AMERITECH

The Hinsdale Challenge

April 10 or 11, 1989

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Tellabs, Inc.
(312) 969-8800
$10.00

THE HINSDALE CHALLENGE

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THE HINSDALE CHALLENGE

AGENDA

9:00	OPENING REMARKS	ORMAND J. WADE PRESIDENT AMERITECH BELL GROUP
	HINSDALE: RESTORATION & RECOVERY	JAMES A. EIBEL VICE PRESIDENT-OPERATIONS ILLINOIS BELL
	BREAK	
	HINSDALE: RETROSPECTIVE INVESTIGATION	MICHAEL J. FRIDUSS VICE PRESIDENT-OPERATIONS MICHIGAN BELL
		N. RICHARD KING EXECUTIVE DIRECTOR ILLINOIS COMMERCE COMMISSION
		JOSEPH R. REYNOLDS, JR. PRESIDENT FORENSIC TECHNOLOGIES INTERNATIONAL CORPORATION
NOON	LUNCH	
1:00	FIRE DETECTION FIRE SUPPRESSION & CONTAINMENT	JOHN SIMPSON DISTRICT MANAGER FIRE PROTECTION & ENVIRONMENTAL CONTROL BELLCORE
	COMBUSTIBILITY & CORROSIVITY	DR. BARBARA T. REAGOR DISTRICT MANAGER ENVIRONMENTAL & CONTAMINANTS RESEARCH BELLCORE
	C.O. DESIGN CONSIDERATIONS	JOSEPH F. LUBY ASSISTANT VICE PRESIDENT PLANNING & ENGINEERING ILLINOIS BELL
	NETWORK DESIGN FOR SURVIVABILITY	ROBERT W. HUMES VICE PRESIDENT APPLIED TECHNOLOGY & OPERATIONS PLANNING AMERITECH SERVICES
	CUSTOMIZED SURVIVABILITY	JOSEPH F. LUBY
	AMERITECH NETWORK PROTECTION PLAN	ROBERT W. HUMES
	BREAK	
3:00	QUESTIONS & ANSWERS	PANEL
4:30	CONCLUDING REMARKS	BRUCE R. DEMAEYER PRESIDENT AMERITECH SERVICES

BRUCE R. DEMAEYER

Bruce R. DeMaeyer, Moderator of "The Hinsdale Challenge," was named President of Ameritech Services on April 1, 1985, following a 26-year Bell System career that included assignments at Indiana Bell and Illinois Bell.

He began his telecommunications career with Illinois Bell in 1959. He held various engineering and operations posts within Illinois Bell's area before joining Indiana Bell in 1977.

During his six years at Indiana Bell, DeMaeyer served as General Manager of Network and later as Vice President of Network Services. He was named Vice President of Operations of Illinois Bell in 1983, a position he held until joining Ameritech Services.

DeMaeyer holds a Bachelor of Science degree in Electrical Engineering from the Illinois Institute of Technology. He is currently a Director of Bell Communications Research, and the National Engineering Consortium, and is a member of the Northwestern University Associates and the Illinois Institute of Technology's Board of Overseers. He is also Chairman of the Exchange Carriers Standards Association, Vice Chairman of the American National Standards Institute, and is a Fellow of the Institute of Electronics and Electrical Engineers.

JAMES A. EIBEL

James A. Eibel is Vice President - Operations and a Director of Illinois Bell. He led the Hinsdale service restoral efforts.

He began his telecommunications career with Indiana Bell in 1962. Following a number of management jobs in the company's construction, engineering and network departments, he was promoted to Assistant Vice President of Data Services in 1978. He was named General Manager of Indiana Bell's Network Operations in 1980 and promoted to Vice President of Operations in 1983.

In 1986, Eibel was named Vice President - Planning and Technology for Ameritech, and was named to his current position in 1987.

He received a Bachelor of Science degree in Engineering from Purdue University in 1958, and also attended the University of Chicago and Butler University graduate business schools.

Eibel currently serves as a Director on the boards of the Illinois Telephone Association, Junior Achievement of Chicago, and the Chicago Association of Commerce and Industry. He is a member of the Executive Advisory Council of the National Communications Forum.

MICHAEL J. FRIDUSS

Michael J. Friduss was named Vice President - Operations at Michigan Bell on December 1, 1988. He served as chief of the Ameritech task force investigation into the cause and origin of the central office fire at Hinsdale, Ill.

Friduss began his telecommunications career with Illinois Bell in 1963 and held various engineering posts before being transferred to AT&T in New York as Manager of Corporate Planning Studies in 1973.

He returned to Illinois Bell in 1975 as Division Plant Manager in Chicago and held progressively responsible positions. In 1983 Friduss was promoted to General Manger of Distribution Services.

On October 1, 1986, he was transferred to Michigan Bell and was promoted to Vice President - Personnel and Support Services.

Friduss holds a Bachelor of Science degree in Industrial Engineering from the Illinois Institute of Technology and a Master of Business Administration degree from Northwestern University. Among his many professional activities, he serves on the National Advisory Committee, College of Engineering at the University of Michigan; and is Financial Planning Director of the Communications Society of the Institute of Electronics and Electrical Engineers.

N. RICHARD KING

N. Richard King is Executive Director - Illinois Commerce Commission, responsible for the administration of the agency's $22 million budget and 420 professional and technical employees.

Previously he was Assistant to Senior Vice President & Chief Financial Officer, Portland General Electric Company; Planning and Budgeting Supervisor, Central Illinois Public Service Company; and Financial Analyst and Staff Coordinator, Springfield City Water Light & Power.

King received a Bachelor of Arts degree in Economics in 1972, and a Master of Arts degree in Economics in 1973, both from Sangamon State University.

JOSEPH R. REYNOLDS, JR.

Joseph R. Reynolds, Jr. is the President of Forensic Technologies International Corporation since 1984.

Reynolds is an internationally recognized electrical engineer with 18 years large loss fire and failure analysis experience. He has been a team leader and primary testifier in large multidisciplinary investigations addressing fire cause and origin, fire and smoke spread, toxicity of fires, fire fighting techniques and fire protection in commercial, industrial and utility applications.

Reynolds major fire investigations include the MGM Grand Hotel Fire, Las Vegas, Nev.; the New World Tower Electrical Fire Investigation, Miami, Fla.; the Turkey Point III Generator Failure, Florida Power & Light; the Nuclear Reactor Thermal Shield, Florida Power & Light; and the Underground Cable Failure, Malaysia.

He received a Bachelor of Engineering Science in Electrical Engineering from The Johns Hopkins University in 1969, and earned Professional Engineering status in 1973.

JOHN SIMPSON

John Simpson is District Manager - Fire Protection & Environmental Control Technology at Bellcore.

He began his telecommunications career in 1961 with Bell Laboratories, was appointed Supervisor in the materials processing area handling such responsibilities as space environment stability of Telstar materials, and deposition of thin films of materials for laser and semiconductor devices. From 1973 - 1983 Simpson served as Supervisor - Fire Protection Technology.

Simpson transferred to Bell Communications Research and in 1984 to his current position.

He holds a Bachelor of Science degree in Chemistry, and a Doctorate of Philosophy in Physical Chemistry, both from the University of Edinburgh.

DR. BARBARA T. REAGOR

Dr. Barbara T. Reagor is District Manager - Environmental & Contaminants Research at Bellcore. She is a leading national expert on combustibility and corrosiveness, and lent her expertise to the Hinsdale restoral.

Reagor has worked for the last 19 years in the field of chemical contaminations associated with telecommunications equipment. She originally joined Bell Laboratories in 1970 as part of the Contact and Contamination Studies Group. In 1983 she joined Bell Communications Research as a member of the Technical Staff and in 1986 was promoted to District Manager.

She earned her Bachelor of Science degree in Chemistry from Monmouth College, her Master of Science degree in Organic Catalysis from Seton Hall University, and her Doctorate in Philosophy degree in Picosecond Laser Spectroscopy, also from Seton Hall University.

Reagor is a member of the Institute of Electronics and Electrical Engineers (IEEE) Technical Subcommittee 1 on Electrical Contacts and Connectors, a member of the IEEE Holm Conference Steering Committee and Technical Program Committee, a member of IEEE Electronic Components Conference (ECC) Technical Program Committee and Co-Chair of the ECC Contact and Connector Subcommittee. She is also a member of the Electrochemical Society, and the American Chemical Society.

JOSEPH F. LUBY

Joseph F. Luby is Assistant Vice President - Planning & Engineering of Illinois Bell. He was responsible for the overall project management of the 1A ESS switch restoral and installation of the new switch and power plant at Hinsdale.

Luby began his career in 1961 as a student with AT&T Long Lines and held various positions in Chicago, Cleveland, and Columbus before accepting a position at Illinois Bell in 1965 as a Trunk Facilities Engineer. He had numerous progressively responsible positions at Illinois Bell and AT&T before being named to his current position in 1986.

In his current position, Luby is responsible for the development of current and long-range network plans, network engineering and technical support, the corporate capital program, and provides staff support for network operations and distribution services.

Luby received a Bachelor of Science degree in Physics from John Carroll University in 1957 and a Master of Science from Northwestern in 1959.

ROBERT W. HUMES

Robert W. Humes is Vice President – Applied Technology & Operations Planning at Ameritech Services. He heads the team charged with development of the common service continuity recommendations for all five Ameritech operating companies; Illinois Bell, Indiana Bell, Michigan Bell, Ohio Bell and Wisconsin Bell.

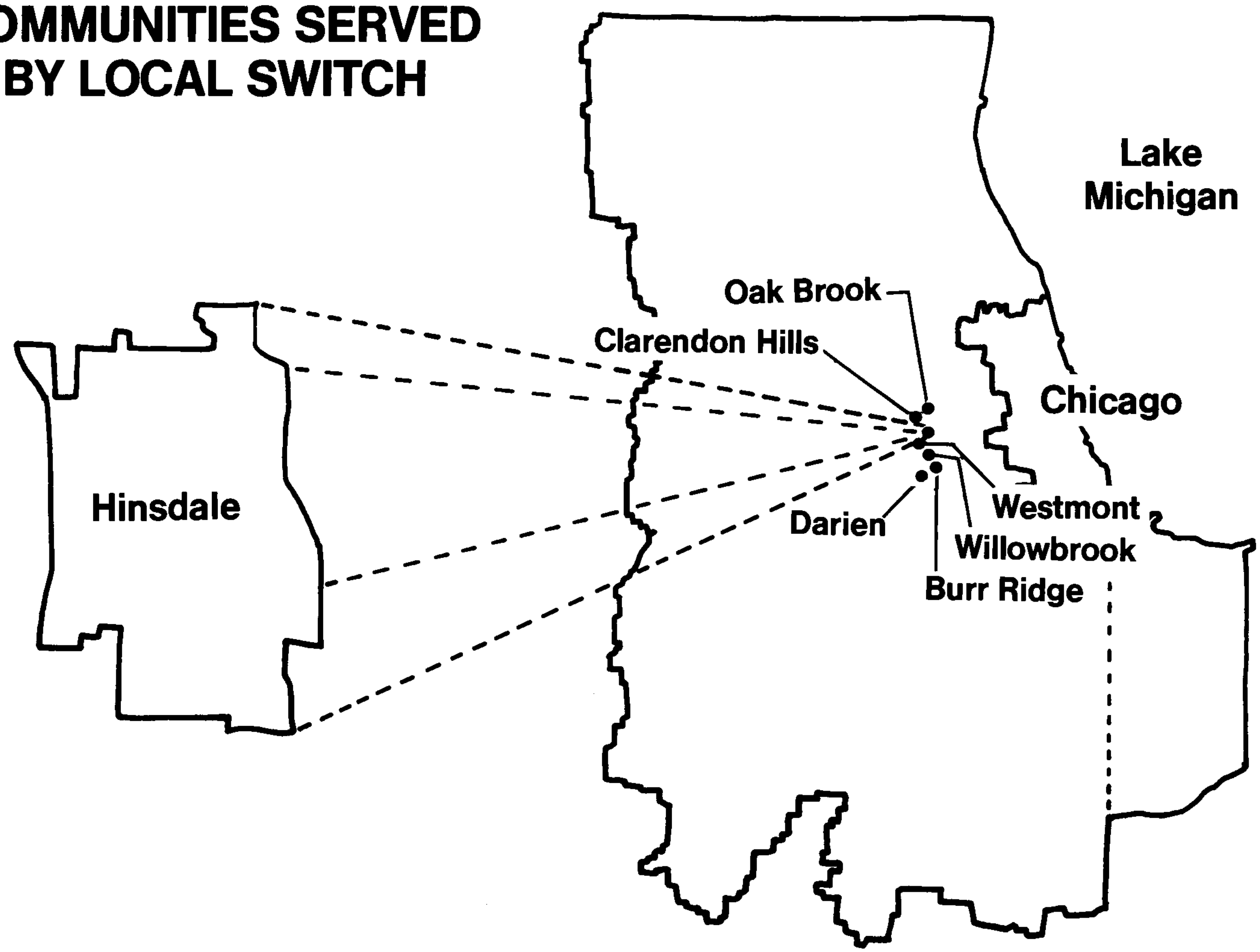
Humes came to Ameritech Services in 1983 as Vice President – Technical Services. He began his Bell System career at Indiana Bell in 1965, spent two years as a Member – Technical Staff of Bell Telephone Laboratories and returned to Indiana Bell where he held progressively responsible network planning positions. He was named Vice President – Technical Services – designate in 1983.

Humes is a member of the Institute of Electronics and Electrical Engineers and is a registered professional engineer. He holds a Bachelor of Science degree in Electrical Engineering from Purdue University and a Master of Science degree in the same discipline from the Polytechnic Institute of Technology.

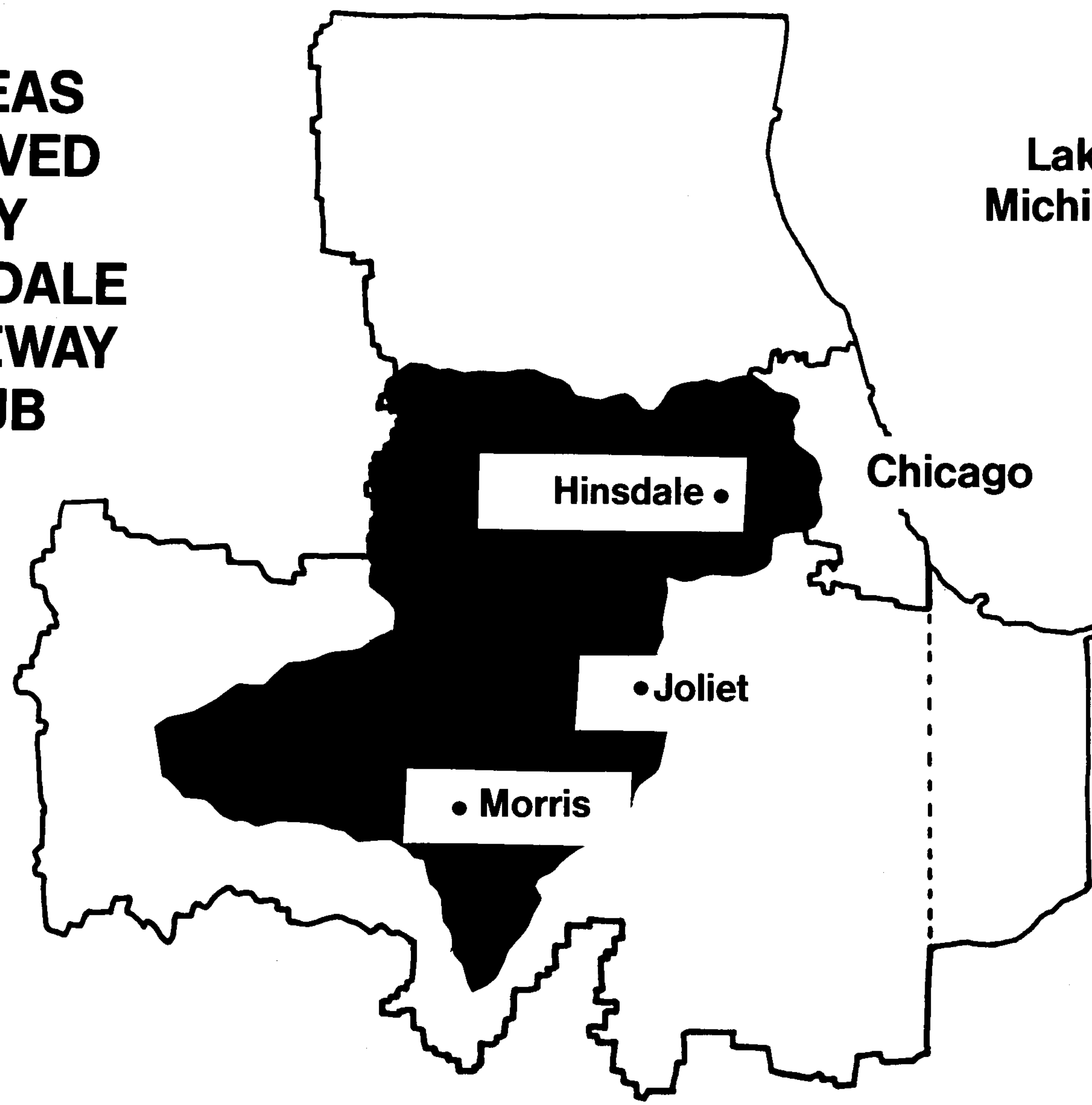
HINSDALE: RESTORATION & RECOVERY

James A. Eibel
Vice President — Operations
Illinois Bell

COMMUNITIES SERVED BY LOCAL SWITCH



AREAS SERVED BY HINSDALE GATEWAY HUB



CONDITIONS ON MAY 8, 1988

- Hinsdale office unattended
- Office alarms monitored by Springfield Division Alarm Reporting Center
- Technicians in office during the day
- Tornado watch in effect

EVENTS OF MAY 8, 1988

- 3:50 p.m. – Commercial power fails, alarms received
- 3:53 p.m. – Alarms cleared
- 3:59 p.m. – Diesel failure alarm, fire alarm
- 4:00 p.m. – Alarms cleared

EVENTS OF MAY 8, 1988

- 4:20 p.m. – Fire alarm received; duty supervisor notified
- 4:24 to 4:29 p.m. – Duty supervisor dispatches technicians, attempts to contact fire departments
- 4:52 p.m. – First technician arrives at Hinsdale office
- 4:58 p.m. – Technician dispatches motorist to report fire
- 5:02 p.m. – Fire Department arrives at Hinsdale office

