Grand Central's Restoration

The mechanical systems that were built to serve Grand Central Terminal constitute an impressive engineering legacy. An ambitious restoration effort will upgrade equipment for heating, ventilation, air conditioning, and fire suppression.

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For more than three generations, the vast, marble concourse of New York City's Grand Central Terminal has been a crossroads for commuters, travelers, and sightseers. But the mechanical systems that heat, ventilate, and air condition the railroad station—while highly innovative in their day—are badly worn after 75 years of service. Though prior efforts have been made to repair parts of these systems, a thorough reconditioning is now needed to ensure continued operation.

In 1988, the process of modernizing Grand Central's antiquated plant began when the Metro-North Commuter Railroad Co., the agency that operates Grand Central, let the first of two design contracts that will ultimately lead to a complete restoration of the terminal. The mechanical portion of this initial effort is being handled by Goldman, Copeland, Batlan P.C. (New York). The electrical engineering is being completed by Carlson and Sweatt-Monenco Inc. (New York). Architectural and structural studies are being performed by Beyer Blinder and Belle (New York).

Grand Past

Grand Central Terminal opened in 1913, following 11 years of construction. It was built on the site of the old Grand Central Station, which was demolished. The new structure was hailed by *Scientific American* as a "Monumental Gateway to America's Greatest City." Its facade has three massive arches that are each 33 ft wide and 60 ft high. The building's exterior is faced with granite and Indiana limestone while the interior is marble, Caen stone, and concrete that has been dressed to look like stone.

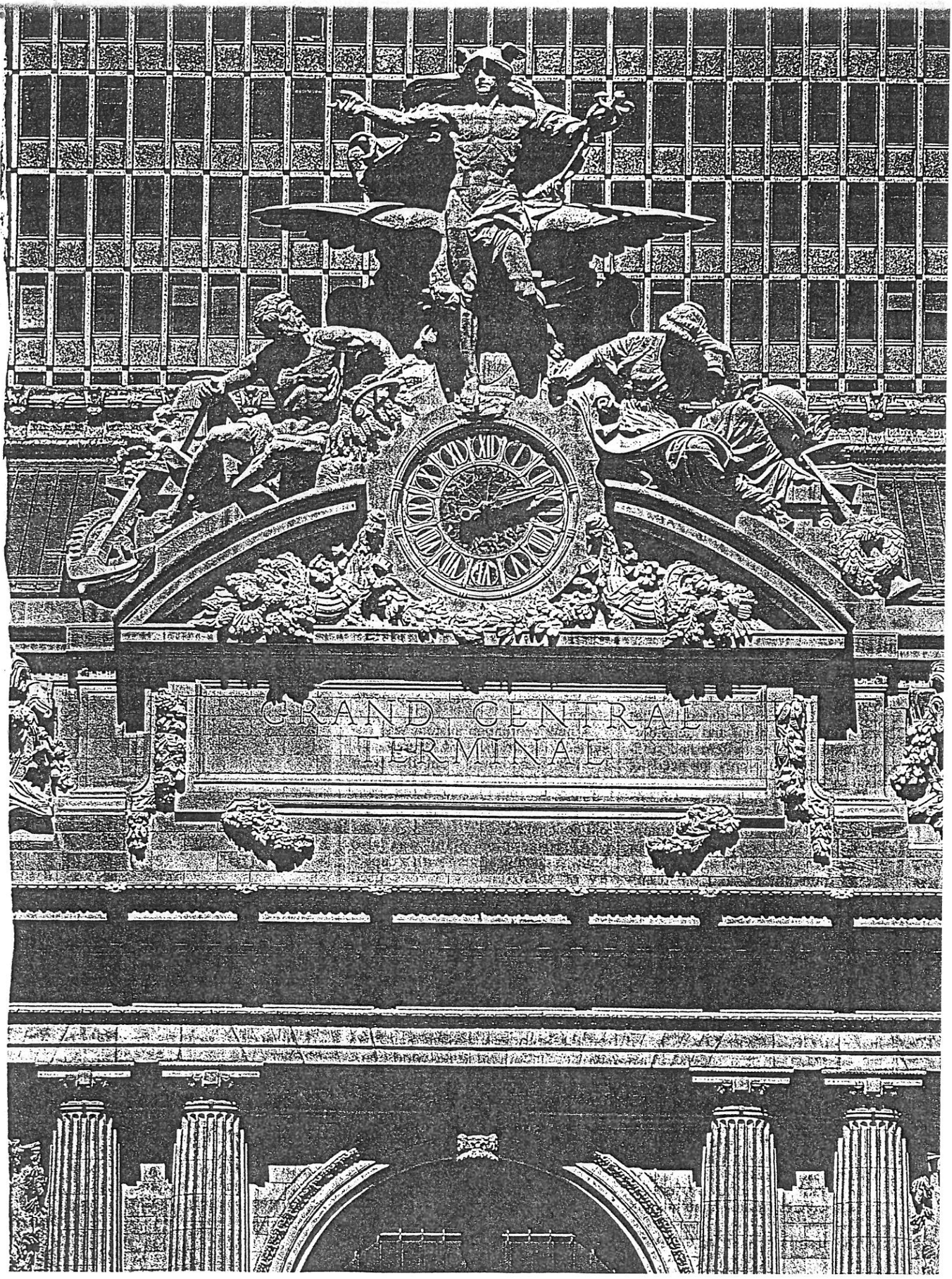
Grand Central's most remarkable feature is the concourse that rises to a vaulted ceiling 125 ft above the marbled floor. The ceiling is painted to depict the constellations in the night sky. Paul Helleu, the French artist who painted the ceiling, reversed the heavenly configurations. One theory is that he was given a globe of the heavens and painted the constellations as they appeared from above the Earth, rather than below.

