

MY CONNECTIONS WITH AIRCRAFT AND SPACECRAFT

by

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When I was born in 1914 it was into a world that was not yet out of the *horse and buggy days*. I wore button shoes, used coal oil (kerosene) lamps in the evening, and went to an outdoor privy when necessary. Our family did go to the store in a buggy or in a bobsled in the winter. It is now the year 2003 and mankind has gone from a buggy to an automobile, an airplane, and is riding rockets into space. At the end of the year, in December, there will be celebrated the 100th anniversary of the first powered flight of man and machine. This occurred on 17 December 1903, on a sand dune just off the ocean at Kitty Hawk, NC. Wilbur and Orville Wright were the brothers who carried out this first in aviation. As I was born on the 11th anniversary of this event near the sand dunes of Indiana perhaps I may be allowed to write a few words about my relationship to aircraft and the follow-on spacecraft during a lifetime. The intended readers are expected to be my children, my grand children, and my great grand children, some day. Incidentally, Wilbur Wright the leader and guiding light for the brothers was also born in Indiana.

The story of the Wrights' efforts and successes is very well told in a recent book:

James Tobin, *To Conquer the Air*; Free Press, NY, 2003.

It was my reading of this book that prompted me to write this memorandum. As a delineation of the avarice, under handed activities, and grabs for glory of their competitors, this book will be hard to match. Various of the names associated with early attempts at manned flight carry considerable tar also associated with them: Glenn Curtis, Alexander Graham Bell, Octave Chanute, Samuel P. Langley and Charles Walcott of The Smithsonian Institute, to name the more important. It was not until 1948 that their plane, the *Wright Flyer* was properly hung and placarded in The Smithsonian Institute. The Wrights were a couple of excellent experimentalists, honest, hard working, and talented. They brought their ideas to a successful conclusion by their own labor and their own finances, using information that was available in the public print. The U.S. Patent Office gave them the basic patent rights on manned flight in 1914.

My earliest memory of airplanes is connected with the early "barnstormers" who flew the planes developed during WW I. These were small aircraft, biplanes that had two open cockpits, one for the pilot and one for passengers, two at most. The pilots of these aircraft were generally ex-army pilots that were small type entrepreneurs attempting to make a few dollars. Either they did stunts at county fairs or took passengers up for a short spin over the nearby countryside. I recall my parents, together, taking such an adventurous ride. I don't remember the day or place, however. I do recall seeking out the landing fields of several of these planes that sat down near North Judson to bring aviation to the hinterlands. My close friend and I upon seeing an aircraft circling, looking for a level meadow to use for an "airport", would run in the direction that it was last

seen until we found the landing location. This might be one or more miles from town and an exhausting search leaving me with a painful stitch in my side. We were allowed to come near the plane, generally, and this made the effort rewarding. Sometimes we were even allowed to talk to the pilot.

My next contact with aircraft was during a small number of flying lessons. The third mate on the SS *Clearwater* was hooked on planes even though he spent long periods on the ship surrounded by the mighty ocean. However, during two of our visits to New Orleans, our home port, there was sufficient time ashore to squeeze in some flying lessons. He prevailed upon me to accompany him and actually take part. These lessons took place in quite small aircraft, in an Aeronca C-3 in the first instance, and in a Piper Cub (or maybe the Taylor E-2 Cub) during the second set of lessons. The lessons were each ½ hour in length. My total time was 3 1/2 hours. Although I enjoyed flying, it was costing me too much!

During my two years, 1935-6, as a radio operator or Sparks, on the SS *Clearwater* I had occasion to contact the two German dirigibles. These were the Graff and the Hindenburg zeppelins. Both were in service carrying passengers and mail between Europe, the United States, and the East Coast of South America. As these aircraft were vulnerable to extremes of weather, their radio operators spent much time on the air asking for weather information from the ships in the area. I participated in this several times. Also, this was during the height of the Pan American Clipper flights from the U.S. down to the various countries of Central and South America. They too were actively seeking weather information and I contacted several of them. These passenger and mail carrying flying boats did not fly after dark, they landed at a scheduled harbor and the passengers and crew went ashore for the night!

After my two years as a salt-water sailor I dropped my anchor ashore at West Lafayette, Indiana, and enrolled for a four-year-course in Electrical Engineering, 1937-41, at Purdue University. This was during the time that Amelia Earhart was doing her world wide flying with her co-pilot, Nixon. She had Purdue University as one of her sponsors and she did some interaction with the Purdue Airport and the Aeronautical Department in return. This was terminated suddenly when she and co-pilot disappeared in the Pacific while on a globe-circling jaunt. I knew that this activity was going on at the time but had no real contacts with the events. In later years Purdue turned out over a dozen or more of the astronauts that flew in the earth- and moon-orbiting spacecraft as well as those that landed and explored the Moon. Neil Armstrong was the most well known of these latter. By that time I had finished at Purdue and was developing antennas for use by these astronauts!

During the four summer vacation periods at Purdue I was able to ship out as chief radio operator on some of the cruise and excursion ships that operated on the Great Lakes. These were excellent positions as I lived on the ship with room and board furnished as part of the remuneration and other expenses were almost nil. Thus, each summer I was

able to fund, nearly, the next year's Purdue expenses. One of the ships was the SS *Seeandbee* that was confined to the lower lakes, Michigan and Erie, as she was too large to get through any of the locks at the Soo or at Niagra. She was a side-wheeler and had a more than usual speed, about 20 mph. Being large, 486 feet long, and fast she was one of two ships that the US Navy commandeered during WW II and refitted as aircraft carriers for training Navy pilots. The complete superstructure was stripped off and a 550-foot flight deck put in place. She was re-christened the USS *Wolverine*. Thus many Grumman torpedo bombers and F4F fighters landed and took off in space that had been my radio room and cabin a few years previous.

I was graduated from Purdue in January 1941 as I had entered in January 1937. Entering in mid-year made scheduling courses an awkward problem. Also, I was classified a Freshman for one and a half years and this followed on so that I was a Senior for only a half year! Thus I missed out on numerous privileges.

