients, a Motion Picture Producer was looking for a Book Keeper and I went to see him.

When I met Roland West, he had a profound impact on me that was to remain for as long as he lived. I worked for him for five years. I started out as a Book Keeper at the age of about sixteen and, a year later, he promoted me to Business Manager for Roland West Enterprises. This was a million dollar-plus business and we made Motion Pictures. "The Bat" ... "The Bat Whispers" ... "Corsairs" and many others with stars like Thelma Todd, Chester Morris and others. We owned five restaurants, apartment buildings, a whole string of vending machines and a number of other investments. By the time I was 18, I was made full manager of this large enterprise and absorbed much about the basic principles of business.

It was an exciting period of my life. Roland and I were truly great friends. He took me everywhere, including his magnificent yacht "Joylita" where I met and befriended nearly all the great film stars of the day; Charlie Chaplin, Mary Pickford, Kay Francis, Alice Faye, William Powell, Tyrone Power ... and literally, scores of others.

Roland had great confidence in me and looked upon me as a son. He spent many hours teaching me the intricacies of life, business, people and of course Motion Pictures. Looking back, I would say he influenced my life more than any other person. He was my 'Father' image until he died.

He had married actress Lola Lane and I vividly remember spending an evening with Lola, Charlie Chaplin, Oona O'Neal and Roland in 1953, shortly before he passed away. He had painted a new dimension into my life and his passing was like losing a father.

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In the late 1930's, while I was still working for Roland West Enterprises --- like so many others --- I recognised the grey clouds of impending war. Europe was indeed in the depths of gloom. Realising the inevitibility of war, I arranged my work hours with Roland Enterprises so that I started work at 1 pm and worked into the night. I then went to Santa Monica Technical College and took a course in Aircraft Welding during the mornings. Having been a soldier, I felt the need to contribute to an essential industry. I finished the course and took a part-time job welding Aircraft in the mornings. However, due to the sheer monotony of having to weld small chrome molybdenum clusters of tubing, I soon became bored. I considered the job a woman's job and decided to take a course in Thermit Welding and a course in Electric Arc Welding. I took my tests at the Long Beach Maritime Commission (California) and passed Test 1#,2#,3# --- all at the same time. It was considered unusual.

I then started work for the California Shipbuilding Corporation as a First Class, 3-Position Welder. The yard was owned by Bechtel McCone and Parsons. I became friendly with Mr McCone, who later became famous when he headed the U.S. Government Atomic Energy Commission, reporting directly to Lyndon B. Johnson .... President of United States.

I worked at 'Cal Ship' (Terminal Island California), on the so-called 'swing-shift' (4 pm until midnight). I was still then working as a manager of Roland West Enterprises. By this time Roland had taken his famous yacht through the Panama Canal to Florida where he spent most of his time. His company had stopped making motion pictures by this time and Roland had retired, leaving me to manage his California investments. It was tough. I worked in Pacific Palisades from 8 am to 2.30 pm, jumped in a car and drove like a madman the forty miles to Long Beach, and worked until midnight!

Holding down two jobs that far apart gave me fifteen hours work, three hours driving, four hours sleep and two hours to eat and unwind.

But, it was at 'Cal Ship' that I fell in love! Madly and completely! Her name was the Liberty Ship. She was a 10,000 ton lady and would, by today's standards, be considered small. But to me she was the biggest, most beautiful thing I'd ever seen. I learnt everything there was to know about the Liberty Ship and became an expert. I knew every piece that went into the Liberty Ship, from the packing gland to the gun mounts on her stern.

Europe had been in the throes of war for some time. Things were looking bad. About this time, Pearl Harbour was bombed and America was sucked into the war. At the shipyard, we went on 12 hour shifts, seven days a week. I called Roland from Florida and asked him to release me from Roland Enterprises. The work at the shipyard was all I could handle.

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At 'Cal Ship' I welded on 20-25 ships. About that time, the W.A. Bechtel Company opened a new Liberty Shipyard called the Marine Shipbuilding Corporation in Saucelito, California. I was offered the promotion of Welder, Gerneral Foreman, and moved to San Francisco to head up the second shift of the day. I took it.

Bearing in mind that these were among the first ships ever to be welded together. it was an enormous responsibility for a young man. I welded about 20 ships for this company consisting of thousands of miles of welds.

In the seventies, Saucelito became the 'hippy-style' capital of the world. A gathering place for the 'flower' people. All I can say is that when I was a shipbuilder during the war, it was a grim place without hippies or flowers..... just grime, smoke and dirty sky.

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The first 'welded' ship ever built (ships had always traditionally been riveted together) was the 'Frelagar' --- built in 1918. It took two years to build and, although I was much too young to even know she existed, her construction is important because it proved that ships could be welded successfully.

She was built for costal service in Britain. Later she crossed the Atlantic and passed through the Panama Canal where she was sold into the Cement Trade. The incident I remember about this ship was a report stating that: "while filled with 10,000 bags of cement, she veered off course and ran into a cliff." "Her bows crumpled up like an accordian --- but, she didn't sink." She was watertight and became a triumph for welded ships. She was dragged off the rocks, her bows were straightened and sailed for many more years. Had she been a riveted ship she would have sunk like a stone. I believe she later became irresponsible once too often and collided with a heavier ship, turned keel-over-deck and sank.

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After a further period of time with the Main Shipbuilding Corporation, I left and went to Charleston in South Carolina and did a few weeks consulting (being somewhat of an expert on the Liberty Ship) for a shipyard there. I later went to Jacksonville in South Carolina where a new yard was just starting. The St. Johns Shipbuilding Corporation was big. It had 28 ways. The Corporation made me Welding Superintendant of ..... 'Liberty Ships'.

At this stage of the war, building ships was a serious game. If the Fuehrer built a ship in 21 days, we had to build her in 20. Then we heard that the Fuehrer could build her in 18 days, so we had to build one in 17. I became a pioneer in prefabricated structures. There was a time when we lifted a superstructure --- fully welded --- weighing 200 tons! We used four, 50-ton cranes!

Today, I wouldn't take a chance like that for anything or anyone --- I've changed my religion to 'devout coward'. In those days I was young and headstrong, and besides, I had a bet with the Maritime Commission Officer. Hell! I had to beat the Fuehrer.

Eventually, the challenge of Liberty Ship building wore off and I resigned to go and work for the Merrill Stevens Dry Dock. It was a repair yard, not a shipbuilding company. There were many ships returning from the war arena which desperately needed repairs. It was probably the most difficult welding of all.

We took in hospital ships, battleships, merchant ships and rebuilt them. Many of them had unbelievable torpedo or shell damage from submarine and air attack. Repairing the hospital ships gave me great personal satisfaction. I was making a contribution.

The type of welding done here was remarkable. We worked everything from engine room disasters to erecting new masts. Every job was different. There were no 'blue prints' to go by; it was a case of 'cut and fit'. One day an urgent appeal came in requesting that a welder with Navy Test 1# and Navy Test 2# report for duty. It was galvanized steel and armour plate welding. This was in Puerto Rico. I didn't really want to go. I'd just bought a yacht and was living on it in Jacksonville, having fun when I wasn't working. But, it seems that no one else had passed these complex tests. I had, so down I went to Puerto Rico to weld for the Navy.

It was wartime of course and all jobs were considered urgent. I didn't like welding galvanized steel in double-bottoms because the fumes are awful. I had to drink a glass of milk every hour to stop myself from getting ill. I was glad when the pressure was off, and I could leave.

I then went to New York City. I had never been to the 'Big Apple' before and the bright lights were tempting. The war was still being waged and I worked for the defence. I was assigned to work as a welder for the Maritime Welding Company in Brooklyn. But, these were small PT boats used for landing troops on beachheads. To me, they were like working on toys after the scores of big ships I was used to. It didn't take long for me to become fed up with working on these 'toys', and after a week, I knew all there was to know about them.

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One morning, while in New York I received a telephone call. The caller was a very senior ranking army officer. That one call ended my shipbuilding days and changed my life.

(To be continued)

DSA 055

THOSE WONDERFUL MEN WITH THEIR WELDING MACHINES

PART FOUR

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At the shipyards, I learned much about stress and warpage. When a ship is welded there is a great deal of distortion. When there isn't distortion, there are "locked up stresses" that could not release themselves. I gave this a great deal of thought. The important thing in welding a ship is to weld with such a welding sequence that the warpage is minimized, and the stresses are minimized. I constantly planned the sequence of weldments so that the stress would be "worked out". For example we would start welding at the middle of the ship and weld toward loose ends to ensure a minimum of locked -up stresses. I sat up many a night trying to improve the sequence.

I also became an expert on heat shrinking. We had crews of men who would heat spots on accurately planned places of a bulkhead and then water would be sprayed around the hot spot. We took advantage of the fact that when steel is heated it expands, but when cooled it contracts more than its original size. Thus we could shrink the warpage out of steel bulkheads.

> This principle can be seen if one takes a cube of metal and heats it. You would be surprised how few times it must be heated and cooled before it becomes spherically-shaped instead of cube-shaped.

While I was in charge of welding at St. John's River Shipbuilding Corporation, Mr O'Mahoney, the General Manager of the Yard, called me one morning to his office. I can remember the shock when he told me that some of the Liberty Ships were splitting open at sea. Fortunately, there were no problems on those I had worked on. However, he asked that I give this problem some thought.

I was ushered into a conference with two gentlemen from the Maritime Commission, the yard Superintendent, Mr Neilsen, and a marine architect. None of our ships had split yet but everyone was panicking because some

ships from the Feuhrer's shipyards had also split in service.

I was asked "Why are the welded ships sinking?" I answered, "Because the steel is no good and the welding electrodes are no good". The marine architect jumped to his feet in anger saying, "All our welding electrodes have Lloyds Approval". I replied that Lloyds may have great expertise about insurance but they hadn't a clue about welding or what constituted a good electrode. "If they did", I remember saying, "they would not approve of such rubbish as the welding electrodes being used.

I then explained that the brittle characteristics of steel is accentuated by welding. Under certain conditions, ordinary steel can behave "arrogantly" and become brittle. I breaks when the critical stress becomes excessive. I explained that the act of welding will inevitably cause locked-up stresses in the steel --- along with internal strains. These have their influences in precipitating and propagating these brittle-type cracks --- if the steel is predisposed to cracking. If the steel is notch-ductile, however, the locked up stresses do not tend to crack. I explained that the steel we were using was not notch-ductile. I further explained that the welding electrodes we were using cuased underbead cracks.

The meeting broke up with scoffing at my remarks. The Marine Engineer blamed the welding sequence. (I knew he was wrong because I had studied the sequence too much to be wrong). The meeting ended with nothing being achieved and no one in agreement with anyone else, especially me.

A few years later I was to be proved right. The bogey that caused so many Feuhrer-built Liberty Ships to crack open (2 sank mysteriously --- just simply disappeared) was caused due to brittle steel failure.

Americans were short of manganese (a constituent of mild steel) and they had inched down to the amount used to make steel. Carbon, however, was in

plentiful supply and it was used too generously. The result was that the steel was breaking because it was too brittle. One shipyard (Fairfield Shipbuilding Corporation) obtained all its steel from Bethlehem Steel Corporation. This one yard had a nil casualty rate. The reason was that this particular steel company supplied notch-ductile steel which did not become brittle when welded. It was also later found that the type of coatings used on electrodes contained moisture. This moisture resulted in hydrogen being trapped in the weld deposit. This caused underbead cracking, which contributed to vessel failure. My theory that it was the materials and not Those Wonderful Men With Their Welding Machines was proven correct, after the war was over.

I learned a lesson from this that has helped me. You can never depend on the quality of the steel you are welding. It may very well be notch sensitive and brittle. Therefore, you must use a welding electrode that can weld notch sensitive steel without failure. This is especially true of maintenance where one rarely knows the 'pedigree' of the steel being welded. Anyone who uses ordinary cheap production electrodes for maintenance applications is really playing Russian Roulette. It is only a matter of time before failure of the part.

The U.S., during the war, built 2710 Liberty Ships --- as alike as peas in a pod, --- yet 1,000 of these came to grief. This shows that ordinary production welding rods in some cases aren't even good enough for production. The lesson I learned was that men's lives could be lost by using ordinary, low quality electrodes. Industry needed better quality electrodes. I vowed that some day I would see that they had them.

This was the dawn of the dream that was ultimately to become Magna .... but that is another story.

When I observed welding electrodes having the approval, and meeting the specifications of the U.S. Maritime Commission; the American Welding Society; The American Society of Mechanical Engineers; Lloyds of London and various other specifications fail, it became clear to me that specifications are not a reliable way to evaluate electrodes.

I reasoned that specifications mean, in effect, the lowest, cheapest, most base quality that could be used. It appeared to me that the opposite should be the case - specifications should, in my view, be the best possible quality that could possibly be manufactured.