The concourse is illuminated through massive side windows and overhead skylights. Until 1988, the skylights were obscured by black paint that was applied as a precaution against bombing raids during the "blackouts" of World War II.

Grand Central's facade is built over an intricate steel frame that supports the above-ground terminal over a double-deck arrangement of tracks below. Prior to 1913, incoming trains were frequently backed up awaiting platform space to unload passengers. The problem was rectified in the new terminal by creating two levels, one for commuter trains and the other for long-distance trains. Arriving commuter trains descended a slight incline to the "suburban" level to discharge passengers. An underground loop system also was constructed to enable incoming trains to circle around and head back out under Park Avenue. Park Avenue was formerly an open cut for tracks that was traversed by the east-west cross streets.

In its heyday in the 1930s and '40s, Grand Central received and dispatched an average of 600 trains each day and absorbed hundreds of thousands of passengers. In 1939, more than 38 million passengers passed through the station, many on their way to the World's Fair. On July 3, 1947, the number of passengers using the terminal set an all-time daily record of 252,288.

In the postwar years, however, the airplane and automobile began to supplant the train as Americans found flying and driving faster and more convenient. With the decline of the railroads came efforts to destroy Grand Central. In 1968, the Penn Central Transportation Co., which owned Grand Central, proposed a 55-story skyscraper that would tower over the station's concourse. Preservation groups rallied to save


GRAND CENTRAL
TERMINAL

the terminal and eventually succeeded in having it declared a New York City landmark. It was saved from destruction, but time, use, and neglect, which continued to erode the building, created the need for the current restoration effort.

Impressive Engineering

The mechanical systems that were built to serve Grand Central constitute an impressive engineering legacy. The original source of utilities for the terminal was a power plant located on 50th Street between Park and Lexington avenues. (Grand Central covers an area from 42nd to 43rd streets between Vanderbilt and Lexington.) The 50th Street plant was equipped with 14,600-hp, coal-fired, water-tube boilers, which produced steam to drive turbines that generated dc power.

The ground level of the plant housed the pumps, compressors, and electrical equipment. A second double-height level contained the boilers. Coal bunkers were on a third level. Coal was lifted to the bunkers by crane or conveyor. Coal consumption was some 200 to 300 tons per day.

