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JUL Central

by

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I. The Perfect Library

I want to tell a story about the building in which I am writing this essay. Not about the long effort to gain a separate library building at Vanderbilt, or about the process that led to the founding of the Joint University Libraries system in 1936. The first director of JUL, Augustus Frederick Kuhlman, has told this story in full detail. Because of strong foundation pressure, and Kuhlman's forceful leadership, Vanderbilt, Peabody, and Scarritt finally adopted a trust indenture in 1938 that provided a separate legal identity for the new system, one that contained at least a dozen separate professional or departmental libraries on three campuses.

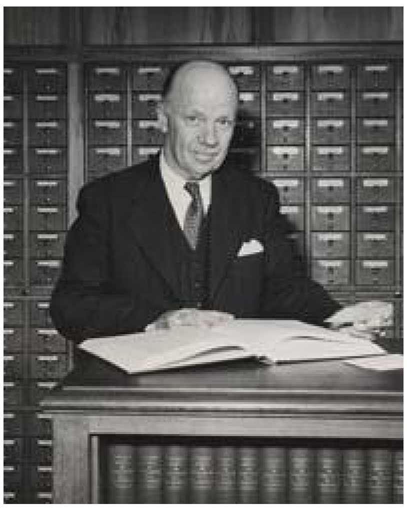

Figure 1: Frederick Kuhlman, Primary Designer of JUL Central

The next, intimidating goal for JUL was a new central library building, a library essential for strong graduate programs at the three institutions. It would provide a new home for the main academic library at Vanderbilt (heretofore located in crowded quarters in Old Main), and for the Library of the School of Religion (a library also critical to the mission of Scarritt), but supplement rather than absorb the other decentralized libraries, including a large educational library at Peabody, the only library in Nashville that met national criteria for graduate work. Despite the great depression, a fund drive to gain two million dollars for various JUL projects succeeded by 1938, with $600,000 raised locally. Vanderbilt contributed a needed site that was as close as possible to each of three campuses. Detailed planning for the new building began in 1938; construction in 1939. The depression, which so imperiled fund raising, proved a great blessing in the construction phase, with costs that now seem unbelievably low (the contract for the construction of the building, less plumbing, heating and air conditioning, was for $475,000; the total cost around $600,000). The new library, which almost everyone soon referred to (inaccurately) as JUL (JUL correctly refers to all the libraries in the system), opened for student use on 24 September 1941. The formal and elaborate dedication ceremonies occurred on 5-6 December, but with final construction details not completed until at least a month later during the opening weeks of American participation in World War II.

Kuhlman's Vision

Kuhlman was the primary designer of JUL Central, although a building planning committee worked with him until completion. No building was ever more carefully planned. Kuhlman visited over twenty university libraries. He was conversant with every new development in library science. He believed that joint libraries, funded by cooperating colleges and universities, was the wave of the future (on this he was mistaken). Thus, JUL Central was to be a model for other similar systems. It had to be perfect in every detail. It was his utopia. Achieving this goal turned out to be an ongoing task, with a constant rethinking of the plans. During construction hundreds of change orders added to the final cost, and made miserable both the architects and contractors. The planning committee could spend hours debating the correct placement of light switches or the special cork bulletin boards, or whether to have one or two pay phone booths off the first floor lobby.


Figure 2: JUL Centra, circa 1940

My task in this brief essay is to clarify the design elements that fulfilled Kuhlman's utopian dreams and that led to a very special library. Of course, any library has to meet the unique needs of those who are to use it. JUL Central, by the original conception, was to be a graduate level library, serving the needs of the already large graduate enrollment at Peabody and a relatively new, growing Ph.D. program at Vanderbilt. At the same time, it was to serve the undergraduate needs of the three campuses, particularly in the humanities and social sciences. Vanderbilt science majors continued to use the libraries developed in biology, geology, chemistry, and physics, and which later merged into the present Science and Engineering Library, while Peabody undergraduates in educational fields had their own library on the Peabody campus. Law and Medical Students had their own libraries, while the large music program at Peabody had a small library in the Social Religious building. The School of Religion library, although housed in JUL Central, remained a separate entity, with its own director, staff, policies, and stack space (the south part of stack two).

A New Library

The library was not intended as an architectural gem. Money did not allow this. But from the beginning, Kuhlman and the head architect, Henry Hibbs of Nashville, wanted an attractive building, one that would please the local donors. The main building, as originally planned, comprised a central tower (approximately 91' by 116') of fourteen stack floors (only eight were completed in the first phase) with eight-feet ceilings (this expansibility all but required a flat roof, of asphalt and pebbles, with copper flashing and down spouts). In what became very confusing later with open stacks, each of the public areas in this central part, which were numbered as floors one to three, matched up with two separately numbered stack floors. Long wings, three stories high, which contained all the reading rooms, flanked the tower to the north and south. They were not symmetrical because of a slightly narrowed 15' extension to the east of both wings, allowing 144' by 30' reading rooms. Also added to the basic plan were two relatively small, low ceilinged penthouses perched at the center of each wing.

