1928

THE MILAM BUILDING

San Antonio, Texas

A National Mechanical Engineering Heritage Site

Designation Ceremony • August 23, 1991

The Milam Building

Photo courtesy of Trammell Crow Company

IN JULY OF 1927 WHEN THIS PHOTO WAS TAKEN, THE MILAM BUILDING WAS THE TALLEST REINFORCED-CONCRETE HIGH-RISE OFFICE BUILDING IN THE NATION.

WHEN IT opened in January 1928, San Antonio's 21-story Milam Building, originally owned by the Travis Investment Company, was the nation's tallest brick and reinforced-concrete structure — taller than comparable concrete-framed buildings in New York and Chicago — and the first high-rise air-conditioned office building in the country.

Named for Col. Ben Milam, who was considered by many Texans the real hero of Texas independence, the 210,851 square-foot tower was a blend of modern technology and Gothic majesty. The owner's progressiveness, ably backed by the architect, consulting engineer and contractors — all of whom were from San Antonio — quickly established 115 East Travis Street as the address of choice for many of the state's and nation's leading oil and gas companies, such as Shell, Standard Oil, Mobil and Sun Ray Oil.

COVER PHOTO: THE MILAM BUILDING-1928. REPRINT OF PHOTO REPORT, "THE MILAM CO. OF SAN ANTONIO, TEXAS." ORIGINALLY, THE REPORT WAS PROPERTY OF D.G. FRANCIS WHO WAS TREASUER OF THE MILAM CO. PHOTOGRAPHER: HARVEY PATTESON. Photo courtesy of San Antonio Conservation Society.

WILLIS CARRIER'S first-of-its-kind air conditioning equipment for a high-rise building promised a constant temperature of 75 degrees Fahrenheit at 56 percent relative humidity. This was a level of comfort conspicuously absent in the South, where summer heat and humidity border on unbearable. Buildings such as stores, auditoriums and theaters had been air-conditioned earlier, but high-rise office buildings required that provisions be made in the original design to allow for ducting and air-handling and control equipment.

Carrier's "Manufactured Weather" allowed doors and windows to be closed year-round, reducing dirt and noise from the street and creating for the first time a comfortable and therefore more efficient working environment. In fact, Milam Company literature espoused air conditioning as the building's principal feature. The building was air conditioned throughout — from the basement cafeteria to the penthouse suite — taking in several stores, a post office, a barber shop and a drugstore (known as the "Linoleum Club") on the street floor and approximately 750 offices in between. Early tenants report that the basement's Milam Grill received daily crowds of lunch-goers who stood in lines pouring out onto the sidewalks, eager for the comfort of the refrigerated air within.

The Carrier Engineering Corporation, today a division of United Technologies, designed and installed the building's semi-automatically-controlled 375-ton maximum capacity air-conditioning system in cooperation with architect George Willis (student of the eminent architect Frank Lloyd Wright), engineer M.L. Diver and contractor L.T. Wright and Company.

San Antonio Public Service Company's electrical engineer Carl Evans worked with Diver to design the subterranean transformer vault, housing three 100-KVA and 12, 50-KVA submersible transformer banks. The Milam Building's 900-KVA peak design load provided for the additional capacity necessary to power 11 air handlers, two refrigeration units, centrifugal pumps, and a semi-automatic airflow control system, all of which comprised the air-conditioning system.

Selecting San Antonio's standard service voltage, 120/208, allowed the electric utility to inter-connect the Milam Building with other transformers in the city's downtown underground network. This provided the new building a high degree of service continuity. In 1928, the year of its grand opening, the Milam Building was one of San Antonio Public Service Company's largest — if not the largest — electric customers in the downtown area.

Willis Carrier, deemed by magazine writers of his day as the "Father of Air Conditioning," is thought to have overseen the Milam installation and start-up. That was two years before Carrier was

RIGHT: A BIRDS-EYE VIEW OF SAN ANTONIO IN 1873, DRAWN BY AUGUSTUS KOCH. EAST OF TRAVIS STREET AND THE SAN ANTONIO RIVER (RIGHT CENTER) STANDS THE LAUX MILL, SITE OF TODAY'S MILAM BUILDING.
LEFT: WHEN THIS PHOTO WAS PUBLISHED ON JUNE 10, 1930, IN THE SAN ANTONIO LIGHT THE CAPTION READ: "THE FIVE-STORY LAUX MILL, ERECTED HERE IN 1870 ON THE SITE WHERE STANDS THE PRESENT MILAM BUILDING, ONCE HERALDED FAR AND WIDE AS THE TALLEST BUILDING IN THIS PART OF THE COUNTRY. WILLIAM B. KREMPKAU, OLD TIME FREIGHTER, FURNISHED THE PHOTOGRAPH."

Photo courtesy of the Institute of Texan Cultures, San Antonio Light Collection.

Photo courtesy of the Daughters of the Republic of Texas Library at the Alamo.

commissioned to air-conditiion both the first railroad car and the Oval Office of then-President Herbert Hoover.

The Air-Conditioning System

THE MILAM Building's air-conditioning and cooling system consisted principally of 11 units of air-conditioning equipment (fans, dehumidifiers, heaters); two units of refrigeration with a maximum 375-ton capacity (nominally 300 ton) for cooling water; water storage and distribution lines made up of tanks, pumps and piping; air-distributing ducts with grills and dampers; and manual and automatic power, air-flow and dampening controls. Generally, one air-conditioning unit (air handler) served two floors, except for the basement cafeteria, street floor and 17th floor, each of which has its own air-conditioning unit, and the four tower floors served by one unit. The refrigeration and water cooling equipment, along with various pumps and tanks, were located in the basement.

A cooling tower, located in the rear of the Milam Building at ground level, had the function of cooling warm return water from the chiller. An axle fan blew air over coils wet with spray water. Originally, this closed system used water taken from the San Antonio River. Today's Milam cooling tower uses City water.