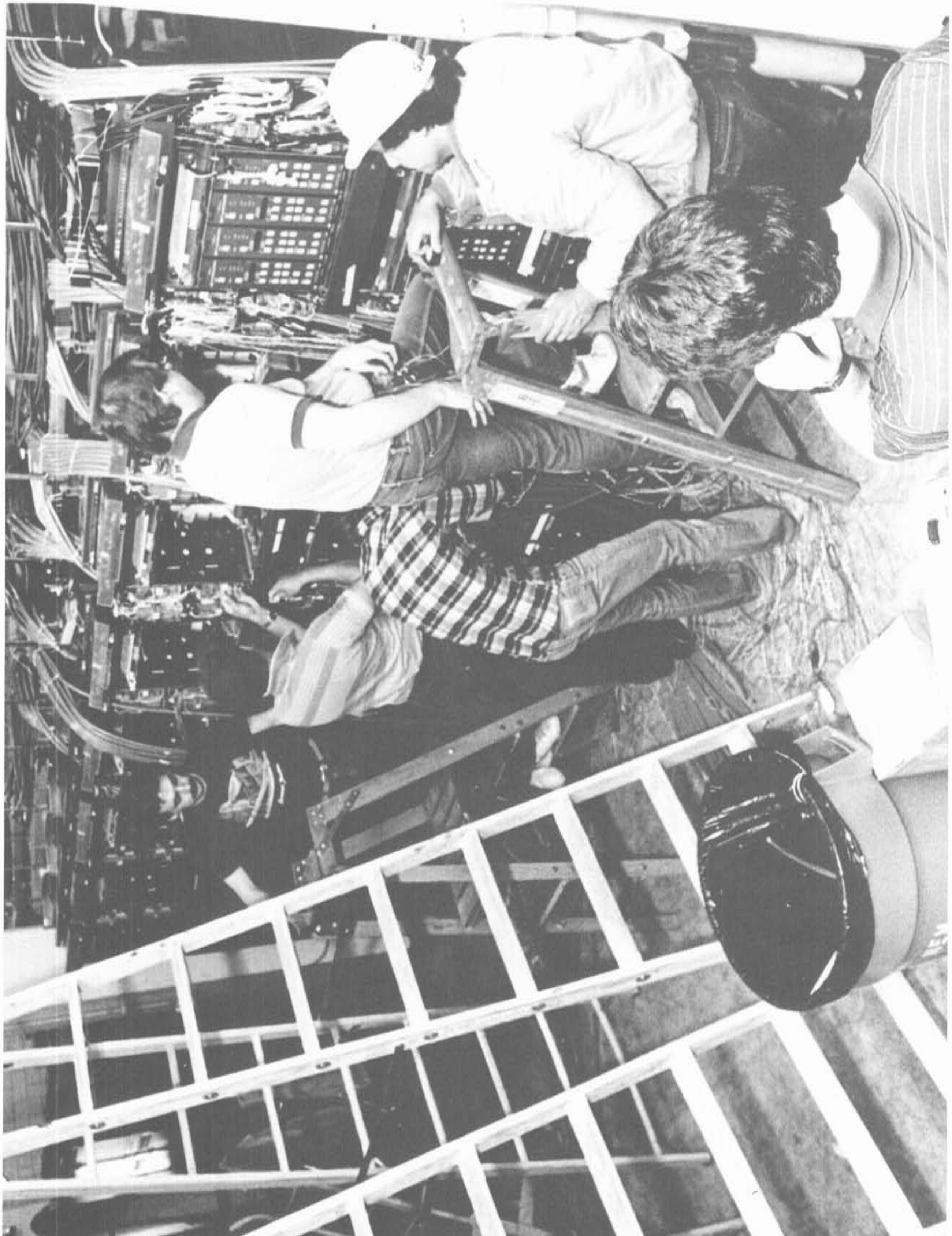
FIGHTING THE FIRE

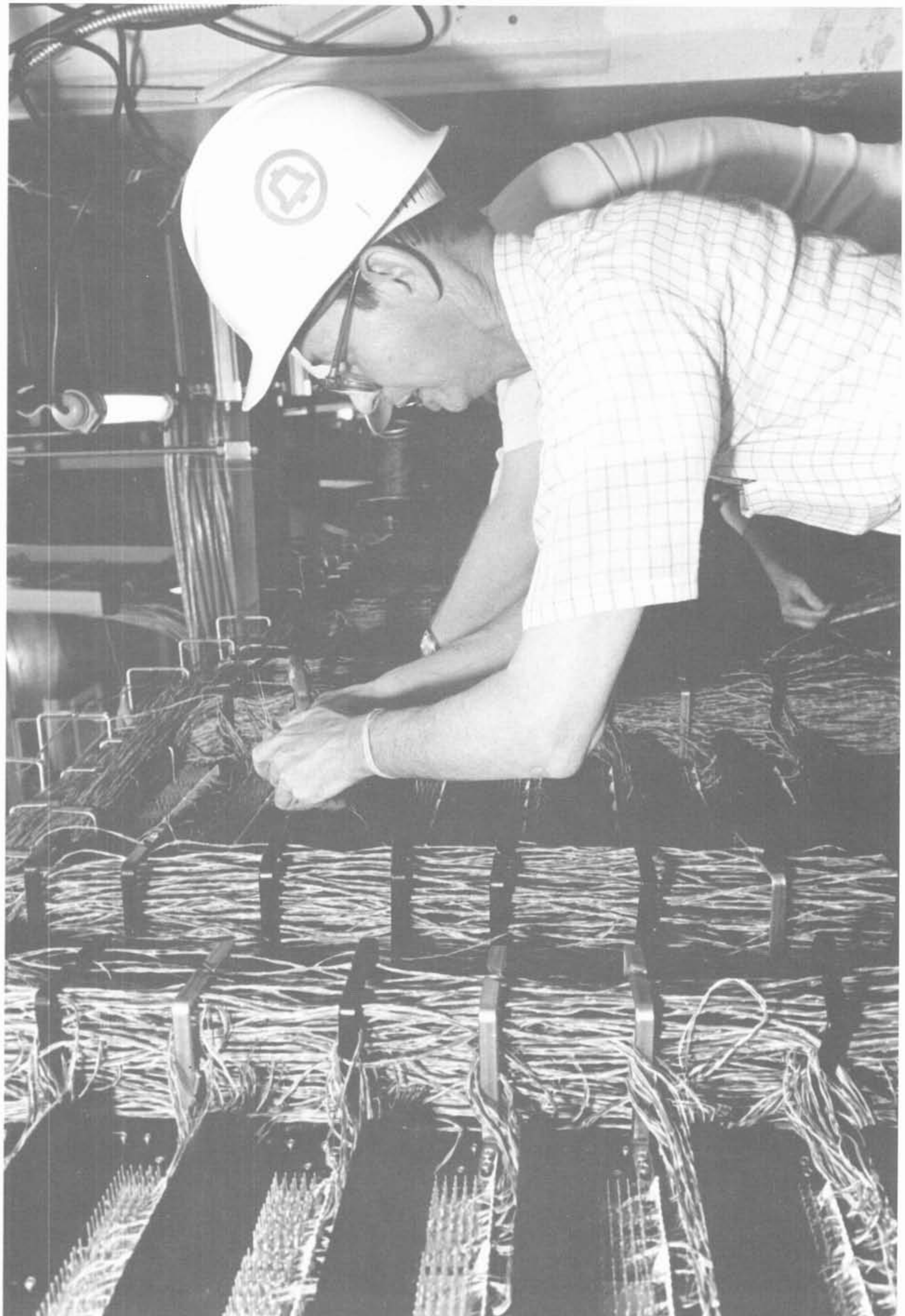
- Heavy smoke on first floor
- Flames continued to reignite
- 7:15 p.m. – flames extinguished
- 11:30 p.m. – fire declared officially extinguished
- 3:00 a.m. – Illinois Bell personnel enter the building

FIRST RESTORATION STEPS

- Inventory the equipment
- Place orders for new equipment
- Project manage restoration of each service component

Restoration of the fiber hub



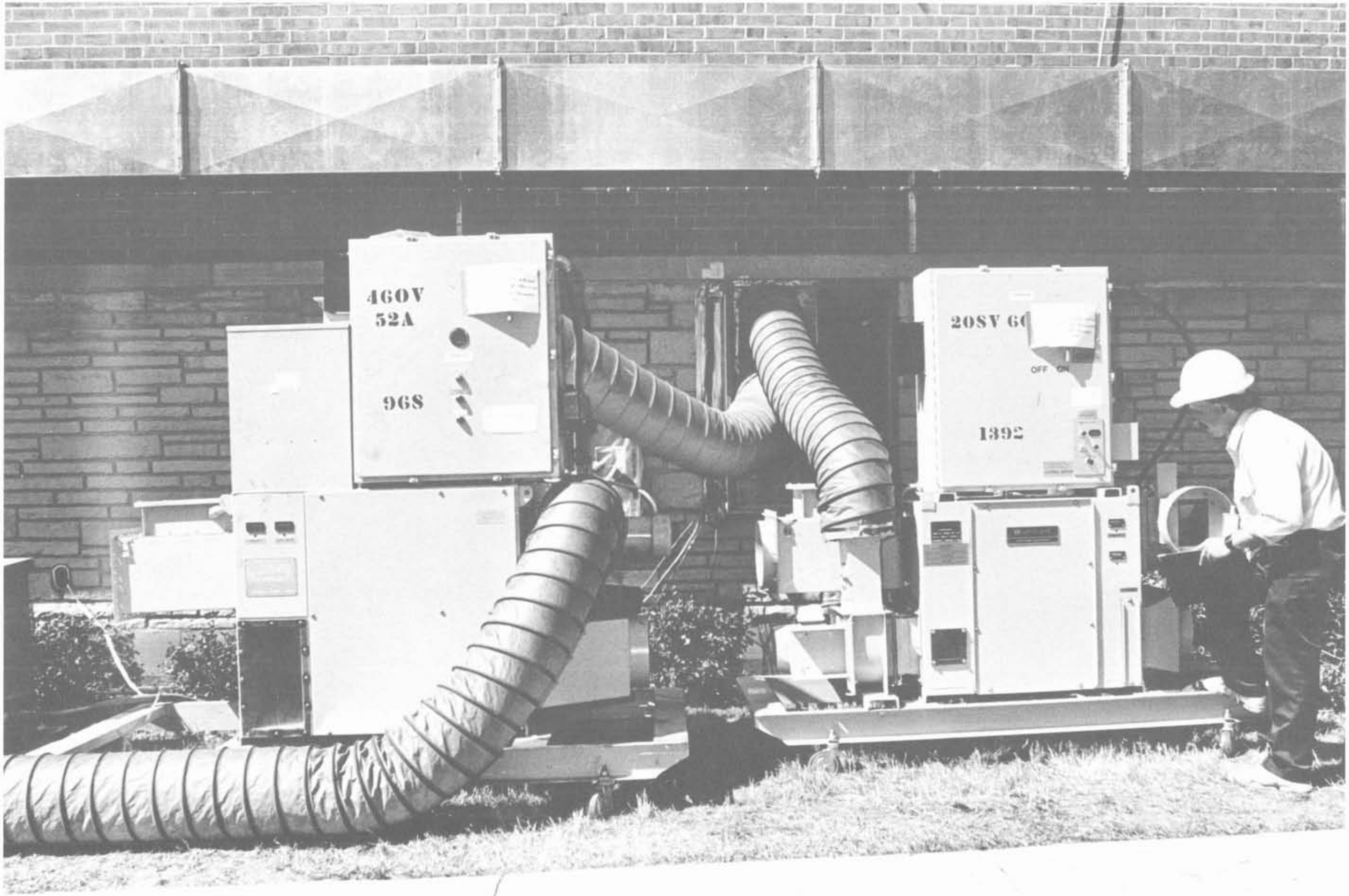


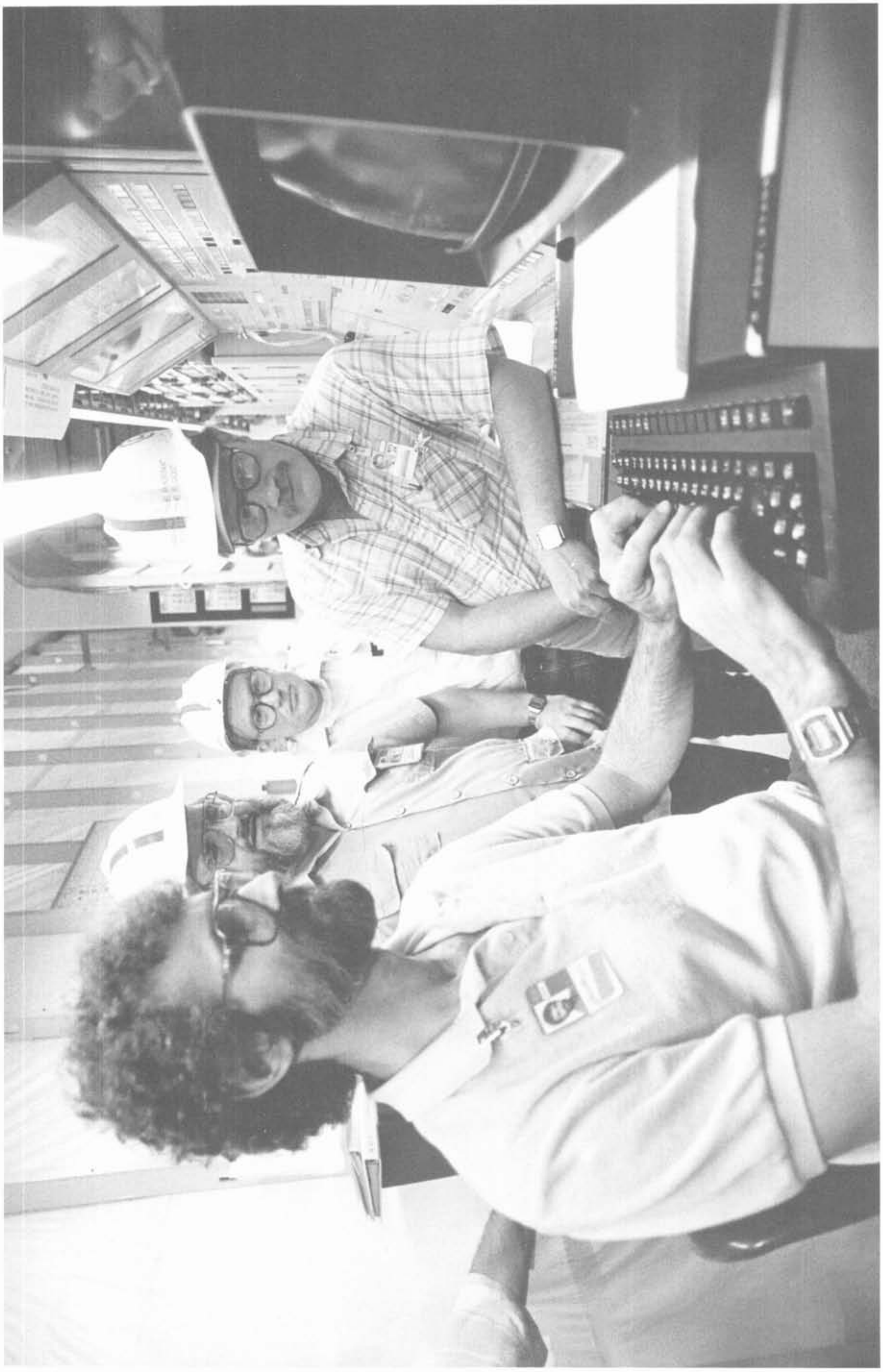
change to customer name/address, old svc ckt #s did not have enough usable info. for restoration

FIBER HUB & SPECIAL SERVICES CHALLENGES

- Some facilities could not be duplicated 10%
- Redesign and re-engineering needed
- Databases not designed for crash program

Restoration of the local switch

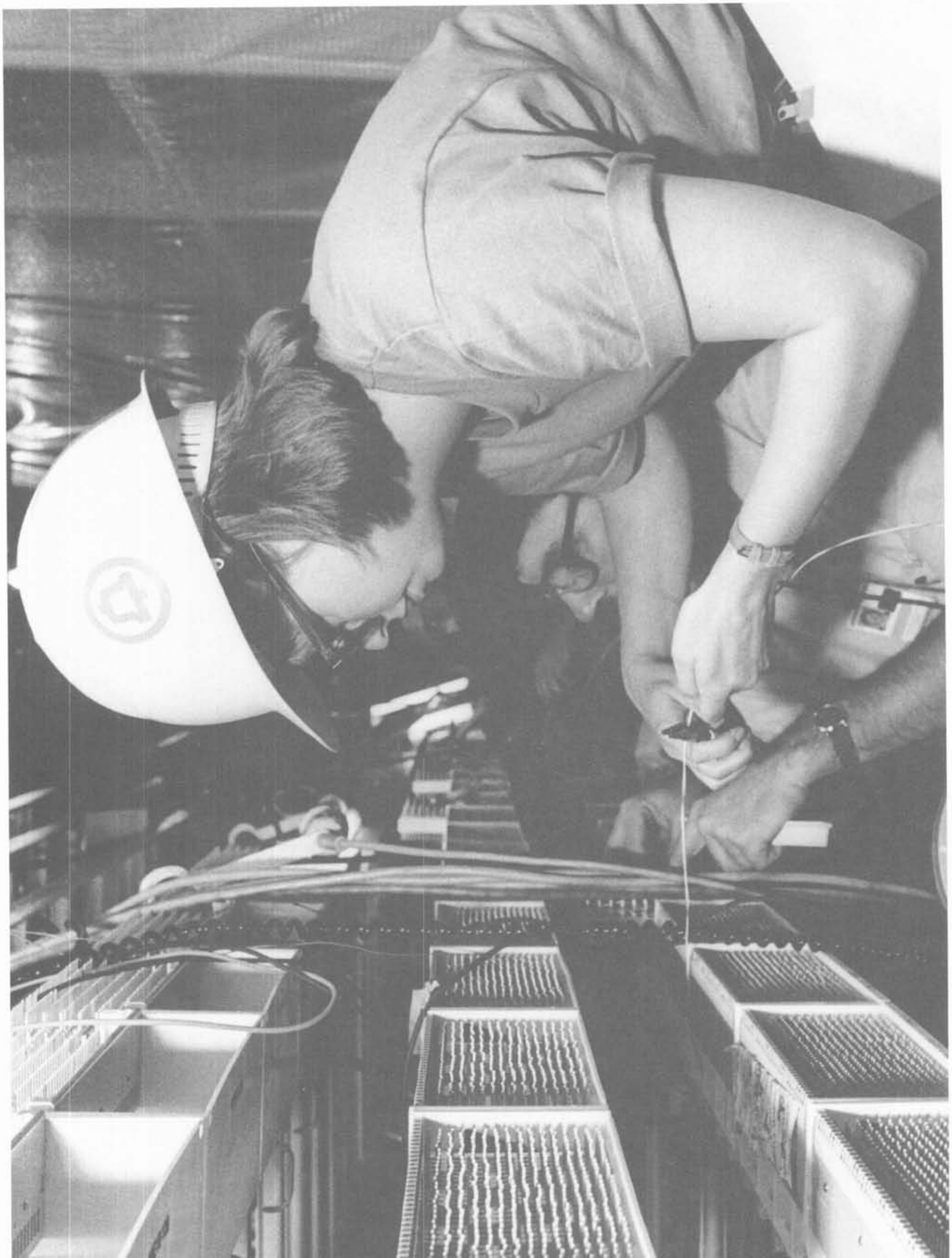

460V
52A
96S
20SV 6(
OFF ON
1392



LOCAL SWITCH RESTORATION PROGRESS

- May 11 — 12,000 customers back in service
- May 14 — 21,000 customers back in service
- May 17 — 30,000 customers back in service
- May 20 — virtually all customers in service


