Willis Haviland Carrier

Father of Air Conditioning

VOLUME-2
Carrier in the Heritage Group Collection

2.6 Letters Relating to Willis Carrier

C O P Y

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PITTSBURGH-DES MOINES COMPANY
NEVILLE ISLAND P. O.
PITTSBURGH 25, PA.

February 8, 1950

Carrier Corporation
300 South Geddes Street
Syracuse 1, New York

Attention: Miss Margaret Ingels, M. E.
Engineering Editor

Dear Miss Ingels:

In reply to your letter of February 3rd with regard to the scientific biography of Dr. Willis H. Carrier, and particularly to his contribution to the altitude engine testing wind tunnel at Cleveland, I have no information as to how detailed a statement you wish, but I am sending herewith a rather general comment. If you wish something different, please advise more in detail what you want and I will try to meet your requirement.

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One of the outstanding contributions to the winning of World War II was the five million dollar high altitude engine testing wind tunnel at the Cleveland Laboratory of the National Advisory Committee for Aeronautics. This wind tunnel was the only one in existence capable of testing the operation of engines and propellers in an atmosphere simulating the actual operation of an airplane at altitudes up to 50,000 ft. The velocity of the tunnel can be controlled at speeds up to the speed of sound. The temperature can be controlled from plus 125°F. to minus 67°F., and the density of the air can be regulated to from atmospheric pressure to 3.43 in. of mercury, corresponding to an altitude of 50,000 ft. The test section of the tunnel is 20 ft. in diameter and may be quickly isolated from the remainder of the circuit for making model changes. The tunnel is arranged to remove a core of air, including the combustion products of an engine operating in the test section; and equipment is provided to replace the air removed with pure air, dried and cooled to the operating conditions of the tunnel. Balance systems are provided for making complete measurements of model forces during operation.

The design and construction of this tunnel required equipment beyond the capacity and limitations of any that had been previously used. The completed tunnel includes the largest air drier which had ever been built. The tunnel also involves the largest refrigeration plant ever built, both in terms of tonnage of refrigeration and the very low temperature level involved.

The circulating air in the tunnel is driven through banks of finned copper cooling coils, 7,650 square feet of surface area, which by conduction through the heat transfer surfaces cools the air to as low as minus 43°F. Adiabatic expansion in the throat further cools the air in the test section to temperatures corresponding to that of the upper stratosphere. The heat exchanger and refrigeration equipment for the tunnel and the auxiliary coils was furnished by the Carrier Corporation. Six thousand five hundred tons of refrigeration was accomplished with fourteen 4-stage centrifugal compressors, each driven by a 1,500 horsepower motor with speed increasers from 1,700 rpm to 6,700 rpm. Freon-12 is used in the direct expansion system as a refrigerant and operates at partial vacuum, entering the compressors at 100 psi in the condensers. Fuel for the operating model is cooled by an intercooler from this system.

Letters 1: To Margaret Ingels, 1950 [Carrier's Biographer]

The refrigeration and cooling system for this tunnel were far beyond anything which had previously been built. Dr. Carrier designed special 4-stage compressors to compress the Freon-12 refrigerant used in the system. He also created the novel design of the condensers used with each refrigeration unit, which made the installation compact and give it the required flexibility to operate under the many specified conditions of temperature and pressure.

No cooling coils had ever been designed for use in a wind tunnel of this kind, and Dr. Carrier outlined the required research work to determine the proper construction of the cooling coils, that is, the tube size, the tube area, the tube spacing, the plate size and spacing, the metal thickness, and general design to meet the extreme requirements of temperature and time, and also to provide storage space in the coils themselves for the water to be removed from the tunnel air during the specified operating periods. The cooling coils themselves are an immense structure, the equivalent of a six story building in height, with complicated piping arranged like the branches of a tree to feed the refrigerant uniformly to all parts of the coil.

Dr. Carrier's designs have been fully justified by the operating results of the tunnel. It has performed within the prescribed limits of the specifications.. This tunnel is credited with the perfection of the multirow aircraft engine which made the B-29 possible, and which was one of the most important factors in the winning of both the European and the Asiatic wars. Since that pioneering work, the tunnel has been almost exclusively engaged in the perfection of turbo-jet engines and has contributed much to the continually increasing efficiency and length of flight of jet propelled planes.

As the designer of this complete wind tunnel installation, it is my opinion that Dr. Carrier's contribution to this project was of outstanding importance and represents a very great technical advance in the art of low temperature refrigeration, which was soundly conceived and brilliantly executed with the result that there was provided a new type of wind tunnel not previously available, just in time for the important type of high altitude aviation research required to make the high flying planes of World War II practical.

Yours very truly,

PITTSBURGH DES MOINES COMPANY

/s/ J. C. Jackson
J. C. Jackson
V. P. Eng. & Research

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/dt

Letters 2: To Margaret Ingels, 1950 [Carrier's Biographer]

Carrier INTER-OFFICE LETTER

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TO	Messrs.	FROM	Margaret Ingels
		DATE	2/13/50
		OFFICE	Syracuse
		SUBJECT	N.A.C.A. WIND TUNNEL

[illegible]. [illegible]. Anderson - Syracuse Office
J. [illegible]. Bailey - Cleveland Office
D. French - Syracuse Office
[illegible]. [illegible]. Gammill, Jr. - Syracuse Office
E. P. Palmatier - Syracuse Office
H. Peacock - New York Office
L. G. Powers - Cincinnati Office
E. H. Rex - Chicago Office
W. J. Wilson - Atlanta Office
A. Zulinke, - Syracuse Office
R. J. Duncan, 13 Barksdale Road, White Plains, N. Y.
W. Jones, 151 West 83rd Street, Apart. 3D, N. Y. C.

cc: J. Chester - Syracuse Office

In my work of gathering material for Dr. Carrier's scientific biography, he has told me much of the N.A.C.A. Cleveland Wind Tunnel installation (Carrier job #75-1135).