The Carrier system was designed especially to handle summer weather conditions, but it took care of winter conditions as well. The system removed heat and humidity during hot weather and added them during cold weather. In 1929, the maximum indoor summer temperature was 80 degrees Fahrenheit with a relative humidity not exceeding 55 percent; the inside winter temperature was 70 degrees Fahrenheit or above with a relative humidity of approximately 45 percent.

Calculating The "Comfort Zone"

IN DETERMINING a comfortable temperature range and relative humidity combination for both summer and winter, the Carrier Engineering Corporation studied local weather bureau records and the sensitivity of San Antonians to the extremes of heat and cold. Carrier staff discovered that San Antonio experienced often long periods of continuous bright sunshine, making the heat of the sun a potent factor in the calculations and design. They further discovered that the hottest period of the day usually occurred around 4 p.m. and continued up until 7 and even 9 p.m. Finally, they found that continuous exposure to the South Texas climate made native San Antonians slightly more heat-tolerant in summer and, conversely, slightly less cold-tolerant in winter than native New Yorkers, for instance.

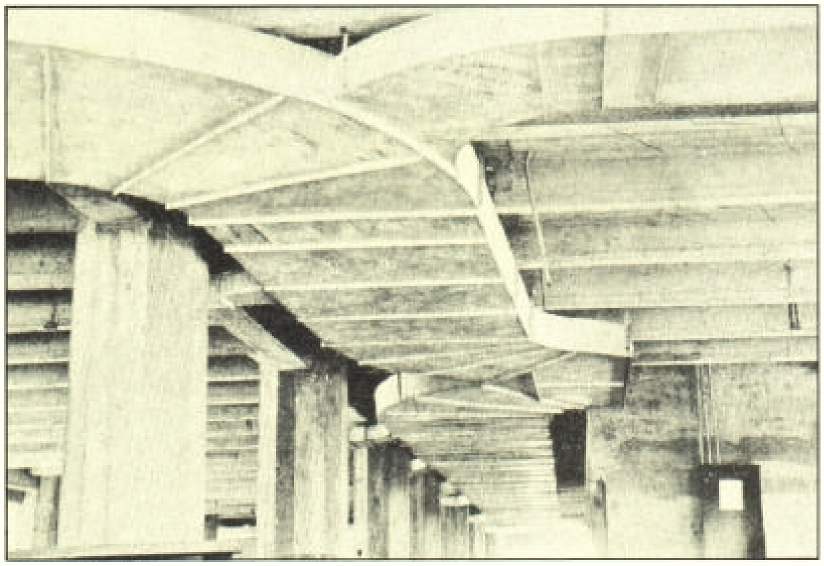
Mrs. W.E. Gill and Lillian Barnett, both tourists from Tulsa, Oklahoma, were captured in this 1931 photo enjoying the air-conditioned comfort of the Milam Building.
Photo courtesy of the Institute of Texan Cultures, **San Antonio Light** Collection.

Once the proper atmospheric conditions were determined, Carrier engineers had to consider inside heat-generating factors (lights, people and machines) and heat-generating factors from the outside to size a conditioning system with sufficient capacity to absorb all the heat. The single-most challenging factor for the engineering team was the high ratio of radiant heat imposed by a "traveling" sun to the total heat to be absorbed, a complication created by the construction of a high-rise office building not found in previous air-conditioning problems.

Radiant Heat and the "Traveling" Sun

NO SINGLE factor presented a greater challenge for the architectural and engineering design team — because of multiple variables — than the conditions affecting radiant heat. In most cases, the problem of radiant heat is handled by gradual absorption and distribution throughout an entire enclosure. In the case of an office building, which is honeycombed with offices, each of which is approximately 1/1000 of the entire building, the heat absorbed through an exterior wall or window of any one particular office primarily affects that office. Without some means of manual temperature control, an office exposed to the sun could be eight to 10 degrees higher in temperature than one not exposed, doubling the necessary air volume requirement for that office.

Controlling radiant heat is further complicated by the "traveling" sun. In the morning, offices on the eastern side of the building require more cooling, while in the afternoon the western side has an even greater cooling requirement. Further complications are caused by cloudy days, when there is no sun and by shifting winds, which vary in both direction and velocity. The magnitude of the radiant-heat problem can be fully appreciated when one considers that these conditions can change hourly.

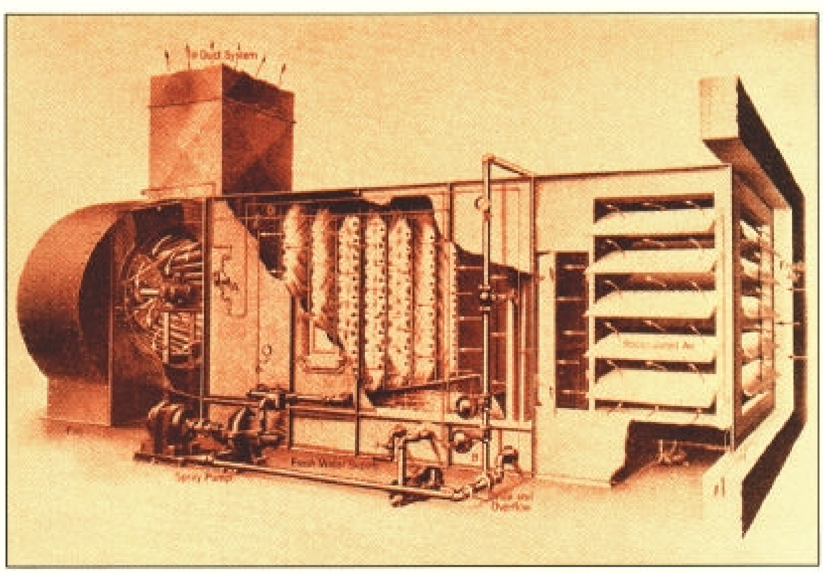


Air-Supply ducts Were Erected Before Ceilings And Partitions Were Installed At The Milam Building. Corridors Were Positioned Directly Beneath The Ducts.