Kuhlman and Hibbs chose an architectural style that both called collegiate gothic, one that closely matched the nearby Vanderbilt Medical School and Hospital. Hibbs fought to get as many outside gothic facades as money allowed. This is still evident in the arched windows in the front and back of the center section, in the rather elaborate entrance facades on both the east and west, in the bay windows on floors two and three of the wings, and the heavy brass doors to the outside. Beautifully cut limestone formed the visible part of the first floor, and a somewhat varied red and brown brick the higher floors. The steps were of granite. The completed building, supported by a framework of structural steel and concrete, was one of the most pleasing in the architectural medley that made up the Vanderbilt campus, which lacked the architectural harmony of either Scarritt or Peabody. But the glory of the building was not outside but in the public areas within, where Kuhlman would accept no compromises on the quality or material or what was most conducive to a perfect learning environment.

Building Design

Kuhlman and his committee had to make certain assumptions about future library use in the three campus area. One key assumption was that modern universities were moving beyond textbook courses. Able professors would increasingly assign multiple readings from several books or journals, which for the most part would be available only for reading within the library. It would thus be the responsibility of libraries to provide large reference and reserve reading rooms to accommodate undergraduates. As planned, the library would have closed stacks, at least for undergraduates, but with all other areas, save the acquisitions and cataloguing departments, open to students and the public. This allowed the placement of outside doors in such a way as to control traffic flow and allow easy student access to all reading rooms, the pride of the library.

The other assumption involved graduate students, who would need carrels or segregated readings rooms to facilitate their research projects. Over half the forty-two faculty research studies, and all ninety graduate carrels (for Ph.D. candidates), were within the stacks, along with several closed typing carrels. This meant that faculty and many graduate students had access to the stack floors. Notably, the stacks were plain and functional, with concrete floors, moveable steel shelving (1217 shelves in the original plan), and plain steel carrels. The stack elevator serving all eight floors was small and unadorned. So were the adjoining stairways that connected the stacks. Each stack level had a tiny toilet (for men and women on alternating floors) that was not much larger than a broom closet, with an outside wash basin (also needed for hand washing by the student workers who either gathered or re-shelved books on each floor).

Expected use patterns dictated the location of all the public areas. Because of the central stack floors, the front entrance was a bit of a problem. This was where everyone but Vanderbilt students would likely enter the library, and this included all the citizens of Nashville who had a stake in the project because of their contributions. The solution was an imposing front facade and doors, leading into a low hallway (really a tunnel) between a divided stack level two. It was well lighted and adorned with display cases as one moved to the main central hallways. To the

Figure 3: Original main entrance to the library

right and left were well-designed and comfortable lavatories, and in the center two sets of stairs up to the main lobby on the second floor. The hallway to the right led Peabody and Scarritt students to the long reserve reading room in the north wing. To the left in the south wing was a small religious reading room (60 seats), which was as close as possible to both the School of Religion (in the old YMCA building across 21st Avenue), and Scarritt (a block east on 19th Avenue). At the east end of this south wing was a bibliographical lab, with numerous reference works, intended primarily for the use of the Peabody Library School.

This lab helped justify another outside door, one added late in the construction (it is not on Hibbs' original blueprints). It was at the extreme east of this south wing, and at the ground floor level (the level of stack floor one). It led into a small hallway, which opened to a stairway leading down to the cavernous basement that held all the utilities. It also led to a stairway and a small elevator, both comparable to those in the stacks. They extended all the way up to the third (or today sixth) floor, and are now used primarily by staff, but the planning committee believed they would offer convenient access for Peabody Library School students who would take many of their courses in the bibliographical lab, one story above this Peabody oriented entrance.

Library Features

The reserve reading room was one of the most carefully planned and idealistic features of the new library. The 165 oak chairs, like these in all reading rooms, were specially designed to foster good posture (most of these are still in use but not so the heavy, long tables).

Books on reserve were available from the shelves along the walls. Students could check them out, for a set period of time, at a central desk. The expectation was that most would not circulate out of the reading room. Clocks, and hourly buzzers, informed students of the elapsed time. Two conference rooms adjoined the large reading room. One was for students in a given course to discuss their reading. Another was for faculty members to meet with students to explain or discuss assigned readings. From my personal experience, I believe that few faculty members took advantage of this opportunity. Also available, but in the south wing of floor one, were three carefully planned and equipped audio-visual rooms,

Figure 4: Three Vanderbilt students seek help from a librarian in the reference room of the library

where students could listen to records or view films or slides. It was expected that Peabody professors would utilize some of this equipment in their nearby bibliographical lab.