Exhaust steam from the turbines was used to heat water in five shell-and-tube, hot-water converters. These same heat exchangers are still in use at Grand Central's 43rd Street Service Plant, which supplies the terminal's utilities today. Seven motor-driven pumps circulated the hot water to the terminal and neighboring buildings. The system had sufficient capacity to supply the needs of 6000 to 7000 homes.

The plant also had two steam turbine-driven compressors with capacities of 1000 and 2000 cu ft/min. These provided compressed air for the operation of mechanical equipment, train brakes, and the terminal's pneumatic tubes, which were used for handling baggage checks.

Two steam-powered and one electric fire pump were also in use. They provided a total of 3500 gal/min to a system of fire-hose racks located throughout the terminal and train room.

By 1918, the number of new buildings near Grand Central necessitated the construction of a second boiler plant at 43rd Street and Lexington Avenue. A 100-ft deep, 225-ft long, 60-ft wide section was carved out of solid bedrock to house the four-level plant. The roof of the plant became a private street that was an extension of East 43rd Street.

The plant's lowest level was used for ash collection and handling, the next level contained the boiler room, the third level accommodated the meter room, and the highest level housed the coal bunkers.

The boiler room stack was incorporated into a corner of the Commodore Hotel, which was built during 1918–19. Coal was dumped into street manholes and fed by gravity to automatic chain grates which fed the boilers. Bottom ash was mechanically lifted to an overhead conveyor system that loaded the ashes into train cars running on the station's loop tracks.

The 43rd Street plant was built with space for six 1400-hp boilers. Two boilers were originally installed to provide steam for the Commodore Hotel; they also supplied the Chatham and Paterno apartment buildings, which were built later. One of the 1400-hp boilers was a standby unit. It had a piping connection to the 50th Street plant that allowed it to serve as a backup.

In March 1929, the New York Central Railroad decided to demolish the 50th Steet plant to make way for the Waldorf-Astoria Hotel. Heating, electrical generation, and other plant equipment—with the exception of the boilers—were moved to a renovated 43rd Street Plant. At that time, the boilers at 43rd Street were demolished, and New York Central contracted with the New York Steam Co. (later Consolidated Edison of New York Inc.) to provide steam.

A new ventilation system was designed to serve the 43rd Street facility. Air was drawn from the train room and from a shaft that terminated near the 10th floor of the Graybar building and was exhausted up the old boiler stack.

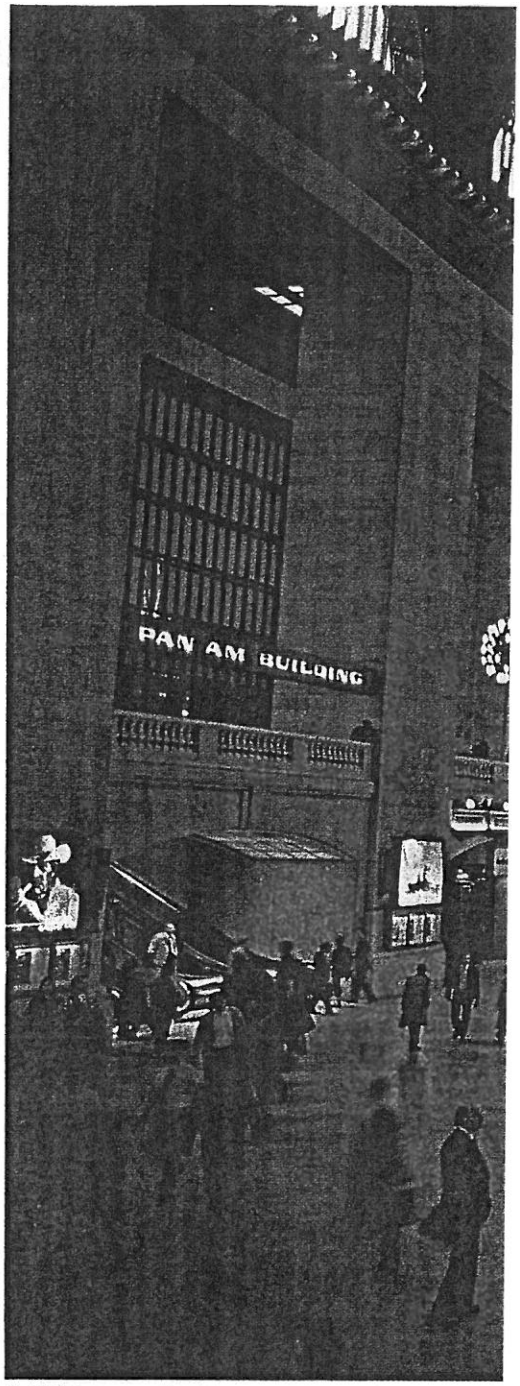
A refrigeration plant was also built. A cooling system with a capacity of approximately 3 tons used chilled brine to service soda fountains and ice cream stands in the station. Heat was rejected to the train room through air-cooled condensers. Drinking water was cooled with an electric compressor.

