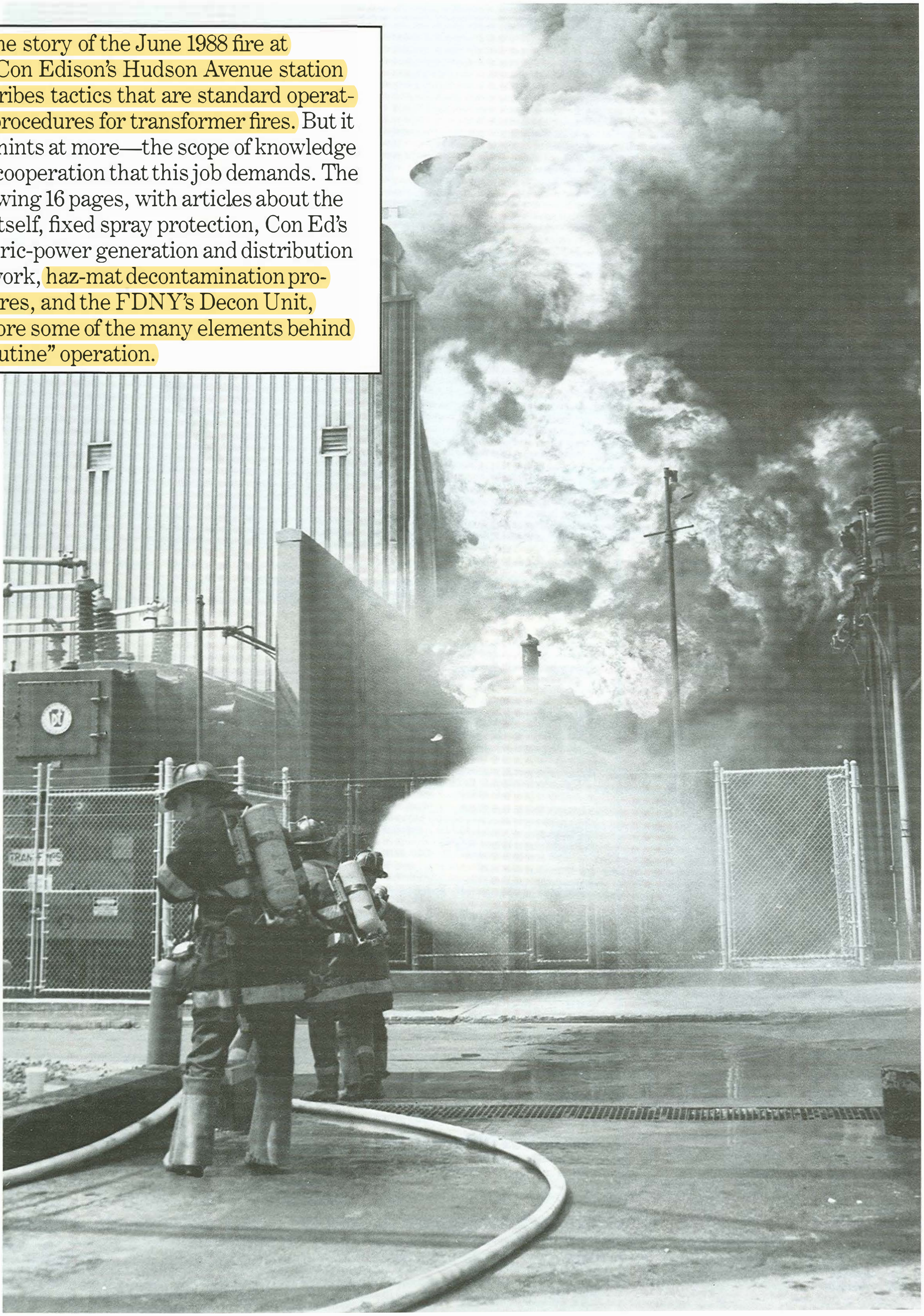
The story of the June 1988 fire at Con Edison's Hudson Avenue station describes tactics that are standard operating procedures for transformer fires. But it also hints at more—the scope of knowledge and cooperation that this job demands. The following 16 pages, with articles about the fire itself, fixed spray protection, Con Ed's electric-power generation and distribution network, haz-mat decontamination procedures, and the FDNY's Decon Unit, explore some of the many elements behind a "routine" operation.



Fog and Foam
vs.
Electricity and Oil

The Con Edison blaze in Brooklyn last year was a classic transformer fire requiring attention to a transformer's special hazards.

by RICHARD TRAVERS
Deputy Chief, Division 10

Firefighters who operated at the Con Edison fire on June 15, 1988, received well-deserved publicity because they faced double heat: the flames and the ambient temperatures approaching 100° F. Ironically, if it hadn't been for the weather, this fire wouldn't have happened.

Con Ed's Hudson Avenue Station, bordering the old Brooklyn Navy Yard on one side and the East River on another, is a generating plant six city blocks in area. Three transformers in an outside "transformer yard" were involved. Each transformer was cooled by 10,000 gallons of oil. The 10-foot cubes, rated at 27,000 volts each, were models dating to the 1920s that Con Ed activated only during periods of peak electrical use. Although it was only the middle of June, New York City was experiencing a heat wave, which resulted in these reserve units being brought on line.

Con Ed believes an internal fault in one of the transformers caused the cooling oil to overheat. As vapor pressure built up, the overpressure valve operated to prevent the transformer casing from rupturing. It did this by allowing the boiling oil to flow into a sump basin over which the three transformers were mounted on steel I-beams. The basin, filled with crushed stone, is designed to catch leaking transformer oil in the spaces between the stones so that only a thin coat at the surface will be left to burn. But as the leak worsened, the oil covered the stones.

When it ignited, the fire's heat caused the oil in all three transformers to boil and flow from their overpressure valves.