The main entrance to the library from the west faced the Vanderbilt campus. It led up short stairs to the second floor lobby, which was the functional core of the library. Here was the main circulation desk and, in beautiful cabinets, the card catalogues (JUL Central, a Union catalogue of all Nashville area libraries including other branches of JUL, and, for reference purposes, recent acquisition cards for the Library of Congress). Fortunately, foundation grants over several years had enabled the completion of all these cards before the library opened. Facing the main lobby, to the north, was a lovely browsing library. To the south was the main JUL office and secretarial suite, or the domain of Kuhlman. It contained a small toilet.

Anyone checking out books had to present a filled out request form to the circulation desk and then wait for the books. To assist student workers in procuring requested books, the library installed a state of the art book conveyor, with carriers at eight-foot intervals on a revolving chain that moved at six feet a second. This conveyor carried books to any stack floor designated by a push button and automatically discharged them into recovery boxes. As one of many examples of the attention to small details, the large receiving box at the circulation desk had a spring supported bottom, such that the last books received were always on top (no reaching down into the bin). Beside the conveyor were vacuum tubes that delivered book requests to any designated stack floor except five (why five was missing remains a mystery). At the time, all this seemed a perfect arrangement for a closed stack library.

The south wing of the second floor was a working area for staff. Access for books and supplies was at the west end of this wing, with a door and stairs leading to the termination of a street that came in from Garland Avenue. It had a turning space for trucks, in what amounted to a very small and soon inadequate shipping and receiving area. Since these staff offices were closed to the public, they had plain concrete ceilings and no expensive paneling, but the total library staff did have a lounge with a small kitchen on the third floor, next to a large women's rest room. The placement of toilets revealed one working assumption-almost all professors would be male, almost all the library staff female.

The whole north wing of this second floor contained the reference reading room. This, along with the reserve room beneath it, was expected to have the heaviest undergraduate use. Students entering from the east could access it through the main lobby, or by a stairway at the northwest of the central section. This stairwell led up from the first floor all the way to one of four corner towers (a structural precursor for the planned future expansion), and to two faculty studies on this firth story (today the ninth floor). It was assumed that most Vanderbilt students would use this stairway, and the outside door to it, to access either the reserve room (down) or reference room and lobby (up), thus limiting the traffic elsewhere. A comparable stairway and tower to the south had less use, but led down to the religion library and on to the basement, and up to the lobby or staff area and floors four and five. The southwest tower had only one faculty study (where I am writing this essay) because of the space devoted to the small but ornate passenger elevator, the only one of three elevators open for public use. The planning committee had debated its necessity, but decided that older faculty with fourth floor research studies might need it. It was much too small for regular student use, and well away from the main circulation routes of students. The two towers on the east did not include main stairwells, but as originally planned each would have had two rather spacious faculty studies accessed by a small stairway from the eighth stack floor. These were completed as planned for the southeast tower, but because the air conditioning architect commandeered the northeast tower for the original cooling system, it is now only an empty shell, one of the anomalies of the present building.

The third floor (and upper floor for most of each wing) was primarily reserved for graduate students, although about two thirds of the south wing contained a science and technology reading room (today the periodical reading room). This reading room was expected to appeal largely to engineering students. The whole north wing was reserved for graduate students, primarily M.A. candidates. It was their special reading room, and a matter of great pride for the designers of JUL Central. It had 150 assigned desks. Like all the tables in all three north wing rooms, these had sloping table tops, for easier reading, and inlaid Masonite over most of the surface to cut down on any glare and to help hold books and papers in place. Uniquely, the graduate reading room had a row of shelves at the top center of the tables. Each graduate student had an assigned shelf, with its own number, and could check out books to the shelf until the end of the academic year (if someone else requested the book, the library staff would simply procure it from the shelf and leave a notice for the graduate student). The shelves around this reading room contained bound copies of most scholarly journals. Four of a total of five research seminar rooms were on this floor, the first such on either campus. One was along the hallway just outside the graduate reading room, and three more on the west end of the south wing. These had blackboards and large, long tables that seated up to 18 students. In the next several years, almost all graduate seminars at Vanderbilt took place in these library rooms. As planned, the third floor was a social space visited regularly by almost all Vanderbilt graduate students, but probably not as often by Peabody students.

Figure 5: World War II soldiers studying in the graduate reading room on the third floor of the library

All reading rooms received special attention. They, along with the air conditioning, were the glory of JUL Central. First of all, they were beautiful. Slightly curved, plastered beams made for an arched top. Between the beams was a sound-proof acoustical ceiling, and suspended from it banks of florescent lights. Surrounding each of the reading rooms were banks of shelves or cabinets, with special paneling elsewhere on the walls. Large windows (20 percent of the wall space) provided good natural lighting. All paneling, shelves, cabinets, internal doors, and window and door frames in all public areas throughout the whole library were fashioned either from quarter sawed sweetgum or, where appropriate, sweetgum veneer. I doubt that any building in the South contained as much prime sweetgum (lequidambar styracielua), an infrequently used wood that is remarkable for its light brown to slightly reddish color and its satiny luster, as well as for its seed balls and the brilliant scarlet and orange color of it starshaped leaves in the autumn. This light colored wood, which required no finish except wax, was perfect for the reading rooms. Black walnut would have been more expensive but too dark, although chosen for a few desks in library offices. Almost all the original wood work is still in place. It has worn well, but the sheer extent of sweetgum can seem monotonous. To cut down on noise, both the reserve and reference reading rooms had special and expensive rubber tile, with asphalt tile in all other public areas.