83

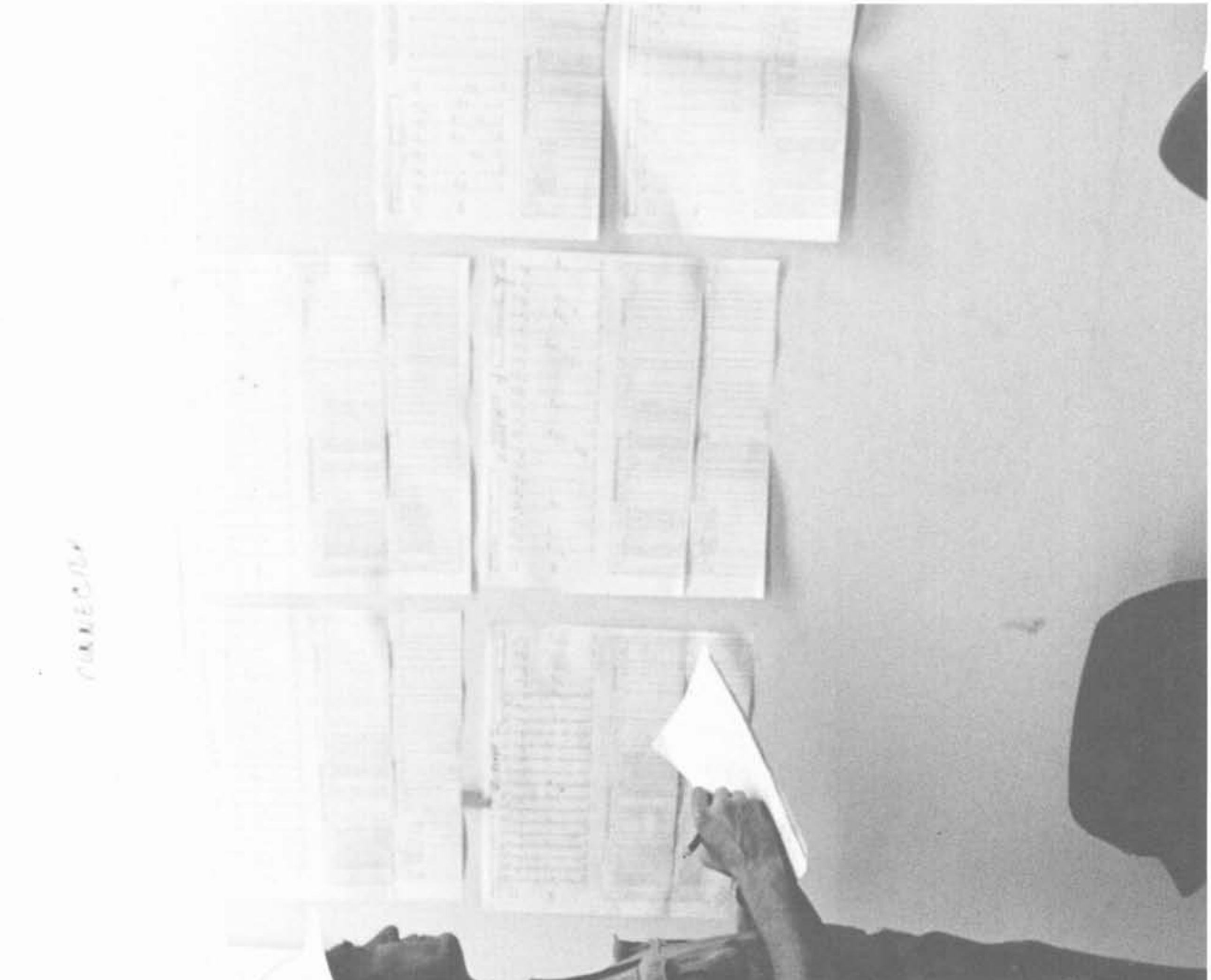


2 Key ~~boss~~ were !
∘ space required
∘ turn up time
- sftw. tools
- computerized

Installation of the new switch

TRANSLATIONS: THE BIGGEST CHALLENGE

- Download similar program
- Development of a “growth” database
- A “miracle” load




ILLINOIS BELL
QUALITY CONTROL
CENTER
QUALITY
ESS
TRANSLATION

NEW METHODS

- Working in parallel
- Testing and acceptance
- Critical path charts
- Quality Control teams
- Project group meetings

HINSDALE: RETROSPECTIVE INVESTIGATION

Michael J. Friduss
Vice President — Operations
Michigan Bell

HINSDALE FIRE INVESTIGATION

ILLINOIS BELL TASK FORCE

MICHAEL J. FRIDUSS, CHAIRMAN

CHALLENGE

- Determine cause of fire
- Find measures to prevent a similar occurrence

HISTORY OF SWITCHING CENTER FIRES

- 1975 — Second Avenue (New York): 170,000 lines
- 1987 — Bushwick Avenue (New York): 41,000 lines

ILLINOIS BELL SWITCHING CENTER FIRES

- 1929 — Downtown Chicago
- 1946 — River Grove
- 1988 — Hinsdale

HINSDALE

- Unprecedented fire
- Unprecedented investigation

INVESTIGATION APPROACH

- Step 1 — Determine what happened
- Step 2 — Determine root cause and origin
- Step 3 — Identify factors impacting on cause
- Step 4 — Determine cause/factor relationship
- Step 5 — Develop recommendations

TEAM SYNERGY

- Illinois Bell
- Illinois Commerce Commission
- Office of State Fire Marshal
- Forensic Technologies International
- Bellcore
- Factory Mutual

INVESTIGATION METHODS

- Examine and test physical materials
- Analyze printouts, reports and data
- Interview key people

PHYSICAL EXAMINATION

- Inspect fire area
- Lower cable racks
- Trace power cables
- X-ray cable rack cross sections
- Dissect cable racks
- Test for combustibility, smoke and corrosivity
- Conduct chemical analyses

Photograph 3-3.
Section 1, after being lowered.

Photograph 3.9.
Section 1 near L cut showing "pocket burn."

FIRE ELEMENTS

- Trigger (Cause)
- Weakness (Origin)
- Failsafes that did not operate

TRIGGER/CAUSE ALTERNATIVES

- External electrical transient
- Internal movement

WEAKNESS (ORIGIN) ALTERNATIVES

- AC flexible armored cable
- DC power cable

FAILSAFES

- Fuses and other protection did not work

INVESTIGATION STRATEGY

- Identify key questions
- Develop timelines
- Conduct academic research

KEY QUESTIONS

- What time did fire start?
- Why didn't DC fuses blow?
- Why multiple visits to remove power?
- Why did batteries show 45 minutes of discharge?
- Did alarm system work?
- Was lack of staffing a factor?
- Would a suppression system have worked?
- Why was most damage caused by smoke/corrosion?

IMPACT FACTORS

- Prevention
  - Central office AC/DC power
- Detection
  - Alarm systems and reporting
  - Central office staffing

IMPACT FACTORS

- Containment
  - Fire suppression systems
  - Fire fighting
  - Materials combustibility, smoke, corrosivity
  - Building structure/security
- Service continuity
  - Network architecture
  - Restoration and recovery

DEVELOP TIMELINES

- AC/DC power
- Alarms
- Fire
- Key people
- Fire fighting

WHAT TIME DID THE FIRE START?

- The fire started at 4:20 p.m.
  - Fire alarm at 4:20:48 p.m.
  - Earlier alarms unrelated to fire
  - Equipment failure at 4:21 p.m.
  - Fire started hot, did not smolder

WHY DID THE BATTERIES SHOW ONLY 45 MINUTES DISCHARGE?

- Hinsdale COT reset disabled diesel at 5:02 p.m.
- Diesel generators supplied power until 6:30 p.m.

DID THE FIRE ALARM SYSTEM WORK?

- Alarm system sensed/reported fire immediately
- Central Office Technician notified Duty Supervisor
- Duty Supervisor tried to contact 2 fire departments

WOULD A HALON 1301 SYSTEM HAVE WORKED?

- NO!!
  - Power cables were energized
  - Halon is heavier than air
  - Hinsdale fire was deep seated
  - Halon breaks down in very hot fires

WOULD STAFFING HAVE MADE A DIFFERENCE?

- No correlation between staffing at Hinsdale and fire prevention, detection, contamination

WHY WAS MOST DAMAGE CAUSED BY SMOKE AND CORROSION?

- Halogen-based wire, cable insulation produced smoke, gas, acid
- Corrosive material contaminated equipment, mainframe

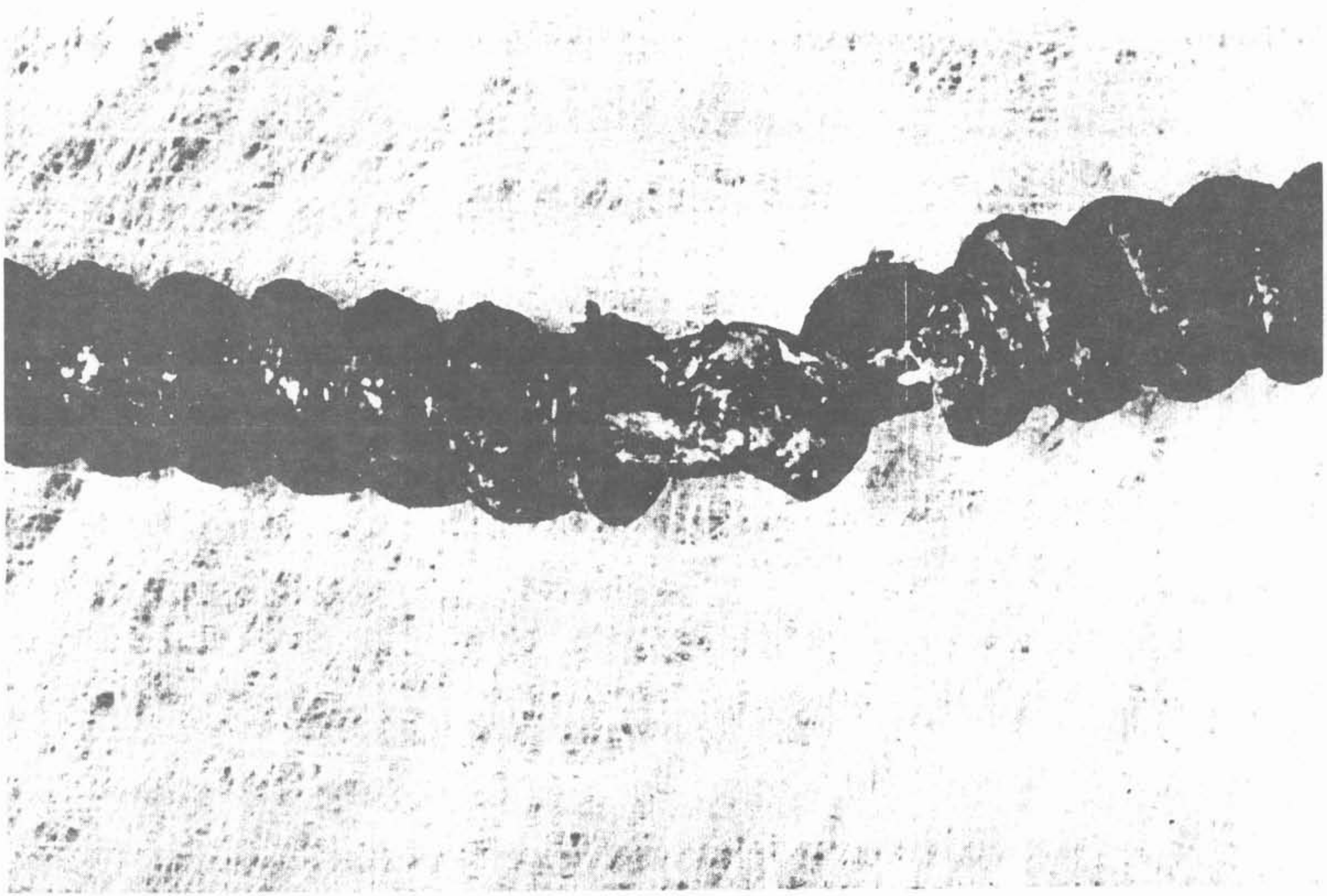
WHY DIDN'T THE DC FUSES BLOW?

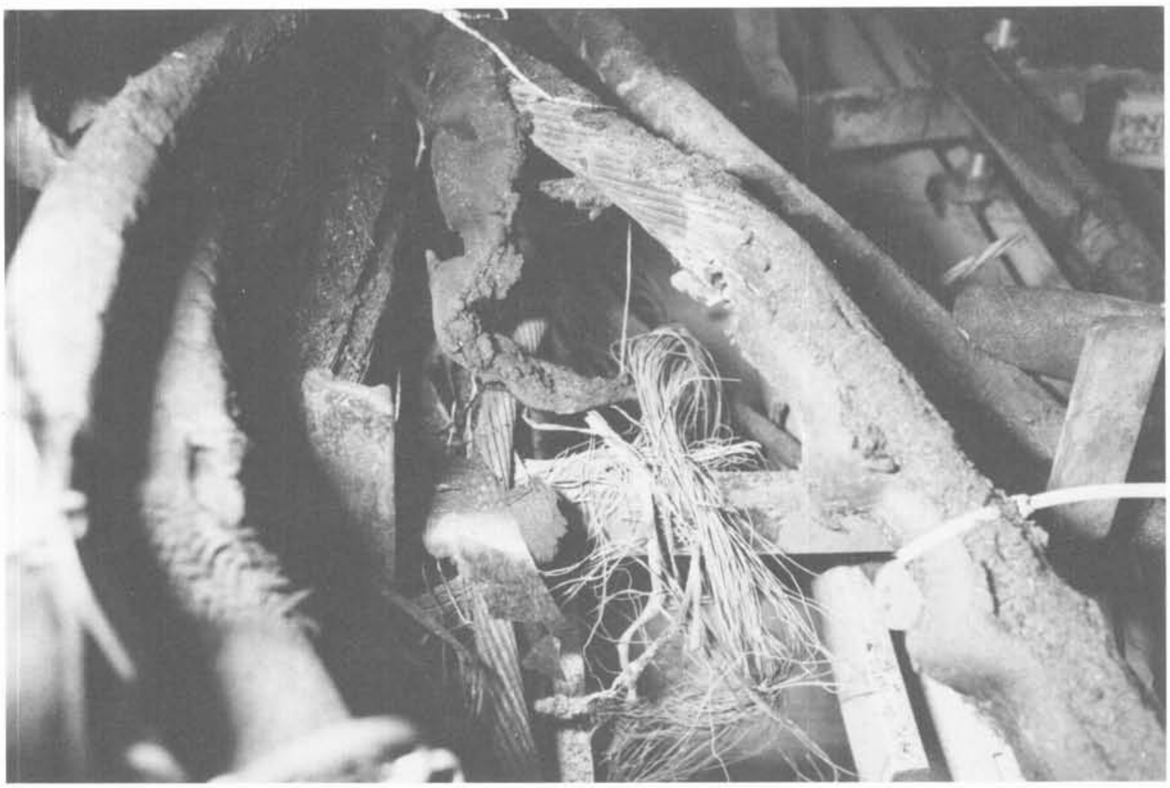
- DC fuses are designed to blow when current exceeds fuse rating over time
- Arcing not recognized as problem

WEAKNESS (ORIGIN) ALTERNATIVES

- AC flexible armored cable
- DC power cable

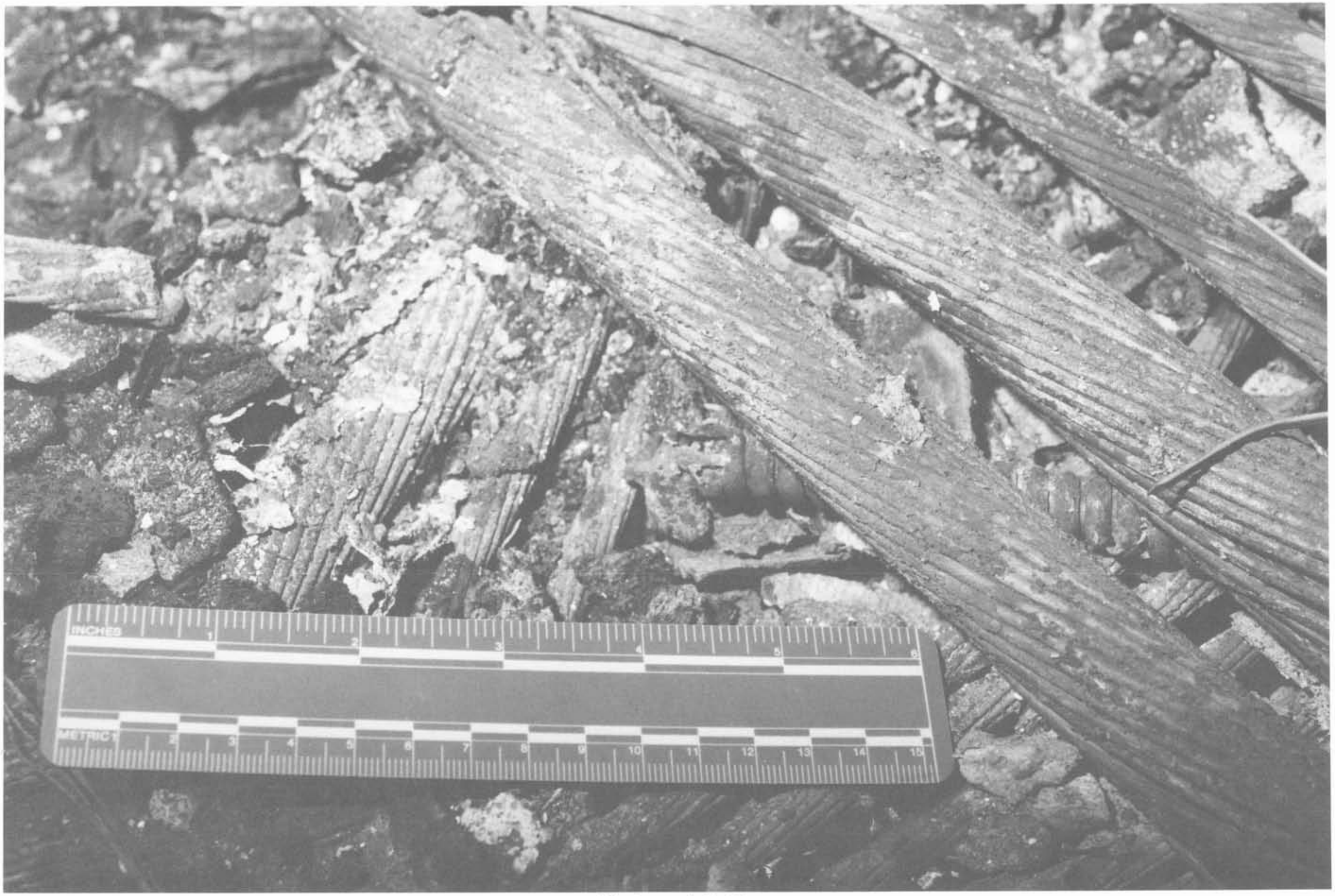
Defective BX Cable





Photograph 3-45.
750 MCM power cable and stanchion; both damaged
by arcing between them, Section 1, F cut.

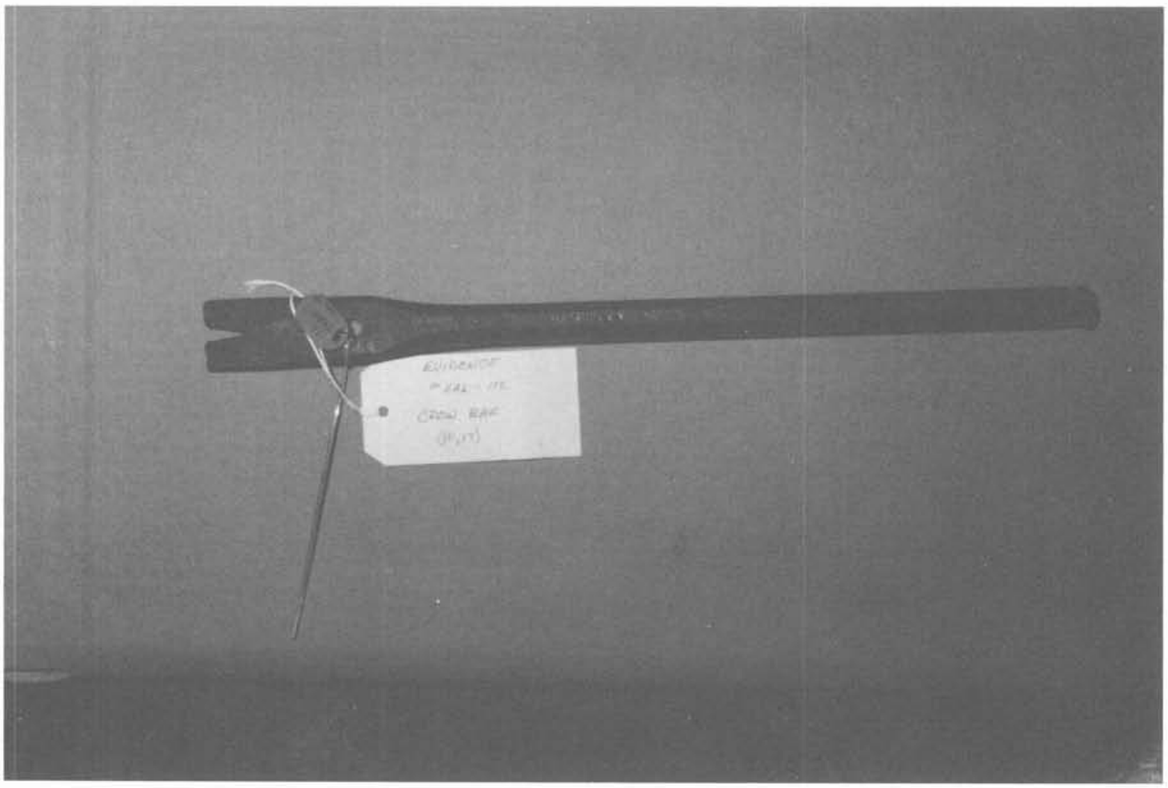
Photograph 3-15.
Armored cable welded to a 4/0 power cable
in Section 1, near L cut.