The phone alarm for box 416 was transmitted at 1442 hours. Ladder Co. 118, first to arrive, was greeted with a spectacular sight: 50-foot-high flames engulfing oil-filled equipment. The exposures were:

1. A boiler building across John Street, a private, restricted street;
2. Two other energized transformers;
3. The switch house, a six-story, fireproof building measuring 402 by 104 feet, with wire glass windows on the top floor overlooking the fire; and
4. Additional transformers across the courtyard. These, however, were relatively secure behind a free-standing, concrete wall.

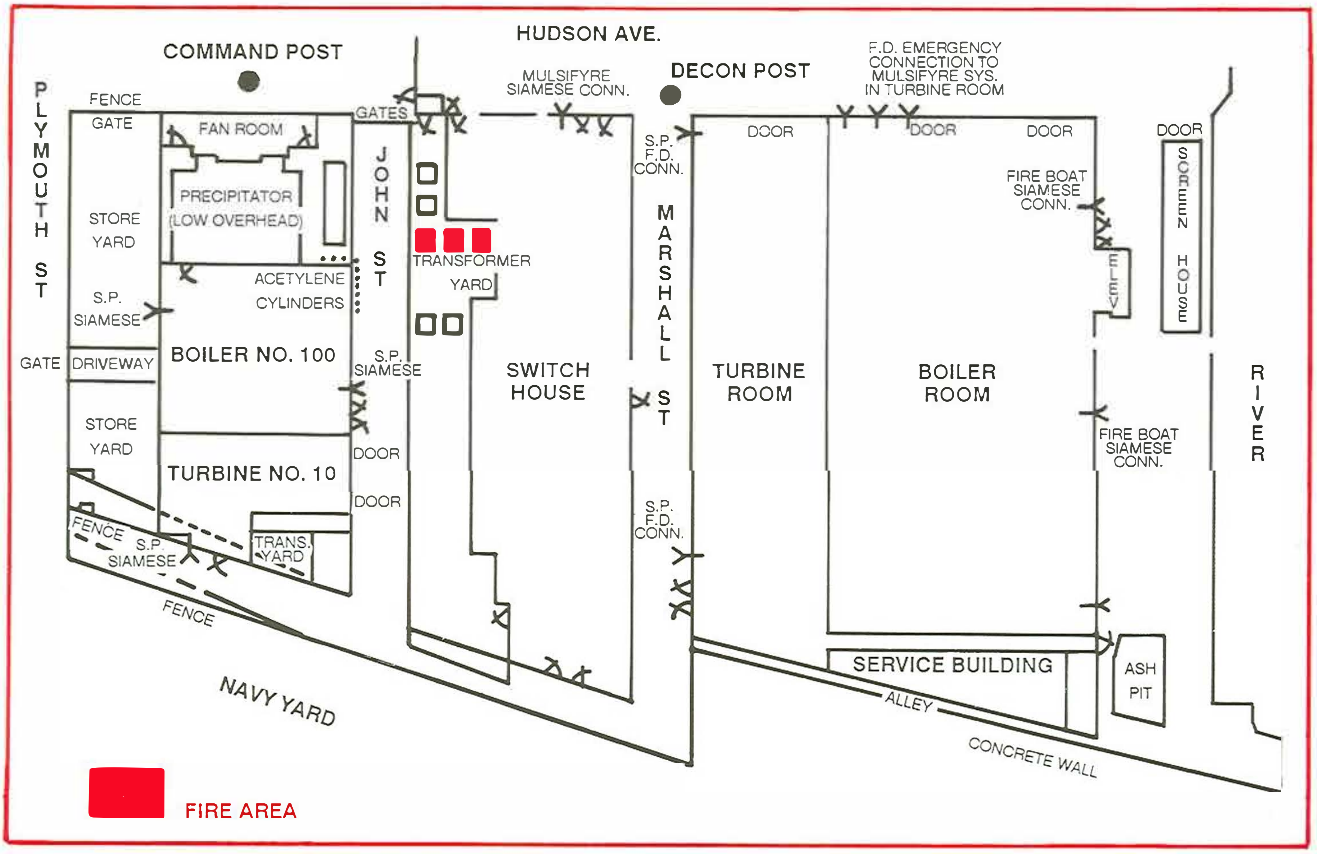
Lt. Paul Ehret promptly transmitted a second alarm at 1444 hours.

GETTING THE FACTS

Besides stretching lines, the first units (including B.C. John Lydon, Battalion 31) began an important task faced in the initial stages of any transformer fire: gathering information. Con Edison officials reported that the transformers had been retrofilled with oil free of PCBs (polychlorinated biphenals). But because the electrical units obviously had been around for a while, the Fire Department remained cautious. Based on the Hudson Avenue station listing in the Critical Information Dispatch System, the Brooklyn Communications Office special-called Hazardous Materials Co. 1 and notified the New York City Department of Environmental Protection.

When D.C. Richard Travers, Division 10, arrived at 1449 hours, the following information was also available:

- The three involved transformers had just been deenergized;
- It would take some time yet to deactivate the two transformers composing exposure 2; and
- It was easy to see that the fixed spray protection system was functioning at low pressure. (See "Fixed



Water Spray Protection" page 5.)

With this knowledge, Division 10 formulated a four-part strategy:

1. Place fog streams on the involved equipment to cool the casings and reduce the high radiant heat which was threatening the exposures. (Although deenergizing the transformers had cut down the risk of electrocution, fog streams minimize that hazard further. See "Con Edison Transformer Fire," by John Fogarty, *WNYF*, 1st Issue of 1972.)
2. Augment the fixed spray protection system which was operating so meagerly.
3. Determine if the leaking, burning transformer oil contained PCBs.
4. Use fluoroprotein-type foam to achieve final extinguishment.