The way the system worked then and, in general, still works today is that the American Welding Society or Lloyds decides a specification on a type of electrode. The specification is usually obsolete before it comes out. This specification, in effect, states that an electrode that meets that specification is the lowest quality electrode that can be used. The American Welding Society doesn't even test the electrodes themselves! An electrode manufacturer needs only certify that his product meets that specification and this is accepted as true.

The specifications for the AWS E 6010 electrode are today, I believe, at least 40 years old, and probably more near 50 years old'. Yet most electrode manufacturers today still sell by this nearly 50-year-old specification. No outside body such as the American Welding Society test the product to see if it does meet the specification.

> The use of specifications and so-called "approvals" have held back quality greatly. There is no incentive for a manufacturer to make a better product - to the contrary, he is penalized if he does put more quality into his product. It costs him more to

> manufacture, yet he has to sell it at the same price as the competitor who schemes to make the very lowest possible quality that he can still claim "meets Lloyds approval" or "complies with the AWS specification".

Specifications are like the high jump at an athletic track meet. When the jumping bar is placed at 6 feet, if a jumper clears it he is said to have jumped 6 feet. If a better jumper jumps 5 inches higher than the mark he is still said to have jumped 6 feet. There is no extra score for clearing the mark better than the others. Today, and for many years past, production electrodes have all been built down to a specification. The race is not to see who can make the best product - the rewards go to the company that can produce the very lowest quality and still claim to meet the prescribed specification.

It is about like having a horse race and giving the same award to every horse that makes it around the track. Not to the horse that gets around the track first. If the system that is used in the Welding Industry were used in horse racing it would only be a short time until old plow horses would be used with fat men riding them. Any old horse could manage to finish the 6 furlongs. There would be no incentive for improving the breed and soon the quality of race horses would disappear. In the Welding Industry, encouraging manufacturers to build electrodes down to a minimum specification ruined the quality of electrodes. Some engineers still today ask for "Lloyds Approval" or "American Welding Society Specifications."

The public needs more protection than it is now getting. Anyone can make a welding electrode using "seconds" steel wire (defective steel wire), put any old mud on it for a coating, state it meets American Welding Society Specifications, or that one special batch they made up several years ago was approved by Lloyds. They can sell these electrodes at a cheap price. Engineers will accept them because "they meet the minimum specifications".

There are no laws to stop them. The public pays with oil spills, deaths and injuries when these "specification and approved" electrodes fail and cause casualties.

When I noticed many years ago that "Specifications and Approvals" actually lowered the quality of electrodes, I looked about other industries to see what "specifications and approvals" the really time-tested and "World leader" products had. I found that all of the really good products weren't built to "specifications and approvals".

For example, the Stradavarius violins were not built to any specifications or approvals, except the integrity of the maker. The Steinway Piano doesn't meet any "specifications or approvals" nor does Christian Dior's fashions, or Chivas Regal Scotch Whiskey, or Aquascutumn men's tailoring or Cadillac automobiles or Steuben glassware.

Few if any great products are built <u>down</u> to a specification - the great products are built up to the standards of the manufacturer's integrity. I vowed then and there, (so many years ago), that I would produce Welding Alloys, Fluxes, and Electrodes that would be the supreme products of our industry - not built down to a specification like all the others. How many lives this decision has saved, no one will ever know.

Something has to be wrong with the system of approvals and specifications. The Tanker Advisory Centre in New York reported on 3rd April, 1978, that "The American and British fleets in 1977 sustained sharply increased casualty frequencies compared with 1976." This is a direct quote and proves the situation is not getting any better when cheap specification rods are used.

The specifications have been written so loosely they are to me a joke. There is nothing is these specs that require good quality (such as deoxidizers, slag formers, stabilizers, high purity metals, finely ground chemicals in the coating, ect). Only the most meager lack of quality is required. As

for quality-control, a blind man with a seeing-eye-dog could almost see that the electrodes meet all the limited quality control requirements that are in the specifications.

The specifications are so liberal and so loose and so undemanding that "anything goes". Little wonder there have been so many weld failures and so many losses of life because of weld failures. No wonder so many people are skeptical of welding.

In the U.S., aircraft construction and maintenance is governed by the C.A.B. (Civil Aeronautics Board). They put the highest possible requirements on the quality of aircraft, and the maintenance thereof. In the welding industry, the U.S. Government leaves it up to the industry to police itself. (Like leaving a fox to guard the chickens). The industry leaves it up to the American Welding Society to write specifications. The A.W.S. writes the most minimal obsolete specs (with the explanation that they don't have the funds to do better). After they have written the loosest of specifications, the A.W.S. doesn't even police these. Anything goes! Most of the other countries in the world accept the U.S.A. American Welding Society specs as gospel and just copy these as their own specs.

This is the reason so many weld failures occur. I sincerely wish the governments of the world would require maximum quality specifications, not minimum, and police them.

DSA 056

THOSE WONDERFUL MEN WITH THEIR WELDING MACHINES

(PART FIVE)

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The most important single day in the history of mankind, in my view, was December 2, 1942.

People, when asked to single out the most important event in man's history, single out many different things. Some say the day the wheel was invented - others say the day man landed on the moon - still others say the day man defined electricity, etc. But, to me, the day man discovered a power source independent of the sun was the day that marked the greatest day this planet has seen.

In all the millennium of years that man has existed on this planet called world, man has been a parasite of the sun. The human body acts and exists on solar power from the sun. Every action, for millions of years has been caused by energy - and every minute amount of energy came from the sun. Industries operate on coal or oil or electricity which is released when coal or oil or wood is treated to give off heat or energy from which power is derived. Man has always been, through the millions of years, a sub-machine that operates on solar power. Man eats beef or grain or fish that ate vegetable matter that the sun created. Until 1942, nothing on earth ever happened that the sun did not make possible.

On 2nd December, 1942, man ceased to be a parasite.

For the first time he had the choice to live on power from the sun, or to live on energy not derived from the sun. For the first time, man could eventually be free of the sun. He could tap an entirely new source of energy which is independent of the sun.

It was on December 2, 1942, that man first demonstrated that energy could be derived from the elements such as uranium or thorium or plutonium or hydrogen, which the sun did not produce.

I am proud to say that I played a small role in making atomic energy possible.

Today, a few pounds of ore gives off heat, and will continue to do so, (like the sun itself) in an almost self-fed process. In numerous countries throughout the world, atomic energy produces power at a cost of less than .002 (US cents) per kilowatt of electric power. Atomic power is more than competitive with coal-produced power. (I won't however be drawn into the controversy regarding conservation, radiation safeguards, etc).

I am proud (in spite of the dreadful manner in which atomic energy has been employed), to have been one of the central people who made atomic energy a reality.

I am one of those persons whose greatest achievement occurred when I was young. I worked on the Atomic Program when I was 25-26-27 years old. I never did anything before and I have never done anything since and I do not plan to do anything in the future, that will match the achievements I made in those few historic years. Those were years when I lived - I really lived, day and night. The vision, the dream of an energy more powerful than the sun. An energy that would advance mankind into a new and totally different era.

I was there - I was a part - of that moment - that instant - when the course of the world as changed. I must say that Those Wonderful Men With Their Welding Machines helped change the world for the better with atomic energy. I was the Chief Welding Engineer of the famous Manhattan Project.

The "Readers' Digest" presented an article in 1948 which stated that the famous Oak Ridge Atomic Energy Plant, had developed 14 new welding processes. I counted 12 new welding processes I helped bring about, but I will not quibble with the Readers' Digest Magazine. I am awed with what happened.

I do want to say it happened (these fantastic results of these new welding processes) because of the position I was in and the opportunity I had. More so than because of any special skill or genius I had or will ever have. Many people have used the word "genius" in describing my work for the Manhattan Project - but I assure you I am not, nor was ever, a genius. I just analyzed the problems and tried to solve them. I made many mistakes and I did a few things right. Some of my results will remain helpful to engineers long after I have perished.

Before we go further, I believe I should explain what the Manhattan Project was. In the early days of the war (World War II) Professor Einstein, wrote a letter to Franklin D Roosevelt, and stated that he had reason to believe that Axis powers were trying to develop an atomic device that could destroy a large segment of mankind in one single thrust. He believed such a device could be built, and he encouraged Mr Roosevelt to attempt to build a similar device faster, and end the war, thus saving many lives.

President Roosevelt immediately established the Manhattan Project.

It was created to develop atomic energy and produce an atomic bomb. This endeavour was successful and Those Wonderful Men With Their Welding Machines played a vital role.

The Manhattan Project is actually a series of hundreds of thousands of engineering projects and consisted of many different installations:-

Brookhaven in New York, The University of California, Argonne National Laboratories, Hanford in Washington, Los Alamos in New Mexico, etc. The largest, by far was the Clinton Engineering Works. I spent most of my time at the Clinton Engineering Works, although I did some work at Hanford and Los Alamos, the Sciota Project in Ohio,and the Paducah Works in Kentucky.

Let me tell you about the Clinton Engineering Works. The U.S. Government acquired the better part of 2 counties (Roane and Anderson) in Tennessee, about 40 miles from Knoxville. This area was chosen because of its size, remoteness, and a nearby river (which was necessary for cooling purposes.) Also this area was reasonably close to the T.V.A. (The Tennessee Valley Authority), which at that time, was the world's largest Power Plant. The Clinton Engineering Works became best known as "Oak Ridge" - the name of the tiny village that was established at the Centre of the Clinton Engineering Works.

The Nuclear Research Centre (Oak Ridge National Laboratory) consisted of almost 150 buildings! In a little building was the "atom pile". The uranium, in the days when I was there, came from the Belgium Congo (now called Zaire). It was semi-refined when it arrived in Oak Ridge in the form of heavy slugs about 1 inch thick and 3 inches in diameter. These slugs were harmless, being only mildly radioactive. After these slugs were processed, they were placed inside a brick made of graphite. The brick was about the same size as an ordinary clay building-brick.

The bricks were placed in a pile alternating between graphite blocks that contained no uranium. This is where the term "atomic pile" comes from. I mention this because most people have heard the term "atomic pile" but few know what the term means.

The Oak Ridge pile (which wasn't very large as far as size goes) potentially contained more power than all the Diesel Engines in the world combined.

At Oak Ridge, we built 3 major areas, each of which were separated by about 8 miles from each other to avoid risk. The first was "Y12" which is an Electromagnetic Plant 7 miles from the centre of Oak Ridge City. This plant consisted of 170 buildings (which I had a hand in constructing) and cost more than the Panama Canal. So far as I know, there is no other plant in the world like it.

Thousands upon thousands of intricate machine units, arranged in battery after battery, in horse-shoe shape, were designed and built. The vacuum unit in this plant is 30 million times as great as that required in standard power plants. One of my jobs was to oversee the welding of magnets nearly as big as a football field! Can you imagine a magnet so powerful that you can't walk by it because it exerts such an unbelievable pull on the nails in your shoes - from 50 feet away?

We built an atomic "stop watch" that could check the speed of atomic particles. If measured in one billionth of a second. We had to construct scales that would weigh invisible specks of matter weighing one billionth of a gram!

"Y12" was based on the Cyclotron unit built at the University of California by Dr Oppenheimer. It could extract Uranium 235 from Uranium 237 and 238. However, it was painfully slow - only a few grams a year was extracted.

Let me tell you about "K25". This area was the one where I spent most of my time. It consists of 70 buildings, one of which was the largest building on earth under one roof. "K25" was U-shaped with "wings" nearly 2 miles long and 133 yards wide. A smaller unit quarter its size, which was built later, adjoins it. "K25" consisted of more than 100,000 instrument dials and nearly 1,000 miles of instrument piping. You can't conceive of the instrumentation required - everything from absolute and differential pressure transmitters to hundreds of thousands of control devices - inside that mammoth construction.

The atomic separation takes place by converting the solid uranium into a gas. Then the gas is propelled at incredible speed through hundreds of miles of pipe. Every few yards the pipe enters a machine about the size of an average living room, a tank-like affair, which has barriers made of

holes less than 2 millionths of an inch in diameter. The screens must withstand incredible pressure. They can't plug up because of dust or corrosion or impurities. These incredible nickel barriers have the precision of a microscope and the durability of a sledge hammer at one and the same time.

The idea was to separate Uranium 235 from Uranium 237 and Uranium 238. It was achieved by having the most powerful pumps ever conceived, speeding the uranium gas through the nickel barriers, trip after trip. Eventually the Uranium 235, (being lighter in weight), would "physically" travel faster than the heavier Uranium 237 and 238. Finally the separation was complete and pure Uranium 235 could be tapped off.

"K25" was the biggest gamble in history. No one knew for certain if it would work or not. It could not be proved on a small scale model - we had to build the largest plant in history to see if it worked! A pilot plant could not produce the same results. It would have been like trying to play football on a one meter square tract of land.

