

CARRIER IN WORLD WAR II  
WIND TUNNEL AIR CONDITIONING

MEMO BY: L. L. LEWIS  
Rev. 9/26/56

The purpose of this memo is to supplement existing records with material not included in "The Father of Air Conditioning" (Page 97) or not readily available in other places. It seems both pertinent and fair to comment that the published account therein was the final result of a severe curtailment and rewrite by several non-technical people - and that the account appearing in Margaret Ingel's 400-Page manuscript may be more accurate inasmuch as it was personally approved by "The Chief".

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It would not be easy to overrate the value of the services rendered by Willis Carrier and the Corporation toward the improvement of aircraft.

The nature of the fighting demanded planes that gave far better performance in abnormally low temperatures at high altitudes. This, in turn, created a great urgency for extending the field of aeronautical research and development - and that, in turn, demanded a much larger wind tunnel which would also provide the necessary conditions of low temperature.

There was evidence that Germany was far ahead of us. Pilot, John Carroll had an opportunity, after the armistice, to look down upon the German wind tunnel which was reputed to have been far ahead of any of ours and to have contributed much to their temporary superiority. John says that his observation was prompted mainly by curiosity and revealed

little as the German tunnel was rather completely covered by earth and carefully camouflaged. It was not until later that he found out what he was looking at and learned that the German tunnel was subsequently dismantled, shipped to this country, and re-erected for the examination and study of our own experts.

... \* \* \*

This country's first venture came with a tunnel constructed in Cleveland, Ohio by N A C A, the National Advisory Committee for Aeronautics. Just how we first got word of it is unknown but the few generalities which came out made it evident that no other man, living at that time, possessed a knowledge, ingenuity, and skill in air conditioning and refrigeration, comparable to that of Willis Carrier.

And, we almost passed up the opportunity to apply it. Management was, at that time, quite reluctant for us to become involved. We were loaded with work in familiar fields and the nature of the N A C A Tunnel would advance us into areas involving great risks and requiring the efforts of many of our people. The argument which finally prevailed, was that we were the only ones who could provide an urgently needed service in the emergency.

Evidence of the benefits which were derived, comes from various sources. According to "Vic" Nelson, the B-29 bomber went into action in the Pacific Theater before the tunnel in Cleveland was completed. Losses were exceedingly high due primarily to mechanical defects and it was impossible to find corrective measures without the use of a suitable tunnel. Appeals for more and more speed were coming from the front - around the clock.

When the tunnel was finally ready for operation, a B-29 was on hand. It was immediately put on test and within about ten days the nature of most of the major defects and the necessary corrective measures were revealed. According to N A C A and Air Force officials, the entire cost of the tunnel was recaptured during this brief period of its operation. While the tests on the B-29 were under way, a jet fighter arrived and was put under guard. It was the second American built ship to be tested and it is hardly possible to evaluate the knowledge so gained and its effect upon jet fighter design.

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The award of the N A C A contract was followed promptly by others of similar nature - and a very brief experience soon proved that all of these projects were entirely too special in nature to be handled by the regular organization - that a special department which could be completely detached from normal operations, had to be organized.

Maurice Wilson was called upon for this purpose and continued to head the wind tunnel department for several years. Among those who were full time members were Victor Nelson, Robert Fullerton, and Ray Duncan as Sales Engineer (who else should be named). And, in turn, it would not be easy to overrate the value of the service rendered to the Chief by these few men.

Obviously, many other Carrier people contributed much, each in his own specialty. The total must have exceeded 25 as that many names are still retained in memory. Notable among the others, were Adolph Zulinski in Centrifugal Refrigeration, Sam Anderson on Heat Transfer and Coil Design, Carl Ashley, and (who else?).

The Wind Tunnel Department carried on until November 30, 1944 when its functions were transferred back into the regular organization. This is recorded in a letter of November 30, 1944 by L. L. Lewis to seventeen individuals in Syracuse and to nine field offices under the subject of "Wind Tunnels - Disposition of Syracuse Files as the Final Step of Liquidation the Home Office special purpose Wind Tunnel Group". Practically all of the files pertaining to installations were then sent to field offices according to territorial jurisdiction and, hence, little is known of what they may now contain.

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As might well have been expected, troubles of various nature developed and persisted. Solving the problems incidental thereto, interrupted the daily work of a number of people and brought some critical attitudes. This is recorded in a letter written by L. L. Lewis to E. T. Murphy on April 21, 1944. Several of its points ~~are~~ ~~are~~ seem worthy of repetition - as follows:

"Aside from providing valuable experience, taking the original NACA contract has put us in line for a very considerable volume of business - a large part of it being had without competition and placed entirely on the basis of the merit which we have been accumulating".

This letter presented two tables: (1) listed 10 contracts headed by \$ the \$1,330,000 for NACA and totalling \$2,156,000 - all taken in '42, '43 and '44; the other, listed the prospects still in sight.

After noting that three of these contracts called for air compressors and total \$537,000, it was stated that "the foregoing includes a definite contribution of experience and prestige in other fields, including that of gas compression".