In an effort to get data from some one who knows the job and was outside of Carrier Corporation, I wrote to Mr. J. O. Jackson, Vice-President, Pittsburgh-Des Moines Company. A copy of his answer to my letter is attached. It is such a grand letter that I feel each of you who had such a big part in the job, and those of you who are still interested in the work, should have an opportunity to read Mr. Jackson has to say.

As I asked for the information for the biography only, and promised to get Mr. Jackson's approval before releasing any write-up made, mentioning him or his company, the letter is to be considered by each of you as confidential.

Mr. Carrier and all of those who worked with him are justified in feeling great pride in the N.A.C.A. Cleveland Wind Tunnel job.

MI:dt
Enc.

Margaret Ingels

Letters 3: From Margaret Ingels, 1950 [Carrier's Biographer]

W. H. Carrier, a Teacher?

Was Willis Carrier a good teacher? I would say he was not. This does not mean to say that he could not pass along his knowledge to others. He understood thoroughly an unusual breadth of technology and, given time, could explain any part of it to others in a way that was unique.

The only reason for disqualifying Dr. Carrier as a teacher involves the element of time. He always described every process or device in exactly the way he had originally reasoned it out from the simplest fundamentals. In all his expressions on education he always stressed the importance of the underlying fundamentals of engineering and in most respects his arguments are sound. However, the fields covered by engineering have grown so broad and complex that formal education must be a step-by-step process. One of building one solution on the results of previously developed relationships; of developing solutions from derived properties of a more complex nature than the original fundamentals. Because of the more basic beginings of his solutions, his overall viewpoint with respect to a given process or phenomenon was often different than that found in the texts and taught in the engineering schools. So, though he was seldom wrong, his arguments with other engineers were many and younger men usually found it difficult to understand his approach and his reasoning.

Even though Willis Carrier never would have succeeded as a formal teacher his associates learned much from him. He taught that no problem or job is too difficult to be solved by concentration, careful reasoning and application of simple basic information. He proved that often an approximate solution to an engineering problem is the best solution providing the extent of deviation from the exact solution is known. It was these things that made him an engineering genius. With a storehouse of well chosen and well understood basic technical information he could tackle with confidence problems in most all branches of engineering. Hence, he was never stopped in achieving his objective by a missing item of information. His accomplishments were many, far reaching, of great variety and executed with a degree of economy that can never be approached by staffs of specialists.

Z.P. Palmatier
9/12/52

Letters 4: Note by Z P Palmatier, 1952

LETTERS

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Recollections of Willis Carrier

Carlyle Ashley's article, "Recollections of Willis H. Carrier," (*ASHRAE Journal*, October 1994) brought back many pleasant memories about "The Chief." I had the pleasure of working for Willis Carrier from 1941 until his death, mainly in the field of centrifugal refrigeration and compression.

One event that I will never forget has to do with the NACA high altitude windtunnel in Cleveland, Ohio that was mentioned in Ashley's article. The installation included six centrifugals, each having its own water-cooled condenser and economizer, but tied together on the suction side feeding the low temperature evaporator coils.

After many months of engineering and testing, the day had finally arrived for start up of the whole system, which was filled with thousands of pounds of R-12 refrigerant. The first test of the complete system lasted well into the night and everybody was happy to return to the hotel after shutting down the system in the usual manner.

When we got back to the job site the next morning, disaster was waiting for us. Water was coming out of the compressor seals, and oil had accumulated on the outside of the compressors and speed increasing gears. It took us some time to reconstruct what had happened. At shutdown time, the normal amount of liquid R-12 refrigerant had remained in the high side of the economizers. After the condenser water pumps had been shutdown, the remaining high pressure liquid in the economizers expanded to the low pressure reservoir of the suction piping and caused the compressors and gears to run backwards and reduce the temperature in the condensers to way below freezing, causing the condenser tubes to freeze and burst. What a mess, most of the refrigerant had escaped or mixed with the water, thousands of pounds, at a time when R-12 was in low supply and rationed.

The manager of the job was Maurice Wilson. After hesitation and mental preparation, Maurice went up to the third floor to report the disaster to the Chief. This was the only time that we on the second floor could hear the "vocal explosion" on the third floor from the Chief's office. But later that day, the Chief realized that the disaster in Cleveland was not due to negligence, and apologized to Maurice and the rest of the team.

One other important technical innovation by the Chief was connected with the air conditioning of gold mines in South Africa. Originally, the cooling of the air was accomplished in traditional air cooling plants above ground. As the mine shafts went lower and lower below the surface, it became impractical above ground, and the Chief designed the first belowground centrifugal cooling plant with special underground cooling towers. The cooling tower exhaust air goes into the upcast air shaft in the normal manner, actually reducing the required fan horse power.

I thought that the above would add to the history of our industry, and the human side of the Chief, a truly remarkable engineer and human being.

PHILIPP GOLDMANN
Miami Beach, Florida

Letters 5 [ASHRAE Journal, February 1995]