During the second semester of my senior year at Purdue I did some job interviewing. The head of the E.E. Department offered me a graduate student position that entailed revamping the University broadcasting station. This would have allowed me to take courses leading to a higher degree as well as furnishing my living expenses. However, as I had been on minimum rations for four years I opted for a position in industry. I ended up with offers from two concerns: General Electric at Schenectady and RCA at Camden. It was a close choice but the caliber of the interviewers at Camden, NJ, swayed me to RCA. I spent the years from 1941 to 1987 on their payroll. Oddly, GE was one of the three concerns that had teamed up to form the original RCA Company and it was the company that terminated RCA by purchasing it in December of 1985.

I completed finals on a Friday and arrived on a bus in Camden on the following Monday to start work in the Research Department of RCA, January 1941. My first activity was as part of a small group developing the first airborne radar for the U. S. Navy. It was designated the ASA. This was a highly secret program with little or no background to build upon and it had an intense schedule and severe requirements. The RCA plant went into work for the war and quickly changed from a 7 ½-hour day to 8 hours for 6 or 7 days per week. We worked many evenings well into the night. During the program several of the more senior engineers dropped out with "nerve" difficulties.

We carried it out to the point of building several prototype models to be used for flight testing. I became part of the flight test crew from RCA. Most of this took place flying out of the Anacostia Naval Air Station in Washington, D.C. We installed the radar system on a Consolidated PBV aircraft. This was a Navy workhorse for ocean patrol. It was an amphibian, i.e., could land on water or land, although we always used the runways. Our early work was installing and checking out the equipment at the Naval Air Station. This was during the fall of 1941, just before and after Pearl Harbor. Things were quite dicey for some time. On one occasion while we were working in the aircraft late in the evening, I had need to visit the laboratory and during my wandering across the field I

heard a loud challenge, "HALT". I did! My challenger was a BIG marine with a bayonet-fitted rifle. I had forgotten to pin on my secret badge and was summarily marched to the Duty Officer for questioning. It ended up with no brig time.

The flights were generally long and tiring. They were flown up and down the coast several miles offshore at about a 1000-foot altitude. Our targets were passing ships. The procedure entailed the use of two antennas situated one on each side under the wing and looking to the side. This was the search phase. When a target was spotted on the display both the antennas were oriented in a forward direction and the aircraft flown so that the signal level into each antenna was equal, this was the homing phase. It was my task to keep the transmitter operating efficiently. There was no heating gear in the plane and I had no flight gear to keep me warm. I also needed to stand during almost all of the trip.

This radar did the jobs for which it had been designed but it had been envisioned to do too much. It could search and track as well as measure altitude with pulse signals. In the search mode it transmitted a 15-kw, one microsecond pulse, at 400 MHz. It was too large, too heavy, and too cranky. It went into a production design at Camden but never became a full production equipment. A somewhat more restrained version, with no altimeter, was put together and tested for the Army Air Force. This was done in a B-18 aircraft. I made only one flight out of McGuire Air Force Base with this configuration.

As a follow-up to this equipment we received a contract from the Army Signal Corps at Fort Monmouth to develop and build a prototype of a ground-to-air radar. The radar was planned to search for aircraft and then track them as they approached. When within range a searchlight would be turned on to illuminate the tracked aircraft for further action. The search and tracking antenna was developed by George Brown and group, principally Oakley M. Woodward. This was my initial contact with Woody and it began an association that lasted for over forty years. We had each signed up with RCA the same month in 1941.

This Search Light Radar, SCR-668-T1, used the same transmitter and receiver from the Navy ASA system. I developed and designed the displays that the operators used to locate and track the signals. Also, I was put in charge of arranging the complete system. It was a mobile setup. The gear was carried around in a U. S. Army truck that towed the Search Light. Another truck towed the generator that furnished the electric power for the Search Light arc light. We started this program while we were still located at Camden but finished it after the Research Department was moved to Princeton in the fall of 1942.

The antenna was an array of small dipole radiators that fitted over the front of the six-foot diameter searchlight. The array was arranged to form four separate beams that could be switched to the left or right or up or down in a sequence. The signals from each of these four positions could be displayed and compared on the cathode ray tube

Indicators. The two operators, one for azimuth and one for elevation, then cranked the search light with antenna in such an angle to equalize the two sets of signals. The searchlight thus followed with the antenna and would be aligned with the target as it approached.

The system worked out very well except for one embarrassing feature. An aircraft could be searched for, located, and then tracked in azimuth and elevation as it approached the radar location. However, as the aircraft came near there was sufficient signal bounced from the ground to the aircraft that the antenna became confused and began to point into the ground instead of at the aircraft! The earth was acting as a mirror and the antenna was locking up on the mirror image. After a few flights that demonstrated this major flaw the project was terminated and I wrote a final report of the program.

Some years previously an inventor type had come to RCA with an idea and a certain amount of data. This was Royden Saunders who had been working in his garage on this equipment. It was a short-range frequency-modulated altimeter to be used by aircraft. Its great usefulness would be when the aircraft was near the earth and required a precise measure of its altitude. Bell Laboratories had investigated this concept some time in the past and had run into what was seemingly a fatal flaw. Saunders claimed that his concept had solved this problem. He was hired by RCA. With time, measurements demonstrated that he was correct.

The agile minds at RCA now applied the concept to a radar-type instrument that had the capability to measure distance to a target other than the Earth very accurately. By using this feature in conjunction with the altimeter feature a system was devised to measure: distance, closing speed, and altitude and to combine the information with an analog type of computer to determine the time for release of a bomb from an aircraft against a surface vessel. The U. S. Navy was interested and funded us. I became a part of the group set up to develop flight equipment to test such a system. When we had something built that might work we went into a flight-test and modify mode of development.

The flight testing of this experimental automatic bomb release equipment was made in a Grumman-built airplane, the TBF-1, Avenger. This was a single-engine, 3-place, torpedo bomber. It was designed to fly off an aircraft carrier. However, we generally were picked up at the Naval Air Station field at the Philadelphia Navy Yard or at the Johnsville NAS in Bucks County just over in Pennsylvania. We made many of these flights. Some were made over the Delaware River targeting buoys and ships of opportunity. Others were made over the Patuxent River operating out of the NAS Patuxent. Here we could target one or the other of lighthouses that were situated in the river and more-or-less isolated from other objects. Later we used an artificial target made up of corner reflectors on a barge. At this target we released 500 pound bombs, water filled, that is. With more refined equipment later in the program we released 2-inch rockets carried under the wings.