Unlike the first three floors, the fourth floor lacked the high, sixteen feet ceilings. It was only the first of a planned seven stack floors that would eventually tower above the wings. A series of eight faculty research studies (the most coveted because of the windows that faced the lawn to the west) lined the hallway that connected the two west stairways and towers. As one would expect, it included only a male restroom. Since it was difficult to find space for all the functions expected of a central library, the planners toward the end of the process decided to add two penthouses at the center of each wing. The one to the south became the beautiful Treasure Room, with even more luxurious cabinets and shelves than the reading rooms. It would house rare books, documents, and artifacts, and be open to the public only on special occasions. To the north was the microphotography lab. This required the most recent technology, in the form of microfilm cameras, readers, and one printer, plus an expensive dark room with drying closets, processing tanks, and enlarging tables, with elaborate plumbing (this is still in place). At the time, it was as up to date as possible in a rapidly evolving aspect of library work, and allowed the library to begin microfilming such bulky items as newspaper files..

With one all-important exception — air conditioning — these were the features that fulfilled Kuhlman's dream and made JUL Central a very special library. Some library supporters wanted extra features. The planning committee considered both an auditorium and a book store, but rejected both as extraneous to the purposes of a library. At the time of completion the library more than met space needs. In fact, the early stacks were only about half full. The planners expected the building to suffice for about 20 years, when the proposed six new stack floors could double its capacity to about one million books. The estimate proved accurate, leading not to the upward expansion (still contemplated as late as 1964), but to the esthetically disastrous addition completed at the front in 1967. Yet, even in the mid-sixties expansibility was still important, with the new graduate wing constructed so as to be able to support the other six, long-deferred stack floors.

The library has worn extremely well, although many functions and needs have changed since 1941. Unfortunately, the later switch to open but secure stacks made most outside doors redundant, wrecked the carefully planned traffic patterns, and pulled the mass of undergraduates into the Spartan and unappealing stacks. Yet, it would be difficult to find many 66-year-old buildings that have remained so little changed over the years. Given the time, and the perceived needs in 1941, is difficult to find any critical feature that Kuhlman and his committee overlooked in those dark years that connected a terrible depression to the most horrible of all wars.

II. Air Conditioning JUL Central

Today, the label "air conditioning" usually refers to the cooling of buildings in the summer. In 1939, as construction began on JUL Central, the label had a much wider meaning, with cooling not necessarily the most important component. Conditioned air then meant not only air warmed or cooled to a certain temperature, but filtered air with controlled humidity, all circulated uniformly in a building. For libraries, two goals were of equal significance, the comfort of people and the preservation of books. For the second goal, a relative humidity of around 50 percent was critical, for very dry air could crack the spines of books, very moist air lead to mold.

The most difficult decision facing Kuhlman and the planning committee in 1939 was whether to air condition the new central library. At first, the principal architect, Henry Hibbs, plus most committee members, believed air conditioning would be too costly. No other libraries in Tennessee, and only two or three in the whole South, had central air conditioning. The committee considered postponing air conditioning, or possibly air conditioning only the reading rooms in the two wings, hoping some of the cooled and dehumidified air would seep into the central stacks. Hibbs feared the design changes necessary to accommodate central air conditioning, and in fact they would require almost continuous alterations in the original construction contract. But from the beginning the committee at least planned for future air conditioning. This meant duct work that would accommodate air conditioning, insulation of walls, and double glazed windows.

One factor helped sway the committee in favor of air conditioning. It was much easier and less expensive to incorporate air conditioning in the original construction than to add it to an older building. And, if JUL Central was to be a model library, a guide to future library design, how could it do without the best possible heating and cooling system? By May of 1939 the committee decided to take the risk and procure a state of the art system. It would be just that, for it decided to hire the ablest heating and cooling engineer in America to design and supervise the installation of the very latest in air conditioning technology. This was the best decision the committee ever made.