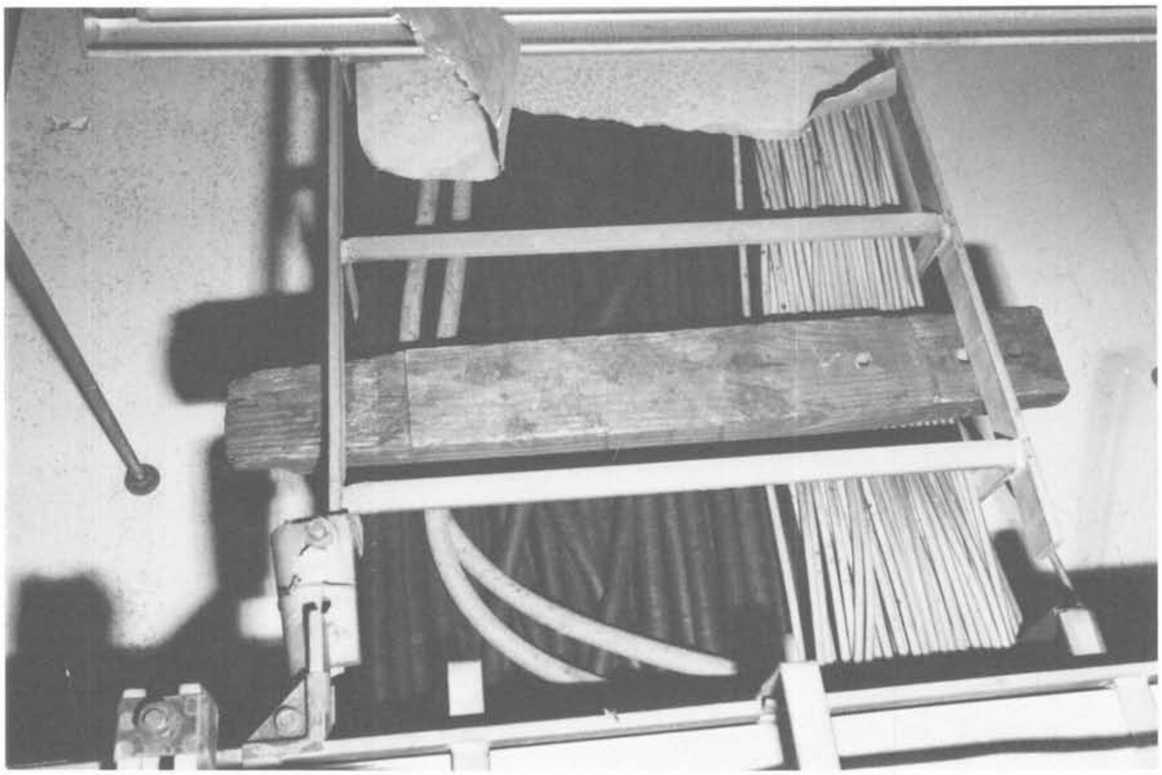
Photograph 3-17
Armored cable welded to a 4/0 AWG power cable in Section 1, near L cut.

IMPACT OF CABLE MINING

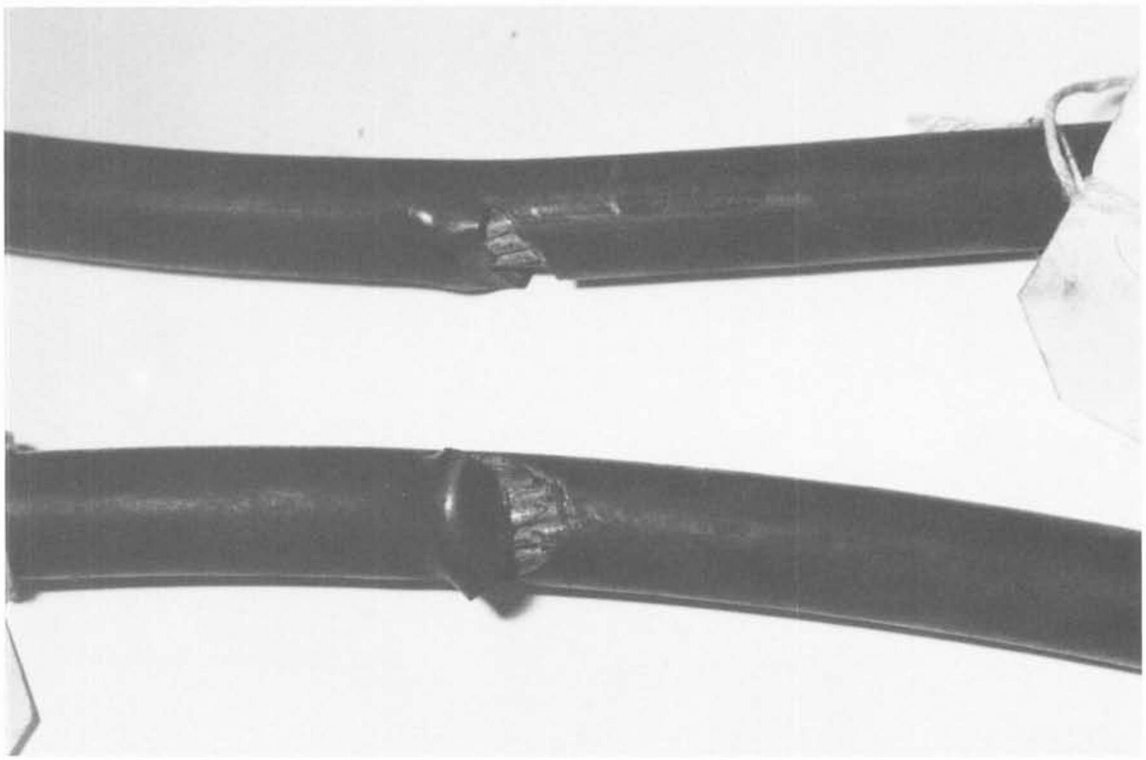
- May have caused or added to weakness



Photograph 3-54.
Prybar found amond cables in cable tray in northeast corner of toll area.



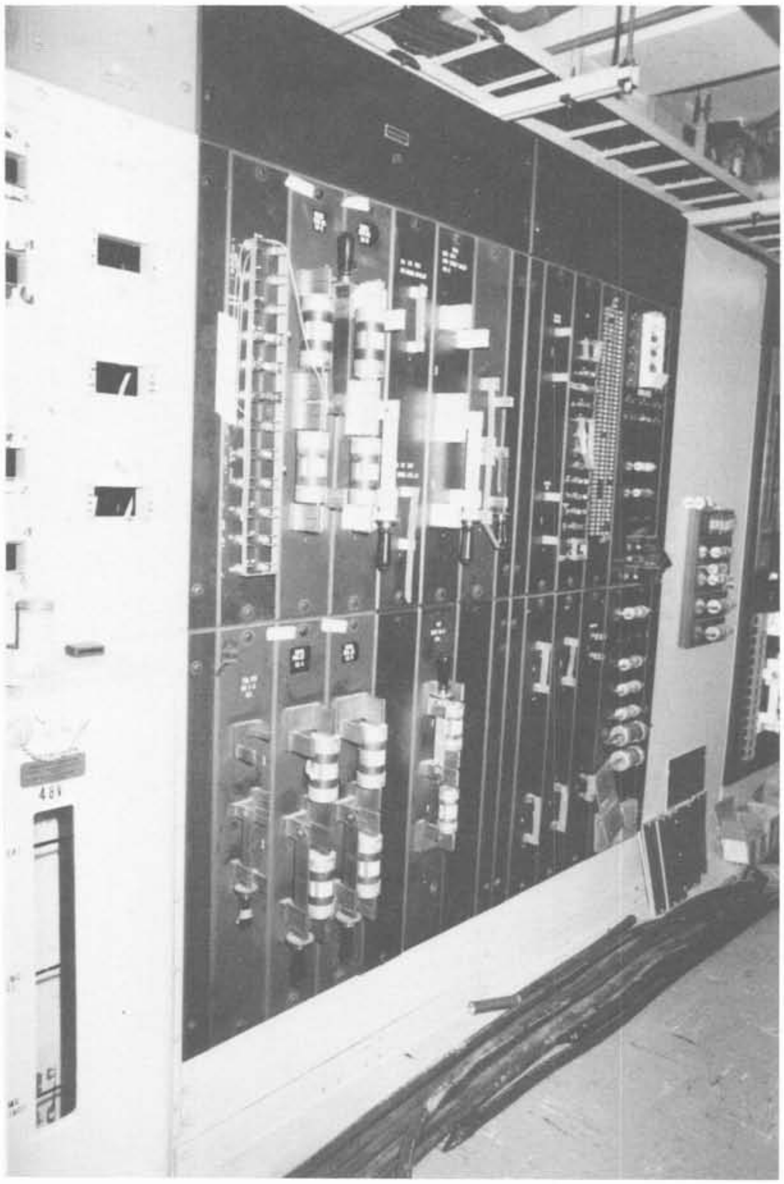
Photograph 3-57.
Exposed makeshift wedge found in cable tray in northeast corner of first floor.



Photograph 3-59.
Torn insulation on extracted power cables.

TRIGGER (CAUSE) ALTERNATIVES

- External transient: voltage spike
- Internal movement in area of origin



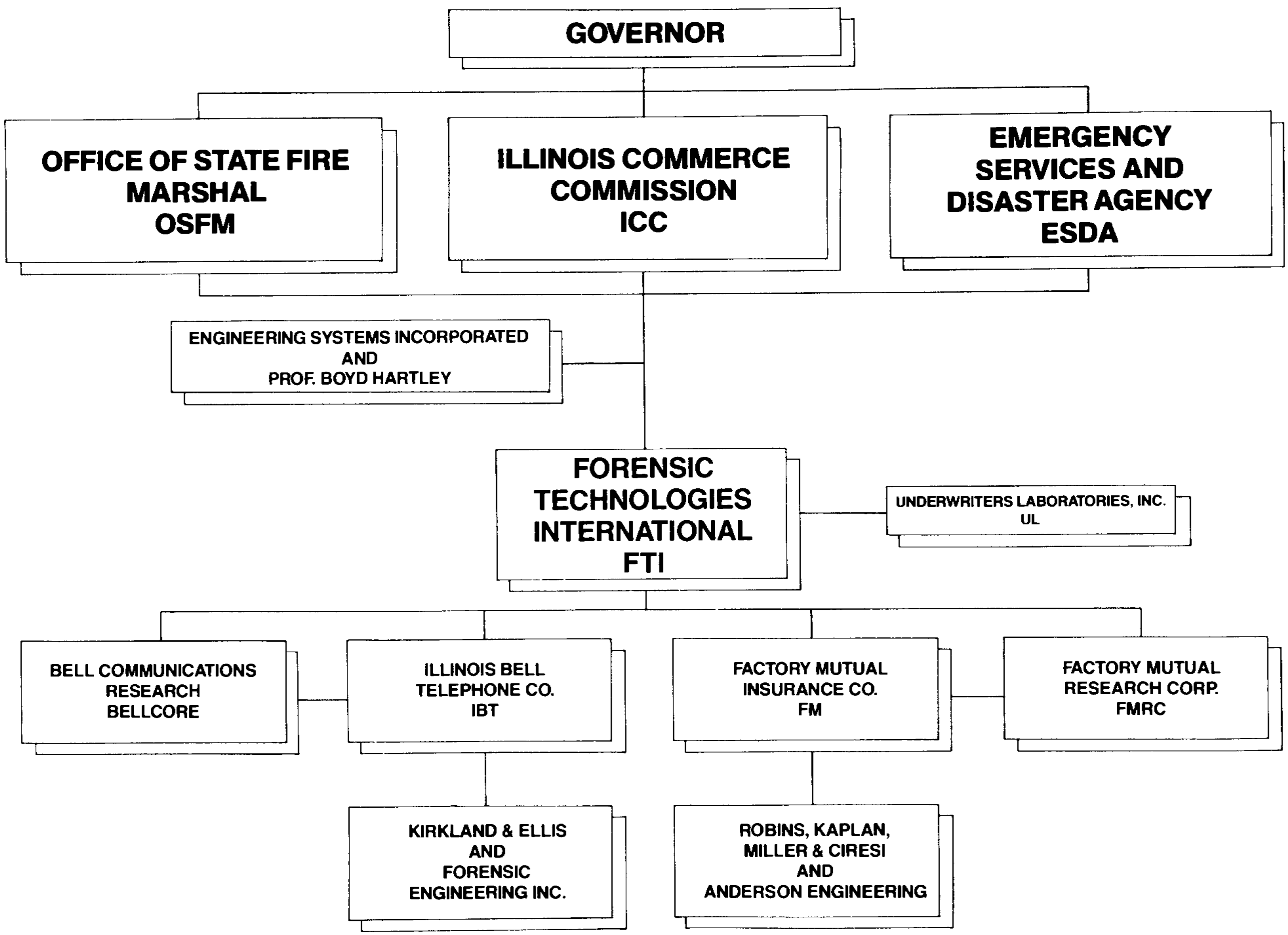
Photograph 3-39.
302 power system 600-ampere main fuses.

WHY DIDN'T THE DC FUSES BLOW?

HINSDALE RETROSPECTIVE INVESTIGATION

N. Richard King
Executive Director
Illinois Commerce Commission

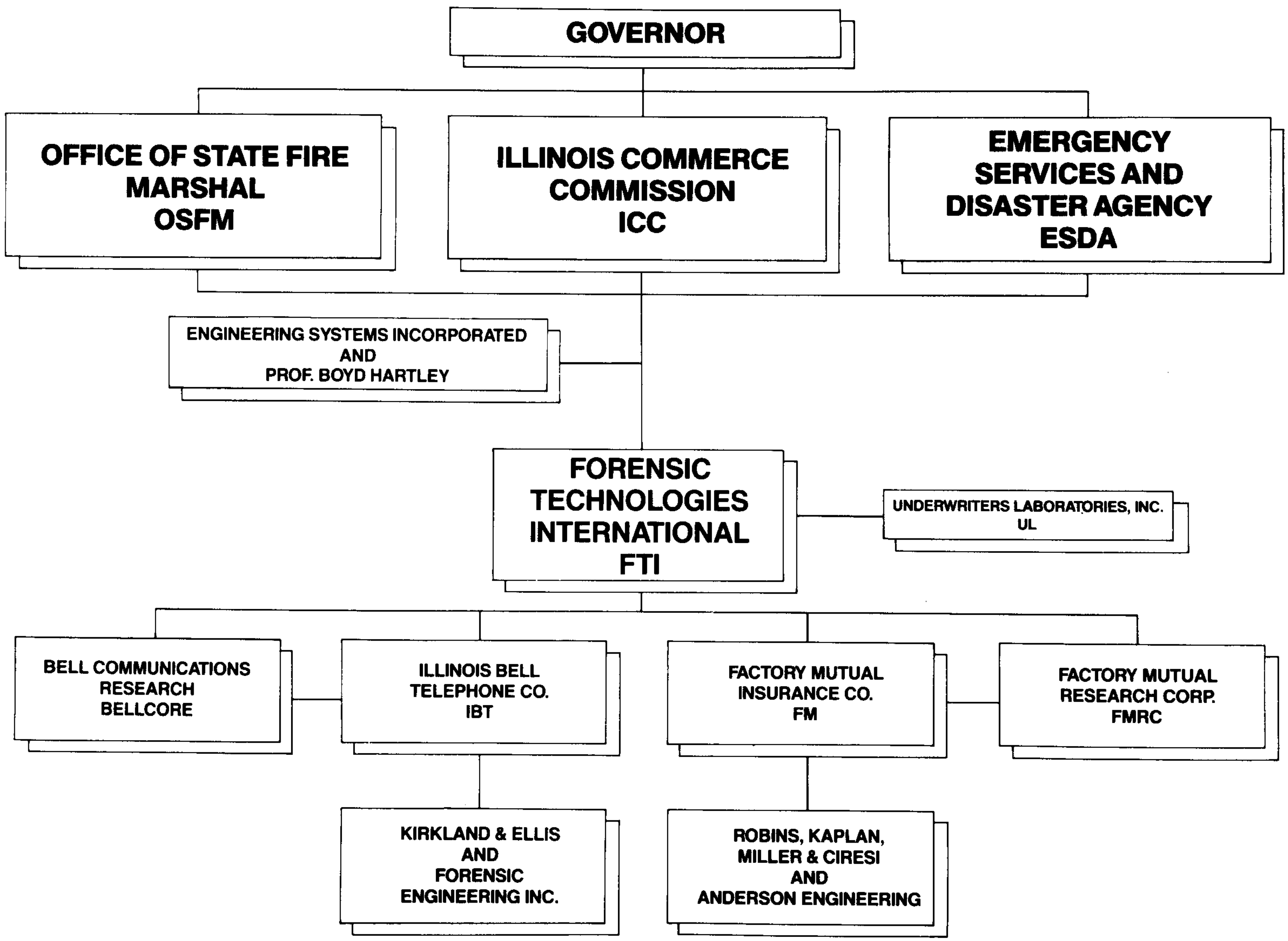
ORGANIZATION IN RESPONSE TO THE IBT HINSDALE CENTRAL OFFICE FIRE



HINSDALE
RETROSPECTIVE INVESTIGATION

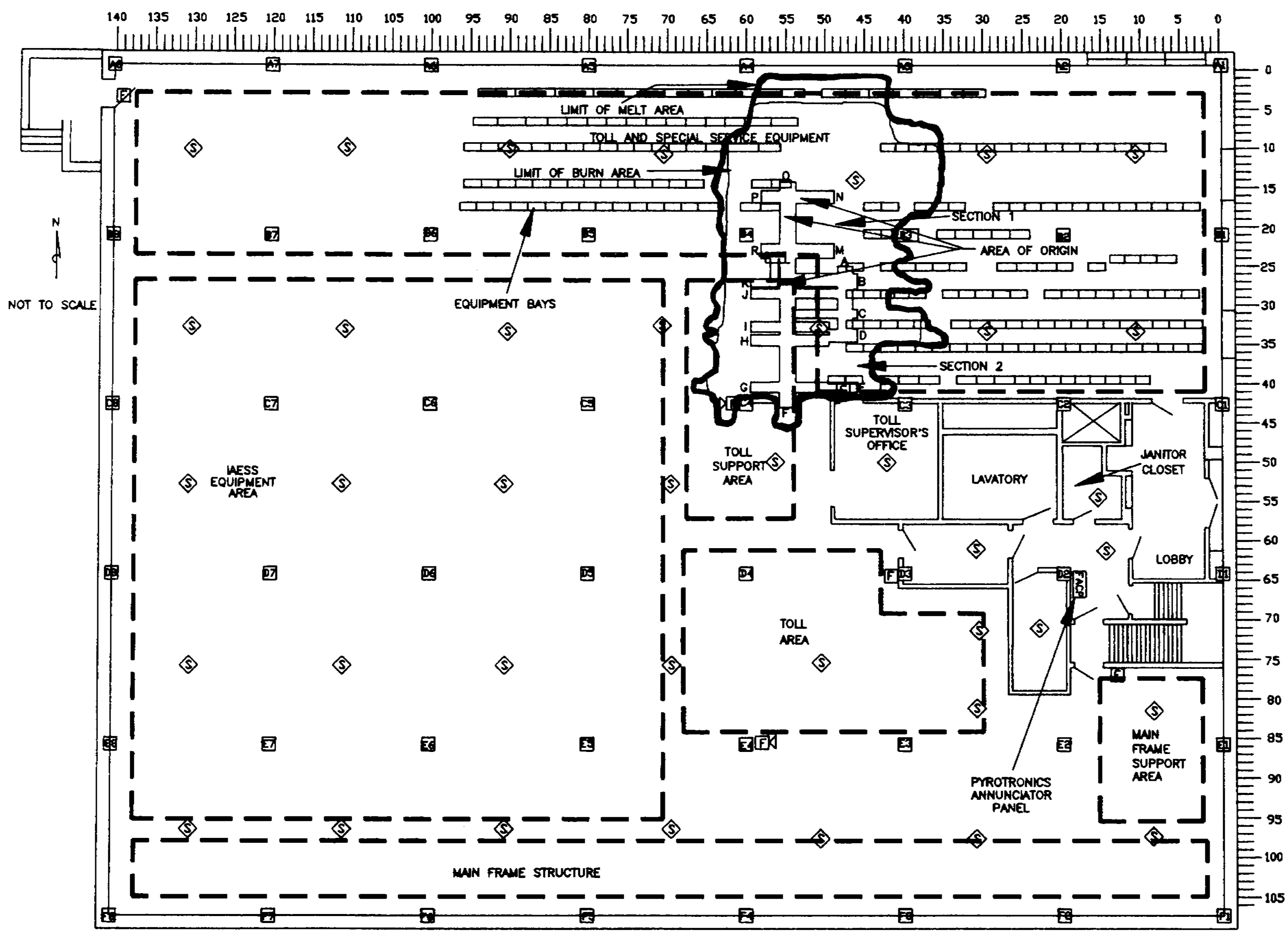
Joseph R. Reynolds, Jr.
President
Forsenic Technologies
International Corporation