Combating variable load due to the changing sun was addressed at the Milam Building through a combination of radiant-heat reduction, individual room control and group volume control in the main supply ducts. For periods during the year when the temperature on the shaded side of the building was slightly lower than desirable, 60 degrees for example, steam heating units located in the main air supply ducts were activated.

On hot days, venetian blinds allowed the most light in and blocked 25 percent of the radiant heat. Cloth window shades created a better radiant insulator, blocking 50 percent of the heat but reducing the light. Street-level awnings reduced virtually all radiant heat. Dampers were placed in the main air-supply ducts to manually shift the bulk of the conditioned air to one side of the building or the other to reduce the problem caused by the traveling sun on hot summer days.

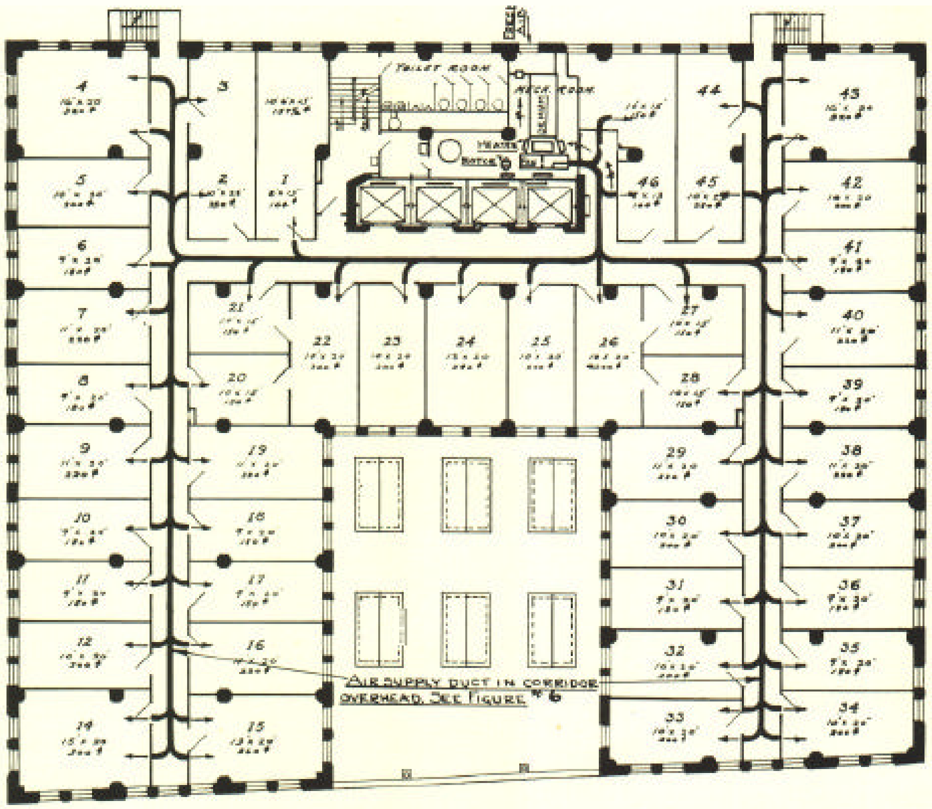
One Of 11 Air-Handling Units Serving The Milam Building, The Unit Received Return Air From The Corridor, Mixed It With A Percentage Of Fresh Air, Pulled The Air Through A Refrigeration Unit To Cool It, A Steam Reheat Section To Dehumidify It And Finally Through A Massive Centrifugal Fan To The Air-Duct System.



Air Distribution

ONCE ALL sources of heat gain had been taken into consideration, Carrier engineers went about determining the correct volume of air to yield the proper temperature and relative humidity. In the Milam Building, approximately eight tons of air were handled every minute — a net change of air every seven to eight minutes — carrying several hundred times more oxygen than the total consumption of all the people inside the building at any given time. This large volume of air was handled by 11 air-conditioning units. For the office floors, the air-handling units were located in the space between the rear building wall and the elevator shaft. Outside air was taken through a window opening and return air through louvres in the corridor Wall.

Good air distribution is considered to be 70 percent to 80 percent of an air-conditioning job according to industry experts and no two buildings are exactly alike in their distribution configurations. In the Milam Building, the main air supply ducts are placed overhead in the corridor. They were originally built of galvanized steel sheet and plastered underneath to match the office ceilings. Air ducts are shallow enough that the corridor ceiling is only 10 inches to 12 inches lower than that of the office ceilings, but with sufficient area to carry 75 percent of the total air volume required for maximum conditions.



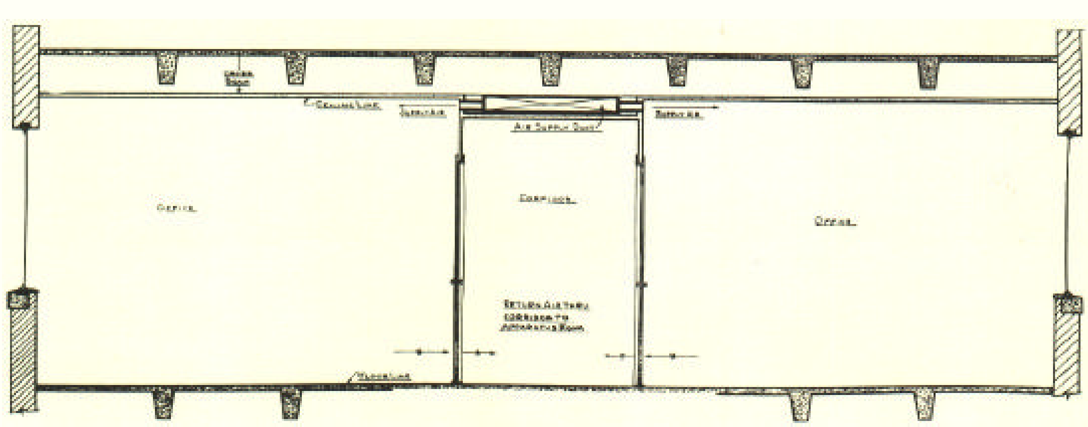
A Typical Floor Plan Shows Office Layout, Air Distribution Ducts And The Air-Handling Equipment Room.