These test runs were all made at low altitudes of 50 to 150 feet over water. The pilots would fly figure eights making high-g turns at each end of the courses. Adjusting the equipment and keeping a log of data was rather tiring under these conditions. I was generally teamed with either C. C. Martinelli or D.G.C. Luck on these tests. Both of them were subject to air sickness and paper bags were used in great quantities. I was never bothered, except for the odor.

One especially noteworthy set of runs was made off the shores of Block Island over a part of Block Island Sound. We were testing the efficacy of use against submarines. One had been designated to be our target and we were to rendezvous with it at sea. It came up to periscope depth and we exchanged radio signals to verify our identity. I operated a Morse code key strapped to my knee. Again the high-g turns made such operating difficult. The sub was, however, being very circumspect, it was war time and subs did not like to have just any airplane making bomb runs against it.

We made many runs, mostly at 50 and 100 feet, over the waves. We took photographs to determine our bombing effectiveness. During this series of runs a very exciting event took place: the engine stopped!! This plane, the largest single-engine plane in the Navy, had very stubby wings in order that it could stow easily on an aircraft carrier. Both features gave it "the glide angle of a brick", as the pilots put it. Luck and I were aboard and there was also an enlisted man for some reason. When the engine quit and the aircraft noise made its dramatic change I turned to look back at the Navy chap for enlightenment. He was scrambling into his life jacket! This worried me for all of a second or two. We were saved from a real crash into the water by the pilot's reaction instincts. He knew immediately that he had run out of gas and switched over to a reserve tank. The engine caught and we didn't drop more than a few feet. We finished our runs and headed for Johnsville. Just as we were about to get a nice view of Princeton from the air at low altitude, poor Luck's luck gave out and he dove for the goop bag. I was riding up in the gunner's greenhouse so was able to get a grand view.

The Frequency Modulated Altimeters went into production at RCA, Camden, and many were put into service in the armed forces. The war ended before the bomb-release equipment was fully developed so the projects were terminated. Dave Luck wrote up a full-size technical book describing this frequency-modulated radar concept.

With the rearrangement of the RCA Laboratories at the end of the war I was moved into a group that had been doing research on millimeter wavelength scanning antennas. I continued here for several years and became a recognized worker in that field. Because of this capability and the fact that I had done considerable experimentation in the use of 35-gHz frequencies I was moved into a project for developing and building an airborne air-to-ground search radar to detect and track moving vehicles. The ultimate user was to be the U. S. Marine Corps and the Navy was in charge of the procurement. The Navy gave it the name: *Night Hawk, AN/APS-56 (XN-1)*.

This was a far-reaching program that required a very narrow beam antenna and a very short pulse radar so that relatively small targets could be resolved from the ground clutter. The antenna had many difficulties connected with it. It had to be light enough to be airborne, small enough to fit into a radome beneath the belly of the plane, and precision built to handle this very high frequency. The aircraft was a P2V or *Neptune*, a long range patrol plane used by the Navy. The azimuth angle scanning or pointing had to be fast enough to seem like a television-type display to the operator.

Azimuth beamwidth: 0.36 deg.; elevation: 1.9 deg.

Azimuth Scan Angle: 29 deg.; rate: 12 to 30 per sec.

With a 10 milli-microsecond pulse length, objects as small as a vehicle could be resolved. The project lasted several years and ran beyond the original schedule by far. However, it did all that had been envisaged and by most standards was a success.

One of the junior engineers had been selected to carry out much of the flight testing. However, before this commenced there arose a personality conflict between him and the project leader. This became serious enough that he shifted out of the group leaving a flight test slot to be filled. It seemed that I was to be eased into the position as a natural choice. I saw this coming and for a couple of good reasons, to me at least, I immediately declined. The program went ahead without me and the test results were impressive. Like many long-term programs, however, the military planning had changed and the Marines no longer had such interdiction as part of their missions. We wrote a large report of the project and it went on the shelf and is now declassified.

While the flight testing was under way I went back to investigating an interest that I had developed during the automatic bomb release program. This involved determining what path an aircraft needed to fly in order that it was always in a position to release a bomb against a particular target. This was a mathematical solution as I did not include the effects of the air drag on the bomb. Thus it included: aircraft velocity, flight path, direction, gravity, and altitude. I made a number of false starts but eventually found a set of equations that solved the problem. I was happy.

At this time there was another rearrangement of personnel and I became a member of the Antenna Group that included Woody and Jesse Epstein and operated out of a remote building known as the Antenna Laboratory. Among other projects, I took on one to improve the antenna pattern of the Commercial Aircraft Radar that RCA was selling to the airlines. This was done in conjunction with the RCA Division located on the West Coast.

The master minds that directed RCA policy decided that the company should combine all the antenna oriented personnel into a single group and that it would be part of the RCA Missile and Surface Radar Division located at Moorestown, NJ. This was a 40-mile commute from the Princeton area and required serious family considerations relative to move-or-commute. We did not move.

The Laboratories' Antenna Group was moved as an entity and was established as somewhat of a separate group in MSR. However, even so, it was a major change in environment as we moved from the friendly atmosphere of a research laboratory into a product line division that included a manufacturing department. Programs needed to be completed on schedule and at cost. Things were different! I managed the change without too much trauma but one of the group quit and another came down with "nerves".

Very soon I became the leader or manager of our little group. Just about this time, the middle of 1961, satellites and space activity were taking off. (Our last child, born in 1960, was named Astro.) Because of our reputation at the Laboratories, management at the RCA Astro Electronics Division (AED) at Hightstown decided that we should develop the Communication Antenna for the Project Relay Satellite. This was a project funded by NASA and was planned to demonstrate relaying signals through a satellite as well as to measure some of the characteristics of space. This program lasted about a year with us and was fraught with a tight schedule as well as difficult specifications, not to speak of the quality control required in all aspects of the final manufacturing of this little antenna. We worked more or less directly with the Space Division and the MSR brass only looked over our shoulders.