ORGANIZATION IN RESPONSE TO THE IBT HINSDALE CENTRAL OFFICE FIRE

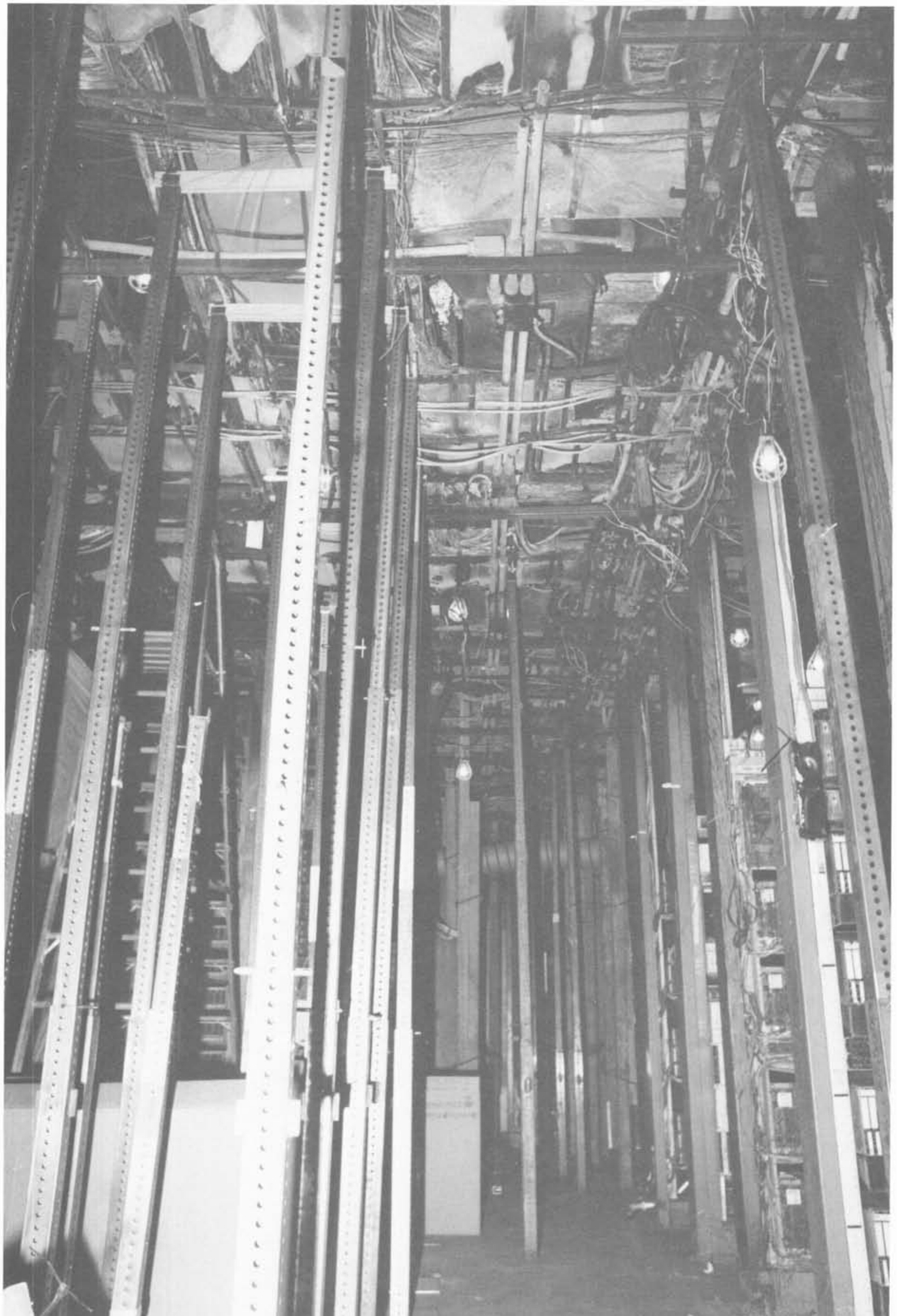


Photograph 2.1.
The Hinsdale Central Office Building during recovery.

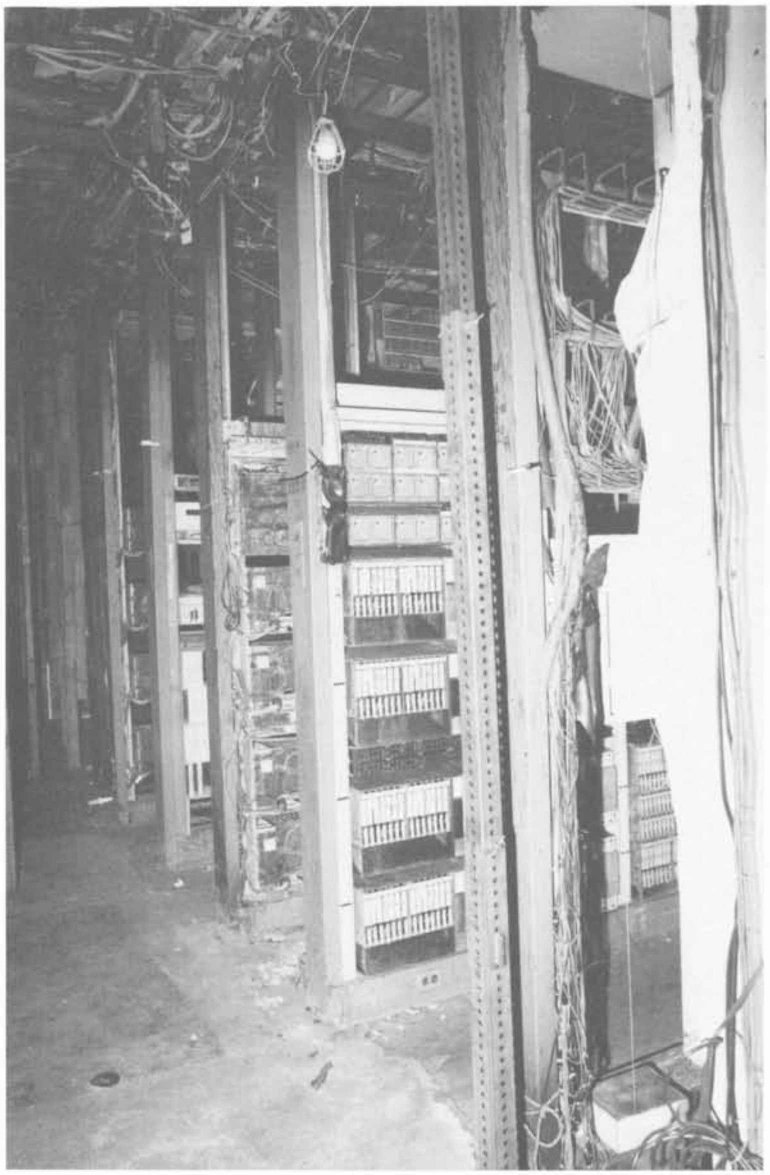
HINSDALE FIRST FLOOR PLAN



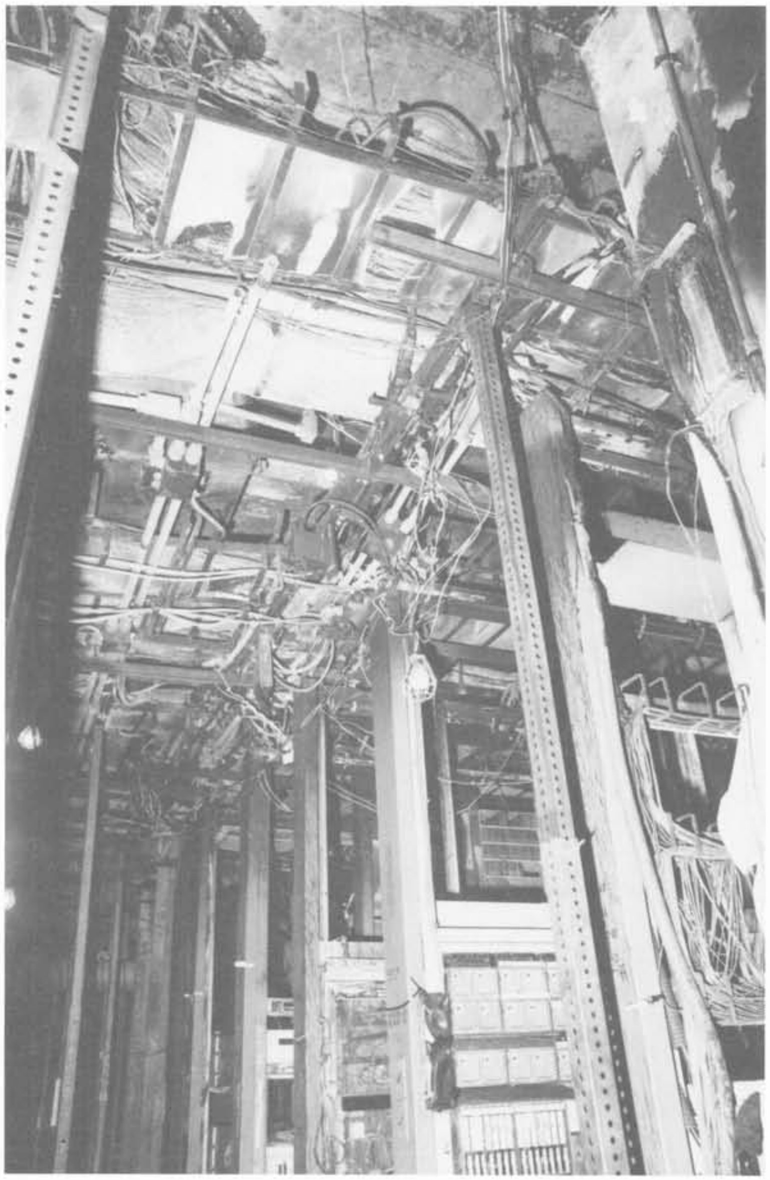
Photograph 3.
Firemen examining card bins after the fire was extinguished.
(Photo courtesy of the Hinsdale Fire Department.)



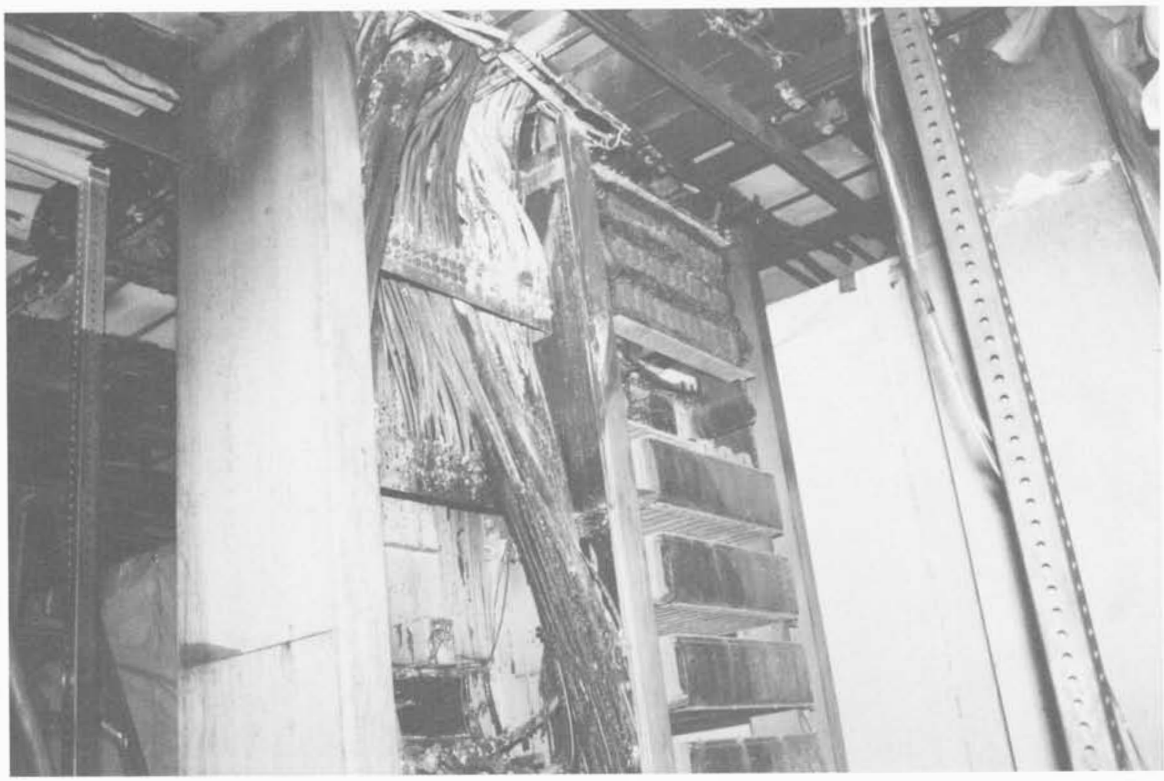
Photograph 2-14.
Cable trays, Sections 1 and 2, looking north.



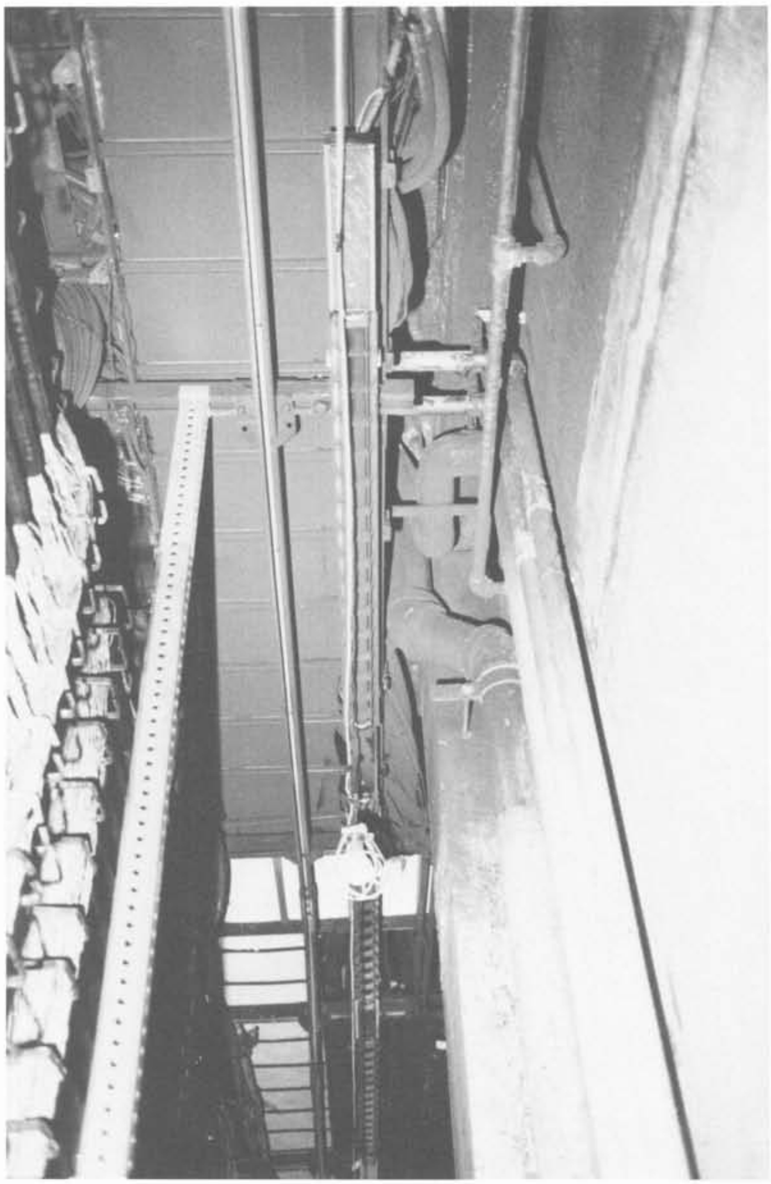
Photograph 2-15.
Equipment bays below section 1, looking north.