Fortunately it did work out - far beyond anyone's expectations. When I was there it actually produced 25 pounds per month of precious Uranium 235.

The pumps, which were assembled by Allis Chalmers, a Milwaukee Corporation, spun faster than the speed of sound! Yet they had to be manufactured by the thousands and thousands. Such results were unbelievable. Yet they were designed with less than one million hours of research.

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Now let me tell you about old Zachary.

Zachary was an old man in the Kentucky Hills who manufactured Tombstones. He had developed his own "secret" method of grinding and polishing granite. When we had to polish thousands of tons of steel in ways never before done, in order to prevent resistance to the high speeds that were necessary, who do you suppose supplied the answer?

Your're right!

Old Zachary taught us how to polish steel like man had never polished steel before.

Zachary was a real Bible Belt man. He was a preacher as well as a tombstone maker. Every time 'Zack' gave me a lesson in metal polishing, he also gave me a sermon about Christ on the mount, the Battle of Jericho and how God would punish the sinners! At the same time I learned how to polish metal in a manner that I don't think many other people alive do. Zack has long since gone to his final reward.

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I wish I had time and space to tell about all the humorous and serious events that occurred at Oak Ridge. One that comes to mind concerned the convertors. (The convertors are the tank-like machines that contain the porous nickel barriers that separate the uranium). These had to be kept absolutely dry and corrosion free during their storage, erection, and testing. They were huge and we had thousands of them. How do you keep them dry and corrosion free inside? Some engineer (Joe Bartol was his name) figured out that the best thing was ladies sanitary napkins. So we ordered these by the millions and millions and packed the convertors with them. They worked better than anything else we found and we continued to use them.

One day I was at the railway station at Clinton, Tennessee, and the stationmaster with whom we were all friendly approached me. "Tell me something", he said, "With all these millions of Kotex pads you are ordering up there, what the hell kind of a Plant are you running, anyway?" I was seldom stopped for words as a young man - but this time I was dumbstruck.

As instructed - I denied we had ever ordered any such thing and told him he surely must be confusing our works with some other railroad customer.

There was one other major section to Oak Ridge. It was "X10". This was built by H.K. Ferguson and oeprated by the U.S. Navy. It was designed to enrich uranium by the heavy water method - the method the Germans tried in Norway. This plant wasn't in production yet when the war ended, and since the K25 plant was so fantastically successful, this method was abandoned. I did become great friends with the Superintendent, my old friend, Frank Buck, who was an engineering genius and a legend in his own time. Frank used to call me once a week regularly at 7 pm on Mondays and ask me welding questions. If he had anything really difficult or urgent, I would come and see him on Tuesdays and try to work out his problems. I was the only Welding Engineer on the entire project. I spent the least time at the "X10" works as it was the smallest of all and seemed to have the lowest priority.

Oak Ridge gave me a completely different world - it was a preview of the future. I became a different person because, at Oak Ridge I shared an awesome responsibility I had so much responsibility thrust at me at such an early age that I had to dedicate myself in a way that I never knew before was possible. In a sense, my entire life, technically, began and ended at Oak Ridge. I had never had to do anything so complex - I have never had to do anything since that even approached what I did at Oak Ridge.

In the next issue I shall tell you about the interesting subject I mentioned in an earlier edition of Those Wonderful Men With Their Welding Machines - the telephone call that changed my life.

DSA 057

THOSE WONDERFUL MEN WITH THEIR WELDING MACHINES

(PART SIX)

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The phone call that changed my life came in the early morning, just as I was preparing to leave for my job at the shipyard in New York Harbour.

The caller was Colonel Cornelius of the U.S. Army Corps of Engineers. He had asked if I was Leon D. Richardson and explained to me he was calling about a matter of great importance to the War Effort and would I be so kind as to help him. He then said, could he ask me some questions. He proceeded to ask me what was the name of my 2nd grade school teacher? What was my first dog's name when I was a child? A few other simple family questions and he was convinced he was indeed talking to the right person.

"Mr Richardson," he said, "the purpose of my call is to ask for your assistance on a matter of paramount importance to the war effort." Colonel Cornelius asked me whether I could help and naturally, being a responsible citizen I accepted. He then went on to tell me that a meeting would be arranged between myself, a certain Mr G. Williams and a Mr J. Stewart on the 19th floor of the Woolworth Building in Manhattan. "The office", he continued, "was the Kellex office." I was later to find out that this office was the special headquarters established by M W Kellog Engineers for the project at hand.

I met Mr George Williams and Jack Stewart early in the morning. They explained to me that the Government wanted me to accept a position as Welding Engineer on the Manhattan Project.

They pledged me to secrecy and explained to me that the Manhattan Project was created by President Roosevelt and was the most important engineering project of all time, and was a secret giant project hidden in the hills of Tennessee.

At that time, less than 20 men on earth knew what the project was all about. All they could tell me was that it was the most important project of America's War Effort and that this project was a race against time. They asked me to make, blindly, whatever sacrifice was necessary.

I asked why and how they had picked me. They said they didn't know as the orders to hire me had came from the Army Corps of Engineers' office. They said the army had been looking for a Welding Engineer and had traced me and several others by inquiries or contact with the American Welding Society, etc.

After I agreed to accept their offer they telephoned Oak Ridge, Tennessee and connected me with Ted Rothermund, the top engineer. I can almost honestly say Ted was an engineering genius. Ted talked to me for 3 hours on long-distance telephone!

He asked me many things, then finally asked that I take a "welding test" over the telephone. I agreed. He gave me 24 questions and I answered the first 21 all the same: "I don't know". I did however gave answers to the last 3 questions.

The first 21 were 'impossible' questions - questions no one had the answer to, such as, "if you weld tungsten carbide to vanadium carbide and subject the weld to a temperature of 150^{O}F below zero, would the weld structure be acicular?" I answered first of all I didn't even know how to weld tungsten carbide to vanadium carbide and, in fact, had never seen vanadium carbide in my life. However, if I had that application to accomplish, I would make laboratory tests and find the answer.

The last 3 questions he asked me were answerable, they were questions like "If stainless steel tubing is joined with 50% silver brazing alloy will the joint withstand a high vacuum". This was a question that I could answer 'no' to because I had the experience in vacuum systems. It was an answerable question. I thought my ignorance of the first 21 questions had put paid to my short-lived career with the Manhattan Project.

Months later, Ted Rothermund was to tell me that he hired me because I had a perfect score!!! The first 21 questions were indeed unanswerable and every man he had examined before had given wrong answers. The last 3 were answerable and I had these right. He reasoned that if a man gave answers to unanswerable questions, he could get them into much trouble.

After the telephone interview, I was hired. However, I was initially disappointed. They put me to work on a drawing board at the Kellex office, designing valves for two weeks. The work I was doing, any junior engineer could do. I knew, of course, what was transpiring. They were giving me an FBI security check "cradle-to-now" to make sure I could be relied on to learn, and keep undisclosed, the War Secrets I would soon be exposed to.

After two weeks, I was cleared and sent on my way to Oak Ridge, the 'Secret City'. I was for the next three years to work, seven days per week, day and night, in a tense secret atmosphere. I was to work one hour with Tennessee Mountaineers who had been recruited for war work, the next hour with scientists, the greatest in the world, the next hour with officials of our sub-contractors. I was to drive a jeep here and there all over the massive project. I was to wade the never-ending Tennessee mud.

I was to be in charge of welding far advanced over anything that welding science had ever conceived before!!! I was to solve welding problems no man before my hour had faced.

It was an exhilarating challenge - I was a young man of 25 years of age stepping into the 21st Century when I got off the train at the Knoxville Railroad Station and met my driver who took me to face the fantastic secrets of Oak Ridge. History was about to be made. And I was to be a part of this great, historic project.

When I first arrived at Oak Ridge, I was astounded by the size of the project. However, what I didn't realize was that this was just the mere beginning. I was later to see it grow to 1,000 times its size!

Here are some statistics on the Clinton Engineering Works, at the Oak Ridge Section of the Manhattan Project.

1. Number of workers: nearly 100,000.
   This consisted of 49,000 in operations and 47,000 construction workers.
2. 14,000 separate items of construction equipment.
3. Lumber required: Two hundred million board feet.
4. Steel used: 150,000 tons.
5. Concrete used: 500,000 cubic yards.
6. Buses: 750
7. 55 miles of railroad and 350 miles of highways.

This was the largest construction project ever conceived and built by man, and it was all completed between February, 1942, and July, 1945. In less than 3 years, the largest construction project ever created was built.

This must be considered one of - if not the - outstanding engineering feat of all time. I worked at Oak Ridge for about 3 years, and during that time I saw absolute miracles happen.

I know all these facts because at the end of the War, I resigned. I saw no reason to continue once the War had ended, even though the General Superintendent asked me to stay on a month longer and write a book on The Mechanical Erection at Oak Ridge. I eventually wrote the book for the Army Corps of Engineers and this became part of a larger book which is today, in the Library of Congress in Washington, D.C.

The Plants were built by private industry, not the Government. The main construction companies were:-

Stone & Webster Engineering Corp.
Kellex Corporation
J.A. Jones Construction Co.
Ford, Bacon and Davis Inc.
HK Ferguson Co.
Owings & Merrill

I personally worked for all the first 5 of these. I didn't work for the sixth.

The operators of the plants were:-

Tennessee Eastman Corporation (Related to Eastman Kodak)
Carbide and Carbon Chemicals Corporation (Union Carbide)
Fercleve Corporation (Related to HK Ferguson Co.)
Monsanto Chemical Corporation
University of Chicago
Columbia University
University of California

I had made many good relations with all of these groups, but especially Tennessee Eastman and Carbide and Carbon Chemicals Corporation. Hundreds of contractors assisted. There were so many sub-contractors I cannot recall them all.

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When I arrived at Oak Ridge, I went to see Ted Rothermund. He was a huge, red-faced, red-haired man and he was a Hell of an engineer. He was the top Engineer, the real Chief Engineer of the project. He told me I had my work cut out for me and he gave me a desk in his office. Since things were not really off the ground yet. he told me I would have some temporary fill-in jobs until K25 started. (K25 was the Gaseous Diffusion Plant.) He told me to "Kill Time" by looking after the welding at the Power House, and to take over the welding at Y12 (the Electro-Magnetic Plant). Can you imagine killing time by looking after the welding on the largest steam power plant ever built (It has a capacity two times that of Norris Dam of the TVA). Imagine killing time by looking after the welding at Y12, where we welded together, piece by piece, the largest magnet ever conceived - it was a horse shoe shape, about 10 feet tall, and about 2 acres in size!

Actually the welding of the magnets sounds a bigger job than it actually was. In fact, it was very much like welding a ship. There was also a great deal of pipe welding and this again was not a great challenge. But, what I did find interesting was welding the instrumentation. There were literally thousands of instruments all connected with tubings. Some of these used rare and noble metals and this was indeed a challenge for me to figure out how to weld all these unique creations together.

In due time the great K25 plant was started. I was transferred over there and told that this one plant was more important than all the remainder put together. Indeed it was. I worked at first with Ford, Bacon and Davis Engineers which was probably the most prestigious engineering firm in the U.S.

First we constructed a huge building (and I do mean huge), where all of the equipment came to and was sub-assembled, and treated, rebuilt, tested, etc. I had to set up here a great deal of submerged arc welding equipment and automatic welding equipment, and to start prefabricating much equipment.

Then the huge processing building was started. My work really became exciting. I was given welding problems to solve that the world had never heard of before. I set up a laboratory and hired Process Engineers and together, we started to work on completely new welding problems. Problems never faced before.

One of the greatest problems was how to weld pipe (from 36" diameter down to tiny tubing) so that after welding, it would be clean on the inside. The pipe was steel, but was nickel lined on the inside. We solved this in 3 ways:-

First: we designed a unique joint so that the nickel lining lapped and joined a few centimeters from the weld joint - this prevented weld slag and dirt from "burning through".

Next: we had the ends of the pipe capped and we purged the pipe with nitrogen gas while the weld was taking place to prevent oxidation on the inside of the pipe.

Finally: we sealed the buildings off from the outside and had dozens of enormous "vacuum cleaners" going at the same time to suck up all dust in the air. The mechanics (as well as everyone else) had to change clothes upon entering and leaving the building and had to work in sterilized clothes, white gloves, etc., much as a surgeon does.

This was a tremendous problem to police, but the absolute cleanliness inside the pipes was necessary because any dirt would plug the tiny holes in the filters in the converters so they could not function. Imagine construction workers working under more stringent sanitary conditions than an operating theatre in a hospital.