This last step couldn't begin until there was enough foam concentrate on hand to create and maintain a foam blanket. An article in the May/June 1989 issue of *Fire Journal* ("Protecting Petrochemical Storage Tanks with Firefighting Foam," by Paul Gillespie) explains the reasons succinctly: "Although it is always advantageous to start foam application as quickly as possible, it is better to wait until adequate supplies are on hand than it is to start prematurely, then run out. Not only is the concentrate wasted, but the fire rapidly returns to full intensity, and it is more difficult to establish a foam blanket on old foam than on an unobstructed fuel surface."

There wasn't yet enough concentrate at the scene. The Maxi-Water Unit responds on this particular box, and it carries foam in its booster tank. Still, D.C. Travers made numerous special calls to supplement that unit's supply and the three cans each per engine, two per truck already on the scene. He also transmitted the third alarm, at 1525 hours.

FOG FIRST

Initially, then, the tactics involved placing two fog handlines, followed by a master stream device with a fog nozzle. Concurrently, lines were run into the fixed spray system's siamese connection. The spray then showed a significant improvement and had a marked effect in reducing the radiant heat.

During this period, the ladder companies were examining the adjacent switch house and reporting fire penetration of the top-floor windows into a locker room and office. Tar on the roof was also burning. A handline was advanced up an aerial, and a standpipe line was operated in this exposure.

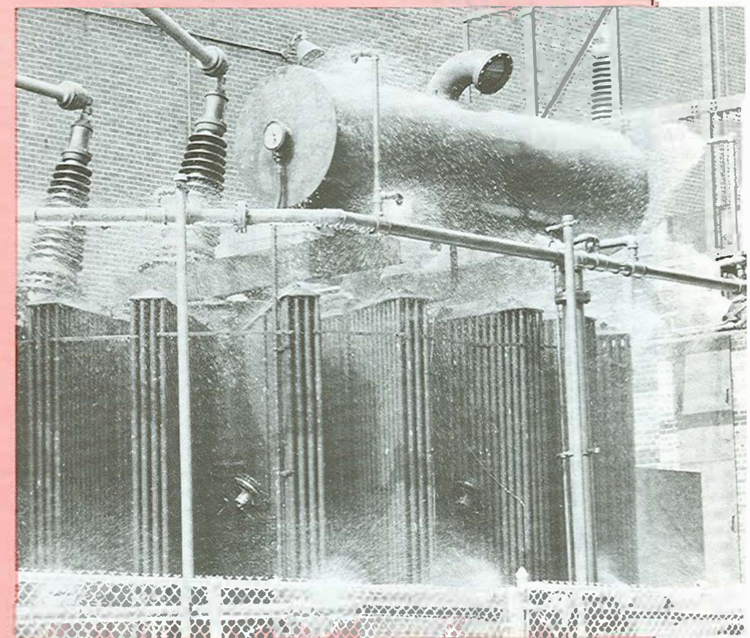
Meanwhile, a number of acetylene cylinders were discovered lined up against a wall almost directly across John Street from the burning transformers, and firefighters undertook their removal.

It would take some time before Haz Mat could approach close enough to get an oil sample for DEP to analyze. Con Ed personnel assured us the oil was uncontaminated, and we noted there were no warning signs posted, as would be required by the U.S. Environmental Protection Agency if PCBs were present at concentrations greater than 500 parts per million.

Fixed Water Spray Protection

Fixed water spray protection—similar in design to sprinklers—is common around electrical equipment such as transformers, rotating electrical machinery, and cables, and around flammable liquid and gas storage tanks and processing equipment. Its main purpose is protection of these high-risk installations.

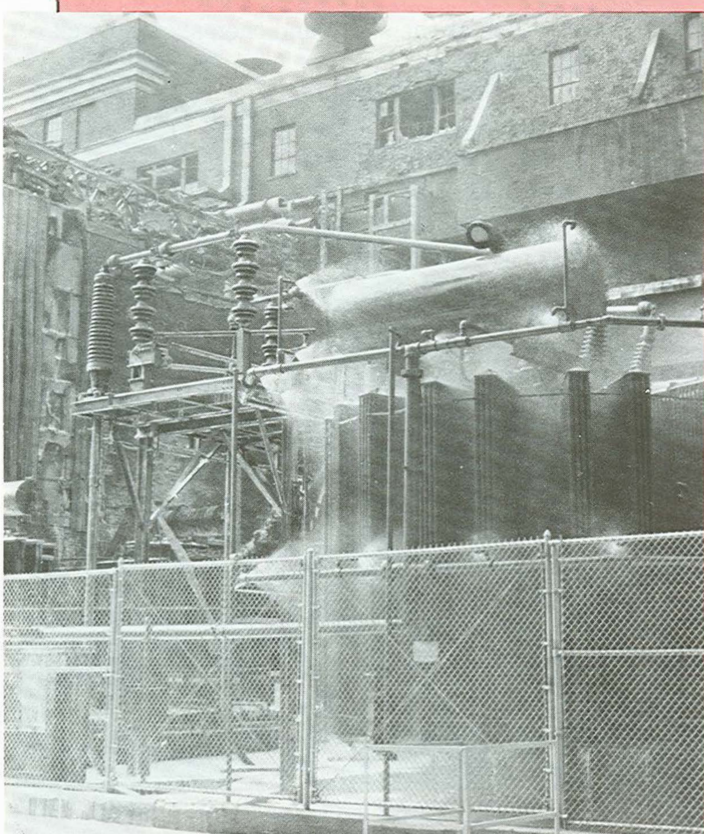
Extinguishment may or may not be a primary function, depending on the equipment being protected. For example, as noted in the *National Fire Protection Association Handbook*, 16th Edition, "Ordinarily, it is neither expected nor desired that escaping liquefied petroleum gas be extinguished by the water spray. However, the rate of burning may be reduced and controlled by the cooling effect of the water on the tanks, and the severity of the exposure reduced until the gas supply to the fire is exhausted or can be shut off." By contrast, quick extinguishment of an electrical transformer fire can prevent the casing from cracking and pouring out many gallons of oil, notes Robert Solomon, a senior fire protection engineer with the NFPA.