Restoration Effort

The primary focus of recent work on the restoration project has been to document existing conditions. This task has been likened to a sort of archeological dig for mechanical engineers, because most past repairs or physical alterations to the terminal were largely undocumented. Goldman, Copeland and Carlson and Sweatt have attempted to locate as many old documents as possible, but they had to make many new flow diagrams of existing vents and pipes.

All told, Goldman, Copeland has produced over 100 drawings of existing conditions and has slowly developed up-to-date diagrams of the terminal's inner workings. All drawings have been transferred to a CAD system.

Information gleaned from these drawings will be used as a basis to develop plans for the next step of the restoration process. Though no firm budget has been set by Metro North, Goldman, Copeland estimates that the mechanical restoration work alone could cost $60 million with another $50 million for the electrical work. Goldman, Copeland has assessed the possible mechanical res-



David Sailors

Monumental. Grand Central's concourse rises to a vaulted ceiling 125 ft above the marbled floor. In its heyday in the 1930s and '40s, an average of 600 trains per day entered and left the terminal. Currently, more than 500,000 people pass through the station daily.

torations in four areas: heat, chilled water, ventilation, and fire suppression.

Direct Steam

In Grand Central's service area, several levels below the street, an array of old steam converters still operates, taking steam from Consolidated Edison (Con Ed). The converters produce hot water, which is then pumped by nine antiquated steam turbine pumps throughout the terminal and to three nearby buildings via a very old piping system that once serviced 11 buildings. (The system must provide heated water at three different pressures, with the highest pressure hot water being used to heat the taller buildings around Grand Central.)

Goldman, Copeland has proposed a new system that would heat Grand Central directly with Con Ed steam, instead of through hot water converters. The old converters would be removed and a new piping system would be installed to send steam heat throughout the terminal.

Chilled Water

The Con Ed steam would also drive new high pressure, two-stage, absorption water chillers that would make use of steam during peak electrical demand. Electric chillers would be used during off-peak hours when electricity is less expensive. One economic incentive for this proposal comes from Con Ed, which is eager to reduce demand for its own electricity, in the form of rebates that would add up to half the cost of the new steam chillers.

The chillers would be connected to an existing set of pipes installed in the 1940s and '50s. These pipes would send the 45° F water around the terminal to provide air conditioning. The present air conditioning chillers cannot handle the terminal's needs. (Evaporative cooling spray coils from the turn of the century can still be seen—although they are not in use—in the large ventilation ducts which circulated the "cool" air.)

Metro-North's Grand Plan

In late April, the Metro-North Commuter Railroad proposed a 10-year, $400 million plan to restore and renovate Grand Central Terminal in hopes of recapturing the station's former status as a civic and commercial center.

The plan, which was formally presented to the railroad's parent agency, the Metropolitan Transit Authority, was the result of efforts by a consortium commissioned by Metro-North in 1988. The group included architectural firm Beyer Blinder Belle (New York), architectural consultants Harry Weese and Associates (Chicago), and engineering consultants STV/Seelye Stevenson Value & Knecht (New York). Over 30 engineers and architects are now checking the walls and ceiling of the main concourse, studying the structure to fine tune the details of the plan. Technicians work on a scaffold 100 feet above the floor, cleaning the surfaces of the 125-ft-high vault with distilled water and handling the building with a reverence due the 77-year-old landmark.