Another problem I encountered at Oak Ridge was vacuum tight welds. We made millions upon millions of welds in the process system and every weld had to withstand a high vacuum test. Girls working for Carbide and Carbon Chemicals Corporation went around with complex machines and when we released a unit to Carbide, (the operators) these girls would pump the unit (which might contain 200 or more welds) to a high vacuum and the sensitive machines would show where the leaks were. When I speak of leaks I am talking about microns and the most unbelievably small leak would show up on the sensitive machines.

Once found, we would have to take that section out and put in a leak-proof section. When dealing with fissionable material, a leak of one micron per hundred years is unacceptable. The standards of welding had to be beyond anything ever attempted before.

There were many applications where we even had to make our own welding electrodes because nothing was commercially available that would withstand the high vacuum test.

There were many challenges - including the welding of many metals I had never welded before such as molybdenum, beryllium, and an endless number of high nickel alloys, etc. Some of these combinations were really unique.

I established a weld laboratory, a welding school, and a welder testing department. The welding school was unique in that we taught about 20 different kinds of welding, ranging from submerged melt to oxyacetylene welding of monel to nickel-plated steel, etc. at the same time.

When I first came to Oak Ridge, Ted Rothermund (who was, to me, a super-engineer) arranged with Colonel Cornelius (the top military man at Oak Ridge) that I be given a "Number 2" badge and a "Priority #2" card. I

didn't realize when it was given to me that it was such a powerful badge. With the exception of a few people, like President Roosevelt who had "Priority #1", my Priority #2 identification was the greatest priority in America. If I had to take a plane, I could have a general's seat if I wanted it just by showing my priority #2 card. I often made trips and anything we needed I could get because of my Priority #2 rating. I remember once I went to Atlanta, Georgia, where there were several hundred arc welding machines available. A major aircraft company had bought them but with my Priority #2 I took them away from them and sent them to Oak Ridge where we needed them. The Priority #2 clearance enabled me to go anywhere, anyplace, even in the most secret government operations. I was one of the few people that was allowed to go into every area at Oak Ridge. My Priority #2 rating let me have anything I asked for, from a scarce hotel room, a thousand fans to cool my welders, or a purchase of rare metals.

I can remember one amusing situation. During the war, copper was in short supply. Surprisingly enough, silver was more available - but naturally a precious metal. At the Y12 Electromagnetic Plant, we had a number of huge electrical conductors. I can remember one bus bar which was about one meter square and about 40 feet long. It was solid silver! In this one plant we used over one-half billion dollars worth of pure silver - not because we needed silver but because it was more available than copper. I say ½ billion dollars worth of silver at 1943 prices. It would be about 4 billion dollars worth of silver at today's prices.

We borrowed the silver from the treasury department. The one bus bar I mentioned was the biggest single piece of silver I have ever seen, and probably the largest ever cast in one piece, in history.

I remember the treasury department had 3 men with machine guns guarding this one piece of silver, day and night. This indicates the strange period and the way we had to work in unusual ways to achieve our results. There was no such thing as "impossible" - if we had to have something and it was not available we somehow got it anyway.

I remember once we were out of monel pipe flanges and we couldn't get any for 2 or 3 weeks from the manufacturer. An engineer named Walter Barto and I stayed up all night, working on it. We made a die out of steel and welding electrode deposits overlaid on the steel. We used an air hammer for a punch press and a huge casting for a work base, and by morning we had made 600 pipe flanges which were nearly as good as the factory one, even with our crude tools.

Another time we made a foundry in 3 hours and cast our own valves for a job when we could not buy nickel valves fast enough.

At one point, the entire project got bogged down because the cell housings could not be welded. Every piece of process equipment and process piping had to be housed in. We built these structures out of sheet metal and then insulated the sheet metal. The reason the housings were necessary was so they could be electrically heated and stay a constant temperature at all times. The uranium was in a gaseous form and if it was allowed to cool it couldn't be pumped "at the speed of sound" through the "miracle" porous nickel filters. There were about 2,000 cells and each were about the size of a typical 3-bedroom house!!!

I had drawn up the welding engineering on these calls - I wrote the welding procedures and specified the materials, etc. The floors were of ½" steel boiler plate and the walls and roofs were of 16 gauge sheet metal. I specified the floors be automatic welded with submerged arc (I bought 30 union-melt machines to do the work) and the cell housings I had prefabricated by Jamestown Steel Partitions Co of Jamestown, New York.

When the prefabricated sections arrived, certain sections I specified to be arc welded and certain sections were to be gas welded. It seemed like a simple job. I did the welding engineering, sent my recommendations to J.A. Jones Construction Company, the prime contractor and considered my

work finished. I had estimated that each cell should require 781 manhours of welding time. They spent 27,000 manhours on the first 4 cells, and not a single cell would pass the air pressure test that the specifications stated they had to meet. It got to a point where the cells had the entire job tied up. Worse, it looked as if the cells would hold the job up indefinitely.

Ted Rothermund called me in and instructed me to spend 3 days watching the cells being welded and rewelded, and to write a report on the cell welding. My report went to Ted Rothermund and from him to the great Colonel Cornelius and from him to H. Von Appen, who was the project manager. Von Appen was a Massachusetts Institute of Technology graduate and, on engineering - no one crossed swords with him. He also was said to be related to J.A. Jones, the project manager who was said to be related to J.A. Jones, the project manager who was said to be related to Harry Hopkins, who was President Roosevelt's right hand man.

Von Appen said I was to go on the Jones Construction Co. payroll and report to "Whitey" Milan, General Superintendent of Mechanical Erection. Whitey was a brilliant engineer, also an M.I.T. graduate.

I don't think Whitey liked me being "rammed down his throat". Soon however, we were good friends and even had Christmas Dinner together on two occassions. Whitey said "If you are to be in this department you will have to do two jobs. You will remain Welding Engineer but, I also want you to be my Assistant General Superintendent of Mechanical Erection!" Here was a loaded challenge! I had (with the foolishness of youth) regarded myself as a good welding man - but a Mechanical Engineer, - I didn't consider myself. I had taken draftsmanship in high school and a few mechanical courses in college. I had had several advanced mathematics classes. None of this, however, was enough for the job of Assistant General Superintendent of Mechanical Erection of the largest construction project and the most complicated in history.

In order that I could straighten out the welding of the cells I was put in charge of cell welding. Bear in mind, before I was in charge of engineering of the cells, not in charge of the work (the engineer specifies how the work is to be done but is not in charge of it - now I was both the engineer and the man in charge of it). First I tackled the submerged arc floor welds. These had micro-cracks in them. The test specimens I had made did not have cracks. Why did they not crack in the laboratory but crack on the job? I investigated and found the flux manufacturer had taken out the manganese from the flux because of the war-time shortages. I bought manganese from Union Carbide Co. and mixed it with the flux and the problem was solved. (A welding flux is either a powder, paste or liquid that is applied to a metal before and/or during welding to improve the cleanliness - and therefore "holding power" of the weld.)

I then tackled the cell housing welding. First I went with a man named John Berglund to Jamestown, New York, and straightened out the fabrication of the sections. No problem. Then I started supervising the sheet metal welders on the job at Oak Ridge. Here I hit a big snag.

The job was strongly Unionized and I was not a member of the Sheet Metal Union. Pat Ryan, the Union Steward for the Sheet Metal Workers told the Project Manager at J.A. Jones Construction Co. that he would put the workers on strike unless I was removed and a Union member put in charge. That night Von Appen, Mr H.A. Doucha (the Assistant Project Manager) and I met for several hours and formulated a plan.

The next morning Von Appen called Ryan in and said he had made his decision. All sheet metal workers could either go to work or terminate! The dissident sheet metal workers lined up to get their termination pay and 831 terminated. We only had about 1,200 and the other 350 or so went back to work. I have never experienced such sheer guts as demonstrated by Von Appen. During an intense labour shortage period, he let 831 out of 1,200 men terminate rather than accept the labour union's "blackmail".

Naturally I have never been so challenged in my life! I had to make good when Von Appen let 831 men go rather than remove me from the job. In a few weeks we had recruited a number of sheet metal workers; some of those who quit came back and were rehired; and we went on to finish the job. In a few weeks I had enough cells finished so that the other work wasn't held up. In a few months I had cells going up at the rate of 2 per day. In fact it became a production line and we were welding cells leak proof in less than 300 manhours.

I then phased myself out of cells (except on a minor basis) when they were going real good. I then concentrated on instrument welding and went back to my laboratory. I spent a great deal of my time on pipe welding and well remember that Midwest Piping Co out of St. Louis had the major pipe contract.

One of their Directors was a man named F.A. Fant. He was an elderly gentleman and had written the American Welding Society Hand Book on pipe welding (I became a member of the American Welding Society, I believe, in 1939). Mr Fant taught me more about pipe welding than I ever knew was possible. My job, as Welding Engineer for the prime contractor was to supervise him. I must admit that it actually went the other way. He knew so much more than me on that subject that I really listened to every word he said.

Another thing that I put the sweat of my life into was the cold traps. After the U235 was finally separated from the U237 and U238, it went to the cold traps and these turned it into a liquid from the gas it had been in. I received my greatest praise and am proudest of my work on the cold traps. The design and welding of these was a real challenge.

I was, for 3 years, totally involved and totally engrossed in my work. Life was very grim at Oak Ridge which was in the centre of the huge Clinton Engineering Works. I did 'however' have conditions much better than most people.

The construction workers lived in "huts" which were tiny houses with 5 cots per hut and no running water except at a community outdoor location. With my "Priority 2" badge I lived in a private room in the Officers Quarters, ate at an officer's cafeteria and had a jeep provided.

There were often blackouts and there was very little to do. Actually we engineers called the total project Oak Ridge (as it later became known) and we called the village of Oak Ridge as "Townsite".

Townsite had one combination chemists shop - general store - news stand, one outdoor bus station, one theatre which showed only war propaganda films, one recreation hall where boys met girls and dance to the juke box. It also had a post office, but little else. No alcoholic spirits were allowed on the premises.

My only recreation was each Saturday night, being unmarried, I would take a young lady (usually a Carbide and Carbon Chemicals operational staff girl) on a one hour ride to Knoxville where there were restaurants and, with the right maneuver, a bottle of wine.

In my spare time the last six months, I wrote a book about Oak Ridge. I had to send it to the army censor before it could be published. I did, after the war ended, but while I was still at Oak Ridge. The censor kept the book and forbade its printing. Two weeks later, Dr Smythe's book came out, which released far more secrets than my book. In fact my book was written so that it didn't give away key secrets! Dr Smythe's book did! I decided then and there that I (see copy of correspondence attached) understood engineering much better than I could understand politics.

I also remember one night I had a call from Colonel Cornelius to meet him at midnight at K31 (one of the final buildings). I couldn't understand why he wanted me to come at midnight on a Saturday night. When I arrived there was the great Colonel with 12 other men. The others were scientists or top executives.

At this historic meeting a metal insulated bottle of the pure stuff - Uranium 235 - was taken from one of the cold traps. Each one of us in turn was allowed to hold the bottle, and then pass it on. Then we bowed our heads in prayer. We had all handled the first mass-produced Uranium 235 the world had known; the material we handled that night was the charge that set off the first atomic explosion in history about 2 weeks later in Santa Fe, New Mexico at the Alamagordo test grounds.

The bottle of material we held - that I held in my hands - set off the world's first Chain Reaction. History was made that night as we all accepted the awesome responsibility for the power we had created.

A few weeks later, I was awarded a citation by the Honourable Henry Stimson, the U.S. War Time Secreatary of War, for my contribution to the development of the atomic bomb (a copy of that citation is also attached). General Groves, the Chief General of the Manhattan Project shook my hand. At that moment, a phase of my life that I never want to experience again (but would not have missed for anything) passed. At that moment my awesome responsibility was over. I was a free man and, thank God, the War was over.

DSA 058

THOSE WONDERFUL MEN WITH THEIR WELDING MACHINES

(PART SEVEN)

---

by Leon D. Richardson
Chairman of Directors
Magna Alloys and Research Pty Limited
Blackwall Point Road
Drummoyne, N.S.W. 2047
Australia

In August 1945, shortly after God and the atomic bomb ended World War II, I left my position at Oak Ridge to go into civilian work and re-start my career. The war years had been a tremendous education to me but they had been hard years. During the war and the two years preceding the war I had worked in 7 shipyards besides spending 3 years at Oak Ridge on the Manhattan Project.

I found, to my surprise, I was now famous in engineering circles. My name and photo was in many of the world's newspapers on numerous and regular occasions. Whenever I went to a city, the newspapermen would pick up my arrival, interview me for the newspapers, and usually radio interviews were conducted. The great miracle of Atomic Power was fresh in everyone's mind and, since I was so closely identified with this great scientific achievement, having been honored by Secretary of War Henry Stimson himself, I was a celebrity among engineers.