The angle of heads and size of droplets are both important to the system's effectiveness. *Photo courtesy of Con Edison*

Solomon lists several differences between fixed water spray protection and regular sprinklers:

- *The size of the droplets.* Sprinkler droplets are larger; fixed water spray droplets are nearly atomized.
- *Placement of the heads.* Fixed water spray uses directional heads. That means designing the system involves more measurements and formulas to point the heads correctly, while sprinkler heads can be placed according to a simpler spacing formula.
- *Size of the head's orifice.* Generally, fixed spray heads have openings that are up to ⅜ inch in diameter, while orifices in regular sprinklers are up to ¾ inch in diameter.



Although the June 1988 fire at Con Edison's Hudson Avenue station damaged the six-story, fireproof building in the background, a fixed water spray system protected this exposed transformer. *Photo courtesy of Con Edison*

Fixed spray nozzles may be either closed (in which case each head operates separately in response to heat) or open, with a control valve connected to a heat detector, so that all heads go off at once. According to the *NFPA Handbook*, the latter is more common: "Because most water spray systems must perform as deluge type systems with all nozzles or devices open, and because a high density of water discharge is often needed, there is a heavy water demand. Each hazard should be protected by its own single system which should be adequate for dependable protection."

Water sources may be municipal water mains or gravity tanks, possibly with automatic fire pumps. The fixed water spray system also is usually connected to a siamese for fire department supply.

After stockpiling concentrate, engine companies switched from a fog stream (page 2) to foam (left) to finish off the fire. *Photos by Joel Shanus* The brutal summer heat exhausted firefighters who operated at the fire (above). *Photo by Richard Skellington*

Our logistical chore of stockpiling enough foam for our final attack was being resolved with the arrival of Battalion 35 as the foam coordinator, of Foam Unit 81 (Engine 260), and of various other units delivering cans of concentrate. The fog streams had reduced the radiant heat and lessened a strong updraft that had been noted during the initial fire stage. (Either condition would have dispersed or destroyed any foam applied before it had a chance to form a blanket.) With those things accomplished, it was now time for the foam attack.

Fog handlines were quickly converted for foam use, and the Foam Unit's deck pipe came into play. After some 15 minutes of foam application, then-Acting Chief of Department Homer Bishop declared the fire under control at 1551 hours.

CONTAMINATION CHECK

As soon as conditions permitted, Haz Mat obtained oil samples. DEP promised lab results within two hours. As a precaution, the Police Department and the Emergency Medical Services set up the PD's decontamination trailer while we were awaiting the determination. (The Fire Department's Decon Unit wasn't yet in service.) About 50 firefighters went through the full decontamination process, stripping naked, placing their clothes in overpack containers, showering, and receiving medical checks by EMS workers. (See "Personal Decontamination," page 16, and "The Decon Unit," page 15.)

At 1730 hours, the DEP reported that it detected only 17 ppm of PCBs in the oil sample. The Fire Department treats any level of PCBs as contamination. The Police Department and EMS, like all remaining city agencies, use the less conservative standard of 50 ppm set by the U.S. EPA. Those two agencies, therefore, closed out their role in the incident. Firefighters who hadn't yet been through the decontamination trailer were ordered to wash down with a booster line at the scene and then shower back at quarters.

LESSONS

1. Regardless of information the Fire Department receives from any plant official, members should consider all electrical equipment live and dangerous. Water should be applied in a fog stream from a distance.

2. Automatically assume an unmarked transformer contains PCBs, until laboratory tests prove otherwise. (See *All Units Circular 266R*, "Polychlorinated Biphenyls [PCBs] Incidents.")

3. Promptly augment the water supply of in-place fire protection systems.

4. Stockpile sufficient foam as soon as you anticipate its use. Begin foam attack only when you're sure a sustained attack will blanket the oil well enough to completely extinguish the fire.

Corrections: In last issue's fire story, "The Fire in the Hole," the photo captions on page 8 were inadvertently switched. And in "FDNY Medals for Valor, 1988" (also last issue), the assignment of a member of the unit that received the New York Firefighters Burn Center Foundaiton Medal was given incorrectly. Fr. Joel Quintalino was detailed to Ladder Co. 1 from Engine 7, not Ladder 7.

The Electrical Network

Familiarity with Con Edison's extensive facilities will benefit FDNY members when fire meets electricity.

Flip the switch and the light goes on. Because electric service in New York City is that predictable, most people never give a second thought to the vast network of facilities that makes up Con Edison's generation, transmission, and distribution system.

The Con Edison system includes about 100,000 miles of wire, more than 200,000 manholes, some 70,000 transformers, and more than 200 substations. Given this scope, it is remarkable that serious fires involving the utility's equipment are quite rare.

But what happens on those rare occasions when a generating station, substation, transformer, manhole, or other structure burns or explodes? Though the least likely outcome is an extensive interruption of service to customers, for the personnel who report, monitor,