Motor-driven dampers were placed in the main duct lines on each floor in the building and arranged to allow the bulk of the conditioned air to be shifted from one side of the building to the other, depending on the location of the sun. In addition, the dampers could be positioned to balance the air flow evenly to both sides of the building on cloudy days.

For more precise area heating, main air-supply ducts on every floor were equipped with automatic steam heaters, located at several key points, or zones, along the inside duct walls. Beyond each steam heater — located several feet further from the source of the air supply — was a thermostat, which measured the temperature in each zone. When the temperature dropped below the ideal, 70 degrees, the thermostat sensed the drop in temperature and added steam to the conditioned air in the main supply duct.

From the main air-supply ducts, connections branched to each office. Within each branch connection was a permanently-set, air-volume adjuster that provided uniformity of air flow throughout the building. Each branching duct dead-ended inside each office at an adjustable air-supply grill in the corridor wall near the ceiling.

This Air Flow Diagram Illustrates That Fresh Air Entered The Offices From The Air-Supply Duct In The Corridor Above While. The Warmer Air Returned To The Air- Handling Or Blower Room Below Through Louvres In The Bottom Of The Door.



Return Air

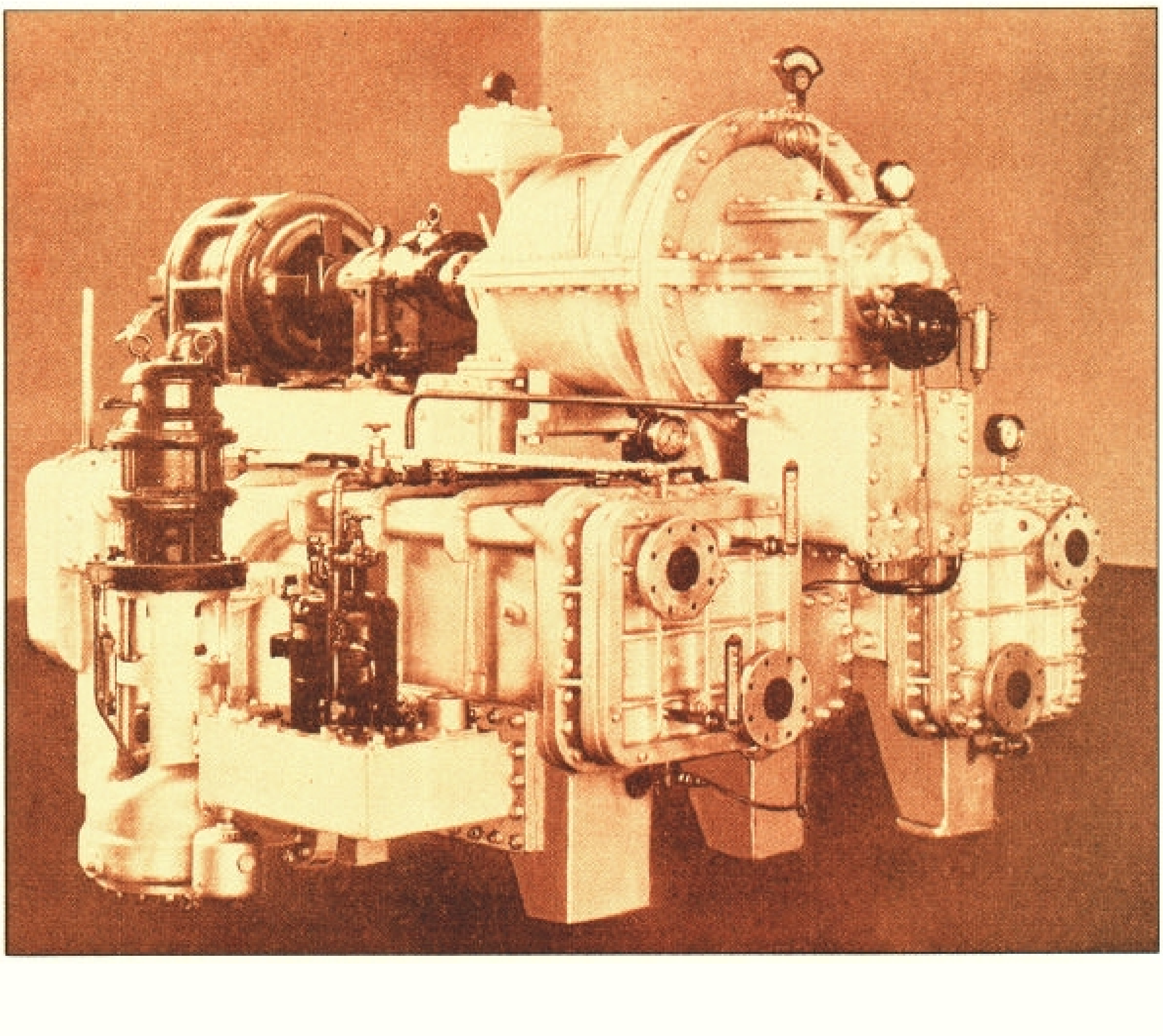
TO OPERATE the Milam's air-conditioning system efficiently, large portions of conditioned air were re-used, re-purified and reconditioned, drawing in just enough outside air for proper ventilation. The air delivered to each office returned to the corridor through "V-shaped" louvres in the lower part of office doors, then returned along the corridor to the back of the air-handling unit near the rear of the elevator shaft. The corridor thus serves as a return-air duct.