I had job offers from every corner. I could pick almost any engineering job I wanted. Now, however, I had an adventurous spirit and still was in my twenties and I didn't want a routine job. I decided to become a Welding and Engineering Consultant. I was called in for consulting work by literally hundreds and hundreds of major companies, for a period of about 15 years.

This gave me a great opportunity to travel and to be confronted with all kinds of Welding and Engineering problems. I was consulted by many, many major U.S., Canadian and Mexican Companies including such giants as:-

Bethlehem Steel Co	Thompson Ramowaldrige
Eastman Kodak	Solvay Process
E I Dupont	Spicer Co
Ford Motor Co	National Cash Register
General Motors	Hughes Tool Co

Petroleos Mexicanos
U.S. Steel Co
and hundreds others.

Standard Oil Co

I visited, in those years every city in the U.S.A. and every city in Canada (having over 25,000 population) and many smaller ones. I found Consulting and exciting way to travel, to meet new people, to face new problems daily, and to learn.

In those years, I did a great amount of work with universities. I visited Purdue, Tulane, Massachusetts Institute of Technology, University of California, McGill University, University of Texas, Case Institute of Technology, and, I suppose a hundred other Universities.

I also did much work with the U.S. Navy, the U.S. Army, the U.S. Air Force, the Royal Canadian Air Force, the Atomic Energy Commission, and also many branches of the military in many countries including the United Kingdom, S.H.A.P.E. Headquarters in Paris, etc. I believe I did consulting work at over 30 U.S. Air Force Bases.

I also made 52 trips to Wright Patterson Air Force Base, the U.S. Air Force Research Centre (where "tomorrow was happening today"). I used to work there with German Scientists who had been hired by the U.S. Government from Germany after the defeat of Germany. Another of my favourite places to visit was Arnold Laboratories in Nashville where the Air Force had giant wind tunnels and laboratories. I visited Sandia Base that developed atomic weapons in Los Alamos, New Mexico, about 15 times. I regularly visited White Sands Proving Grounds in New Mexico. The sand there was like sugar and it was hot. I worked with the laboratories that fired German V2 rockets that had been brought over from Germany after the War. This was the Genesis of the Program that put a man on moon and I was delighted to be in on the beginning. They had some real welding challenges I was called in on. (My work at White Sands is covered in the next chapter).

I conducted Welding Seminars at many military bases such as Marion Engineering Depot in Marion, Ohio, and I can't remember how many others.

I really did travel in those days. I would be in Fargo, North Dakota, one week, Salt Lake City, Utah, the next, Kansas City, Missouri, the next, London, England, the next, Paris, the next, Newfoundland, the next, and so on. I was for many many years, seldom in the same city 2 weeks in succession. I travelled to remote areas in Canada, I visited mines all the way from Canada to Arizona to Cyprus.

I became somewhat of an expert on Railroad Welding and I used to ride the trains with the Railroad Welding Engineers, visiting a railroad workshop here and another there. I flew so much that I chalked up one million miles just with United Airlines alone by 1957!

I wrote constantly. I would send articles to magazines such as Iron Age and they would publish them and send a nice cheque which was a good way to augment my consultant income. I can't remember ever getting a rejection slip and I had well over 500 articles published in technical journals (maybe a thousand -I lost count years ago). I became well known as a technical lecturer also. I spoke before a thousand or more technical Society Meetings in those interesting years.

I spoke before 60 chapters of the American Society of Tool and Manufacturing Engineers. I spoke before countless chapters of the American Welding Society, The American Society for Metals, The American Society of Manufacturing Engineers, and The Refrigeration Society of America. I spoke before the Instrument Society of America, The American Society of Locomotive Engineers, and many many other groups..... so many I can't remember them all without getting out old scrap books and newspapers clippings.

I spoke in many countries making lecture tours of the United Kingdom, Canada, Mexico and South America. It would be difficult to imagine a person who has made more lectures before advanced professional technical groups than I did during those busy years.

In 1959, I and Fred Rochll formed a company called "Superweld Incorporated" with headquarters in Detroit, and my consulting work was greatly diminished. I will tell about this in a later chapter.

THE H.K.FERGUSON COMPANY
INCORPORATED

25 West 43 Street
New York 18, N.Y.

June 2, 1945

Mr. L. D. Richardson
Room 252 Stina Hall
Oak Ridge
Tennessee

Dear Mr. Richardson:

This is to acknowledge receipt of your wire of May 31st and to explain that absence from the city delayed an answer.

It is quite possible that we can use a man of your wide experience in welding in our organization, and I have already discussed the possibilities of this with Mr. A. Kingsley Ferguson, our President.

We are enclosing with this letter our personal history statement in triplicate. Will you please send one to Mr. A. Kingsley Ferguson in the Hanna Building, Cleveland 15, Ohio, and one to Mr. V. M. Fulton, our Personnel Manager, who is presently staffing a job in Pine Bluff, Arkansas. I am giving both of these men a copy of this letter to let them know that I consider you particularly well qualified, both from your engineering background and years of practical experience, to fill a position as welding consultant for our company or any one in similar work.

I had almost given up hearing from you as I was under the impression you were going to Guadalajara with Whitey Milan.

With best personal regards,

Yours sincerely,

THE H. K. FERGUSON COMPANY

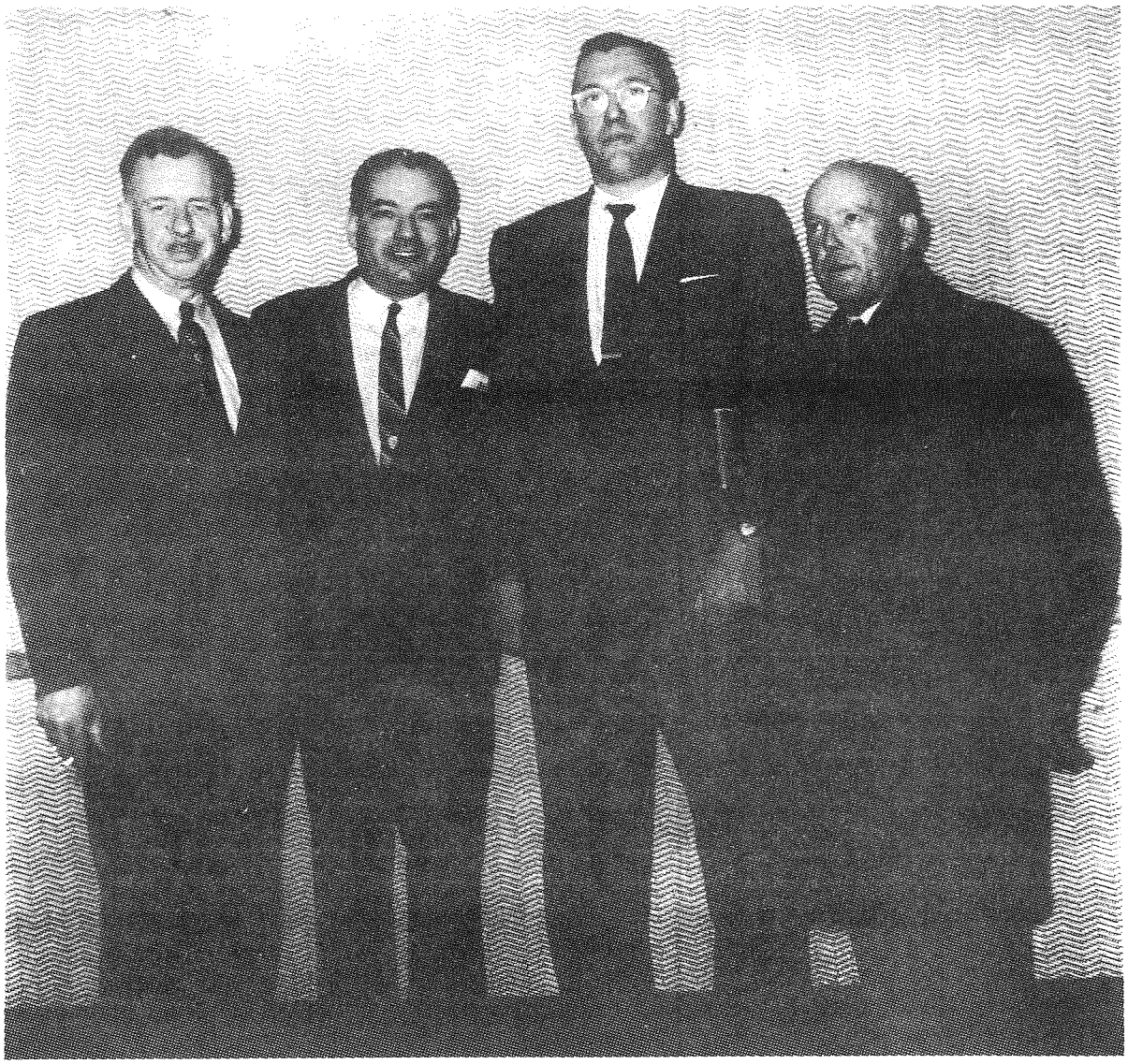
T. K. Rothermund

TKR.T
cc Mr. A. Kingsley Ferguson
cc Mr. V. M. Fulton
c/o The H. K. Ferguson Company
Pine Bluff Arsenal, Pine Bluff, Ark.

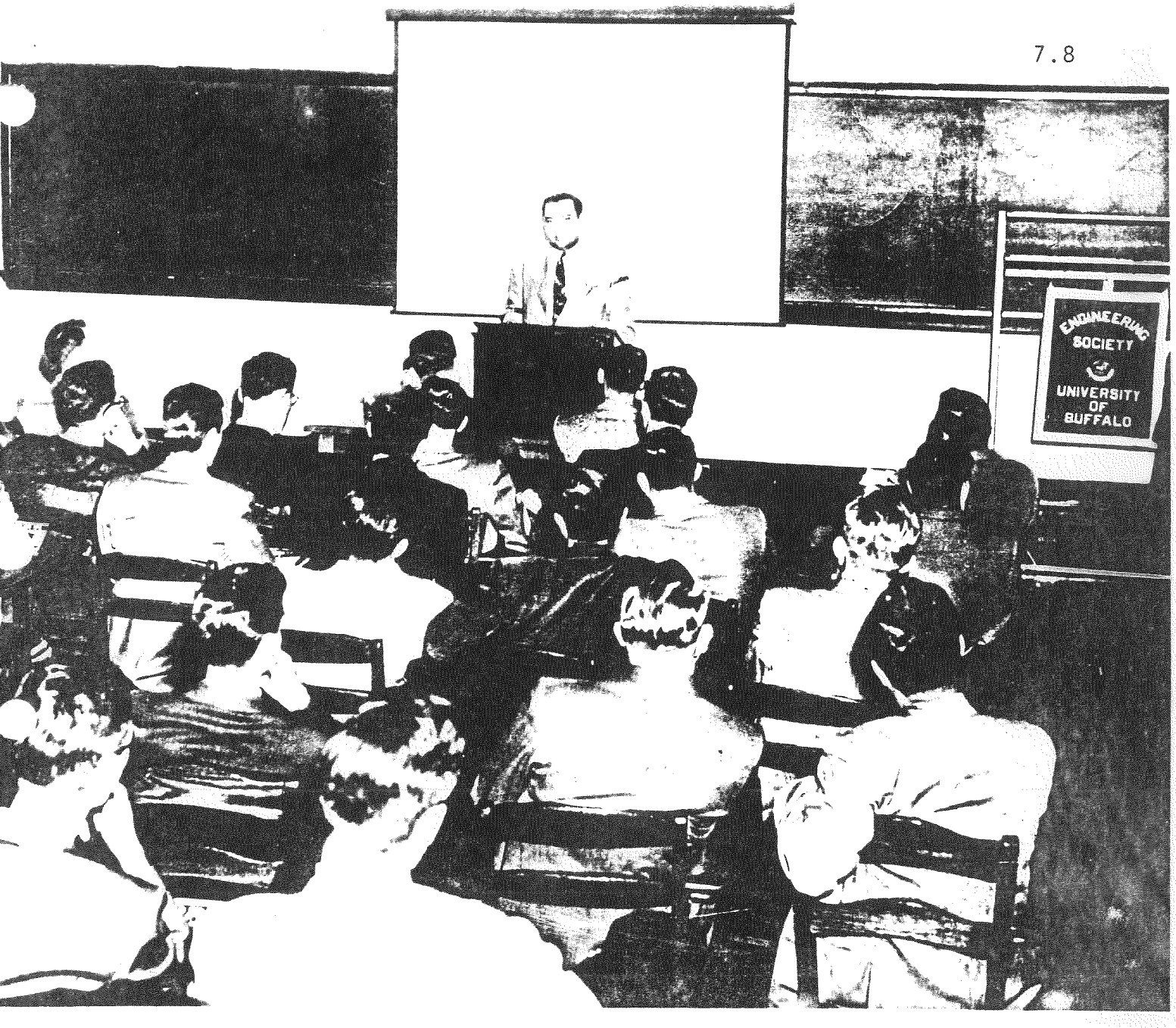
INDUSTRIAL ENGINEERS AND BUILDERS
MAIN OFFICE · HANNA BUILDING · CLEVELAND 15, O. · CHERRY 5870
NEW YORK OFFICE · 25 W. 43RD ST. · NEW YORK 18, N.Y. · BRYANT 9-7257

After the war I became a Welding and Engineering Consultant. Above is Letter from my old Oak Ridge chief "Engineers of Engineer's, Ted Rothermund, inviting me to work as Welding Consultant at the Pine Bluff Arsenal.