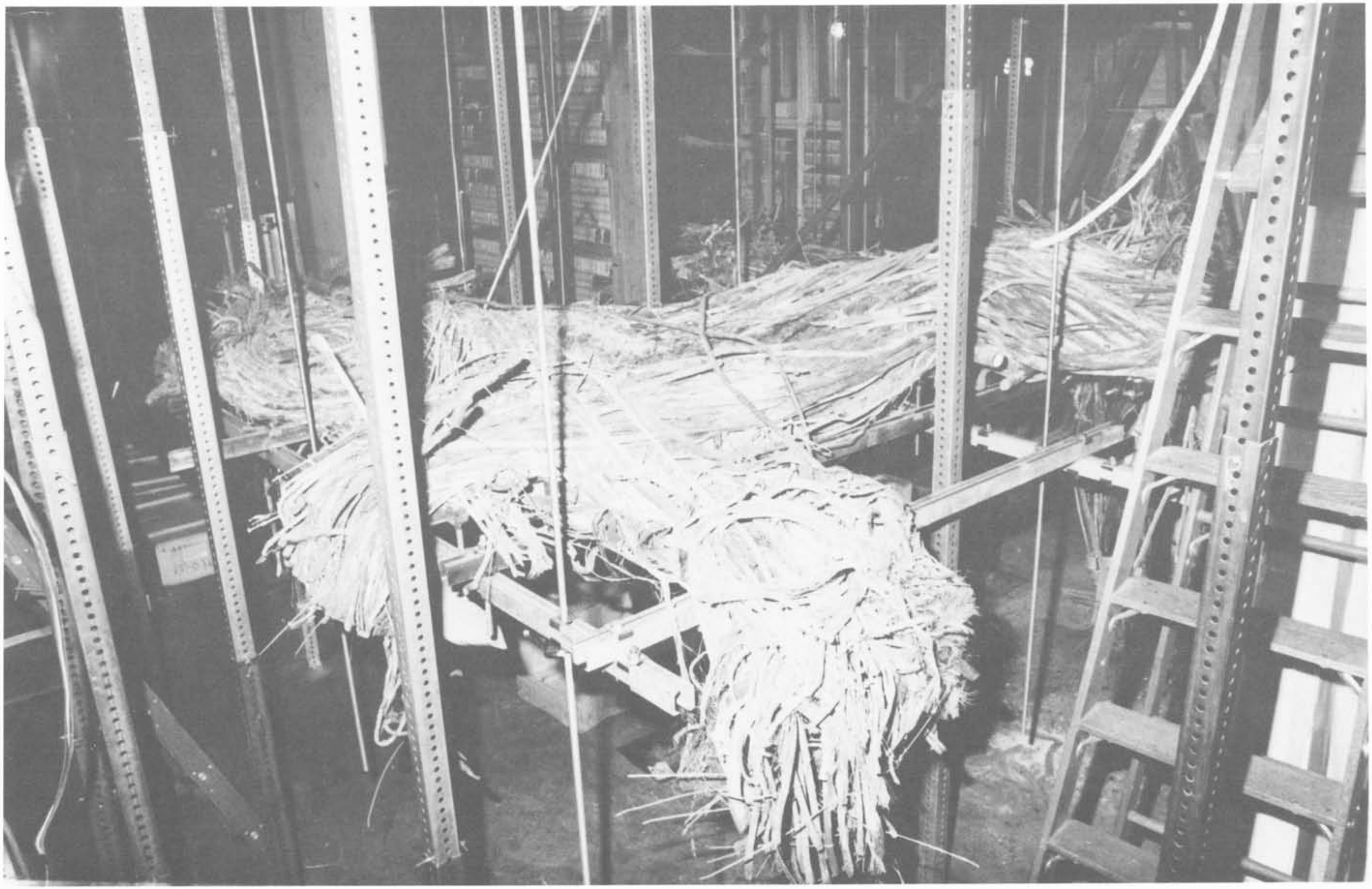
Photograph 2-16.
Equipment bays below section 1, looking north.



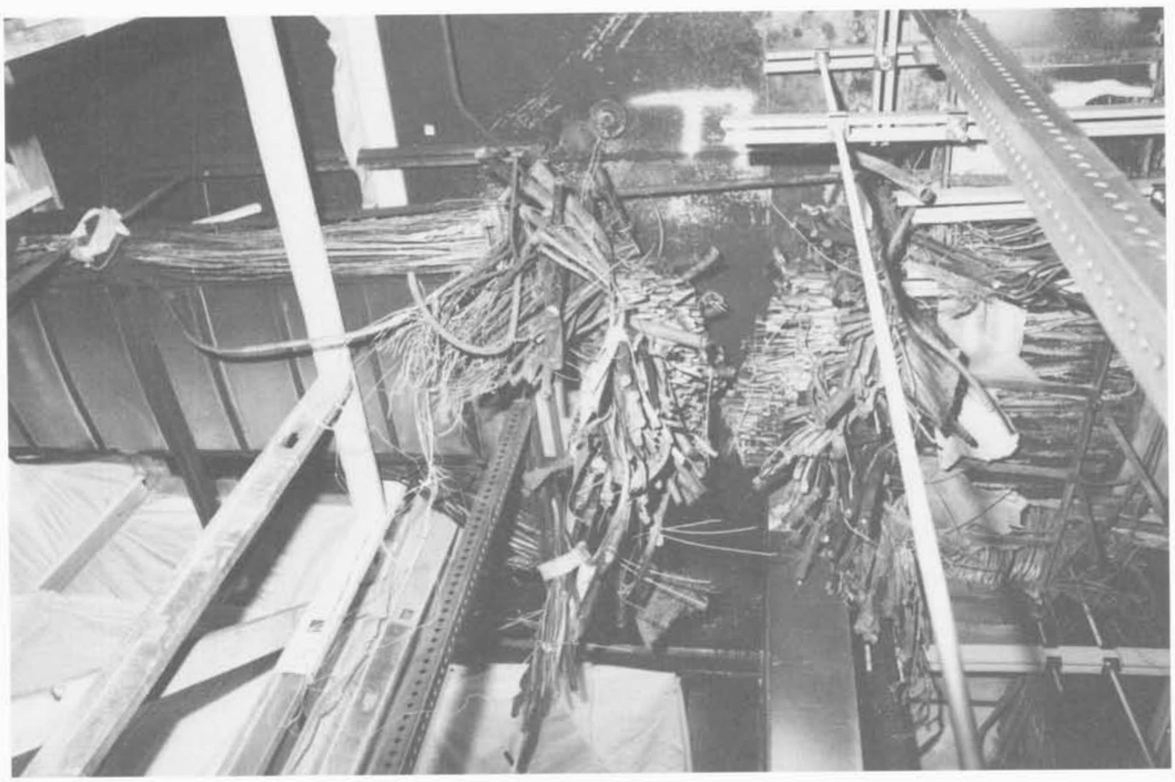
Photograph 2-17.
Rear of BDFB.



Photograph 2-18.
Smoke damage on bottom of cable tray
and upper walls.

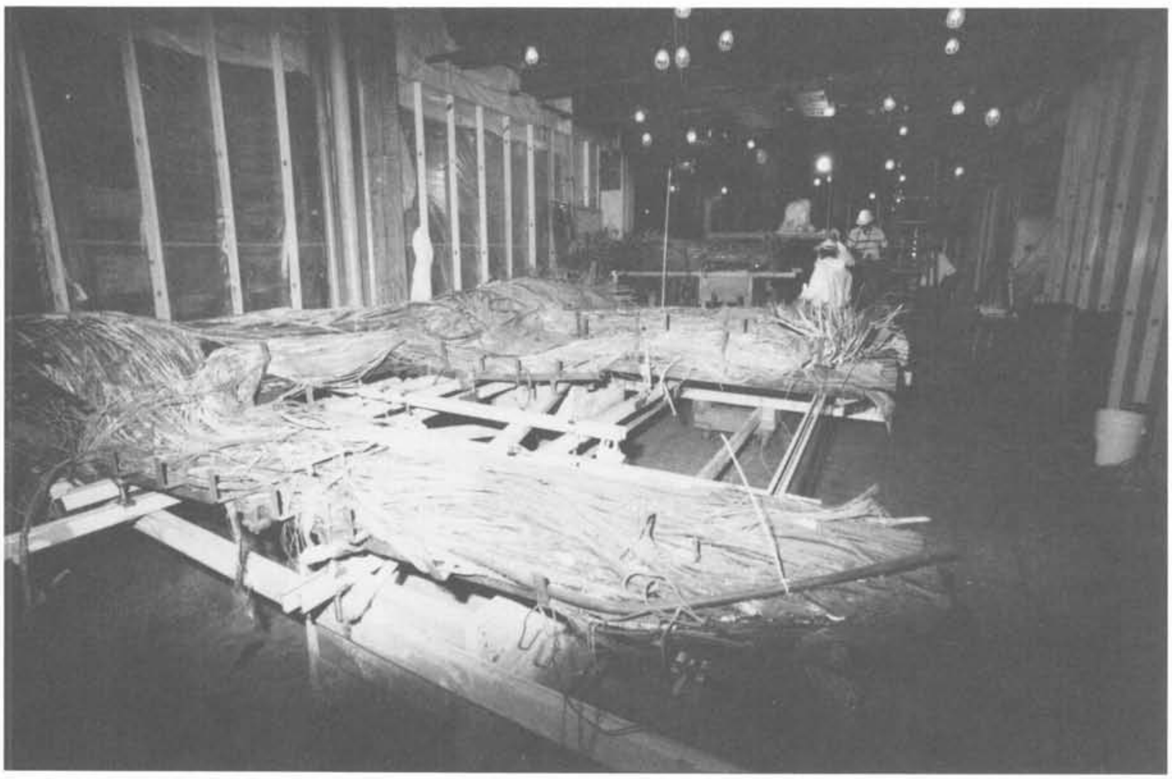


Photograph 3-1.
Section 2 after being lowered.



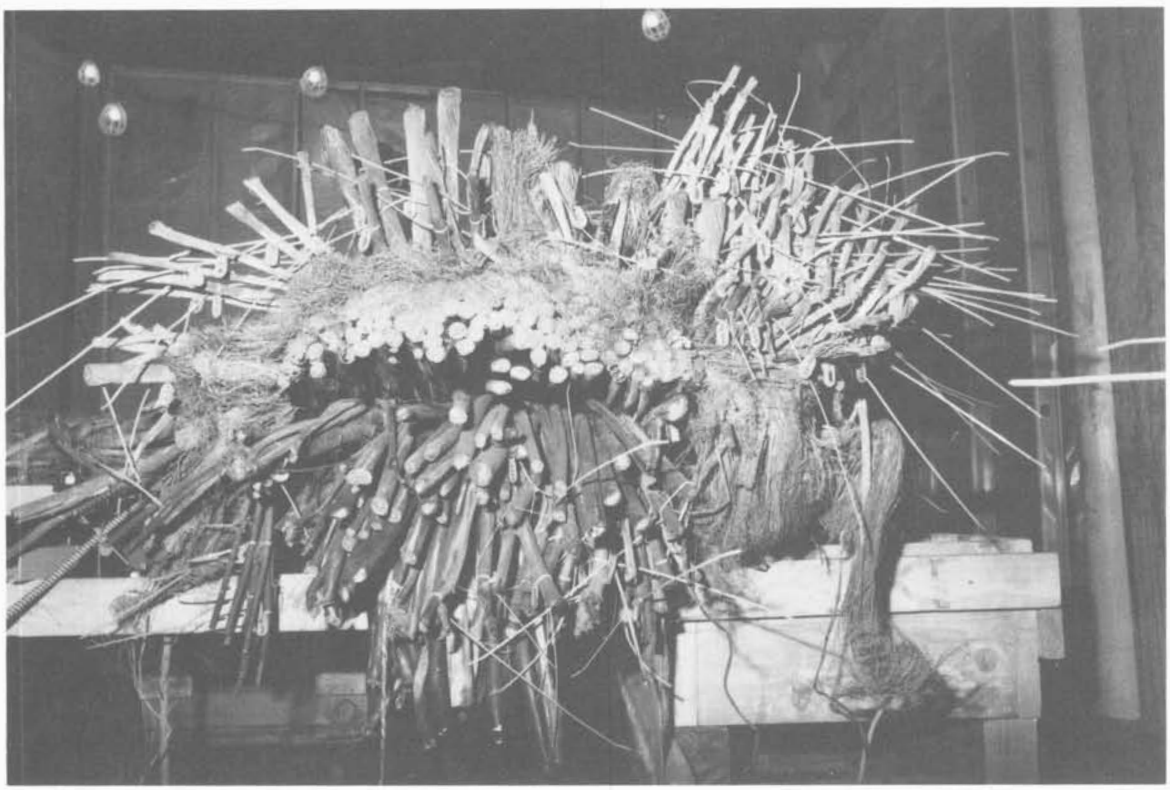
Photograph 3-2.
Section 1, F cut.

Photograph 3-4.
Part of ceiling area above Section 1.



Photograph 3-5.
Section 1, moved to examination area of HCO.

Photograph 3-6.
Section 2, moved to examination area.

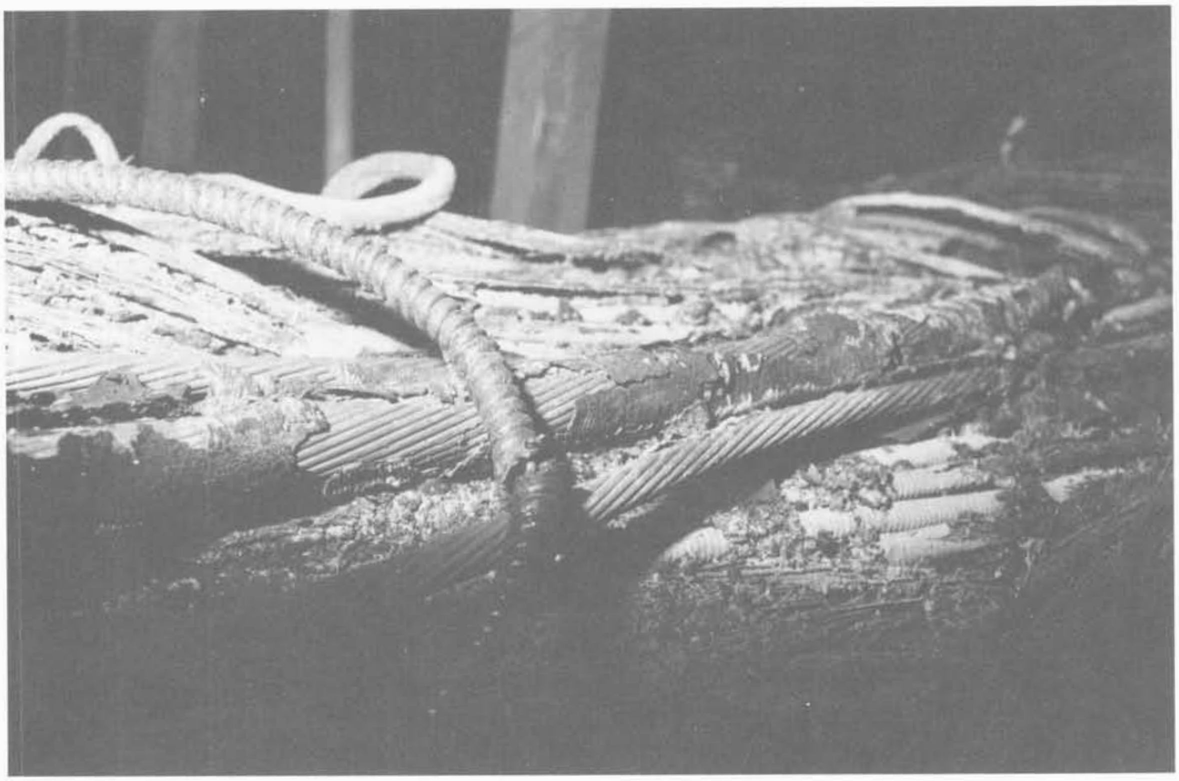


Photograph 3-8.
L cut with identification tags.

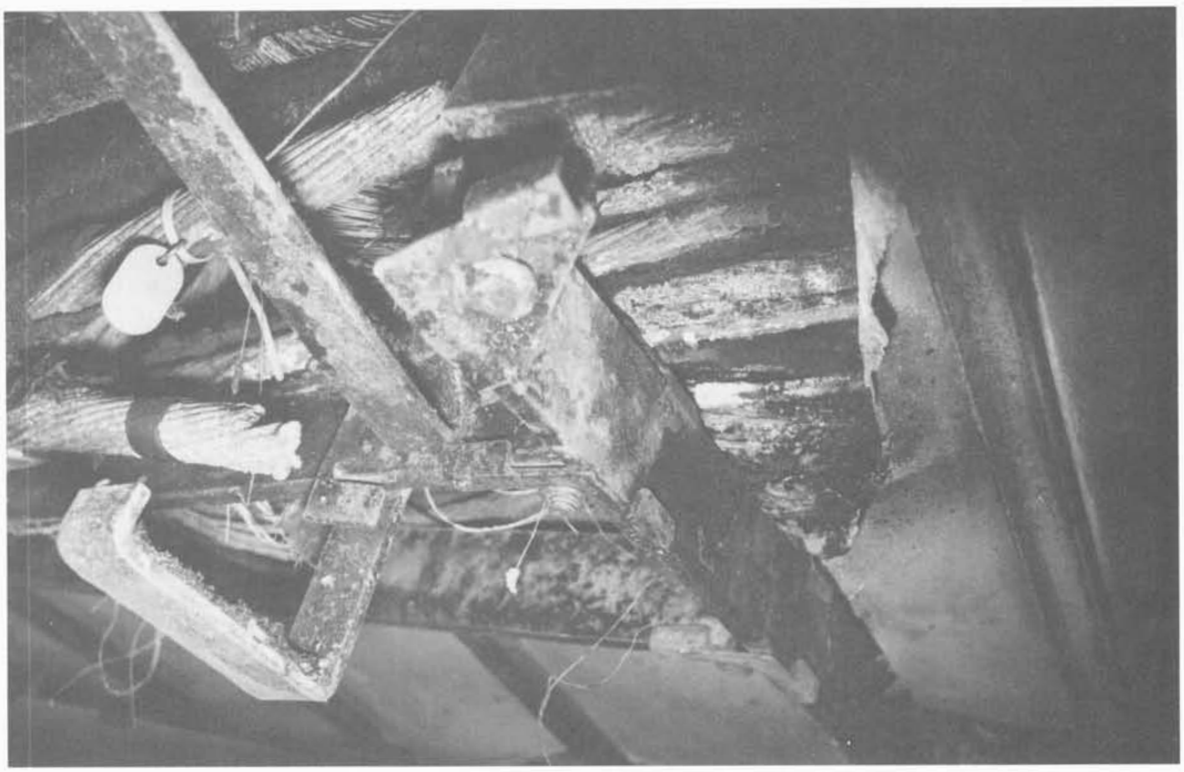
Photograph 3-10.
Close-up of "pocket burn," Section 1.

Photograph 3-11.
Removal of communications cables from Section 1.

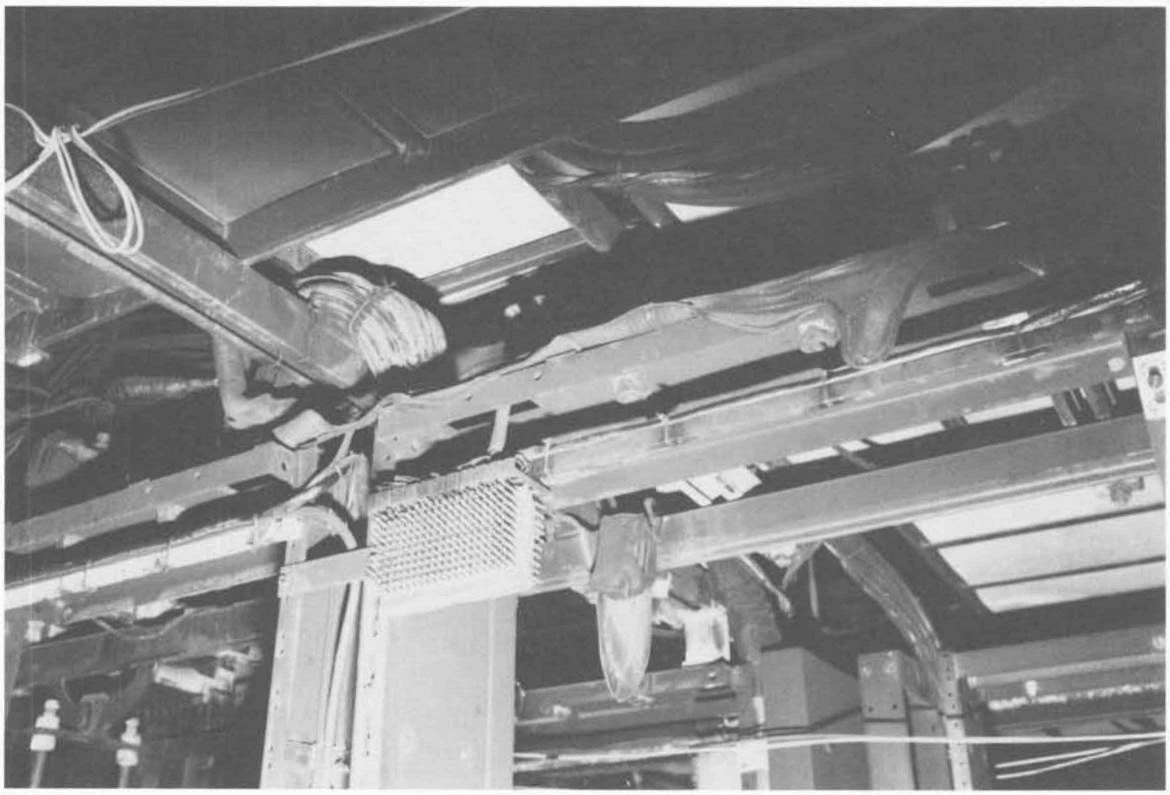
Photograph 3-12.
Large power cables arced-in-two in Section 2, near O cut.