During periods when the air was heated or cooled, the engineer could, at his discretion, bring in outside air beyond the volumes required for ventilation, although taking in more fresh air than necessary increased the cost of operation. The building engineer was considered the best judge of the requirements, which is one reason manual control of fresh air was preferred at the Milam Building over fully automatic control.

Lavatories in the Milam were not air conditioned or ventilated as part of the main air distribution system — they were cooled by air leakage from both the corridor and the stair tower and independently ventilated. Corridor air leakage, therefore, provided for some lavatory cooling.

Outside return-air dampers were originally controlled manually to bring in 100, 70, 40 or 15 percent outside air, depending on existing weather conditions. All of the dampers for the 11 air handlers could be controlled manually from the basement by the building engineer. During periods when the air was heated or cooled, the engineer could, at his discretion, bring in outside air beyond the volumes required for ventilation, although taking in more fresh air than necessary increased the cost of operation. The building engineer was considered the best judge of the requirements, which is one reason manual control of fresh air was preferred at the Milam Building over fully automatic control.

ONE OF THE TWO ORIGINAL CARRIER CENTRIFUGAL REFRIGERATION UNITS USED IN THE MILAM BUILDING. EACH UNIT HAD THE CAPACITY TO CHILL 650 GALLONS OF WATER PER MINUTE AND OCCUPIED APPROXIMATELY 215 SQUARE FEET OF FLOOR SPACE.

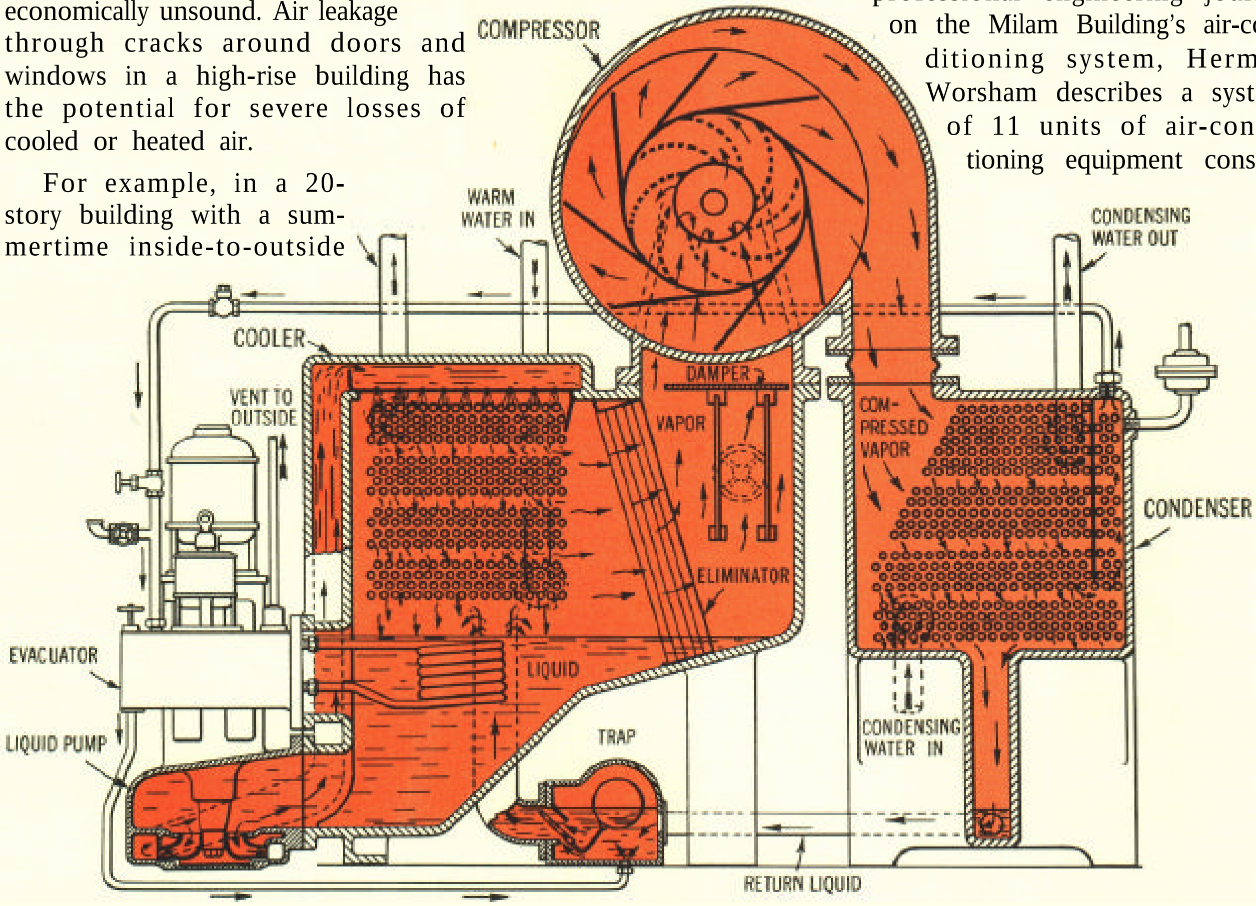


Air Leakage

THE TIGHTNESS of a high-rise building is a factor that affects the quantity of fresh air to be used. The more air that leaks from the building through windows and doors and other openings, the greater the demand for fresh-air replenishment. Special windows were incorporated into the Milam Building's design to make the structure quite tight. For this reason, little conditioned air was wasted, which helped keep the cost of operation down.

Had not building tightness been a design consideration, the entire air-conditioning project potentially could have been inefficient and thus economically unsound. Air leakage through cracks around doors and windows in a high-rise building has the potential for severe losses of cooled or heated air.

For example, in a 20-story building with a summertime inside-to-outside temperature differential of 20 degrees, a column of denser, cooler inside air one-foot square and 200 feet high (20 stories) will weigh 0.6 of a pound more than an equal column of outside air. The total volume of air inside such a building will weigh 7,500 pounds more than an equal volume outside. The column of denser air exerts a tremendous downward pressure, tending to force its way outward on the lower floors. As it does so, outside air is drawn in at the upper floors. The pressure is sufficient, with a 20-degree temperature difference, to create an outward and downward velocity of 1,360 feet per minute through any cracks or crevices.