In retrospect it is to be noted that the centrifugal machine known as the 17044 which The Chief designed specifically for this job has since become a very important item in our product line.

# CARRIER CORPORATION

SYRACUSE, NEW YORK

OFFICE OF THE  
CHAIRMAN OF THE BOARD

March 3, 1945

Mr. S. W. Anderson  
Carrier Corporation  
12 South 12th Street  
Philadelphia 7, Penna.

Dear Mr. Anderson:

For some time now the NACA Wind Tunnel Project has been successfully concluded. Before this notable installation is wholly a matter of history and becomes forgotten, I wish to take this opportunity to express my special appreciation and commendation of the very fine work you did in connection therewith. Without the fine experimental set-up which you designed for testing the performance of the coil, as well as the very thorough analysis of its performance, it would have been impossible for us to have designed and sold this job with any confidence. Your follow-up of the construction of the coil in the shop to insure proper inspection and test of turbulators controlling the uniformity of refrigerant supply in the circuits, and your general supervision of the whole manufacturing process so that the completed installation met all of the specifications without having to make a single change or replacement, was a remarkable achievement. As you know, personally, from the test results, the design and construction of this portion of the system was practically without flaw. This reflects the greatest credit on your ability and thoroughness on an installation which, had it been unsatisfactory or unsuccessful, would have caused terrific losses.

I want to congratulate you on this successful and noteworthy accomplishment.

Sincerely yours,



WHC:HW

W. H. Carrier

Father of Air Conditioning: Willis Hamilton Carrier  
Margaret Ingels Arno Press, N. Y. 1972  
repr. Bantam, 1952

## XIII

DURING World War II the nation's production was greatly aided by the industry Willis Carrier fathered, by the company he and Irvine Lyle created, and by Carrier's personal engineering talents.

The need for turning out more goods faster than at any time in America's history was translated not only into a call for air conditioning but also refrigerating equipment capable of producing extremely low temperatures. These were especially needed in the synthetic rubber and high octane gasoline programs so vital to war machines. At one point, it was necessary to remove Carrier heavy-duty centrifugals from great stores such as Tiffany's, Hudson's, Lord & Taylor's, and Macy's for installation in war production plants. Carrier air conditioning and refrigerating equipment was required for warships and cargo vessels, for munitions plants, and for factories specializing in the production of such essential war material as bombsights and other precision instruments. Thousands of walk-in coolers for food storage were ordered by the armed forces for use both at home and in war zones. Special portable coolers were manufactured to permit the servicing of airplanes in hot climates. Air conditioning units were produced for military-photographic and bombsight-repair trailers.

The war work of Carrier Corporation was not confined to products in its own field. The company turned out airplane

engine mounts, sight hoods for guns, tank adapters, and other military and naval items. However, its principal assignment outside the air conditioning field involved the redesign and exclusive production of the "Hedgehog," a device for discharging 24 anti-submarine bombs simultaneously in a prearranged pattern.

In recognition of its over-all contribution to the war effort, Carrier Corporation was awarded the Army-Navy "E" six times, an honor attained by only thirteen other companies.

Irvine Lyle died early in the war, on June 7, 1942. His age was sixty-eight years, of which forty had been devoted to air conditioning. He was succeeded as president by Cloud Wampler, forty-seven-year-old Midwestern businessman who had been a director of the company and executive committee member since 1935, chairman of the finance committee since 1938, and executive vice-president since September 1, 1941.

At the time of Lyle's death, Willis Carrier, then sixty-six and past the so-called "retirement age," was engaged in what he later referred to as his greatest engineering achievement. Shortly before his own death Carrier stated:

Once, I accomplished the impossible. That is, the task seemed impossible when I first tackled it. And because of its success, high officials in the Air Force told me that World War II was shortened by many months.

Others familiar with his work agreed that there never was a more difficult, more exacting, or more vital air conditioning and refrigerating system than the one designed for the National Advisory Committee for Aeronautics and installed in its wind tunnel at Cleveland, Ohio, to simulate freezing high-altitude conditions for the testing of prototype planes.

When the N.A.C.A. proposed this wind tunnel in 1940, nothing comparable in size had ever been considered. In it the complete engine assembly and propellers would be tested under flying conditions. Ten million cubic feet of air per minute had



to be cooled to a temperature of 67 degrees F below zero. Carrier believed that his centrifugal refrigerating machines would be particularly advantageous. He also believed he could be of some use in selecting the cooling equipment, as his calculations indicated that standard coils required to cool the air would not fit into the space. After Congress approved the expenditure of \$4,900,000 on the wind tunnel in July of 1941, government engineers drew up plans and specifications for an experimental cooling coil using streamline tubes.