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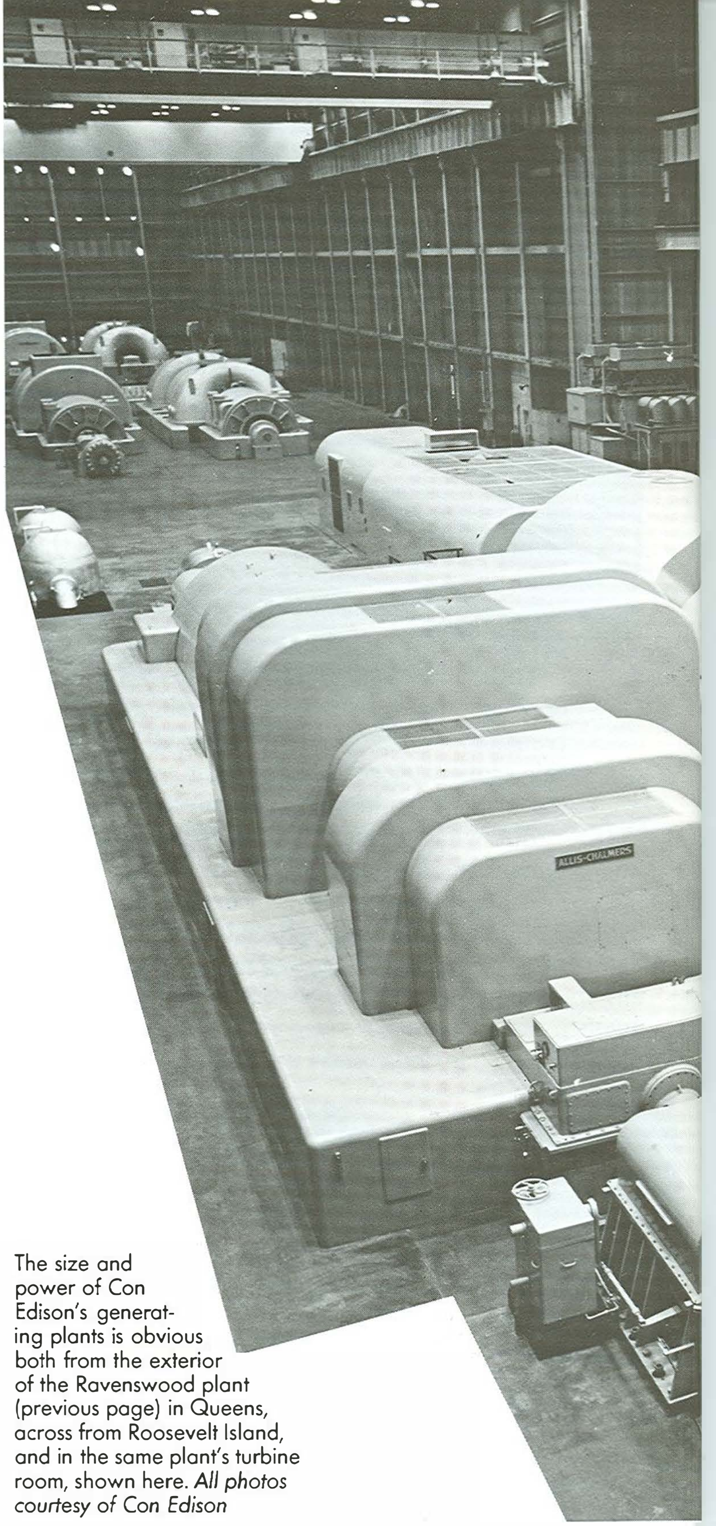


The size and power of Con Edison's generating plants is obvious both from the exterior of the Ravenswood plant (previous page) in Queens, across from Roosevelt Island, and in the same plant's turbine room, shown here. *All photos courtesy of Con Edison*

and fight utility fires, fires and explosions are special situations that require close attention to safety principles and procedures.

Within New York City, electricity is generated at eight power stations that use oil or natural gas for fuel. Four additional sites house smaller gas turbines that also burn fossil fuels to generate electricity during peak demand. This electricity is generally produced at 13,000 volts.

Upon leaving the generating station, electricty travels through transformers that increase its voltage to between 138,000 and 345,000 volts. This step is taken in preparation for moving the current to the areas in which it will be distributed, because high-voltage current travels long distances more efficiently than does low-voltage current.

The current moves along transmission lines to substations located in neighborhoods throughout the city. There, more transformers reduce the voltage to between 4,000 and 33,000 volts. The electricity is then fed through a grid of cables and transformers that take it right to the customer's door. On the way, the voltage is further stepped down to the 120 or 208 volts normally used in the home or the office.

Though built-in redundancy reduces the chance of major customer inconvenience in the event of a fire, there is more to pay attention to than just the possible destruction of equipment or buildings. Because of electrical, structural, and other concerns, firefighting tactics must be different from those applied to other kinds of fire. In anticipation of such incidents, precautions and procedures are in place at Con Edison to help ensure the safety of both firefighting and utility personnel when fire does break out.