Woody came up with a concept that was difficult to understand for any person not knowledgeable in the antenna art. NASA felt it necessary to hire antenna consultants from a West Coast think tank for advice and analysis. Unfortunately for us, the *thinkers* devised an experiment that proved the concept would not work! However, we went ahead and it did work but only after a lot of B, S, and T's. The first deliverable model was transported in my car by Woody and me to AED on a late Saturday evening in a dense fog, so much so that we missed the turnoff for the plant and the antenna ended up at the Wilkinson house over Sunday.

This little gem of an antenna was 18 inches in height and was mounted at the top of the satellite. It was informally referred to as the *Lollypop*. The patterns for both the receive at 2200 MHz and the transmit at 4000 MHz were toroidal in shape. There were two of these satellites built and launched into an orbit that varied between 800 and 4600 miles above the Earth. The Relay Satellite Program was a complete success and two launches were made, each operating long beyond the specified time requirements.

Almost immediately we were included in a proposal to NASA to develop and build a spacecraft that would travel to the Moon and then orbit the Moon while taking photographs and sending them back to NASA. The photographs were to be used by NASA to determine where to land the coming astronauts. This was the Lunar Orbiter Program. The Boeing Corporation was the prime contractor to NASA with AED sub-contracting the Communication Sub-system.

In this program I was given complete charge of all aspects of the development, design, build, test, and delivery of the Antenna System, i.e., I was the Project Director. The antenna was a 3-foot diameter parabolic-dish type, mounted on a four-foot boom that could be rotated by command from Earth through the Lunar Orbiter Spacecraft System. Our part was the dish, feed, boom, rotary joint, drive motor, and angle read-out mechanism. The design was good but the quality control in the build and test phase was quite difficult. As we were delivering the five flight models and shortly before the first launch we discovered a fault in the boom of the Qualification Test Model! To insure reliability we were required to add a clamp to all the flight models. This came to be called "the band aid". These clamps were added at the launch site at Cape Canaveral.

Despite this little perturbation in an otherwise good program the antenna was a complete success and met all specifications in the five flight models over their full missions. There were beautiful photographs of the Moon surface sent from the Moon to Earth through our antenna and one showed up in a full display on the front page of The New York Times. At the termination of each of the five missions the Orbiter was sent to the Moon in a crash landing!

RCA was an important part of the communications systems used on the Apollo Program to land men on the Moon. The Lunar Orbiter noted above was one of these systems. The Lunar Excursion Module (LEM) was the spacecraft that actually carried the astronauts to a Moon landing. There were several communication links used by LEM to stay in touch with the Earth, the Orbiter, and the exploring astronauts

Our S-Band Erectable Antenna was designed so that the Moon-landed astronauts could send messages directly to Earth rather than relaying them through the Command Module that was orbiting the Moon while the astronauts were landed. It had the appearance much like an umbrella. The electrical design was not difficult, using a short helical antenna to feed the circular parabola. However, the mechanical design of the double-folded ribs and the gold mesh reflector posed severe analysis and test problems. The self-erectable mechanism had to work in the Moon environment and we could only test it on the Earth. It was transported in the LEM packaged in a cylindrical can, 13-inches in diameter and 39-inches long. When taken out on the Moon it would be mounted on its tripod and then deployed or erected to be about 8-foot in diameter. A simple optical sight allowed it to be trained to the Earth for a direct communication link. Missions No.12 and 14 successfully employed this antenna.

Also developed by my group was the antenna that was used in the Lunar Communication Relay Unit (LCRU) on the four-wheel, two-man vehicle, Lunar Rover Vehicle or LRV, as it explored for rock samples on the Moon This antenna was a 38-inch diameter dish that could be folded and deployed much like an umbrella. It was mounted on a vertical boom to be trained to link to the Earth. The reflector design made use of the experience gained from the larger S-Band Erectable Antenna. The material used was a gold-plated flexible mesh fastened to 12 ribs. It weighed 2.75 pounds and had a gain of

23 db. The width of the beam was 5 degrees. The media has shown many photos of the little Rover with deployed antenna. This LCRU was used on the last three Moon landings: Apollo Nos. 15, 16, and 17.

There were no known failures of these numerous antennas. All the Rovers and the deployable antennas remained on the Moon when the various LEM's blasted off to return to Earth.

The next of our space antenna programs was for the Viking Spacecraft. Martin Marietta Corporation was the prime contractor to NASA, and RCA AED subcontracted the Communication System. The mission entailed launching a spacecraft that carried a capsule in which was stored the Viking Lander. This spacecraft would travel for 11 months on a trajectory to Mars. Here it would go into an orbit around Mars then eject the capsule into a landing phase. During the landing phase the capsule would be opened so that the Mars Lander could make a soft landing on the surface of Mars. There were two launches and landings, spaced about a month apart.

Required were three antennas: a UHF broad pattern antenna that would communicate with the mother ship as it continued to orbit Mars; an S-Band antenna that would receive commands from Earth over a very wide angle; an S-Band antenna that would send data to earth directly. This last was the so-called high-gain antenna, a parabolic dish type. It could be trained in two orthogonal directions with commands from an on-board computer or from the direct Earth link.

The electrical performance requirements on the antennas were not really severe. However, the environments that the antenna must survive and those that it must perform in were very severe. Extreme temperature ranges put great stress on the materials. The program required the capsule to be heated to a very high temperature before launch to sterilize all components that would be landed on the Mars surface. There should be no contamination of the planet Mars. The low-pressure gases of the Mars environment during operation were subject to ionization and electrical breakdown. Devising tests to simulate the Martian operational conditions was in itself a major task. The breakdown problems with the UHF antenna were particularly difficult. Our final solution was to encapsulate the tips of the radiators in foam cylinders about 4 inches long. Boeing engineers, our bosses, named them the *RCA Beer Cans*.

Good engineering coupled with various redesigns to recover from test failures finally brought us to a satisfactory launch configuration. Both launches had completely successful landings and no failures during the operation over each of the specified 90-day data-collection phase on Mars. As a matter of fact both of the Landers continued to operate long beyond their planned mission time. NASA finally allowed some of their engineers to continue obtaining data in an unofficial operation. It was my considered opinion that two minor miracles had allowed these Landers to land right-side up on the boulder and pot holed surface of Mars.