Photograph 3-13.
Armored cable arced to 4/0 cable in Section 2
near N cut, (before extraction).

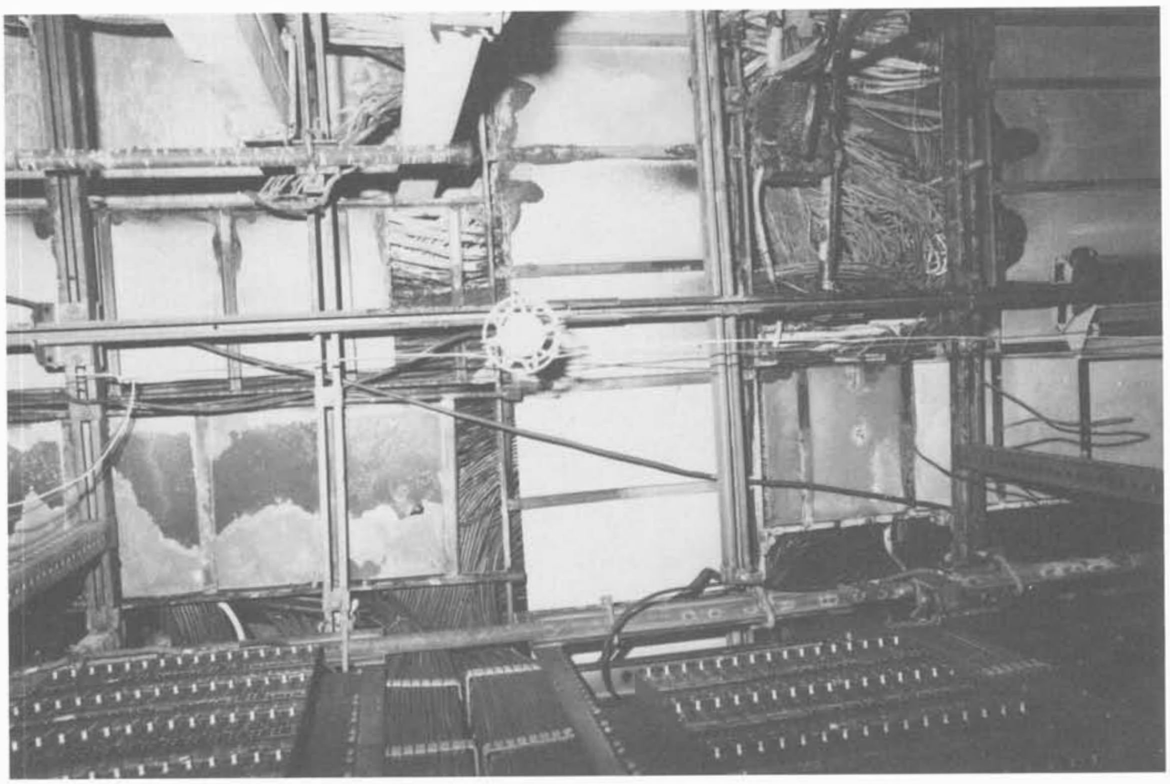


Photograph 3-16.
Damage caused by arcing from cable to tray frame.

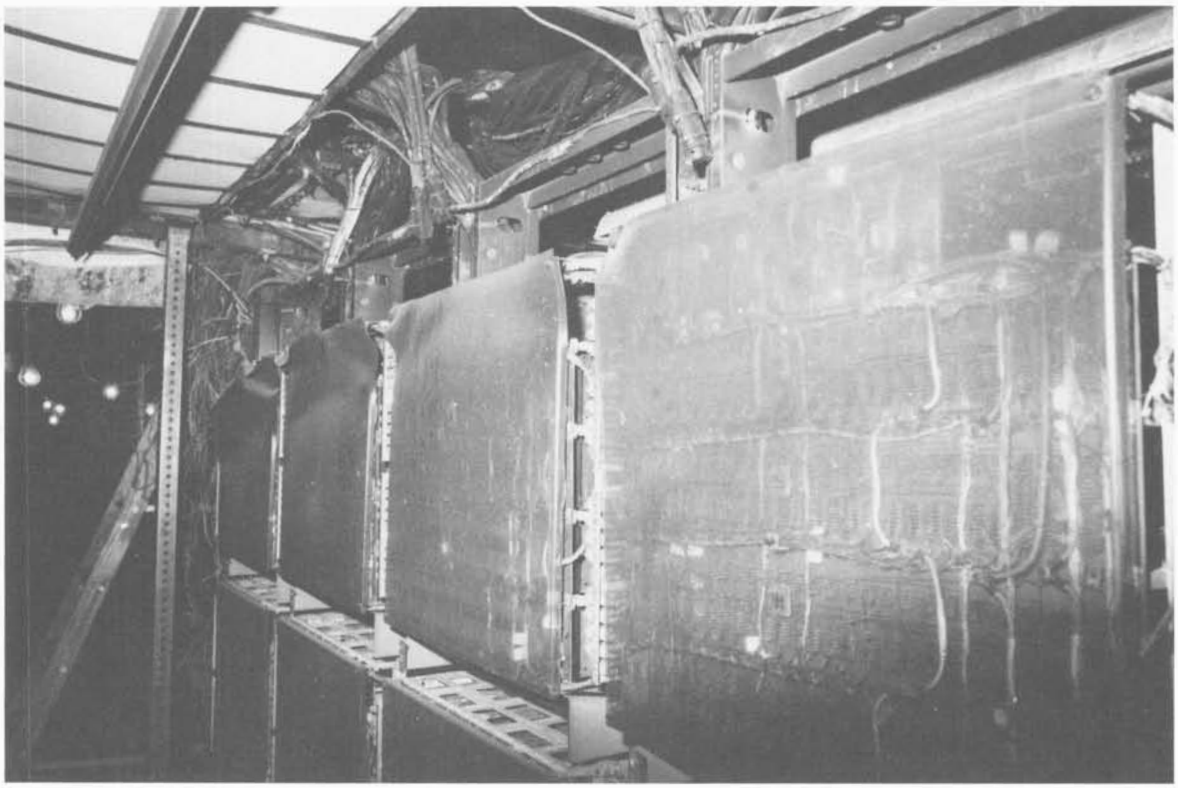


Photograph 3-18.
Melting of plastic cable covers and connectors at equipment bay frames below cable trays outside fire area.

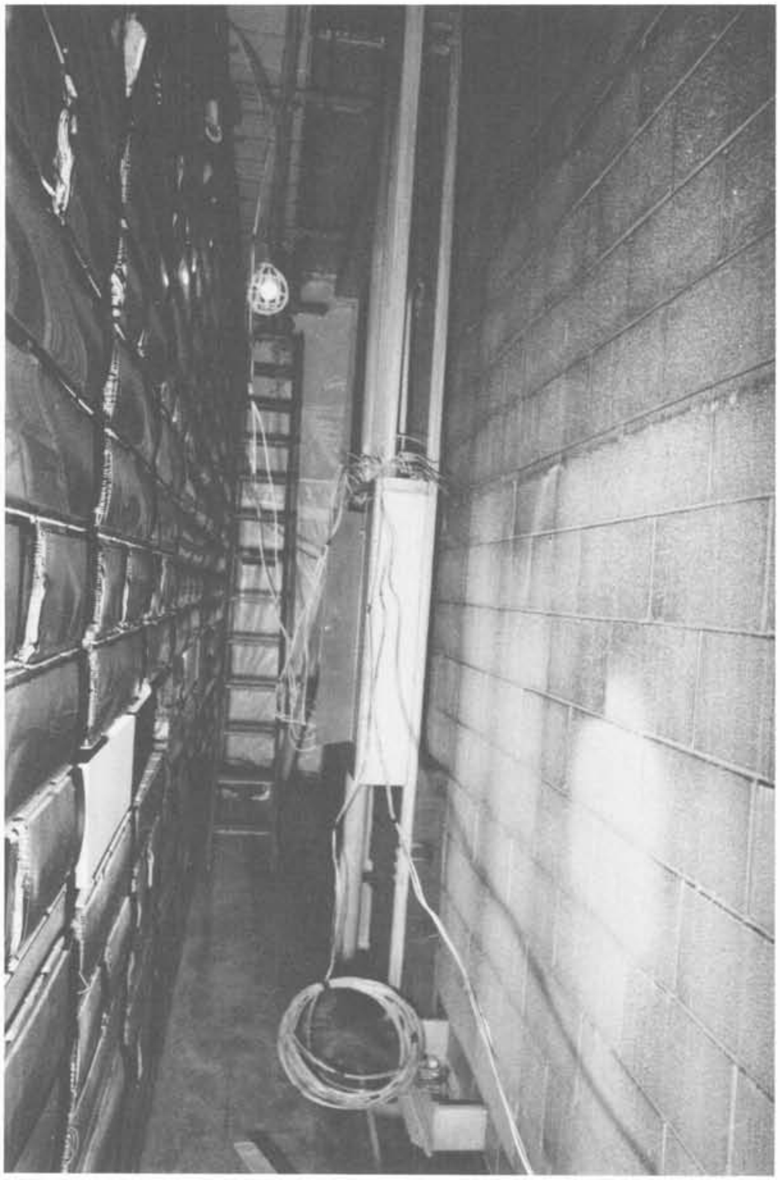
Photograph 3-20.
Spalling of concrete above arced cables in cable trays, Section 2.



Photograph 3-21.
Burn and melt limits near north wall.

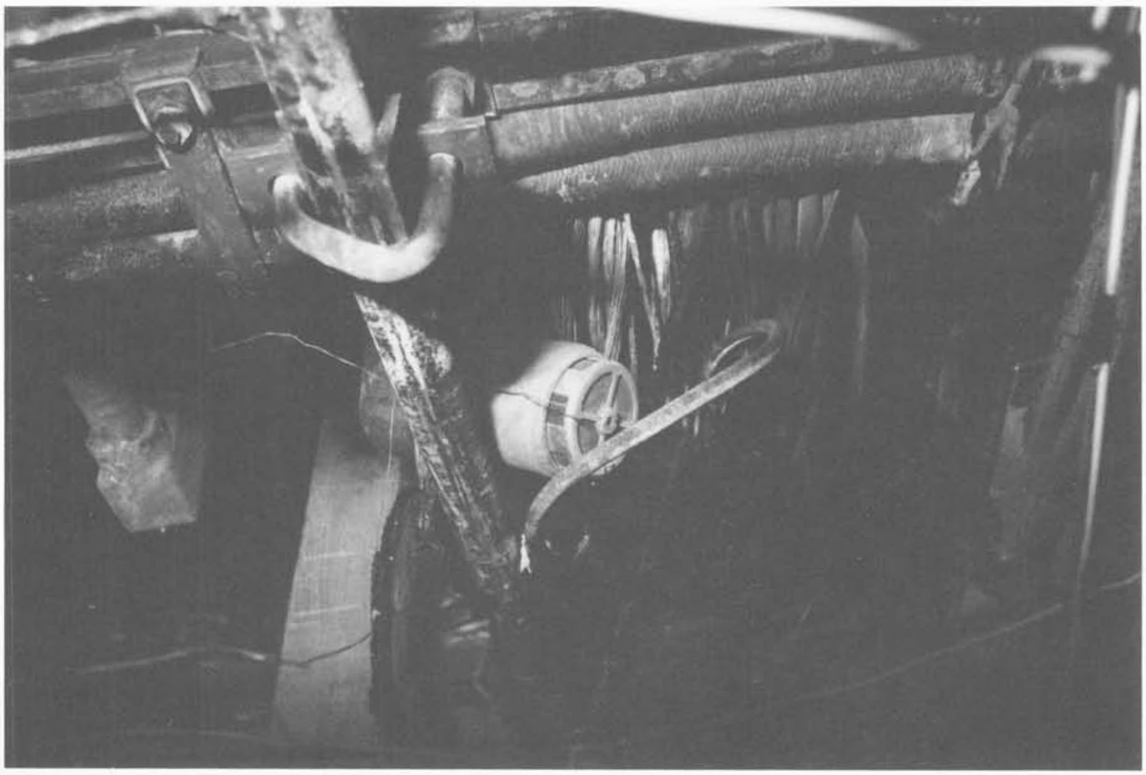


Photograph 3-23.
Soot buildup on equipment bays above B cut, Section 1.

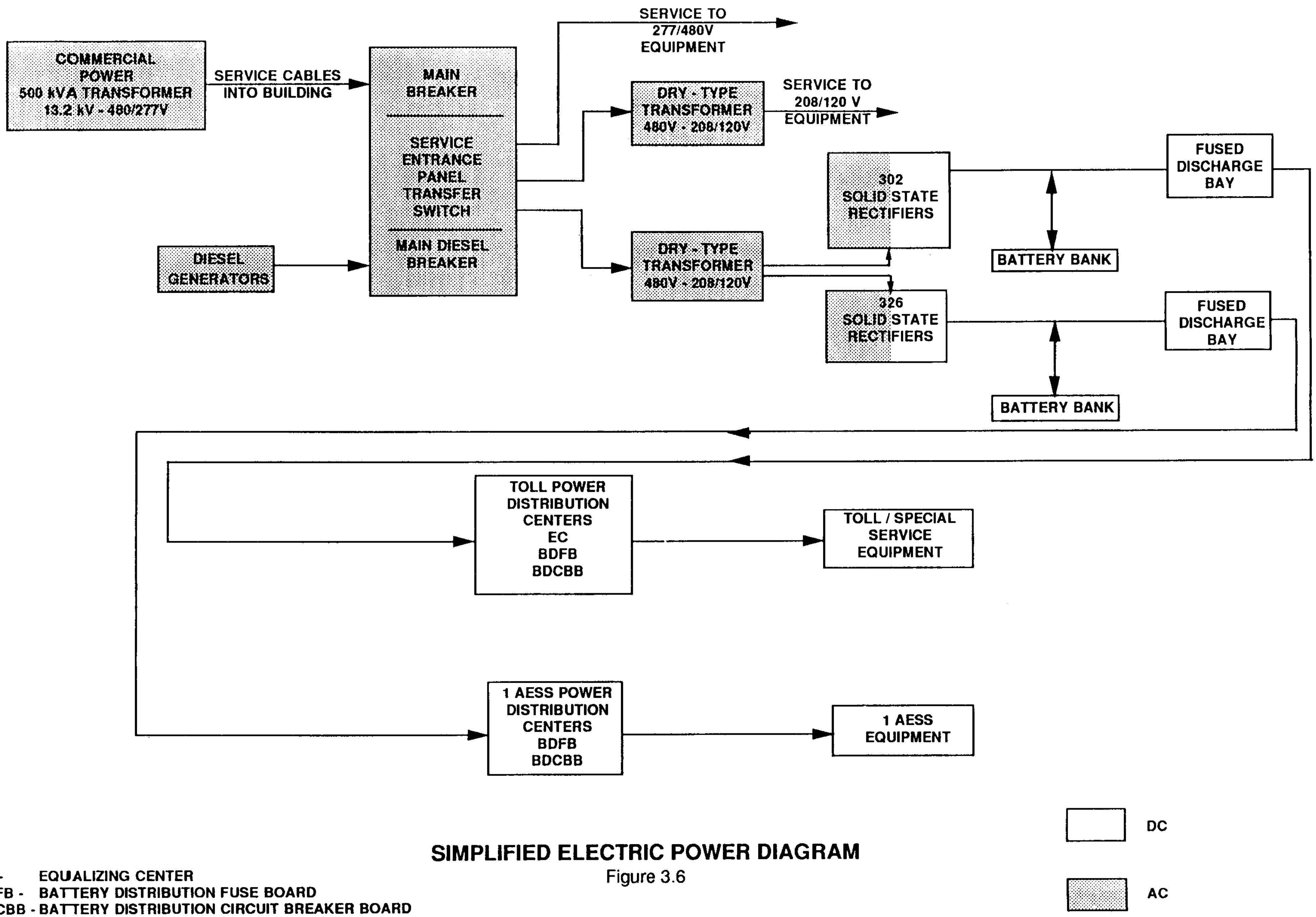


Photograph 3-25.
Smoke damage in northwest corner of toll area,
first floor. (North wall.)

Photograph 3-26.
Pyrotronics fire alarm annunciator panel
on the first floor.



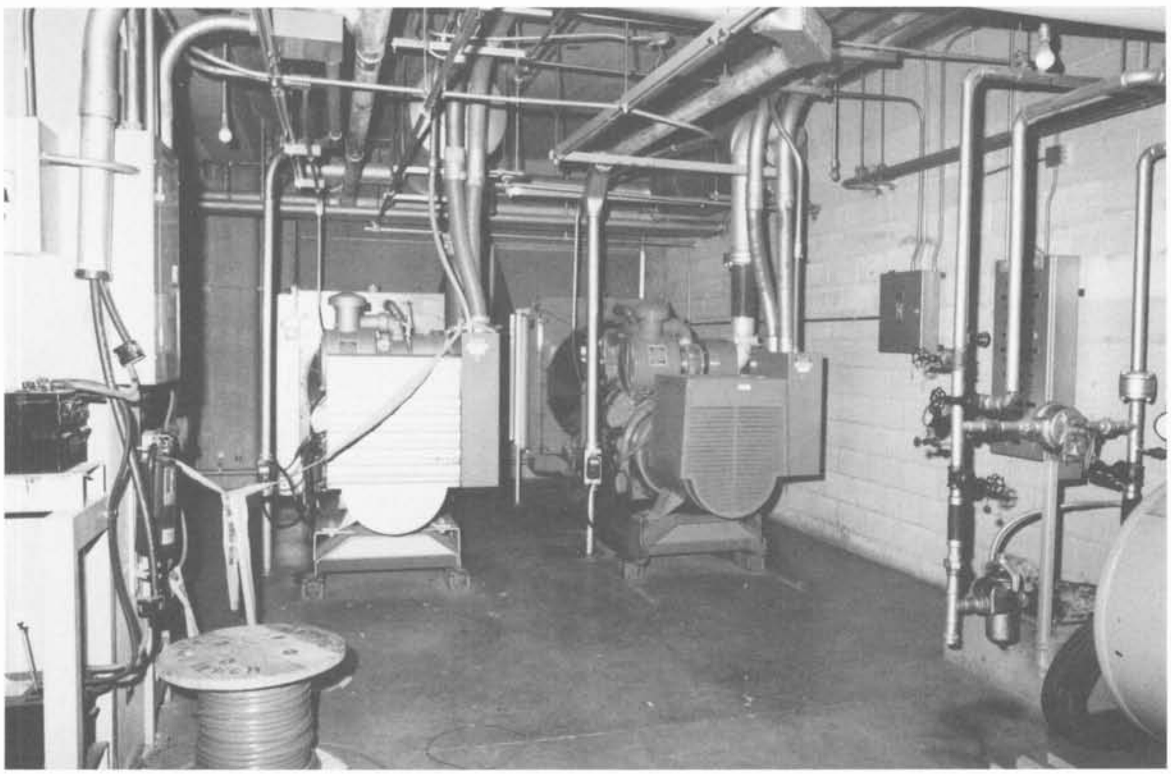
Photograph 3-27.
Pyrotronics ionization smoke detector (typical).