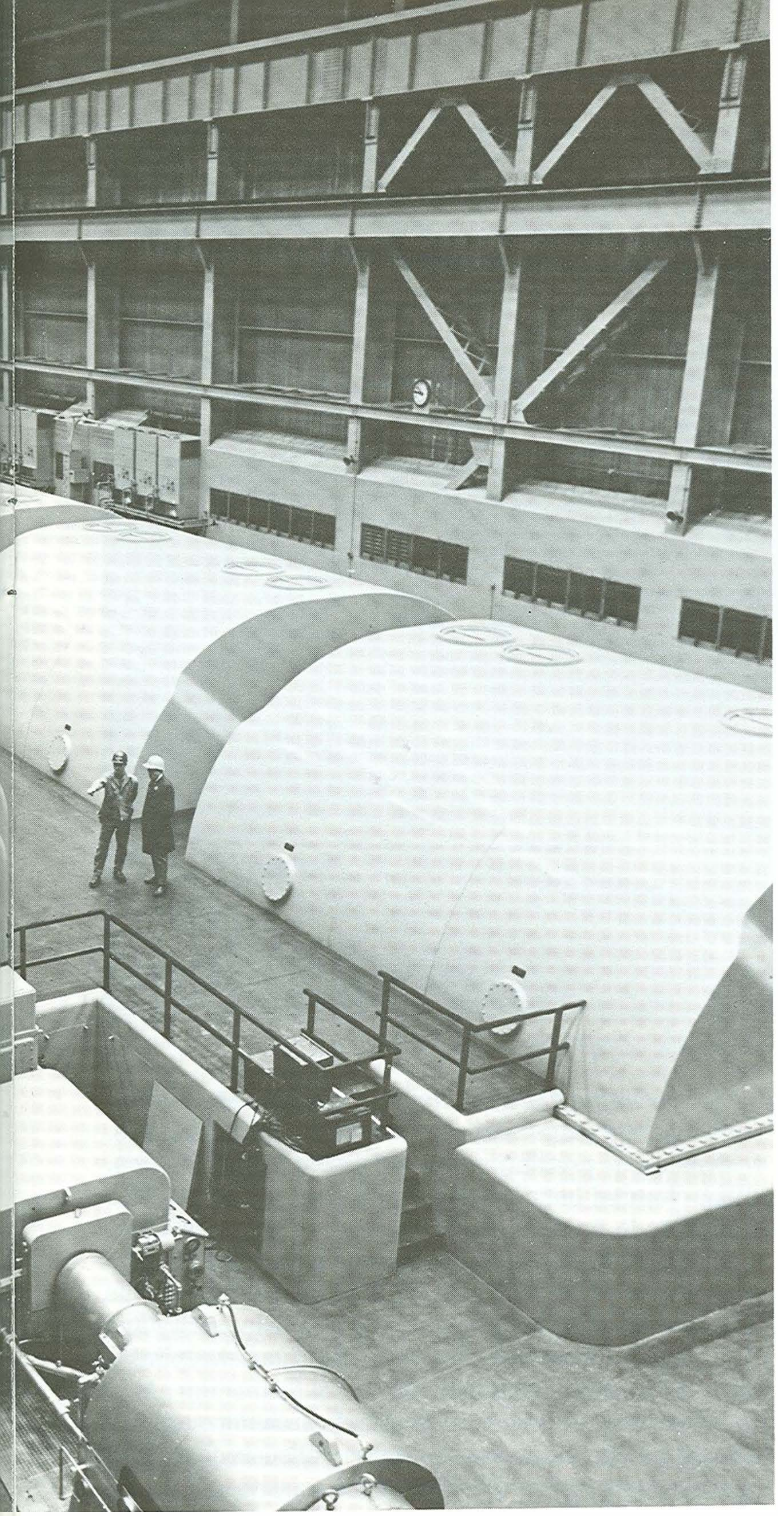
HIDDEN BUT IN PLAIN SIGHT

Live electrical equipment—equipment in which electricity is flowing—is perhaps the greatest danger to personnel fighting a utility fire. Although the equipment is in plain view, the current flowing through it is not. If equipment is energized, touching it, leaning a metal ladder against it, or playing a hose stream on it invites electrocution. According to Janet McLay, a Con Edison senior safety administrator, "Overhead clearances also have to be maintained around high-voltage equipment because of static fields," which create arcing to other equipment or to people who come too close.

Unfortunately, a cursory visual inspection cannot determine how much current is flowing through a unit, or whether or not it has been cut off. The variety of equipment alone—from three-pronged receptacles in the wall, to feedwater pumps, to the huge generators themselves—mitigates against conclusive labeling. Panel or pilot lights may or may not be present, and not everything has moving parts that grind to a halt if electrical service is severed.

Transformers are the workhorses of the Con Edison transmission and distribution system and provide the means through which electricity can be moved economically. Located in underground vaults, outdoor yards, substations, and generating stations, their very variety in size, shape, and location poses a multiplicity of problems.

As a transformer raises and lowers voltage, large amounts of heat are given off, requiring that the transformer be both insulated and cooled. Although sometimes air-cooled, transformers are more commonly cooled with oil; small transformers contain less than 10 gallons, while large ones approach a 20,000-gallon capacity. Stable under normal conditions, with a flash point of approximately 300° F and an ignition temperature of about 650° F, some types of transformer oil can burn intensely if subject to the extreme



temperatures created by an electrical arc.

Although fire barriers and oil-containment measures are standard precautions in transformer installations, the rupture of a large transformer can spread thousands of gallons of flaming oil to adjacent structures. Furthermore, the heat can be so extreme as to collapse or deform structural steel, and radiant heat alone can ignite other equipment and materials, such as surrounding brush.

Chemical hazards exist, too. For many years, polychlorinated biphenyls—PCBs—were a component of transformer oil because of their relative flame resistance and excellent insulating qualities. Now known to break down into toxic components under high heat, PCBs have been almost completely phased out of this application, through installation of new equipment and retrofilling of old. Nevertheless, oil-filled equipment, with PCB concentrations from less than 5 to more than 300,000 parts per million, remains in portions of the system. Although units are made in a variety of shapes and sizes by more than a dozen manufacturers and PCB concentrations change as transformers are drained and refilled, transformers with more than 50 parts per million of PCBs are labeled as containing the substance. (The U.S. Environmental Protection Agency requires labels on transformers containing 500 ppm or more of PCBs. Con Edison uses its own label for 50 to 499 ppm.) In addition, Con Edison provides the FDNY's Toxic Substances Unit and Hazardous Materials Co. 1 with monthly updates on the PCB content of underground transformers in New York City.

Even where high concentrations of PCBs are not an issue, transformer oil splits into potentially dangerous gases when exposed to an initial electrical arc: hydrogen, methane, acetylene, and ethane.

WHAT'S IN THAT MANHOLE?