Carrier believed they were on the wrong track. So he and his engineers began building their own test apparatus to secure data that would prove the superiority of the coil he recommended and provide convincing arguments for the abandonment of the streamline tubes. Meanwhile N.A.C.A. was conducting experiments on the streamline tubes at Langley Field, Virginia. Carrier went to Washington, called on Dr. Vannevar Bush, Director of the Office of Scientific Research and Development, and had him arrange a lunch with Dr. Jerome Hunsaker, chairman of N.A.C.A., who brought with him Dr. George W. Lewis, N.A.C.A.'s director of research. Carrier later told of the luncheon:

Dr. Lewis asked me if I thought the tests on the streamline coils at Langley Field had value. My answer was not polite, and I'm afraid I scared our representative by my outburst. I told Dr. Lewis that the boys conducting the tests did not know what it was all about, and that too much money and, of more importance, too much time had been wasted already. "Heat transfer experts should be called in," I told him and suggested, among others, Professor William H. McAdams of Massachusetts Institute of Technology.

Carrier came home convinced his recommendations for the cooling coil would be considered, and therefore concentrated on its design for the wind tunnel.

The research involved two inter-related problems—the cooling coil and the refrigerating system. The amount of heat removed from the air blown over the coils depended upon the capacity of the refrigerant inside the tubes to absorb the heat. As "Freon-12" which was specified as the refrigerant had never been used in any sizable system to reach the low temperature of minus 67 degrees F, the coil tests involved basic research on the refrigerant itself. This in turn involved the design of the refrigerating system. Of the two inter-related problems, that posed by the cooling coils was the more difficult. Carrier later said:

Calculations indicated we would need a direct expansion coil with a face area of approximately 8,000 square feet. The wind tunnel, 51 feet in diameter, had only 2,000 square feet of cross-sectional area. Quite a feat to fit 8,000 square feet into 2,000! Yet the solution was actually simple to accomplish. We jackknifed the sections, folding them down like a collapsed accordion until the coils fitted into the tunnel.

There were many questions on which no data were available. To answer them a miniature wind tunnel was built on the mezzanine floor of Carrier Corporation's power plant. As a result of tests in this tunnel, Carrier and his associates found a way to secure vaporization of the refrigerant throughout the full length of the cooling coil. They did it by distributing the refrigerant in such quantities and at such pressures that there would be an excess of liquid for each tube.

By January of 1942, Carrier engineers had redesigned their centrifugal compressor for "Freon-12." The fourteen 1,500-horsepower refrigerating machines, in addition to maintaining conditions of air simulating altitudes up to 30,000 feet, had to cool fifty pounds of gasoline per minute for the engines, cool the make-up air to the tunnel, chill water, and refrigerate the coils for an icing tunnel located nearby when the wind tunnel was shut down.

Bids were opened on March 4, 1942, and on March 16 Carrier



Corporation was awarded contracts for both the cooling coils and the refrigerating system. Then began the exacting work of testing many component parts. Carrier said:

Much was not standard, nor could it be, for such an unusual installation. We planned on using many new devices, any one of which could cause failure of the entire system. To guard against such catastrophes, we carefully checked everything before shipment. For example, we tested approximately 12,000 tubes, each fitted with a turbulator.

In developing new equipment for the wind tunnel, from weighted valves in the refrigerant circuit to suction dampers for controlling capacity, we followed a principle which I found from experience was a wise one. We researched and built the valves ourselves. We had to have them to make the job work; later, should a market develop for them, we would turn our drawings and specifications over to a manufacturer of valves.

More than a year passed before the entire tunnel was ready for operation. After many shake-down difficulties and numerous false starts, the system was ready on April 24, 1944, for a formal run-in test. Carrier was there for the start up and every one of his engineers who had worked on the job was assigned a "battle station." In short order N.A.C.A. knew it had what it needed to help win the war.

After the war Willis Carrier announced that he was going to rest. So he set out with Mrs. Carrier—his third wife, whom he had married in 1941—on a three-month trip to South America. Everywhere they went in their tour, which covered thirty cities, people flocked to pay him homage. Leading industrialists, scientists, and educators honored him at banquets and receptions. It was proof of the power of the idea he had fathered which in forty-five years had crossed all international boundaries.

For the next three years Willis Carrier followed a routine that

revealed the inner courage of the man. At doctors' orders he stayed horizontal twenty hours a day because of a heart ailment. But his enforced physical inactivity never quieted his restless mind. In February, 1948, he was made Chairman Emeritus of Carrier Corporation. In 1949 he was still coming regularly, though less often, to the office and his home visiting list was long. Carrier engineers were frequently in touch with him. Mainly, though, he was on his back, a pad of paper on his knees, his slide rule close at hand, figuring out ways to simplify complex calculations or to reduce vague concepts to concrete terms.

In September, 1950, he said:

My routine is broken at intervals with trips to New York Hospital for check ups. I am due to go there later this month, but have advanced the time to coincide with a lecture at Columbia University. Dr. Richard Planck, an internationally famous refrigerating engineer, is to be the speaker.

It was his last journey in quest of knowledge. Willis Haviland Carrier died in New York on October 7, 1950, shortly before his seventy-fourth birthday. He had pioneered an industry, helped create and build up an enterprise, and measurably advanced scientific knowledge. "Father of Air Conditioning" is a title that fitted him well!