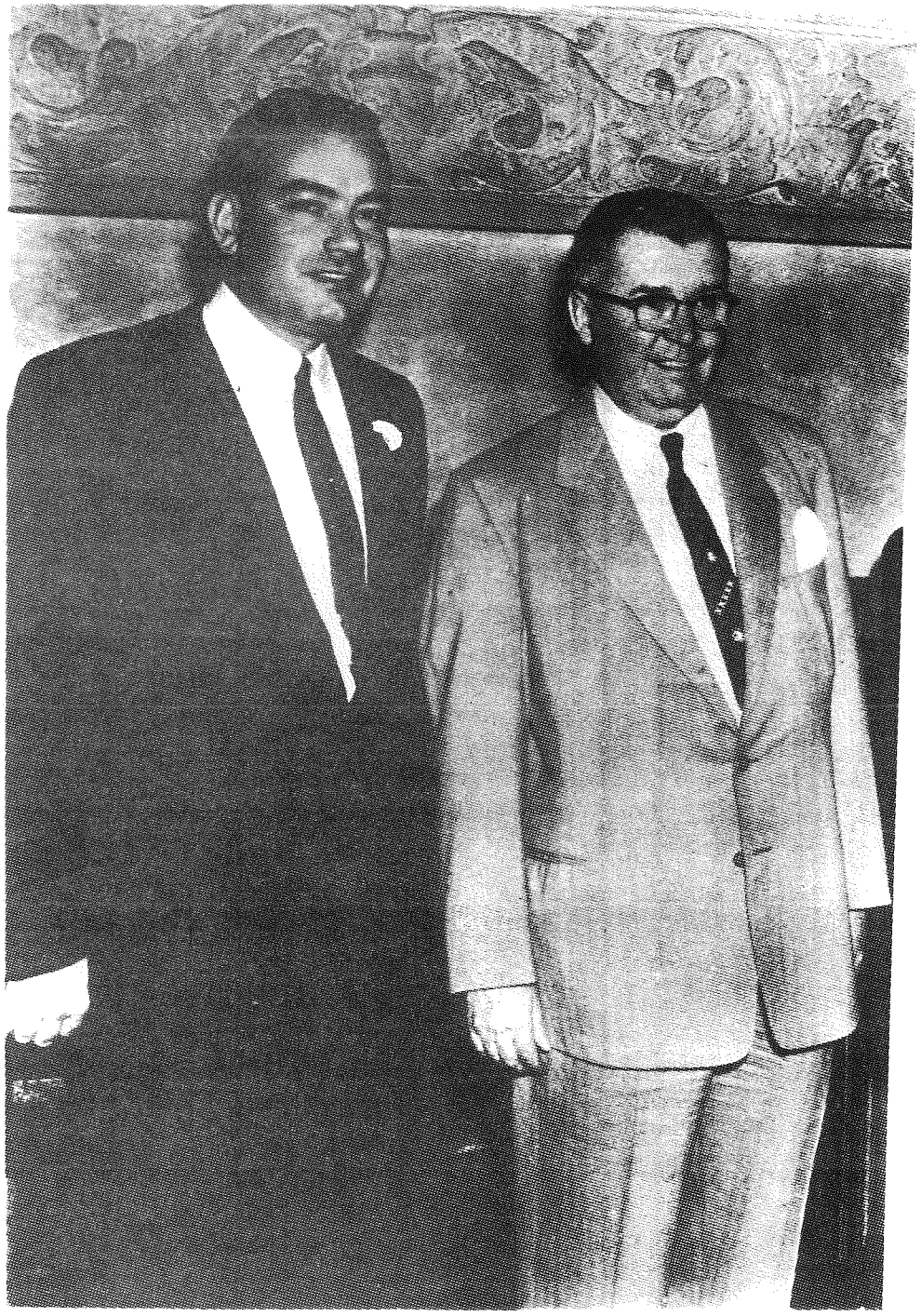
My desk in 1947 in Dallas, Texas.



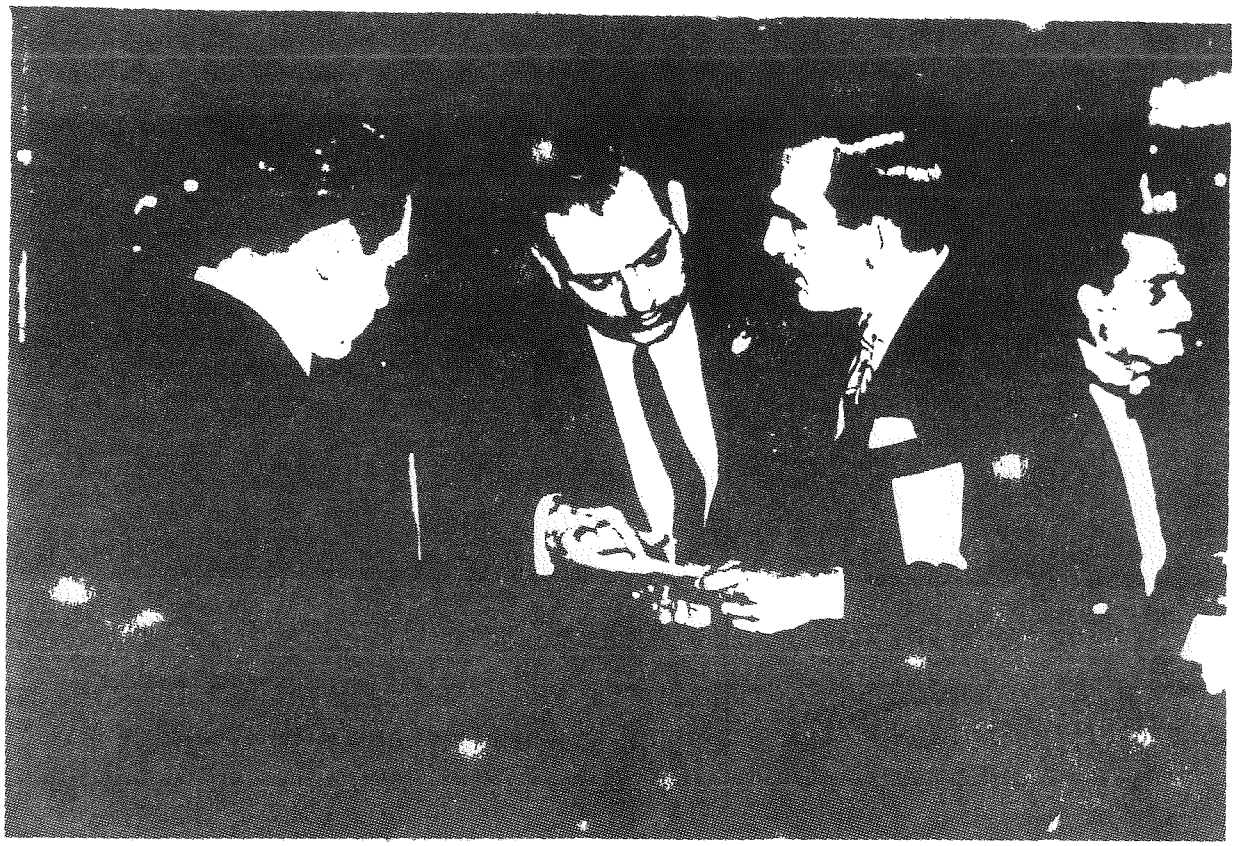
With officers of the University of Rochester in 1949.



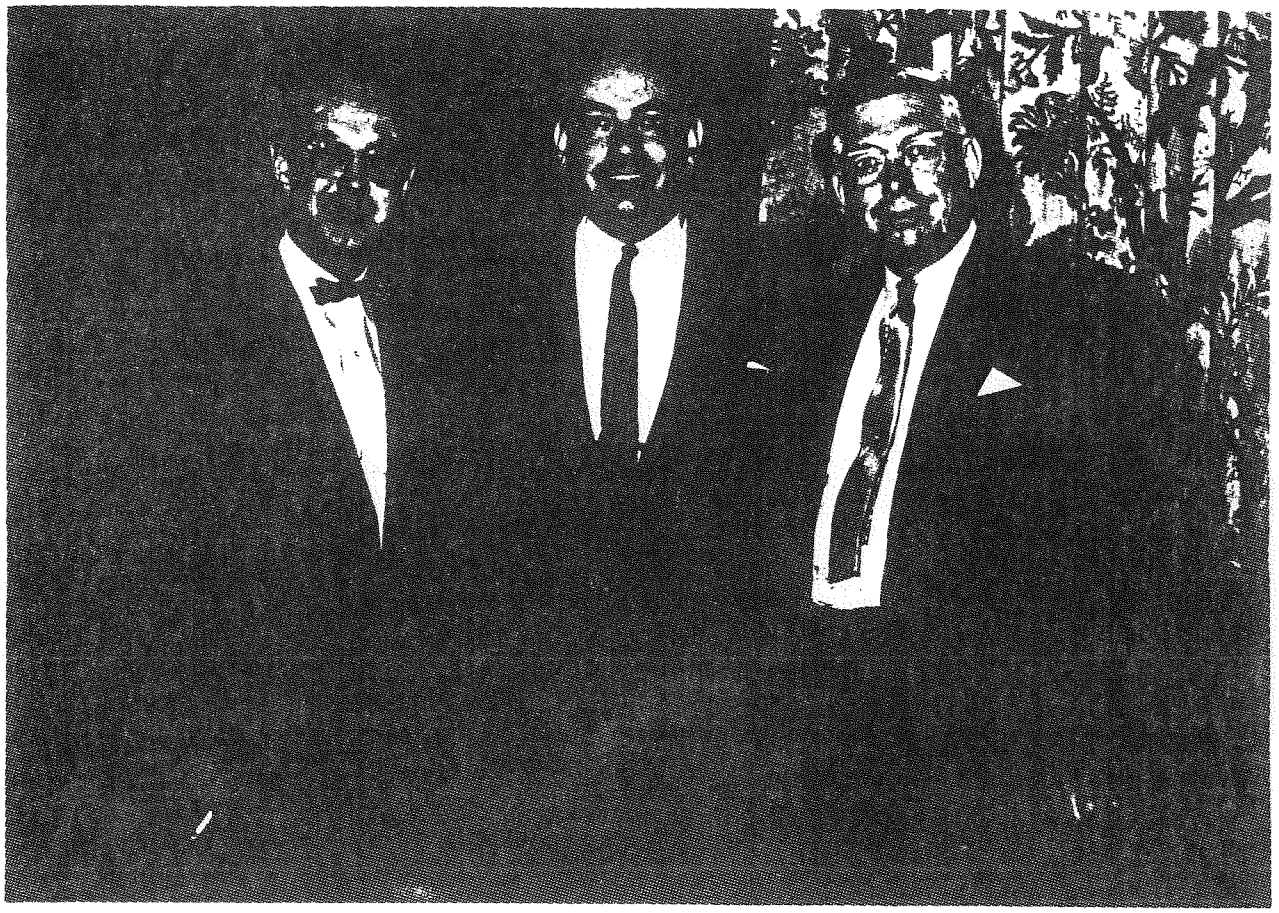
Lecturing at Engineering Society, University of Buffalo, in 1950.