Besides renewing the terminal's architectural and structural integrity, Metro-North's plan would expand retail space 43 percent, from 105,000 to 150,000 sq ft. As a result, Metro-North hopes to double retail revenue to $14 million in five years and reach $20 million in 10 years. Balconies overlooking the main concourse would be filled with restaurants and cafes, and shops and services would line a concourse off Lexington Avenue. The main waiting room would be converted into an area for performances and civic events. Two movie theaters would be built on the lower level.

To improve the flow of the more than 500,000 people who pass through the station daily, the proposal calls for creating a new entrance on Lexington Avenue, connecting the main concourse and lower levels with more escalators, constructing additional entrances and exits on train platforms, and building a double staircase to the east balcony, similar to the one that now leads to the west balcony.

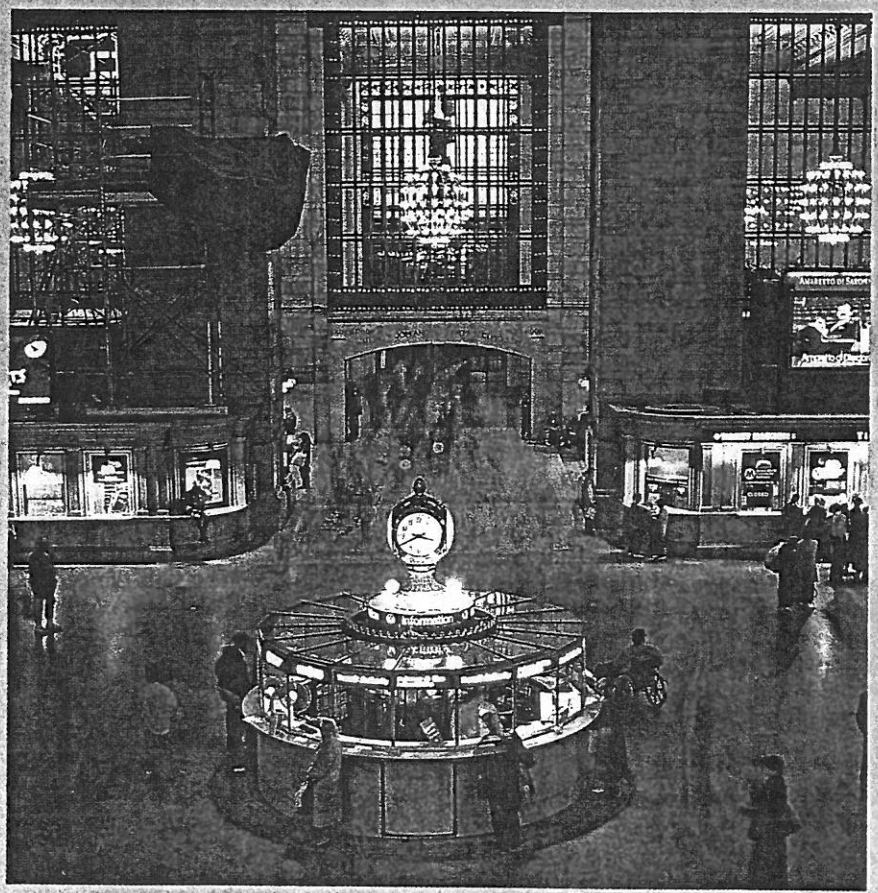
Metro-North would also update the building's mechanical systems, including steam and water pipes, electrical wiring, and security and fire protection. Crumbling limestone and terra-cotta cornices would be repaired. In addition, the Caen stone facing the terminal's interior, pink Tennessee-marble floors, travertine and fleur-de-pêche marble detailing over doorways, three vaulted Guastavino tile ceilings, and the Bottocino marble found throughout the building would be cleaned and restored.