Library Engineer

Figure 6: Photograph of E. E. Bryan

Even as the committee debated alternatives, E. E. Bryan, supervisor of buildings and grounds at Vanderbilt, began the search for the ablest engineer. He also supervised detailed investigations of the average heat and humidity in Nashville, and the direction and speed of summer winds. Detailed climate charts awaited any prospective engineer. Bryan wrote letters to dozens of experts, and soon found that a majority agreed that the ablest engineer in this specialty was Charles S. Leopold of Philadelphia. In ordinary times, he would not have been available for what was, in effect, a rather modest project. He had supervised the air conditioning of such large buildings as the capitol of the United States and the Palmer House hotel in

Chicago. But in the depression such contracts were few and far between, and when approached he eagerly sought the job. He did not come cheap. He asked to receive ten percent of the cost of the air conditioning equipment, and payment of all costs for his almost weekly trips to Nashville.

Because they were interactive, Leopold had to work out the specifications for all the plumbing, heating, and air conditioning of the new library. These were the basis of bids by various contractors. As Bryan had pointed out to the planning committee, it was all but certain that the Carrier Corporation would win the contract for the main components of the air conditioning. It had a near monopoly in the field, and had introduced a series of innovations in the late thirties that shaped the system Leopold selected for JUL. In 1939 the Carrier Corporation installed a new, experimental air conditioning compressor for two buildings at the New York World's Fair. At the fair's closing, this compressor was purchased by the Melrose Theater in Nashville, meaning two very similar local systems installed at roughly the same time. But Carrier only sold the basic components of its system-compressor, condenser, and evaporator. Leopold had to solicit separate bids for over a dozen electric motors, including the huge one for the compressor, a bid won by Allis Chalmers.

A series of discoveries had led to modern air conditioning. After 1931, these included all of the major components that, despite many refinements, are still in use today. The cooling effect of evaporation, and the warming effect of condensation, is at the heart of any air conditioning system. As far back as ancient Mesopotamia, people had learned to use evaporative cooling by forcing air through water saturated cloth. In very dry climates, such a simple form of cooling is still effective and inexpensive, but it does not control humidity. The Romans collected and stored winter ice, and used it to cool rooms, either by stacking it around the walls or blowing air over it, with the risk of very high humidity. By 1850, the cooling potential of evaporation led to the first ice making factories, and a lucrative summer business. In this case, a gas (then usually a toxic and corrosive ammonia) was compressed by pistons driven by steam engines. This heated and condensed the gas. The resulting liquid, under high pressure, circulated through pipes or tubes, where it was cooled either by flow of air or water, and then allowed to escape through a pressure valve into coiled evaporating tubes. The rapid evaporation of the expanding refrigerant cooled the tubes to below the freezing point of water, with large blocks of ice forming in areas surrounded by the tubes. The same principle later allowed for the creation of skating rinks, and by the 1920s to home refrigerators.

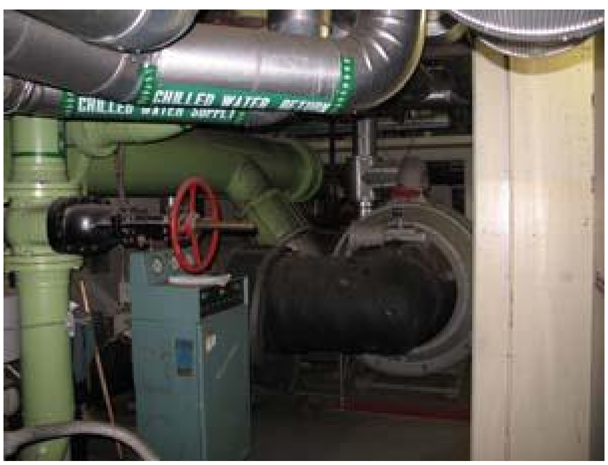

Figure 7: Carrier's chilled water pipes

In 1902, Willis Carrier began the rather long process of using such a refrigeration system to cool and dehumidify the air in buildings. At first, human comfort was not a major concern. The largest commercial market was for a system to control humidity in factories, such as in textiles, which needed a constant high humidity (around 80%), or others (paint, plastics, pharmaceuticals) which needed air as dry as possible. To meet these needs, Carrier conceived of a humidity control device that first made him famous, a devise that he would refer to as "dew point control." It alone has led to his recognition as the inventor of air conditioning (not, be it noted, of either cooling or refrigeration).

Carrier's new device continued in use until World War II, and was at the heart of the system installed in JUL Central in 1941. The basic concept seemed counterintuitive. Carrier decided that one could use a fine spray or mist of water to lower the humidity of air that circulated in a building. If warm and moist air flowed through tiny drops of very cold water, or something close to a fog, these water droplets would create millions of condensation surfaces (like a cold glass is a condensation surface). If the temperature of the spray was below the dew point (the temperature at which air is fully saturated with water vapor) of the circulating air, the spray would condense some of the moisture out of the air. How much depended on how much cooler the spray was than the dew point of the flowing air. Thus Carrier gradually perfected an apparatus to utilize this principle. He perfected brass nozzles that would emit a fine spray into a dehumidifying box through which moved the circulating air of a building. He calculated the temperature of the spray needed to attain any given humidity. He used a standard refrigeration system (compressor, condenser, and evaporator) to chill the water of the spray to the temperature level needed to attain his targeted level of humidity (usually 50 percent). In effect, the degree of chilling needed for the spray determined how much compression, and pressure, was needed in the refrigerant before it entered the condenser and evaporator. In so far as the motor that powered the compressor could vary its load to match the needed amount of compression and cooling, Carrier had a type of thermostatic control over the whole system and its energy consumption. Until 1920, almost all his installed systems were for humidity control, not for human comfort. What he needed was a more efficient compressor and, most of all, a much better refrigerant than a very toxic ammonia.