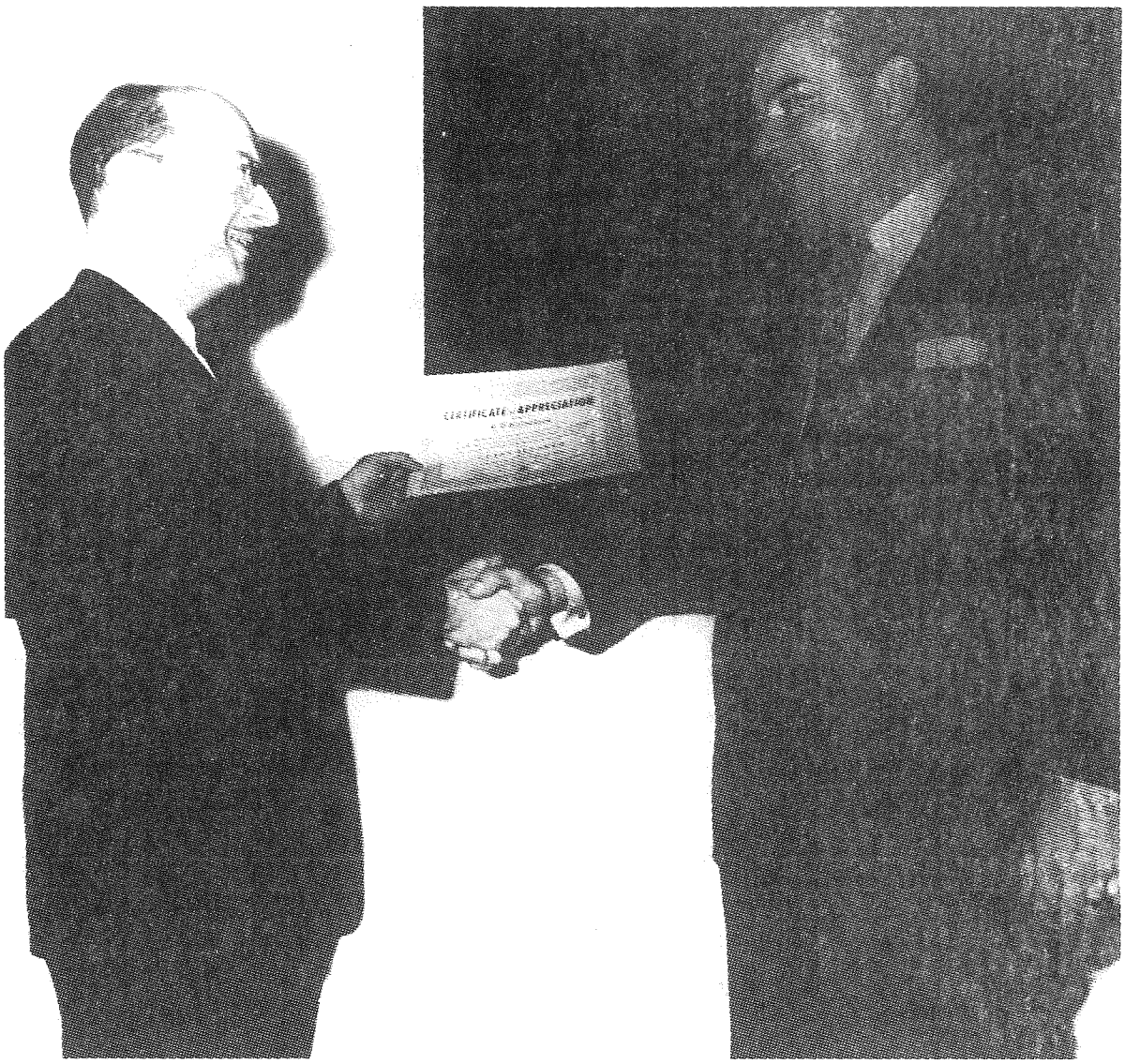
With U. S. Senator Thomas Burke at the Mayor of Cleveland's office in 1951.



With the Editor of the British Welding Journal in London in 1952.



Lecture before American Foundryman's Society in Pittsburgh in 1954.



Receiving a Certificate of appreciation from the American Welding Society in Cleveland in 1955 as Speaker of The Year.

Being received by his worship, the Lord Mayor of Glasgow and the Chairman of the Productivity Council at the Mayor's office.

After lecture before Canadian Institute of Metals in London, Ontario with society officers.

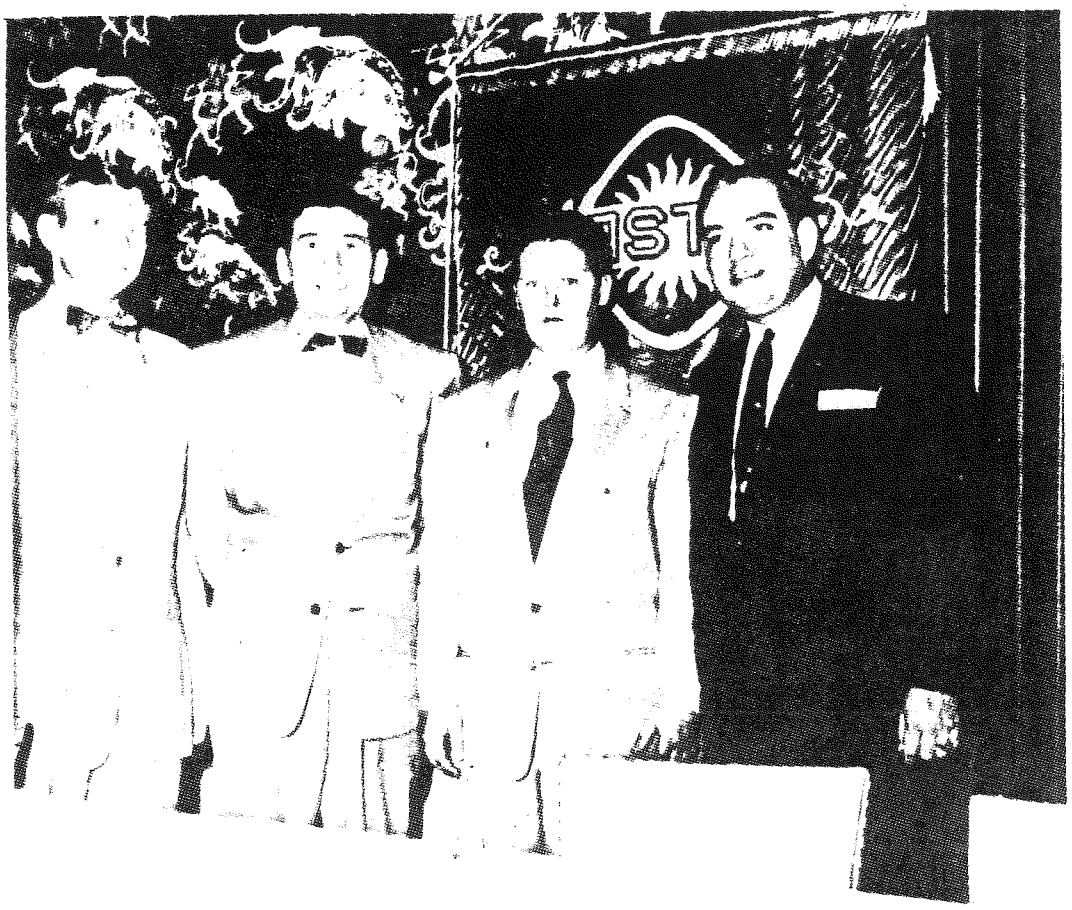
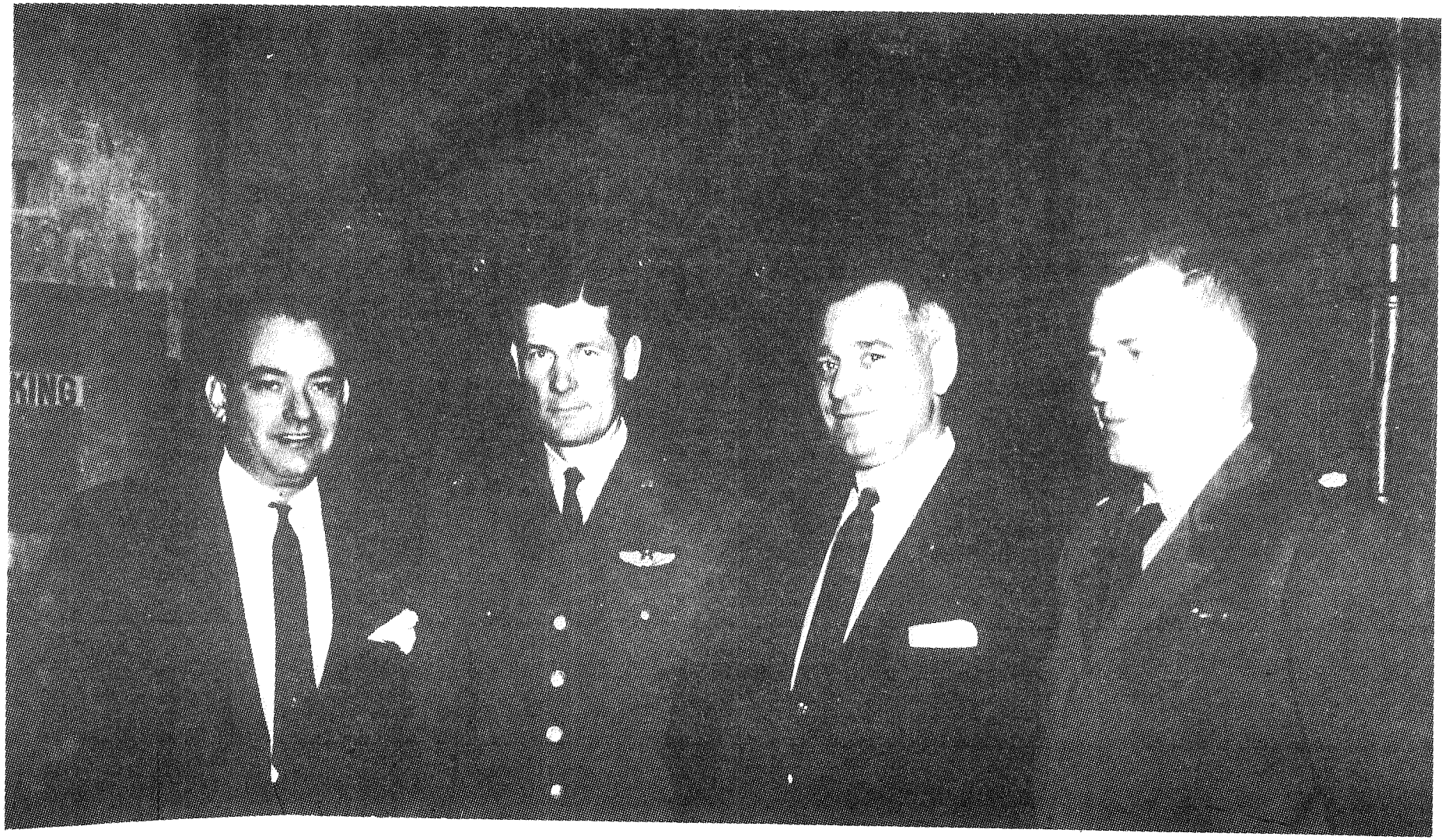


Photo taken after a lecture before The American Society of Tool and Manufacturing Engineers, Montreal, Quebec.

Lecture before the Institute of Mining Engineers in Sudbury where the famous Nickel Mines are located.

Photo taken at McGill University after Seminar conducted by Leon D. Richardson.



Official U. S. Air Force photograph taken at Thule, Greenland with Colonel Frank Ellis, a security guard, and Major John White. I was brought to this base very near the North Pole to solve welding problems related to arctic defences.

DSA 059

THOSE WONDERFUL MEN WITH THEIR WELDING MACHINES

(PART EIGHT)

by Leon D Richardson

Chairman of Directors,
Magna Alloys and Research
Pty Limited
Blackwall Point Road
Drummoyne, N.S.W. 2047
Australia.

"THE HOMESICK ANGEL"

"Dianna" was the most beautiful thing I had ever seen (or so I thought at the time). She seemed to go straight to heaven, with nary a hesitation, hiccup or detour. "She's a homesick angel!", 'Budweiser' shouted in thick German.

'Budweiser' and I were so excited that we played just like children and pranced and danced. We started throwing sand at each other ..... laughing, crying, screaming .... all the while tears were running down our sunburnt faces. It was a fantastic moment in history.

Soon we were joined by 'Pabst' and 'Schlitz' and 'Reingold' and the five of us danced and shouted and hugged and embraced as if the home team had just won the championship.

This all happened in the New Mexico Desert near Las Cruces, which is spanish for "The Crosses". We were at the United States Navy's White Sands Proving Grounds. We had just test fired the first guided (radio-controlled, to be exact) military ballistic rocket ever to be fired on American soil. It was, in fact, a German V2 rocket (albeit with 'American' guidance systems).

The year was 1946. 'Budweiser' and I had managed to get very close to the flying chute (as they were called before the term launching pad gained wide acceptance). We had buried ourselves in the sand, with only our heads protruding. We wore dark glasses over our eyes and had made the unofficial countdown for the launch ..... he in German and I in English.

We were both frightened silly, yet refused to run off to somewhere safe. The adrenalin coursed through our veins and threatened to burst through our very skins, like a boiler with a stuck safety valve.

'Pabst', 'Budweiser', 'Reingold' and 'Schlitz' were German scientists and, no doubt, the best scientists in the world at that time. After World War II ended, the Bolsheviks started grabbing German scientists as fast as they could find them and "repatriating" them to mother Russia. The United States finally got smart and also grabbed as many scientists and stockpiles of German rockets, V2's and blueprints as they could get to. Fortunately for the Americans, they got the maestro of rocketdom - Von Braun.