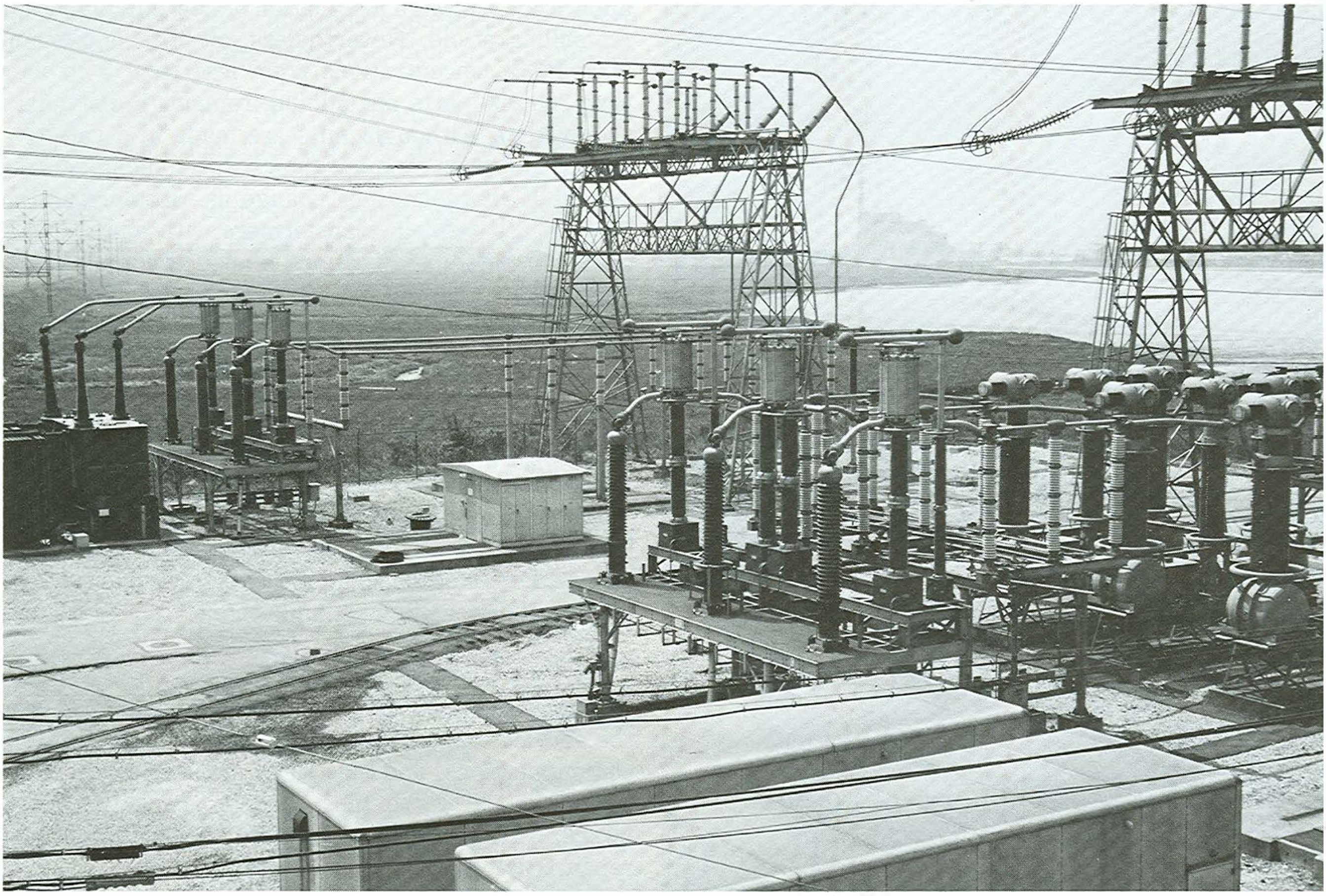
New York City's underground is a wonder. Most of the services that we take for granted, such as water, communications, and electricity, pulse through elaborate grids of which most people are only vaguely aware. If they think of them at all, it's when they see a repair truck or walk over a manhole cover.

Complicated equipment is generally not found in manholes, but a number of fire and explosion hazards are. Much of the older cable in the underground system is insulated with oil-impregnated paper, which can leak if the welded pipe that holds it is improperly sealed, and can burn readily if ignited. Furthermore, since the cable is pressurized, a pinhole can sometimes make the oil spurt, creating an aerosol or plume effect. More modern types of cable don't present this problem, but they have risks of their own. In particular, the polyvinyl chloride (PVC) used to insulate some cables can break down into hydrogen chloride, a potent respiratory irritant.

Manholes also tend to act as sumps—low areas that receive drainage—for natural gas that leaks from gas mains or, to a lesser extent, is released from decomposing organic material on or in the ground. Although gas that flows through underground mains has a characteristic odor added to it to aid in the detection of leaks, this odorant is filtered as the gas passes through the ground, leaving an invisible and nearly odorless explosive. Other substances, such as leaking gasoline, carelessly discarded motor oil, or illegally dumped chemicals, have also been known to make their way into manholes, creating dangers that sometimes cannot be anticipated.

Location is the key to the types of hazards to expect, especially at generating stations and substations.

Generating stations all have certain common risks. Fuel oil and natural gas to feed the boilers are universal, as is lubrication oil, which circulates



The Goethals substation in Staten Island is a neighborhood-level facility for reducing voltage from transmission-line levels.

through all rotating machinery; the occasional empty fuel tank can accumulate vapors that create an explosion hazard. Compressed gases in cylinders are used for welding and other purposes, and hydrogen is used to cool the massive generators. Station structures also have common features, most particularly the open gratings used instead of solid floors.

Although the major source of concern in substations is the transformers, auxiliary equipment, such as switchboards and batteries, can release toxic gases and heavy smoke when burned. Sulfur hexafluoride, used as an insulating gas for circuit breakers in some locations, also breaks down into toxic components when burned.

PRECAUTIONS TAKEN

The news isn't all bad, however. Because many of the hazards are so well known, appropriate protections are built into the system wherever possible.

Large transformers are provided with high-density deluge water spray systems that function automatically in case of fire. (See "Fixed Water Spray Protection," page 5.) Carbon dioxide systems—equipped with prealarms to prevent possible suffocation when activated—are in place in some unmanned locations, and halon systems are found in some computer rooms. These systems are tested regularly to ensure that they function flawlessly.

Additional system-wide precautions include the use of air cooling rather than oil cooling for relays when feasible, and foam systems to protect oil tank storage.

Numerous precautions are taken with transformers. When located outside, they are placed as far apart as possible to minimize the spread of fire to other equipment and buildings. Also common are moats containing gravel, which provide drainage for oil in the event of a leak. (See "Fog and Foam *vs.* Electricity and Oil, page 2.) Brush is kept clear, and housekeeping is maintained to high standards.