By this time the use of earth-orbiting satellites, building upon the Relay experience, had come into use as reliable relay stations between two or more earth points. The military saw this as an opportunity to update links between ground forces and proposed an airborne command post that could be in continuous touch with deployed military units. A major piece of such a system would be an antenna that could continuously track a communication satellite. RCA MSRDC proposed such a communication system and we were to furnish the tracking antenna system. This was known as the "Super High Frequency Tactical Satellite System (SHF TACSAT). A three-foot dish antenna was to be mounted on gimbals so that it could maintain the satellite within its beam despite motion of the aircraft. In order to handle a wide band of frequencies the base frequency needed to be at the so-called X-band, about 9000 MHz. This was a step up from past communication links and required development and design of high precision components. Of particular need was a rotary joint between the aircraft and the pointing antenna. It was required to pass two bands of frequencies: transmission and reception, so that the high-powered transmitter did not interfere with the sensitive receiver. Woody pulled some phase and polarization concepts out of his bag of tricks to come up with a very successful solution. Several of these systems were delivered to the U. S. Air Force.

The RCA Space Division, AED, had been growing all during the Apollo Program and it continued to build and launch the weather satellites of the TIROS Program for NASA and other government agencies. Initially the TIROS used rather simple antenna systems that Woody had conceived and had acted as an advisor during build and test while he was still at the RCA Laboratories. With the advent of communication satellites RCA must certainly be an important player. AED was competing with the Hughes Aircraft Company for the commercial versions. Initially AED used our Canadian RCA plant to devise and build the spacecraft antennas for their entry into the modern Communication Satellites. However, it was evident that there were considerable funds being sent north of the border and it was felt that better control could be maintained if the antenna work was done at home.

The antennas for the communication satellites were relatively large parabolic type reflectors that used an assortment of feeds in the focal point region. The patterns were required to cover a particular area of the Earth with specified gains. For instance, one configuration was required to cover only the 48 states. In the design limit the pattern would be a close outline of the 48-states. Design tools included the number, the size and shape, and the location and relative excitation of the multiple feed horns. The focal length and outline shape of the parabola also went into the design.

There was a Communication Systems Department operating at AED that included several antenna engineers. However, they were not set up to handle the large antennas. The net was thrown and I was selected to transfer from M&SR to AED in 1977 for the purpose of setting up and heading an Antenna Group. The first important task was to

develop or otherwise obtain a computer program that could accurately determine the patterns of any proposed antenna configuration. We started this amid some internecine squabbling within the Systems Group. With time this was settled by the squabbler leaving to pick up the management of a motel that he had inherited! Also, I brought up from Moorestown one of the engineers who had been in my group. He was very capable, had a PhD, and wanted to work up into supervision. As I was planning to retire in a couple of years, it was a match. He took on the computer programming and we had a working organization.

My last spacecraft antenna activity was in directing the Search and Rescue Antennas for the project of the same name. The equipment for this project was being added to one of the NOAA Satellites that RCA had under contract. The search and rescue mission sought to locate downed aircraft, or others in distress, by sensing signals sent from a beacon activated upon the pilot's command or automatically upon a crash. The spacecraft would listen for variation in the beacon signal to determine the location as is passed over or near the beacon. The data was then transmitted to an earth station, analyzed, and rescue action taken. The antennas needed to operate at the three beacon frequencies: 121.5, 243, and 406 MHz. It was an international project with the French and Canadians handling the spacecraft electronic equipment hardware. The project went well and when I retired in 1980 the antennas were being installed on several of the spacecraft. The system is currently in use and has located many thousands of distressed persons.

After my formal retirement from RCA in 1980, before the CEO Bradshaw sold out to Jack Welsh of GE, I talked RCA into using me as an expert consultant, so to speak. I continued at RCA on a half-time schedule for another seven years. Most of my activity was related to communication satellites antennas, naturally. As I was able to set my own schedule and mostly select the projects I wished to work on, this period was a halcyon finish to my working career. Oddly, as GE now owned RCA, I ended up working for the *other* company that had offered me a position back in 1941!

The following story almost brings us back to the origins of flying as it concerns a wood and fabric aircraft built in 1919. Colleen Sampson was a long-time personal friend of my wife and me. In Colleen's late years Virginia acted almost as a caretaker making many trips into Bucks County assisting her. As a result, partly, Colleen gave her by will one half of her personal possessions. Shortly after this distribution, my wife handed me a small box, saying: "*Here, these may interest you!*" I opened the box to behold what would be a major coup to any collector of historical memorabilia. It was filled with medals and medallions that had been awarded to Lt. Harry Sadenwater, U.S. Navy, for his part in the first transatlantic crossing by air from North America to Europe. This had occurred in 1919 from Newfoundland to the Azores. Harry had been the Radio Officer in the NC-1 Flying Boat.

Following the end of WW I there was a flurry of activity aimed at doing firsts with airplanes. One such was crossing the North Atlantic Ocean. The U.S. Navy entered into this and had three aircraft, called flying boats, built in a design resulting from the combined efforts of the Navy and the Glenn Curtiss Company. These were quite large and made of wood and fabric following the precepts laid down by the Wright Brothers in their basic controlling U. S. Patents. The planned flight path over the water was monitored by a string of 21 Navy destroyers spaced some 50 miles apart. They acted as mileposts and were prepared to rescue any downed aircraft.

I had known Sadenwater, slightly, when we were both employed by the RCA Laboratories during WW II. However, I had not known the connection to Colleen. I started out with the telephone directories for the New York area and right off located a Harry Sadenwater in Long Island. Sure enough he was a nephew but knew essentially nothing of the career of his uncle! When the tale unraveled it all became clear, naturally. Colleen had spent her adult life as a telephone operator, first in New York City and then at RCA Laboratories when it was located at Princeton in 1942. Her husband, Harry Sampson (the first of the three Harrys) had been a taxicab owner and entrepreneur in New York City. He died and Colleen struck up a friendship with Harry Osgood the Purchasing Agent for the Laboratories. He was the brother-in-law of Sadenwater and a bachelor.