During the war years, I had worked for the U.S. Corps of Engineers, Manhattan Project, in New York at its nerve centre, and then for four years at the actual project construction site at Oak Ridge, Tennessee. I occassionally made trips to Los Alamos, New Mexico and a few other "hot" spots during this period, either to requisition or to provide technical assistance.

The atomic bomb and God had thankfully ended the Second World War, and I had become a consulting engineer - a troubleshooter for difficult projects.

The U.S. Navy (for some reason that I have never understood, even until today), was given the original franchise or project of initiating the U.S. Missile Program.

The first project undertaken was, of course, to test and improve the capabilities of captured German V-2 rockets in the New Mexico desert. I was called in as a consultant. It had taken a considerable amount of effort, tiring trips and much work before we fired "Dianna". It was here that I watched the first launching of the V-2 from American soil.

We test fired quite a number of German V-2 rockets during the weeks I was there and each one was given a female name. It was a rule that no Germanic names be used (the holocaust wrought by Nazism was still too fresh in every mind).

For some hazy reason that I cannot, in honesty, fully recall, they gave me the priveledge of naming the first one. I named her Dianna and actually wrote her name across the "belly" of the rocket housing with a lumber marking crayon.

I had named her Dianna for two reasons. I was young and arrogant and Dianna sounded somewhat similar to my own middle name (which is Don), to satisfy my own ego. Dianna was also the huntress of Greek mythology and it seemed an appropriate, aggressive and fitting name for this first rocket.

When I first went to White Sands on this project, I was instructed to work with four German scientists who had just been "recruited" from the remnants fo the German war machine. I felt the assignment also encompassed keeping an eye on them and their work - even though there were no official instructions to that effect.

I couldn't pronounce their names as they carried virtually unpronounceable German gutterals and I gave up after but a few tries. So I decided to call them the only Germanic-sounding names I knew and could easily remember. Hence their rather commercial-sounding nicknames of 'Budweiser', 'Pabst', 'Reingold' and 'Schlitz'.

Now, before I go into the engineering problems we faced at that time, the reader must bear in mind that in those days, the transistor had not yet been invented. The science of electronics was really only in its infancy and we called the slow-working, heat-producing, delicate glass valves "state-of-the-art" electronics!

Even with this rather crude missile guidance system of the audion-type vacuum tube, we only had one minor malfunction. This good record was, perhaps, partly due to good luck, but I feel it was in great part due to the meticulous attention to detail paid by these great scientists of the day.

One of my main duties at this Navy project was to help perfect the vacuum tubes that controlled the guidance system. I therefore made many trips between the White Sands range and the U.S. Air Force's Aeronautical Research Center at Dayton, Ohio.

At Dayton, I worked in an instrument laboratory where almost everyone was a "liberated" German scientist. Using my old "memory association" trick to differentiate these new co-workers, I dug deep into my limited vocabulary of Germanic-sounding names to come up with 'Lowenbrau', 'Michelob', 'Pilsner' and 'Coors'. I even called one 'Heinecken', which is Dutch, but word associations drew no national boundaries. 'Heinecken' sounded German to me!

When I eventually ran out of these beer names (which were the easiest Germanic names to remember), I had to resort to 'Strudel' and 'Schnapps' At the time, it seemed easier to remember these names than their impossibly difficult German names.

My favourite was 'Budweiser'. He and I shared the same tent at Las Cruces. At night, to while away the time, we made a deal. I would teach him English and he would teach me physics. I think he got the better deal and he progressed rapidly while I still struggled with gravity and various elementary physics laws. I did however pick up some useful knowledge on the mystery of electronics, instrumentation, vacuum tubes and (comparably) primitive methods of electronic communications used by Germany during the War. He even taught me how to blow glass and make a tube. Just for fun (and I suspect to prove his theories), 'Budweiser' and I rigged our tent up with gadgets that we could control from a distance. We could make coffee in our tent by triggering the percolator from far away.

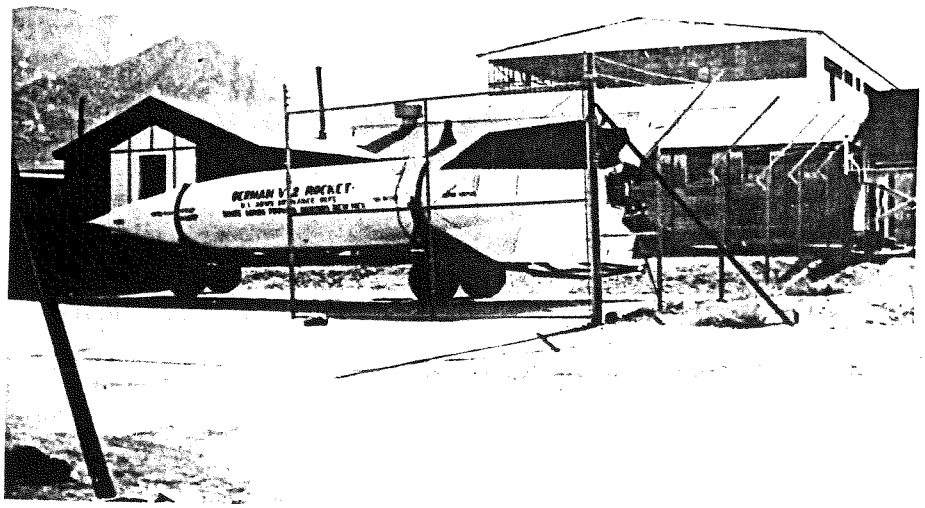
The reader must remember that what we accomplished then seemed miraculous at the time. When compared to today's electronics, the simplicity of our electronics is like comparing the electronic complexity of a doorbell to that of a computer. 'Budweiser' was great fun to work with and he taught me a lot.

Most people believe the space age dawned when Russia launched their Sputnik satellite at the end of the 1950's. I believe the pioneers of rocketry were really the Chinese who invented rockets and actually used them to carry explosives. Though highly inaccurate, these rockets were used in battle long before gunpowder found its way to Europe!

It still amazes one to think of how accurate H.G. Wells was when he wrote his famous science fiction novels in the 19th century. In fact, some of his predictions were deadly accurate.

He was soon followed by a whole new legion of science fiction (sci-fi) novelists and many predicted the development of atomic energy, orbiting space capsules (satellites) and space travel. It is perhaps interesting to note that when World War II befell Europe and as the U.S. prepared for the inevitable involvement in that global conflict, I tried to buy some of these fiction books on atomic power. But the U.S. Government had quietly removed and/or confiscated all such books from all book stores and publishers, under the cloak of "National Security."

Amongst these "pioneering" sci-fi writers of the day were Edgar Rice-Burroughs (later of Tarzan fame), Arthur Clarke, Hublein, Wiley Lee and many others. It was perhaps, in retrospect, fate that brought the child, who had read Rice-Burroughs' fantasies of space travel, to a face-to-face meeting with reality when later, I was to watch "Dianna" disappear into the heavens.

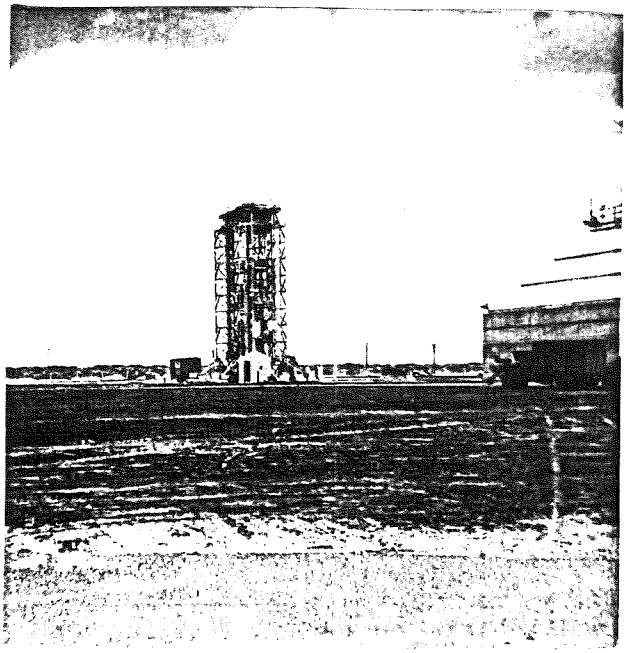


This is "Dianna" - the "Homesick Angel".

I can still vividly remember the "launching chute" in those days when we worked on ironing out "Dianna's" intricate guidance system.

The "launching chute" looks like child's play compared to the tracked, self-contained, multi million dollar launching pads used today at Cape Canaveral but it was pure technology at the time.

I took this picture snapshot of the "launching chute" as an amateur photographer the day we "freed" Dianna.



This launching chute at White Sands was the structure from which the German V-2's were launched. It is difficult to believe that, from this primitive structure, only about 8,000 days later, a man was put on the moon. This photo is probably the only photo of this kind outside U.S. Government archives.

I will never forget that day at Las Cruces when we fired this V-2. There we were, 'Budweiser' and I, buried in the sand and half out of our wits.

"You know, my friend," said he, "if Dianna does not launch, she will probably spray us with her hot, explosive propellant!"

At launch, Dianna seemed to pause for an instant in mid-air, as if to gather steam, and then she went up, amid a myriad Kaleidescope of brightly burning tail gases. It only took 'Budweiser' and I seconds to leap up from our make-shift, do-it-yourself, blast shelters.

Dianna's power seemed to light up the darkening desert sky and then our Homesick Angel departed. Compared to today's rockets that launch heavy, space-bound loads, Dianna was puny. But to me, she was the goddess of the skies.

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As mentioned earlier, I worked with a splendid team of German scientists and researchers both at White Sands and at Wright Field.

I was considered by some scientific people as an expert on such applications as making vacuum-resistant welds, and high purity welds with "clean" metals.

The U.S. Navy and Air Force were not satisfied with the performance and reliability of existing vacuum tubes used in the V-2's guidance system and our job was to "stretch" the capacity of these tubes to the limits of technology.

It should perhaps be mentioned that, if it were not for the U.S.-developed proximity fuses for anti-aircraft weapons, the toll and havoc that the German rockets could have wreaked on England would have been quite devastating. It wasn't the weapon that won the war but it's importance is mentioned here to enable the reader to get a proper perspective of the situation at that time. (These fuses used tiny vacuum tubes).

I was given seemingly impossible tasks such as joining molybdenum to beryllium and to refine chromium to a state more pure that it had ever been. Additional tricky assignments included joining tiny pieces of these and other metals to one another without diffusion of one metal into another and within the confines of a vacuum tube!

These tasks can be likened to carving, letter by letter, the Lord's Prayer on the head of a pin ..... it can be done but it isn't easy.

And did I succeed ? Only partially. The German scientists wanted the moon and sixpence. I only gave them half a moon and thruppence.

I did manage to weld the tiniest pieces of the most pure metals together with a minimum of metal diffusion - which was fully one order of magnitude better them had been done before. But they wanted no dilution.

We did get very close ..... painfully close at times to eureka. I am told that my contribution helped America get quickly into the space age, but I don't know ..... in retrospect my contribution seems very small.

What I do know however, is that I learned a lot, and knowledge is priceless.

In the subsequent years, I went on to work on many rocket projects. They were all given non-descriptive names for security reasons. Some I remember were 'Long John', 'Little Joe' and 'Red Eye'. There were many, many projects as space budgets were large. A lot of these projects came to grief and were dropped. However none, even the sophisticated Minutemen of today, can compare to "my" Dianna.

Man's advance into outer space in the 40 years since I saw Dianna rise into the sky, has been phenomenal. Every technological advance has been followed by yet another.

I agree, however, with John Naisbit who said in his famous book "Mega Trends", that during our life time, man's pursuit of advance will bear far more fruit in the realms of communications than the actual exploration of other planets.

We are already witnessing the informational advantage of forecasting weather by satellite, mapping by satellite, surveying earth's resources by satellite and, most important of all, communicating by satellite.

Man's conquest of outer space has already completely "collapsed the information float". To illustrate:

When Abraham Lincoln was killed by an assassin's bullet, I am told that it took five days to get the news to London. But when President Kennedy was assasinated, the London papers were printing preliminary reports within minutes.

The London Sentinel Newspaper telephoned their correspondent in Dallas, who was only four blocks from the scene, and it was London that informed this man that Kennedy had been assasinated! And that was over 20 years ago.

Today we are living in a yet more advanced communication state. Cities like Sydney, London, Tokyo or New York, thousands of miles apart, communicate with each other within a satellite echo/land line transmission "delay" of just 7 seconds.

And for me, this remarkable age of man's exploration of space started with the successful launch of the Homesick Angel, way back in 1946, at a desert site at White Sands.