In This Typical Diagram Of Carrier Centrifugal Refrigeration, The Refrigerant, Dielene, Reached Nearly Atmospheric Pressure At The Compressor Outlet In The Condenser. The Trap With Float Acted As An Expansion Valve To Hold Higher Pressure In The Condenser. An Evacuator Removed Air And Water Contamination From The Enclosed System While The Eliminator Prevented Liquid Slugs From Entering The Compressor And Damaging The Blades.

During the winter, the air inside is lighter and the direction of air leakage is reversed, leaking in at the bottom and out at the upper levels. Thus the building becomes a huge stack. Because temperature variances in the winter are usually greater than in the summer, the "stack" action is even more pronounced. It's apparent that structural tightness was an important design consideration for the 21-story Milam Building.

Air Delivery

IN A 1929 technical article from a professional engineering journal on the Milam Building's air-conditioning system, Herman Worsham describes a system of 11 units of air-conditioning equipment consisting of fans, dehumidifiers, heaters and motors (see air-handling figure, bottom of page 3). He states that dehumidification was accomplished by a spray water system of air conditioning. Research shows that such a system was installed in 1924 at the Palace Theater in Dallas, Texas, however, visual inspections and staff interviews seem to indicate that such a system did not exist at the Milam building. Therefore, it is possible Worsham was in error and that the 11 original air handlers were actually surface condensation systems with cooling coils. The present-day air-handling unit consists of air filters, cooling coils, heaters and a centrifugal fan.

Refrigeration and Cooling Equipment

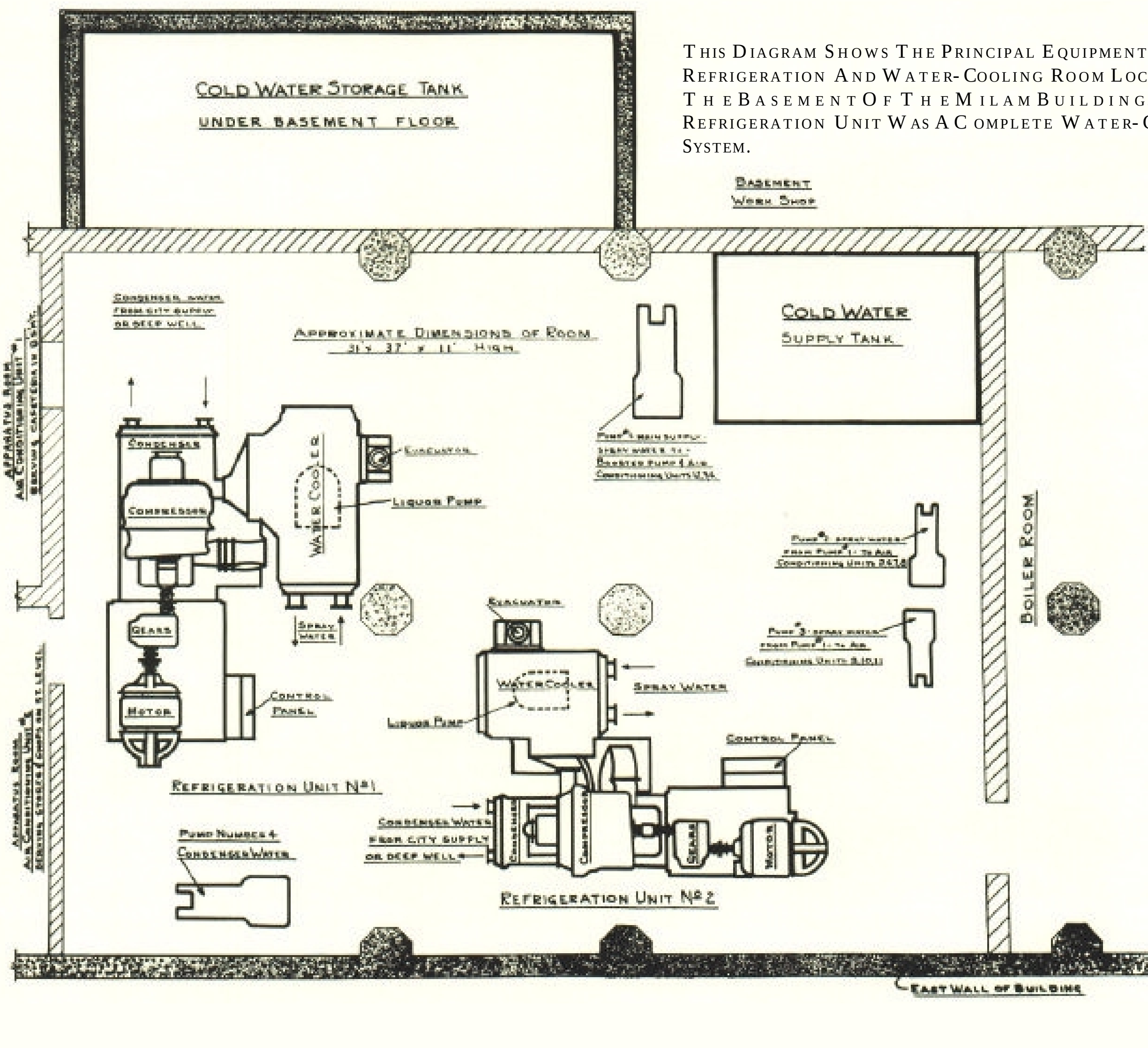
THE REFRERATION and cooling equipment is located in the basement. Originally, two centrifugal refrigeration units with a total cooling capacity of 375 tons (nominally 300 tons) served the Milam Building. That capacity approximates the cooling effect of 375 tons of ice (750,000 pounds) melting over a 24-hour period.