He had all of these by 1931. In 1922-23 Carrier perfected the first centrifugal compressor, or what eventually became the standard for large capacity air conditioning. All early refrigeration systems had compressed ammonia by reciprocating or piston type motors. They were not very efficient, but are still used in many small capacity air conditioners. In them, the main shaft from an electric motor has cams, which connect by rods to pistons within cylinders, much like in an automobile engine. As the piston moves down in the cylinder, it pulls in refrigerant, which is pressurized as it moves up and released through a pressure valve into the condenser. Carrier's centrifugal compressor was a turbine type, already used for many water pumps. In it, the main shaft from the electric motor had attached impellers (like blades on a fan), which rotate at a rapid speed in order to compress air. Such a machine is simple, with no cams, no rods, no pistons, but the speed of the impellers requires a very strong mounting and casing. The impeller in the compressor for JUL Central had a rotating speed of over 500 miles an hour at the outermost rim of the compression chamber. Early centrifugal compressors had two moveable vanes to control the flow of refrigerant though the impellers, with less flow lowering the load on the motor (and thus the energy consumed). Later compressors usually had multi-speed motors. Such a compressor proved ideal for large, chilled water systems, and matched up perfectly with Carrier's dew point control dehumidifiers.

As late as 1930 Carrier had searched but had not found his perfect refrigerant. He had replaced ammonia with a gas that contained chlorine, but it was far from perfect. What was needed was a stable, non-toxic, non-flammable, non-corrosive gas with a relatively low condensation temperature. At first unknown to Carrier, chemists in the Refrigerator division of General Motors, and then at Du Pont, had synthesized a family of gases with just these properties by the mid-twenties. We now refer to them as chlorofluorocarbons (or CFCs). Du Pont subsequently registered a trademark name for the CFCs used as refrigerants-Freon. Carrier began using Freon in his centrifugal compressors in 1931. It would be forty years before humans began to realize that CFCs help deplete our stratospheric ozone layer, which is the main barrier to harmful ultraviolet radiation.

Even before Freon, air conditioning for human comfort had taken off in the prosperous twenties, in commercial buildings but not yet in private homes. By the mid-20s several factories both cooled and dehumidified, most using the Carrier system. In 1922 a movie theater in Los Angeles began installing air conditioning, and opened in 1923. At about the same time, three movie houses in Texas added air conditioners and, with much publicity, so did the Rivoli theater in New York in 1925 and just afterward a new Madison Square Garden. The air conditioning of the Hudson Department Store in Detroit, in 1924, was one of the first for a large, multi-storied building. Even more publicity greeted the air conditioning of the House and Senate chambers in Washington in 1928-29, with Leopold as the engineer. By the beginning of the depression in 1930-31, many large city theaters were air conditioned, as well as some multi-story office buildings and department stores. In the early thirties the Carrier Corporation developed a compact room air conditioner, but such was the lack of demand in the depression that it never marketed it. Home air conditioning came into its own only after World War II. When the planning committee for JUL Central decided for air conditioning in 1939, a few buildings in Nashville already had air conditioning, including one state office building, one bank, and the Davidson County Court House. The Cain-Sloan department store installed air conditioning at the same time as JUL, and perhaps alone in Nashville offered as many engineering challenges as JUL.

Figure 8: Compressor, rear view

Tailoring the Specs

Fortunately, Leopold was hired before building construction began. Thus, he was able to integrate his heating and cooling system into the specifications provided the main contractor. Most of these involved the basement, but also the allocation of needed space for all the duct work. JUL Central had a huge basement, of two levels. The upper basement, in the central tower, included stack floor one, which is approximately eight feet high. The southwest stairwell, and the public elevator, offered the only non-stack access to this basement area. The stacks in this lowest level do not extend to the outer walls on either the east or west of the building, leaving an eight feet wide tunnel for the ducts that connect the two wings. The basement areas in the two wings are twice as deep as stack floor one, or around 17 feet high, with the north basement extending for the whole 144 feet, the south one only about half of this distance. As planned from the beginning, the north basement would house the main electrical, heating, and cooling equipment. A new tunnel from Garland Hall extended the Vanderbilt steam plant's pipes to the northwest basement (JUL would have to pay Vanderbilt for its heat). An outside stairwell leading down to twin doors at the north end of the library provided access to this deepest basement and to all the utilities.