However, several obstacles threaten the proposed face-lift. Although Metro-North requires $400 million to complete its plans, it has not yet solidified sources for these funds. Part of the total amount would be supplied from the next capital plan, which will be submitted to the state Legislature this year. With the city and state facing tight budgets, however, the agency said it would need to tap various private sources, which it did not name.

The question of air rights also could stand in the way of the project. The terminal's owner, Penn Central Corp., was barred from raising a skyscraper above Grand Central in 1978 when the U.S. Supreme Court upheld the building's status as a city landmark. But Penn Central's legal status, should it wish to initiate future construction, remains unclear. "Until the questions of ownership of the terminal and disposition of air rights are resolved," said MTA chairman Robert R. Kiley, "it is inconceivable we could move forward with a scheme [such as has been proposed by Metro-North]."

The third problem is a social one. What would happen to the large number of homeless people that frequent the terminal? Although Metro-North did not address the question, advocates for the homeless said the plan would drive the hundreds of people from one of the city's last remaining public areas that provide shelter.

Whether or not its grand plan goes smoothly, Metro-North is currently renovating the station on a smaller scale. Independently of the recent proposal, Metro-North has begun overhauling mechanical aspects of the railroad, such as tracks, signals, and switches. The Park Avenue tunnel extending from 57th Street to a portal at 97th Street, where the four tracks become elevated, is being rebuilt. And the agency has already spent over $34 million on a new copper roof to halt water damage, and to renovate elevators, video terminals, the schedule board, and third-rail transformers. *—Irene Kim*



David Sailors

Face-lift. Metro-North's $400 million renovation plan would renew the terminal's architectural and structural integrity, add retail space, escalators, and new entrances, and update most mechanical systems.

There are limitations, however, to the amount of air conditioning Grand Central can produce because of its limited roof space. Charles Copeland, a principal at Goldman, Copeland, estimated that the total available cooling capacity is about 3600 tons. As much as 2000 tons of this amount may be required to completely cool the terminal and shops in and around the concourse.

Fresh Air

When Grand Central was first opened, air was circulated through the lower train room by drawing it from the train shed which opened to fresh air directly above. Parts of the terminal also were—and still are—ventilated by gratings in the sidewalks. This method of ventilation was acceptable in the era of the horse and buggy, but is potentially hazardous today because of the pollution from automobile exhausts. Copeland said Goldman, Copeland is studying new sources of fresh air to reduce the contaminated air that currently circulates throughout the terminal.

Goldman, Copeland was surprised to find that the majestic interior columns in the station's concourse are hollow. The columns were specifically designed as air shafts, but have never been used. This affords engineers ample room for moving air around the above-ground terminal without having to consider new vent systems. New vents would require permission from the New York City Landmarks Commission, which must ensure that the restoration does not affect Grand Central's original architecture.

Goldman, Copeland has also proposed a system of fans in the train room that will exhaust and circulate fresh air. The fan systems could also be used to control smoke from the occasional fires that break out in this subterranean area.

Fire Prevention

The threat of fire is an important concern. A recent small fire in the train room created smoke so dense that it hampered firefighters' efforts. The proposed exhaust fans, working in conjunction with a series of smoke zones, would help prevent smoke from enveloping the entire area. The exhaust system would also be effective in drawing off the various fumes that collect in the below-ground work areas.