Eventually Osgood became old and died just as most of us will. He left all his possessions by will to his good friend, Colleen. Osgood's sister, Grace, had married Harry Sadenwater. His estate went to his wife, Grace, and when she died her estate went to her only child, son Paul. When Paul died in California his estate went to his nearest relative, uncle Harry Osgood. This was the path of the medals that had ended up in my lap. With this bonanza came the question, "What to do with them?" Up to that time it seemed that no one had had much interest in these medals. The current survivors were not even aware of the medals or the acts of valor for which they had been awarded. I could keep them. I could give them to one of my children, an avid collector of any thing. I could donate them to some U. S. Navy museum. Thus, like many possessions they became a concern. I wrote and inquired of one or two pertinent museums and they would willingly accept the medals.

When I had told the Long Island nephew about my find, listing only the Navy Cross, he could not handle such a problem and passed it on to his sister over in Bucks County. She wrote me and made enough of an impression that I sent them this single medal, exhorting them as to its historical significance. Some time later she sent me a brochure that they had worked up with a full cover photograph of the cross and considerable published material that they had researched about Sadenwater and the milestone flight. This pleased me to the extent that I immediately sent them the remainder of the booty and washed my hands of further personal responsibility.

Two of my brothers were intimately connected with aircraft. Leo flew a P-38 fighter-type aircraft during WW II doing photo-reconnaissance in the Pacific arena. He flew more than 70 missions over long distances photographing Japs and their installations. He reached the rank of colonel in the U.S. Air Force. Harold, our youngest brother, was a lieutenant in the U. S. Army Air Force. He served as a navigator in B-17's making mapping runs over Europe at about the end of WW II. After his army service he spent his working career in commercial aviation, mostly at Eastern Airlines.

My retained papers contain a certain amount of information about the above-described programs at RCA. Many of these programs are referenced and can be found on the Internet. They contain program summaries and some of them have photographs of our antennas. As I recalled and put this memo together my thoughts were further reinforced about the interesting career that I have had as an engineer in electronic communication. It started in September, 1934, when I left Oxford, Indiana, and hitch hiked to New Orleans, Louisiana, to become a shipboard radio operator. For 53 years I was paid to do what I enjoyed doing. That much of this was connected with aircraft and spacecraft is evident.

DEDICATION

Dedicated to the memory of Wilbur and Orville Wright, inventors.

FIGURES

(see following pages)

Description of the Figures:

1. The three airplanes shown are types that I spent time in. The Taylor E-2 was the predecessor of the Piper Cub.
2. It was a cold winter day when this was shot showing the Searchlight Radar Director equipment in a deployed arrangement.
The Nighthawk is under test on the roof of the RCA Laboratories at Princeton. It is looking toward Princeton
3. The Relay Antenna was being tested at the Medford Test Range on a fly-screen mockup of the Spacecraft.
My female technician, Judy, is holding the Lunar Orbiter Antenna, demonstrating how light it was.
4. Both of the erectable antennas are shown in operational positions on the Moon.
5. This is a prototype of the Viking Spacecraft. The High Gain dish antenna is a flight model under construction in our White Room. Notice the "beer can" appearance of the UHF antenna.
6. The black protrusion on the top of the aircraft was the radome for the antenna.
7. The SAR antenna shown was a test model.
This SATCOM antenna was on a pedestal in a test chamber and patterns were being taken. It was built for our RCA Global Communications, Inc., company and

would be put into synchronous orbit. It had six feed horns and four parabolic reflectors. Their patterns covered the 48 states, with a spot beam for Hawaii.

Note: This memo should not be construed to be a listing of all the programs at RCA in which I had a major part. There were many others that had little or no connection with either aircraft or spacecraft.