When Leopold completed his specifications for the air conditioning, he was able to open bids for all the duct work and all circulating fans and to specify the cooling capacity of the completed system, but at first offered alternative possibilities for the compressor or compressors. I am sure he was in constant contact with the Carrier Corporation, and aware of a rapidly evolving technology. For a few months, he held out the option of two compressors, and stopped the construction of faculty studies in both the north towers, in case both were needed for cooling towers. But by 1940 he had accepted a Carrier bid for one large, centrifugal compressor. This freed up the two faculty studies in the northwest tower.

The library contained 1,350,000 cubic feet of space. Based on local climate data, Leopold believed it would take 194 tons of refrigeration to cool the building when the combined heat and humidity reached record levels. A ton as a measure of cooling derived from an earlier era, for it reflects the amount of cooling produced when a ton of ice melts over a twenty-four hour period. Thus, Leopold required Carrier to furnish a 200 ton compressor. It had to be capable of cooling 965 pounds of fresh air per minute (this entered through screened louvers at the northeast corner of the north basement) at a temperature of 95° F and a dew point of 80°, plus 3000 pounds of circulating air (back from the library above) at 78° and 65° dew point. Its target temperature was 76° with a relative humidity of 50 percent. The variance allowed was slight, or only one degree of temperature above or below this target, and one or two percentage points in the humidity. The installed system would meet these targets, at least in the early years. Note that the maximum conditions were not likely to be exceeded. Obviously, Nashville temperatures often soar above 95°, but when temperatures are this high the dew point is never close to 80°, and when, during rainy weather, the dew point may rarely exceed 80°, the temperature will never be close to 95°.

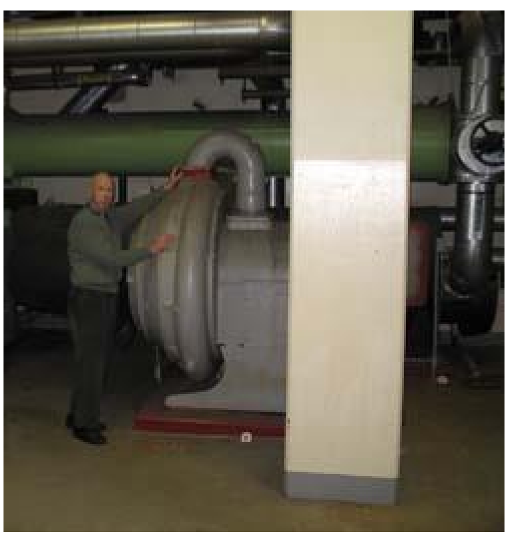

Figure 9: The author alongside the compressor

The 200-ton Carrier compressor was an impressive machine. It still is in its presently unused but basically unchanged condition. It worked for over forty years and, if needed, I am sure it would still chill water for cooling. But it was at the small limits of centrifugal compressors. Most in Leopold's earlier installations were three times as large. The one for JUL had only one set of impellers and not the two or three on large machines. It had two thermostatically controlled vanes to control the flow of Freon, and thus also the variable energy demands on the motor. The circular chamber for the impellers was fully five feet high. The motor and compressor were very heavy. The motor, with a speed of 3540 RPM, even if perfectly balanced, was sure to produce both a loud noise and some vibration. Thus, Leopold required the general contractor to dig a pit down to bed rock and pour a concrete platform on top of this for the compressor, all before pouring the concrete floor of the basement, and to place a separator between the platform and floor. Thus, the compressor would not shake the whole building.

The compressor forced the circulating Freon into the coiled tubes of the condenser, which was mounted above the compressor. Here under pressure the gas condensed into a fluid, with the condensation heating the Freon. One way of stating the task of an air conditioner is to get heat out of a building. The compressor used inertial energy to condense and heat the refrigerant (the present Vanderbilt chiller uses direct heat and not compression). The problem was how to cool the condenser coils and transfer the heat to outside the building. In home or automobile air conditioners, a flow of air does the cooling. This is not the most efficient way to do it, and thus is rarely used in large units. A flow of cold water works best. One way to get this is to pump cool water from a well through the condenser, and then allow this heated water to flow to an outside sink or back into the well. Such a well can support the most efficient system possible. Vanderbilt had no such well, and could not afford to buy enough city water to provide a steady flow. Thus, as in most large systems, it opted for a cooling tower, one that used evaporation to cool the condenser water. Most cooling towers (like the present unused and ugly tower on top of the graduate wing of the library) are constructed on the outside of buildings. JUL Central may have been unique. Leopold, in order to save money, and to hide what is usually a loud and ugly tower, decided to convert the northeast tower of the library into an internal cooling tower.