Since office rental space produced most of the owner's income, space limitations necessitated the use of a compact system of refrigeration. In addition to compactness, the system also had to be simple, safe and economical. A storage tank for chilled water was originally provided under the basement floor, which allowed the refrigeration equipment to be operated at non-peak electric rate periods to reduce the cost of operation. With one refrigeration unit operating at night, the tank had the capacity to store enough chilled water so that only one refrigeration unit was required in service the following work day. If the weather was cool that day and the chilled water was not needed, it could be held for several days with only a slight rise in temperature.

Also, both refrigeration units could be shut down and the building cooled with chilled water from the storage tank alone. The use of storage water from the tank was under positive automatic control, with the amount of chilled water withdrawn varying from zero to 100 percent depending on load. The tank was designed to prevent relatively warm returning water from mixing directly with the cold tank water.

Chilled water was delivered to the 11 air-conditioning (air-handling) units by three motor-driven centrifugal pumps, located near the collection tank in the refrigeration room. In the Milam's chilled-water system, it was necessary to use an open system of water circulating lines, thereby losing the "head" due to the elevation of the water in the risers.

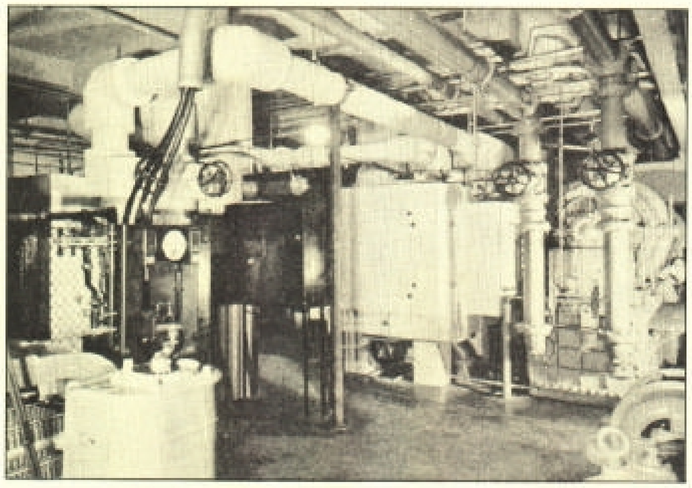
Given this condition, dividing the 11 air-handling units into three pumping groups permitted a savings in the total power consumption for pumping. Pump 1 was large enough to handle the entire quantity of chilled water at a pressure sufficient to deliver it to all the units on or below the 5th floor. Pumps 2 and 3 were booster pumps, with Pump 2 supplying floors six through 14 and



This Diagram Shows The Principal Equipment In The Refrigeration And Water-Cooling Room Located In The Basement Of The Milam Building. Each Refrigeration Unit Was A Complete Water-Cooling System.

Pump 3 serving the air handlers on floors 15 through 21.

The Milam's air-conditioning system returned the warmed water to the evaporative cooler to be cooled by the refrigeration equipment for return to the upper floors. The Carrier system at the Milam Building was designed to deliver about 1,200 gallons, or 50 tons, of chilled water for air conditioning per minute.



THE MILAM BUILDING'S REFRIGERATION ROOM AS IT WAS IN 1928. THE COMPRESSOR AND CONDENSER OF ONE REFRIGERATION UNIT IS LOCATED AT THE EXTREME RIGHT.

Controlling the System

THE ENTIRE Milam air-conditioning system was designed with a combination of manual and automatic controls. At a time when computers and microprocessors did not exist, it would not have been prudent to overload with automatic controls a system dependent upon a matrix of climatic variables. In 1928, it was the philosophy of the architect and system designers to allow the building engineer to decide when, where and how to move the building's large volume of fresh and conditioned air. Individual tenants had limited control over the temperature in their office by adjusting the air-flow at the register (building regulations prohibit opening Windows, but tenants then, as now, were instructed how to open them in case of an emergency). But control was more of a semi-automatic function that followed a decision by the building engineer. From his post in the basement, the engineer could open and close the fresh-air or main air ducts and start or stop any of the air-handling units at the main control panel. He could also turn an air handler on or off at the unit inself.

With the successful installation of the Milam Building's first-of-its-kind air-conditioning system for a high-rise office building, other companies and institutions, such as the U.S. Government, began to follow suit. Prudent southern businessmen began to view air conditioning—once thought a frivolous luxury – with eyes like the inventor's. Carrier's "Manufactured Weather" eliminated dust, noise, perspiration and fatigue in the office environment and helped increase efficiency. Building owners found they could get 10 to 15 percent more rent for air-conditioned offices, while southern owners discovered how cool offices helped them retain tenants, even in the summer months.

The partnership struck between the Travis Investment Company and the Carrier Engineering Corporation on the nation's first high-rise air-conditioned office building—the Milam Building —heralded an evolution of an environmental kind. It was the first step in transforming the inner-offtce environment in the South from drudgery and discomfort to optimism and productivity.

Works Cited

Haggard-Kothman, Leytha Sue. *Prairie School Architects of Texas, Milam Building Architect George Willis.* Master's Thesis. University of Texas at Austin, 1988.

Hall, Franklin. *"Who Will Go With Old Ben Milam Into San Antonio?".* **San Antonio Express,** 2 February 1930.

Ingals, Margaret. *Father of Air Conditioning, Willis Haviland Carrier.* New York: Country Life Press, 1952.

Janny, John. *He Drys Air With Water and Cools It with Steam.* **American Magazine** Vol CXV. Springfield: Crowell Publishing, 1933.

Moore, Paula. *Friendly Ghosts and Fond Memories Mark Milam's Long, Trend-Setting History.* **San Antonio Business Journal,** 4 September 1989, Page 13.

Schultz, Gene Church. *Gillette Company Lowers the Heat in San Antonio's Historic Building.* **Air Conditioning, Heating and Refrigeration News.** Troy: Business News Publishing, 23 April 1990.