When located inside substations, transformers are separated by noncombustible fire walls—in fact, substations are constructed of fire-resistive materials throughout. Fire walls also surround outdoor yards.

Inside generating stations, all firefighting equipment is painted red and sprinkler systems red with green bands, as per applicable codes. Exits are clearly marked, and fire extinguishers are always close at hand. Furthermore, personnel are "well-informed and trained for fire emergencies," according to Lotah Fields, Con Edison's senior fire prevention specialist.

Training for power plant personnel consists of up to a full day of classroom work and of actual experience fighting what the U.S. Occupational Safety and Health Administration defines as "incipient-stage" fires—just-started fires that can be controlled with extinguishers or small hose systems without the need for protective clothing or breathing apparatus. On the subject of training, one of the utility's fire protection engineers, John Meier, notes that one of the most important aspects of fire education involves training employees *not* to fight fires that are beyond the incipient stage. "The New York City Fire Department is among the best in the world," he says, and adds that they are better-equipped than any company employee to handle fire emergencies.

THE "WHITE HAT" PROCEDURE

All of the safeties built into the system notwithstanding, the most important prerequisite for fighting a utility fire with minimal injury to either people or property is correct information, received in a timely fashion, from someone who is knowledgeable about the location and the situation. Con Edison addresses this concern in a written corporate instruction.

Popularly known as the "white hat" procedure, it delineates a process by which a knowledgeable authority takes charge of the situation and acts as liaison to the Fire Department and other responding agencies. To distinguish this person from other Con Edison employees, who wear blue hard hats, the field authority wears a white hard hat at all times.

In power plants, the white hat—most often the watch general supervisor—has access to an emergency operations cabinet that contains information such as system and relay drawings, station diagrams, log books, a current list of all equipment containing PCBs, and charts that show emergency posts and jobs for all staff (which in power plants number more than 100 people). He or she knows which equipment is live, can order that equipment be deenergized, and is empowered to direct Con Edison forces as necessary. The white hat meets Fire Department personnel in a predesignated area, briefs them, escorts them to the incident site, and provides them with information and cooperation until the incident has ended. In a manned substation, with just a handful of employees, this procedure functions in a similar manner.

At unmanned locations, this procedure also prevails. While a manhole fire may burn itself out before Con Edison personnel reach the scene, a substation fire generally does not. A white hat is dispatched as soon as remote monitoring detects a substation incident. However, because travel is involved, the Fire Department might arrive on the scene first. FDNY personnel are not expected to begin suppression efforts within the Con Edison installation until the white hat arrives to give them the information they require. However, they should take the necessary actions to protect life and any exposed property.

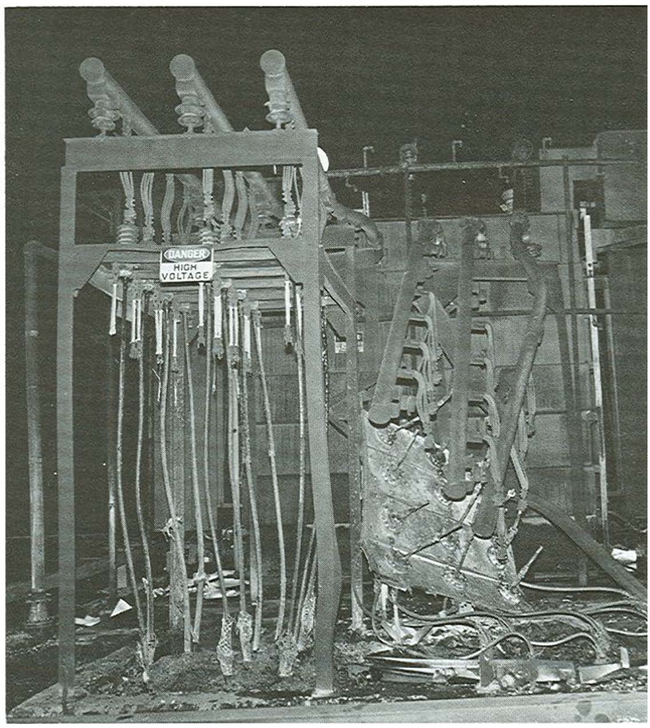
As a supplement to the white hat procedure, familiarization tours of each substation and power plant are arranged for members of units that normally would respond to those locations. This permits a staging area to be planned in advance, and allows inspection of layouts and equipment particular to each site.

The best proof that training, cooperation, built-in protections, and the white hat procedure work when applied together is provided by the record of a recent fire at the Ravenswood Generating Station, box 7181, in Queens.

Early on the morning of March 15, 1989, the hydrogen-cooled Unit 30 high-pressure generator was reported burning. The almost colorless flame indicated to trained personnel that it was hydrogen-fed. The unit was taken out of service, steps to eliminate the source of hydrogen were taken, and the unit was purged with carbon dioxide.

The Fire Department was called. Arriving four minutes later, fire personnel were met by the watch general supervisor, who acted as the white hat, and the safety supervisor. A command post was established and, after the situation was explained, there was mutual agreement that the fire be allowed to burn itself out. This occurred soon after the fire was first reported, and, after complete elimination of the hydrogen source, the emergency was declared over.

According to Joseph Busacca, the safety administrator at Ravenswood, everything went right according to procedure. Safety systems kicked in as required, Con Edison personnel acted to minimize damage but did not attempt to fight the fire, and Fire Department personnel, rather than wading into a dangerous situation unarmed, waited at the staging area to receive the information they required. Damage was so light, the unit returned to service the same day.



High-voltage cable is twisted like spaghetti in the aftermath of a transformer fire at the Astoria Yard in Queens during May.

After high praise for all involved, Busacca commented, "I couldn't believe how nice and smooth things went"—indicative of the way things should always go, even when no amount of rehearsal can ever be enough.