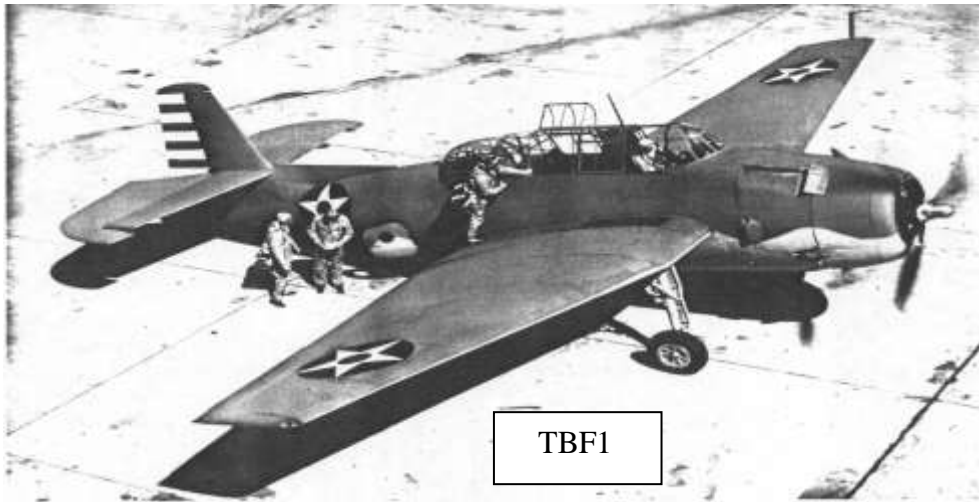
Wm C Wilkinson

File: WCW AirSpace edit.doc

15 July 2003; Rev. 11 Aug 2003; Edit 25 Sept 2016 (WCW III)



Taylor E-2



TBF1

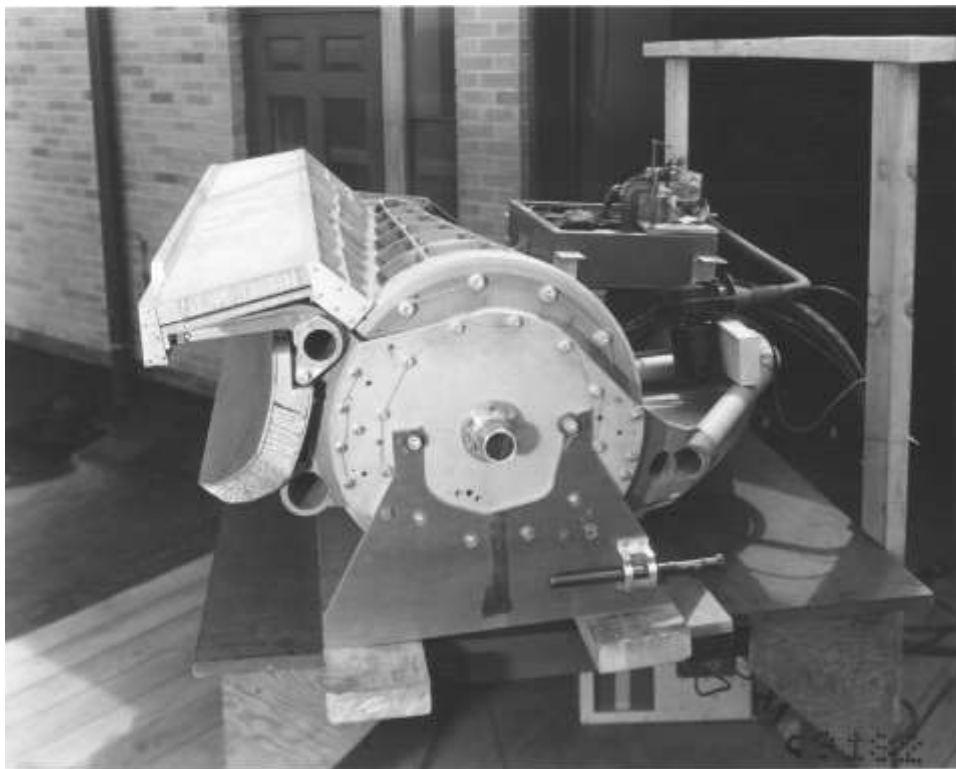


PBX-5a

Figure 1.



Searchlight Radar System Deployed for Operation



Nighthawk Air-to-Ground Radar Antenna (under test)
Figure 2

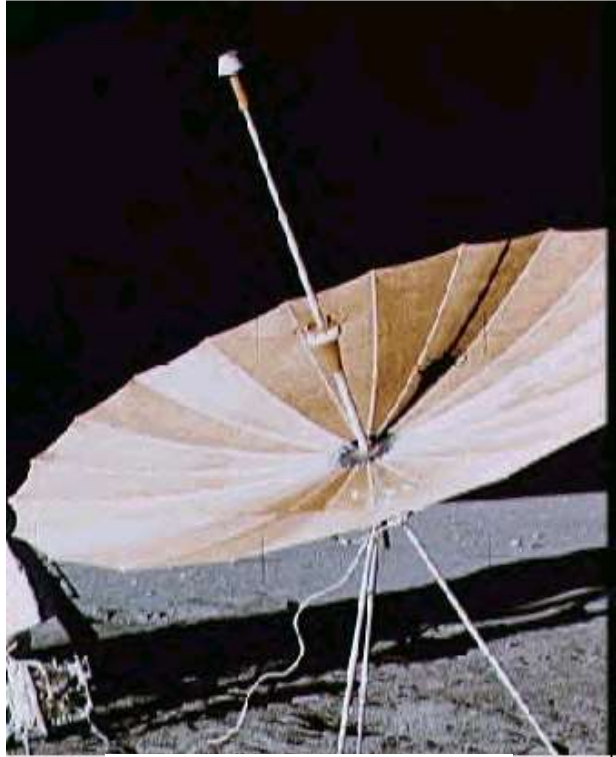
Relay Antenna
on
Satellite Mockup



Lunar Orbiter
Antenna



Figure 3

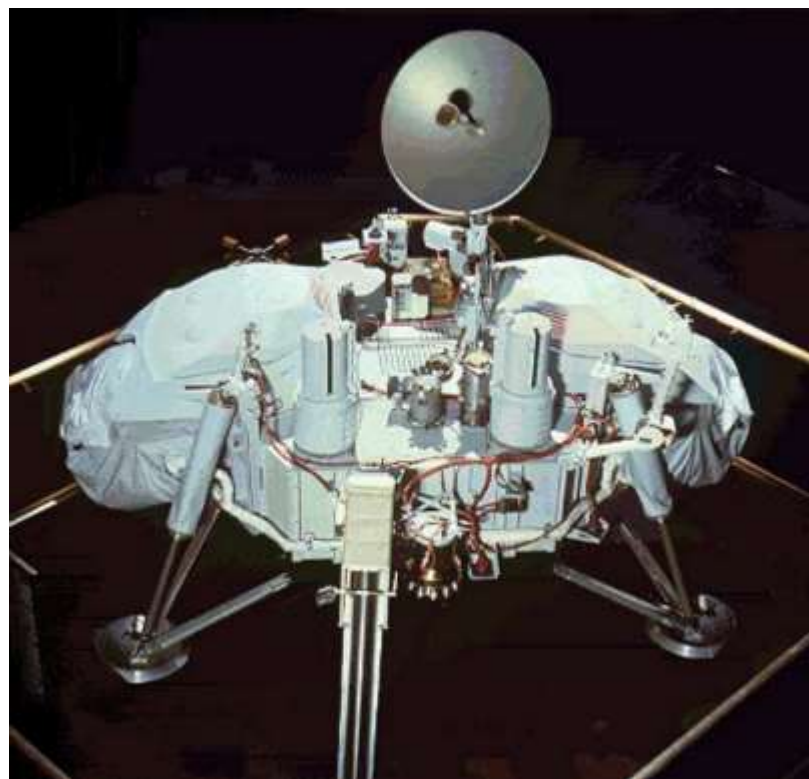
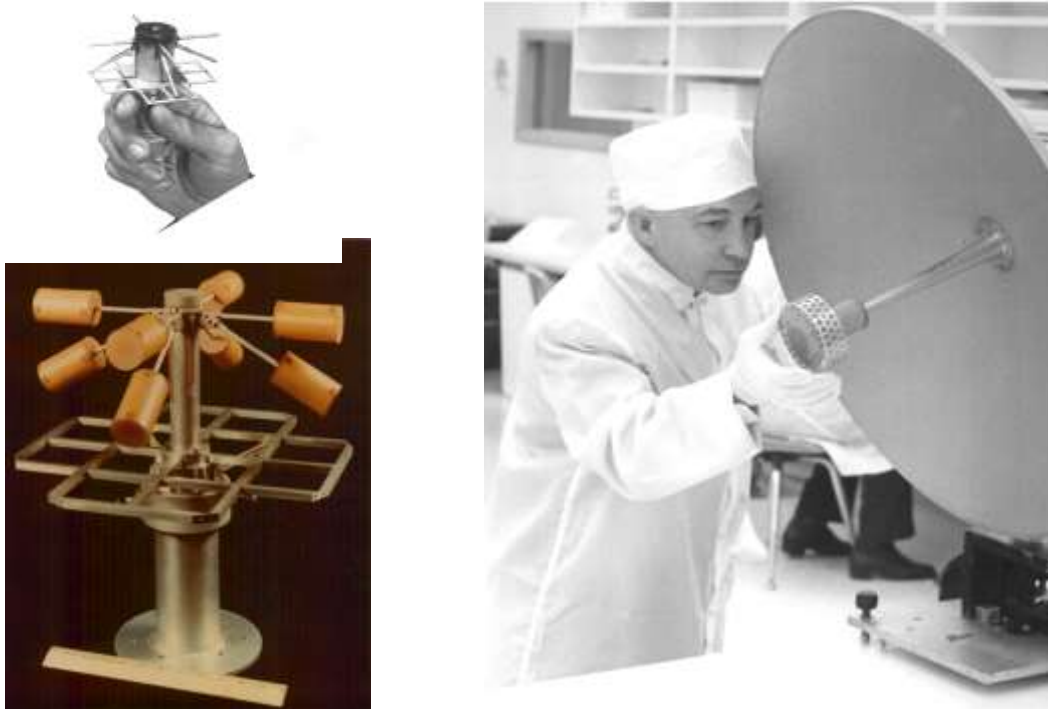