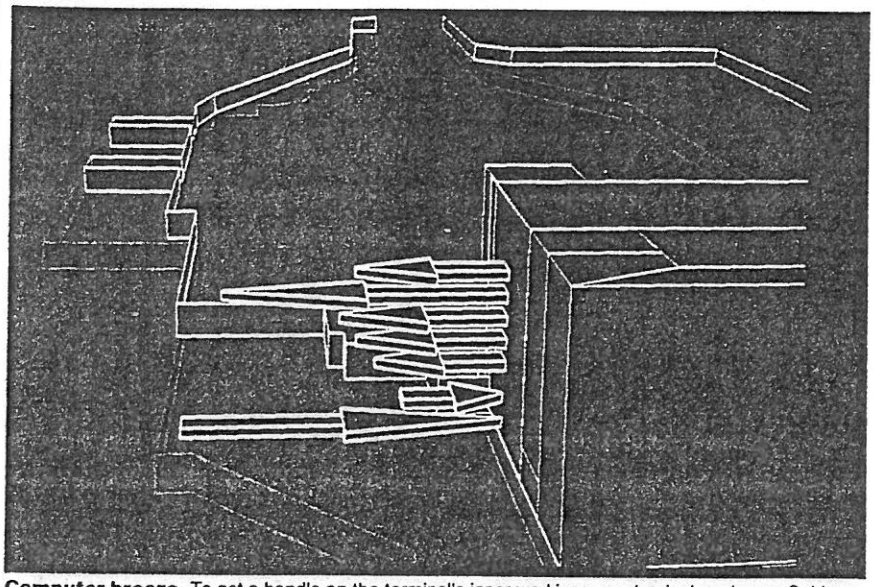
At present, air is circulated to the terminal's lower levels by a variety of old dc and 25-Hz ac fans. In the proposed restoration, all of these fans would be replaced by modern 60-Hz ac models.

The 75-year-old air compressors used to supply air to the ejectors that force sewage from the terminal's system into the city's sewers would also be replaced by new compressors.

Tight Budgets

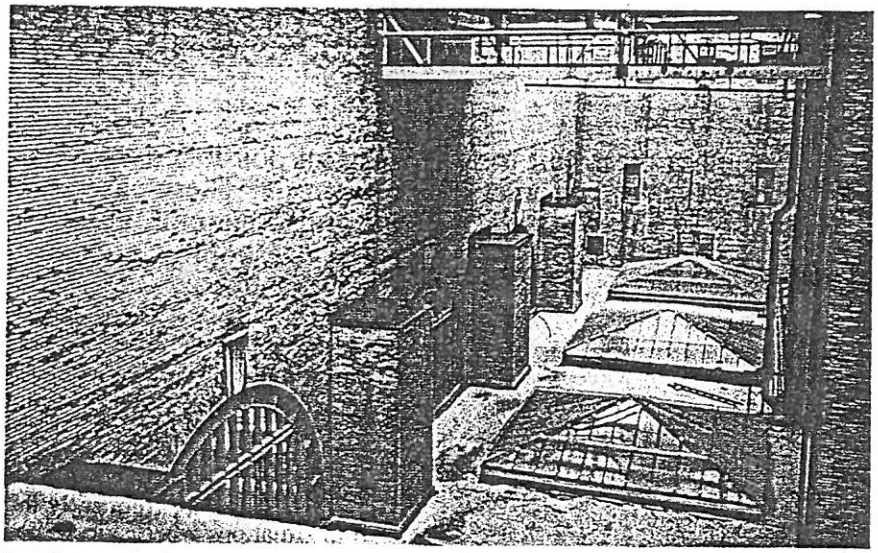
The new mechanical system would be completely monitored from a central control area equipped with electronic sensors and computers. The sensors would monitor outdoor and indoor weather conditions and determine when to increase heat or add chilled air. The fire control system would respond automatically to any fire emergency and have the ability to control the exhaust and supply fans.

If tight municipal budgets allow their completion, the proposed mechanical improvements to Grand Central should keep the terminal going well into the next century. A clear picture of how uses of the terminal may change in the years ahead, however, has not yet emerged. These, too, largely depend on budget constraints. One proposal, according to Copeland, is to create a major transportation center for New York that would be designed to attract not only regular commuters, but also tourists, city residents, and airline passengers who could purchase tickets at the station and then take trains to area airports. ■



Goldman, Copeland, Batlan

Computer breeze. To get a handle on the terminal's inner workings, mechanical engineers Goldman, Copeland, Batlan produced over 100 drawings of existing conditions and transferred them to a CAD system. This Autocad simulation of airflow in and out of the terminal was used in the analysis and design of new ventilation and smoke control systems.



Goldman, Copeland, Batlan

Let the sun in. There are restrictions on the amount of air conditioning Grand Central can produce because of its limited roof space. In the proposed renovation, the old cooling towers *(partially visible at top)* will be removed to allow better natural lighting through the main concourse skylights and windows.