Severns, William **H. Heating, Ventilating and Air Conditioning Fundamentals.** England: John Wiley and Sons, Chapman and Hall, 1935.

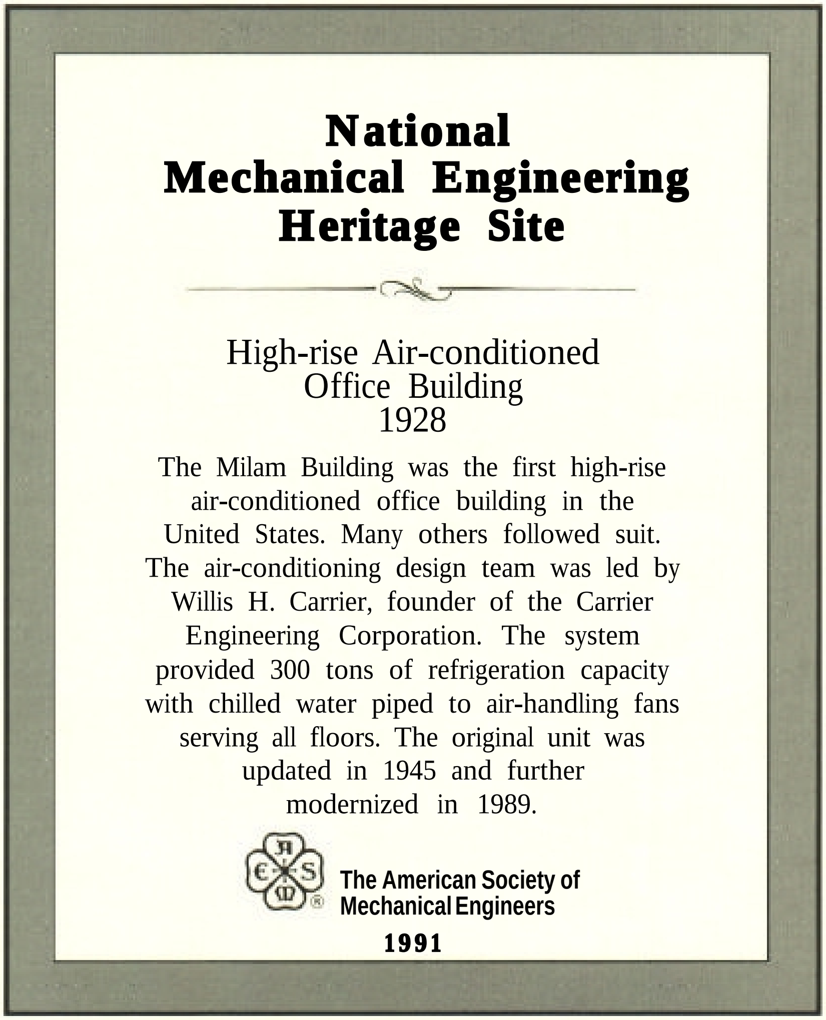
The Milam Building, Pioneer in High Rise Comfort. Gibbs and Sells Public Relations. New York: n.p., 31 August 1989.

The 21-Story Milam Building. **The Weather Vane, News of Manufactured Weather: Carrier Corporation Quarterly** Vol 3-9. Newark: n.p., 1929.

Worsham, Herman. *The Milam Building.* **Heating Piping and Air Conditioning** Vol 3. Chicago: Domestic Engineering Co., 1929.

The ASME History and Heritage Program

THE ASME History and Heritage recognition program began in September, 1971. To implement and achieve its goals, ASME formed a History and Heritage Committee, initially composed of mechanical engineers, historians of technology and (ex-officio) the curator of Mechanical Engineering at the Smithsonian Institution. The Committee provides a public service by examining, recording and acknowledging mechanical engineering achievements of particular significance.



The Milam Building is the 4th National Mechanical Engineering Heritage Site to be designated. In addition, two Mechanical Engineering Heritage Collections, 99 National, 34 International and 12 Regional Historic Mechanical Engineering Landmarks have been designated. Each reflects its influence on society, either in its immediate locale, nationwide or throughout the world.

The History and Heritage program recognizes our technological heritage and serves to encourage the preservation of the physical remains of historically important works. It provides a roster for engineers, students, educators, historians and travelers and helps establish reminders of our past, pride in the present and hope for the future.

Acknowledgements

THE SAN ANTONIO Section of the American Society of Mechanical Engineers gratefully acknowledges the efforts of all who contributed to the designation of the Milam building of San Antonio, Texas as a National Heritage Site. We are especially grateful to Bob Korte, editor of Heating Piping and Air Conditioning, who allowed the reprinting of technical copy, refrigeration photos and diagrams from Herman Worsham's 1929 feature story *The Milam Building.* Particular thanks are extended to the San Antonio Conservation Society, San Antonio Library, Daughters of the Texas Republic and to the Institute of Texan Cultures for providing period photographs and historical and biographical information for publication; to United Technology Corporation and the Carrier Corporation, particularly, John Sanberg for arranging funding for the Milam designation, Carlo Raineri who tracked down original records on the air-conditioning equipment installed at the Milam Building and to Anne Millbrooke who provided information about their founder, Willis Carrier; to Trammell Crow Company, particularly Milam property manager Henry Dirks III who sponsored The Milam Commemoration Ceremony; to City Public Service, particularly Stephen School, who organized the publication of this brochure, CPS Lithographic Services, and to the engineers of the Distribution Engineering Division who supplied information about the underground vault installation for the Milam project; and to Roger C. Hill who provided information about his father Russell Hill, head of the Travis Investment Company. We acknowledge our indebtedness to Ben Milam, Alamo hero for whom the building was named; Willis Carrier, mechanical engineer and inventor who provided the Milam Building's refrigerated air; to Mortimer Diver, structural and mechanical engineer during the Milam Building's construction; and to Russell Hill, head of the Travis Investment Company, whose foresight and leadership caused the first high-rise air-conditioned office building in the U.S. to be built.

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