S-Band Erectable Antenna



Lunar Rover Vehicle with Erectable Antenna

Figure 4



Viking Spacecraft with Antennas

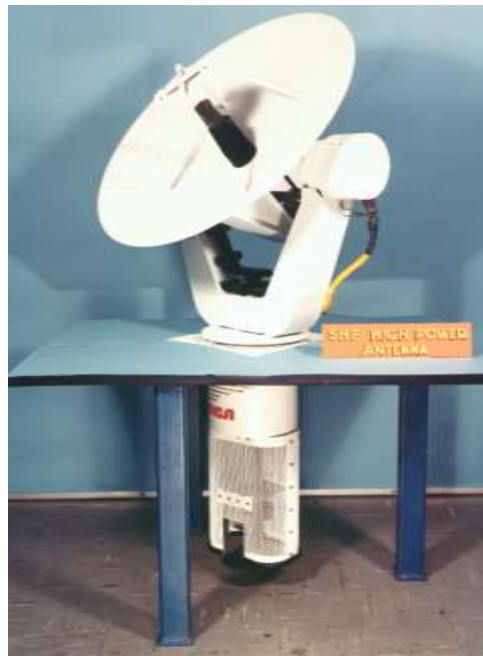
Figure 5



Model of Aircraft to carry this Communication System

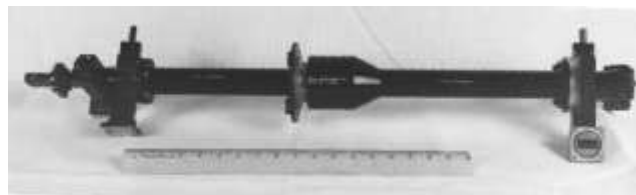


Rear View



Front View

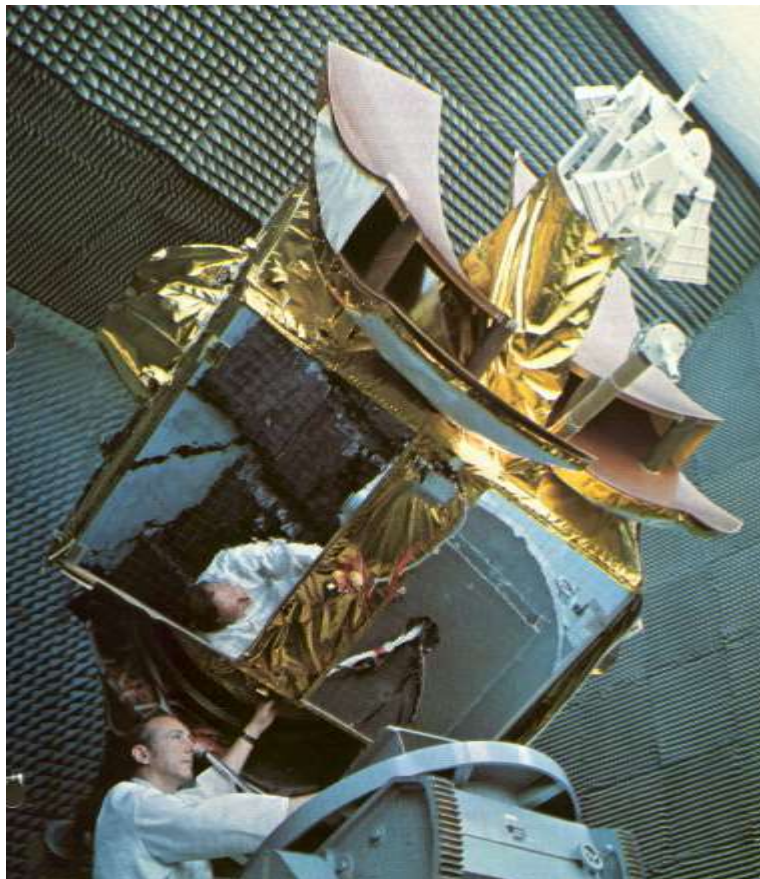
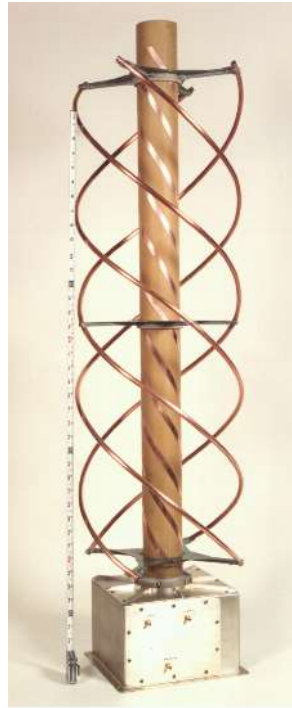
Dual Mode Rotary Joint



Super High Frequency Airborne Tracking Antenna System

Figure 6

Search and Rescue Antenna System



RCA SATCOM Communication Satellite
Figure 7