Making It Work

Here is how Leopold did it. He used a pump to push the heated water out of the condenser and up to near the top of the northeast tower. He placed, on the roof of the tower, a twenty-five hp exhaust fan, which pulled outside air in at the bottom of the tower, through louvered openings that, from the outside, appeared to be windows. He covered the walls of the tower with cooper sheathing, and created an even thicker copper pan covering the floor. In the old Carrier tradition, he used brass nozzles on the walls of the tower to release water in a fine mist, which drifted down through the upsurging air. Redwood boards, which stretched across the tower, created additional surfaces for the falling water. This all maximized the rate of evaporation in the water, and thus the degree of cooling. The water flowed back, by gravity, to the condenser, at a temperature of 80° or less, or a drop of 15° from its entering temperature.

So cooled by water, the refrigerant was ready to do its work in the evaporator. It moved from the condenser through a thermostatically controlled pressure valve into the evaporator, another large unit above the compressor. Here the Freon, in coiled tubes, expanded and evaporated, cooling to a controlled temperature (determined by the level of pressure created by the compressor). These coils cooled the bath of water surrounding them, creating the chilled water that air conditioned the library. The evaporator had an output of up to 690 grams of water per minute at a temperature as low as 45°. What happened next, for the cooling and not the heating, was quite different than in systems today. Normally, such chilled water circulates to pipes or coils within the main plenum and there cools the air. The condensation that forms on the coils, and is drained to the outside, lowers the humidity.

Figure 10: Carrier's Control Panel

Leopold still used the old Carrier dew point system. He had the contractor construct what he called a dehumidifier. It was a large box, a miniature version of the cooling tower. All the air that was to circulate in the building flowed through this box. Surrounding the inside of the box were 240 small brass spray nozzles, which created the fog-like surfaces for both cooling and dehumidifying. The thermostatically controlled temperature of the chilled water determined the humidity and temperature produced in the circulating air. The extracted humidity simply added to the volume of chilled water. Except for a small amount of chilled water used to cool the compressor motor, it was all pumped through the dehumidifier. This system offered more cooling surfaces than coils in a plenum, and in this sense was more efficient. It also allowed an exact control of the humidity, but the heat caused by the internal condensation slightly lowered the cooling capacity of the unit, particularly in very humid weather.

Even before it entered the dehumidifier, the air had passed through an electrostatic filter. This involved a circulating curtain, which passed through an oil pan at the bottom of its circuit. This was supposed to remove the dust and dirt, which sank to the bottom of the pan as removable sludge. But such was the air in Nashville that the device was not perfectly self-cleaning. Periodically, the engineer who supervised the system had to take out the curtain and clean it.

A 25 hp fan near the compressor pulled in the fresh and recycled air, and moved it through the filter and dehumidifier and then through large ducts to both wings of the library. But it was not powerful enough or properly located, to provide a balanced flow of either heating or cooling through all the complicated rooms and stack floors of the library. Thus, Leopold added six supplemental circulating fans (driven in each case by either a five, ten, or fifteen hp motor). He thus cut the library into six zones, and used the smaller units for either smaller or lower zones, and the larger units for either larger or upper zones. Each of the six large circulating units had sets of disposable filters, or ninety in all. The careful design of all the ducts, dampers, and grills (by 1941 this was a science in itself) completed the strategies Leopold used to bring clean, properly heated or cooled, correctly humidified air to every corner of the library, down to closets and carrels.

Perfect Control

The goal of the system was not only perfect control over temperature and humidity, but to achieve this at the smallest possible cost. The system was first tested in May, 1942. It seemed to work perfectly. It was a complex system. A full-time engineer presided over its operation. It had only one or two brief down periods during each of the first five years, with the various contractors making needed adjustments. In the summer of 1942, the system was on only from June until the end of the Peabody summer school (Vanderbilt had no summer school) in early August. The operating cost for the summer was only $1250, or $1.66 per hour of operation. Throughout the war, the system was off when the students were not present on either campus, meaning long periods when the staff had to open windows and suffer, while the books did not gain the benefit of controlled humidity. From 1942 through 1948 the average annual cost was $1283. After this, the system was in use longer during most summers, and costs were higher. Almost everyone acclaimed the system and loved to visit the library in summer. When I came to Vanderbilt as a graduate student in 1951, this was the first air conditioned building I had ever experienced. As late as 1951 no other buildings on any of the three campuses had central air conditioning (Peabody air conditioned a new Payne Hall in 1952).

Leopold's original system remained intact until the new addition in 1967, when a new cooling tower replaced the one in the northeast tower, and additional compressors supplemented the original Carrier Unit. Only in the eighties did Vanderbilt University replace all the original system. Ironically, the present system, with its chilled water supplied by a central unit on the Peabody campus, has to make use of some small, supplemental compressors on the roof, and does not provide as balanced heating and cooling as the old Carrier unit in 1942. My faculty study, for example, effectively has no central heating or cooling.

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B&W photos courtesy of Vanderbilt University Special Collections and University Archives.
Color photos by Neil Brake.

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