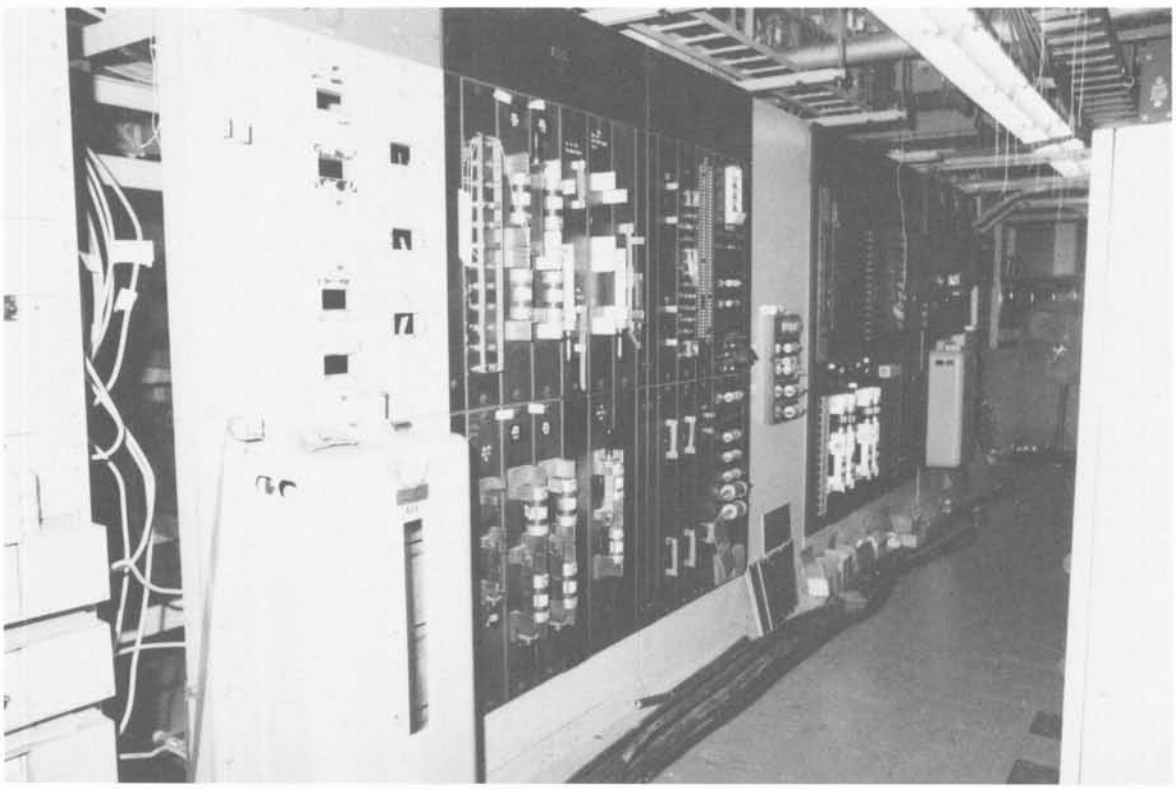
SIMPLIFIED ELECTRIC POWER DIAGRAM

Figure 3.6

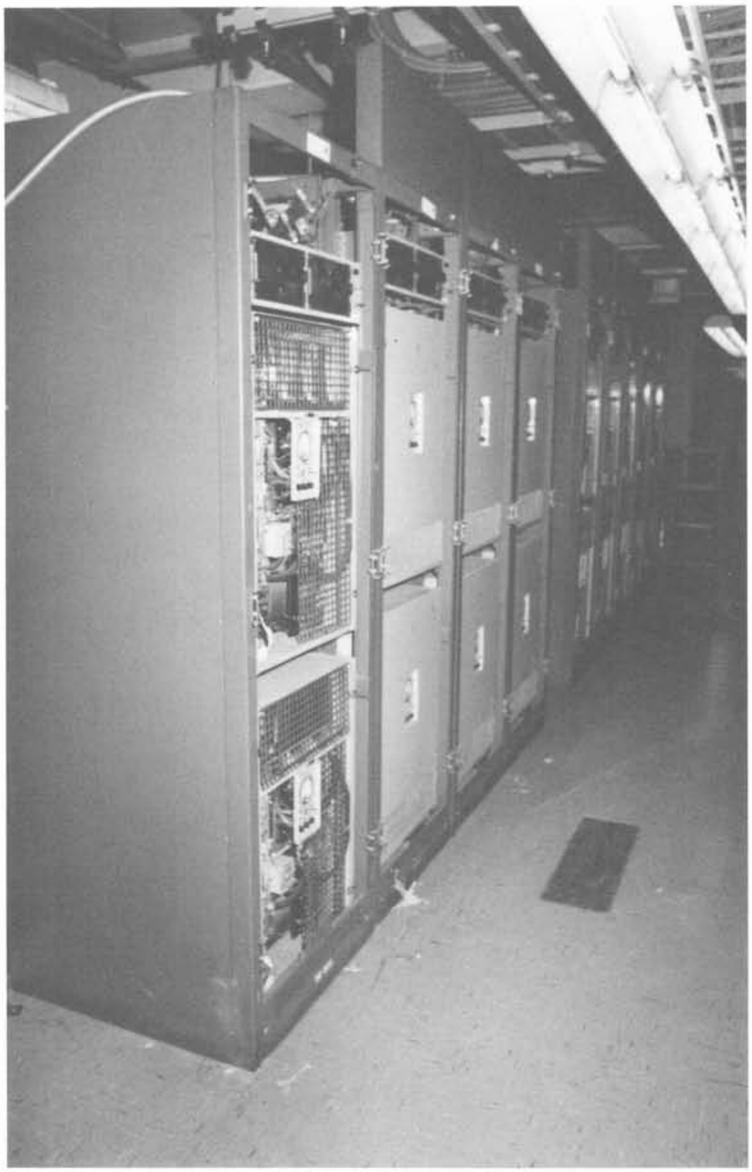
EC - EQUALIZING CENTER
BDFB - BATTERY DISTRIBUTION FUSE BOARD
BDCBB - BATTERY DISTRIBUTION CIRCUIT BREAKER BOARD



Photograph 3-34.
Diesel generators in basement.



Photograph 3-38.
302 power system fused discharge panel.



Photograph 3-32.
326 power supply regulator bays in basement.

Photograph 3-33.
326 power supply fused discharge bay in basement.

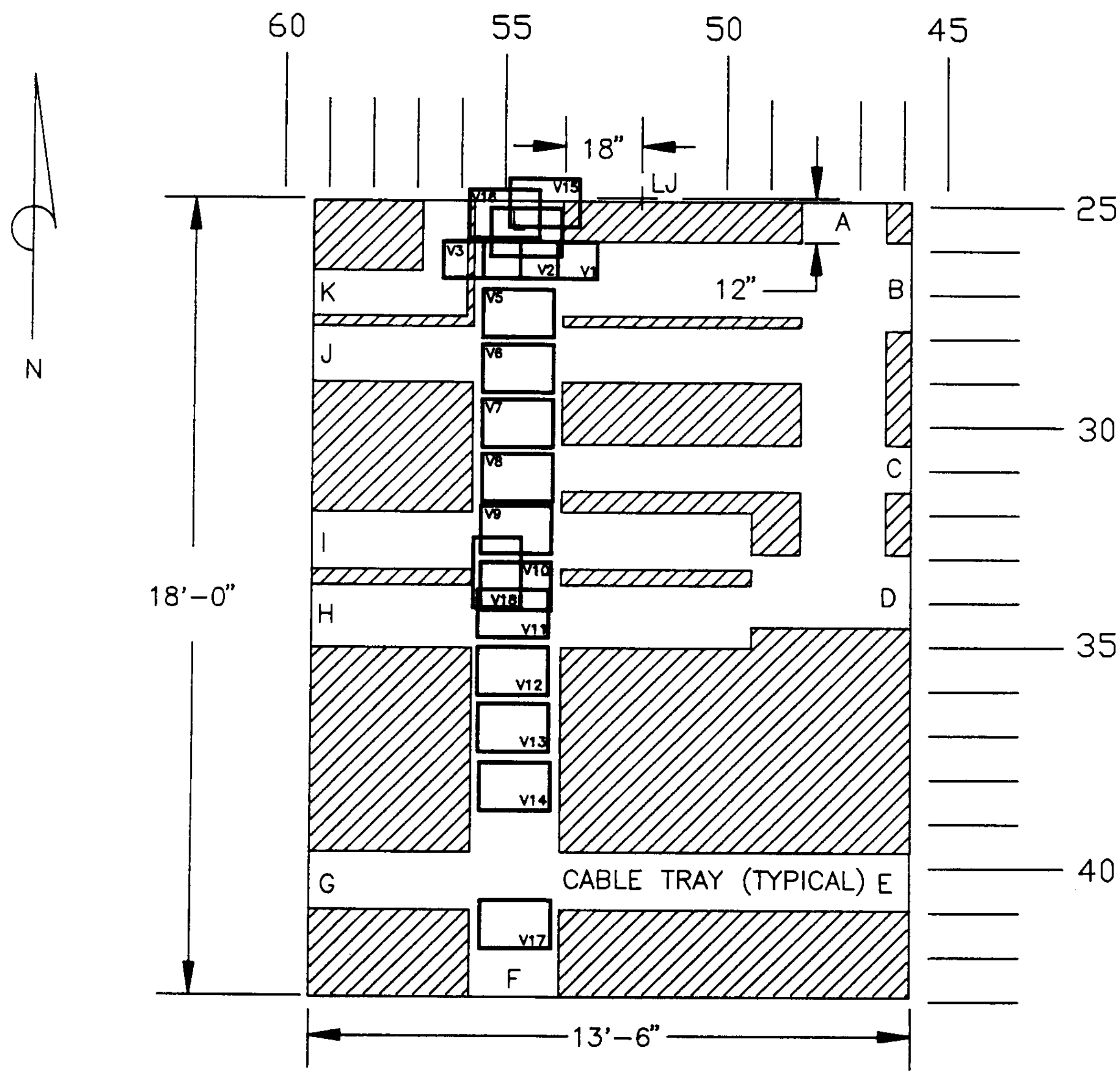
Photograph 3-42.
Section 1 and 2 extractions prepared for shipment to storage facility.

Photograph 3-43.
Loading Section 2 into truck for transfer to storage facility.

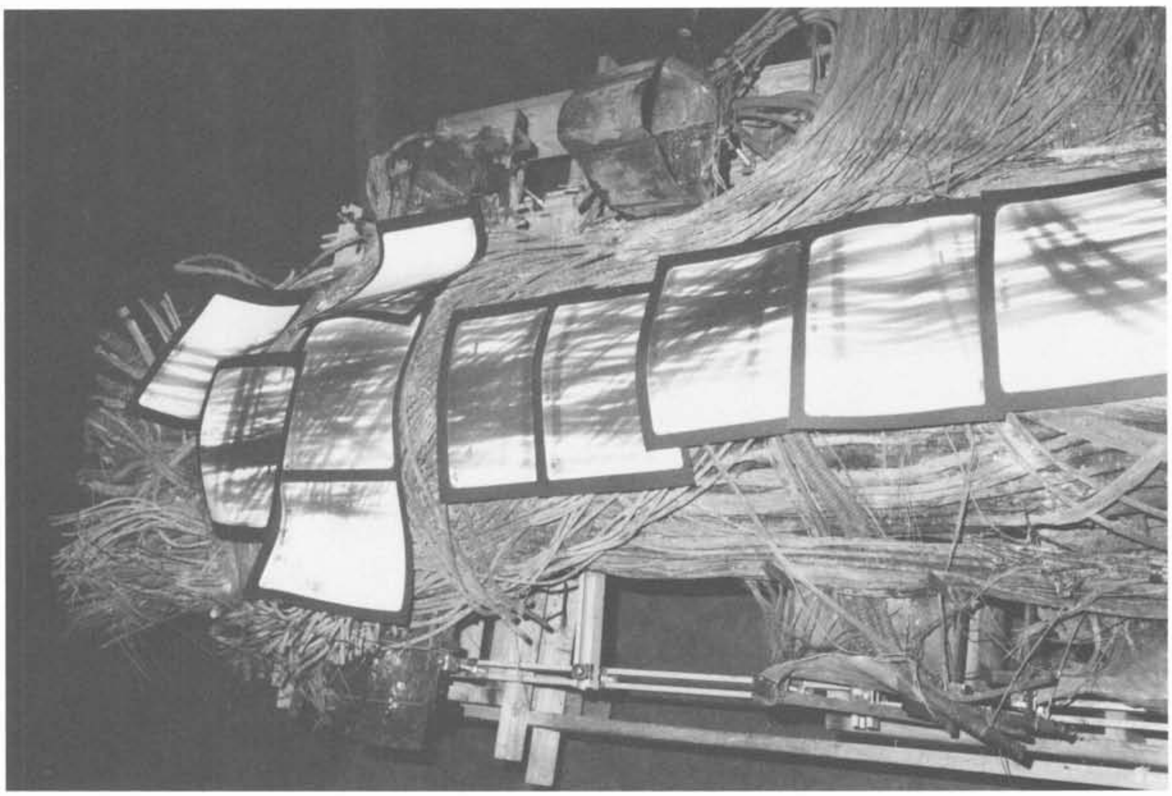
Photograph 3-44.
Dissection of Section 1, removing artifacts of special interest.

Photograph 3-46.
Dissection of Section 1, removing artifacts of special interest.

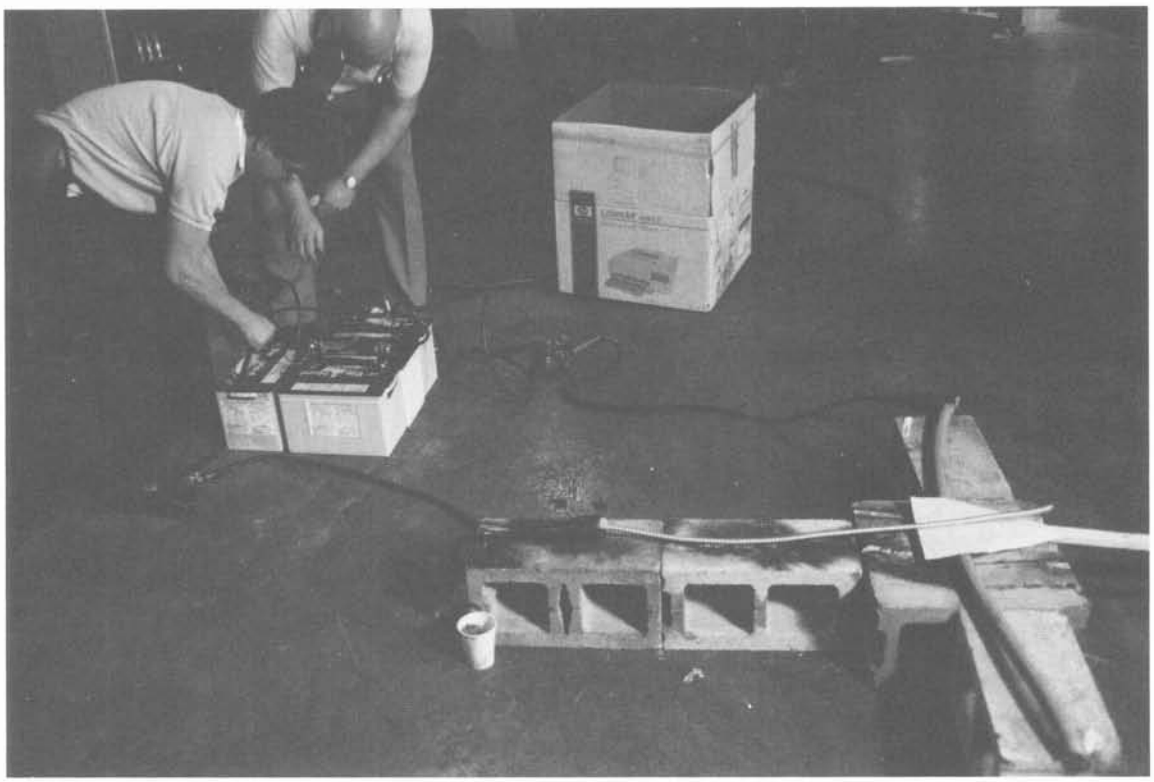
Photograph 3-52.
Communications cable deformed by pressing against cable tray stanchion.



CABLE TRAY SECTION 1
RADIOGRAPH LOCATIONS
Figure 3.7

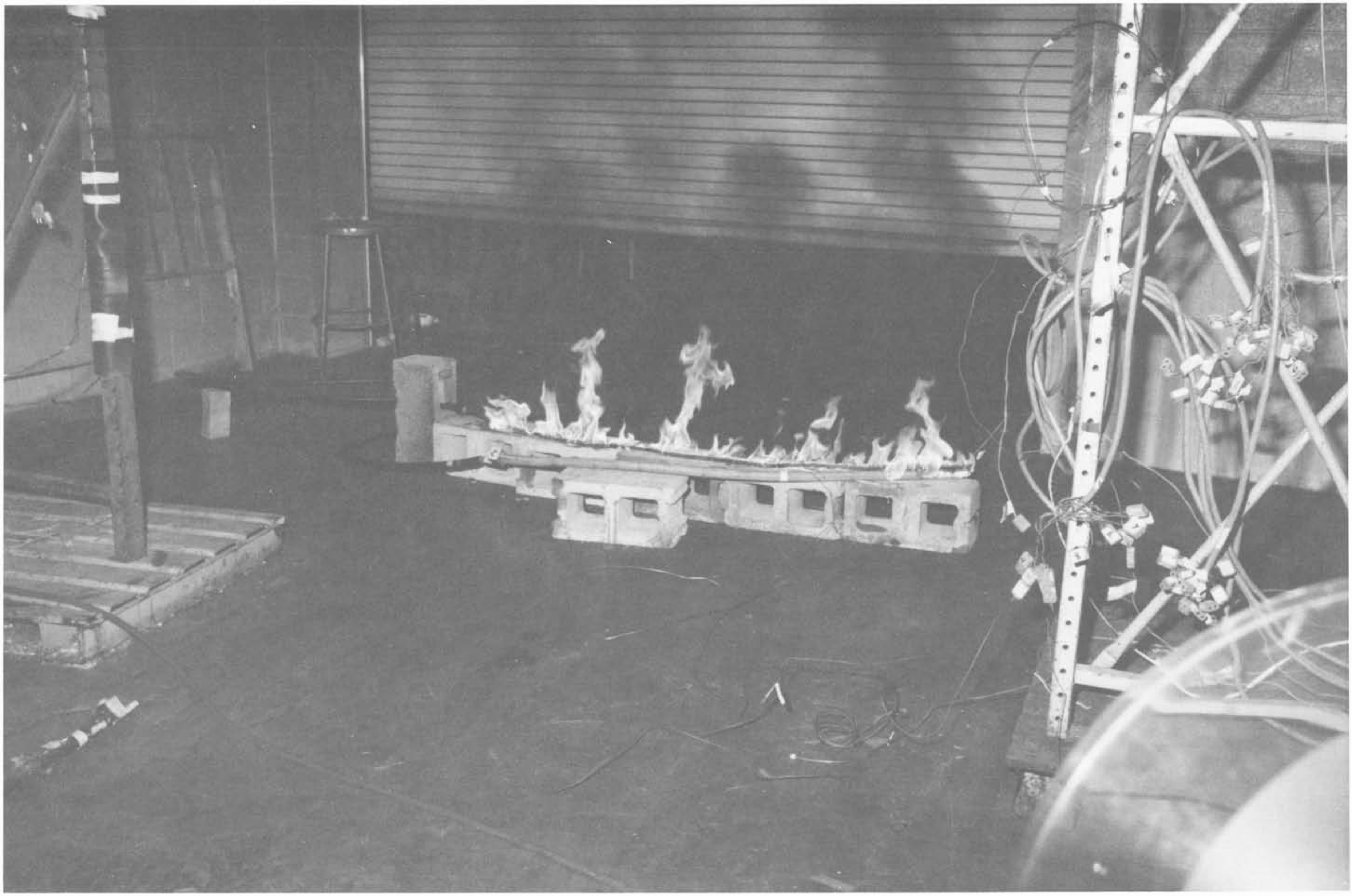


Photograph 3-60.
Radiograph prints positioned on L cut end of Section 1.

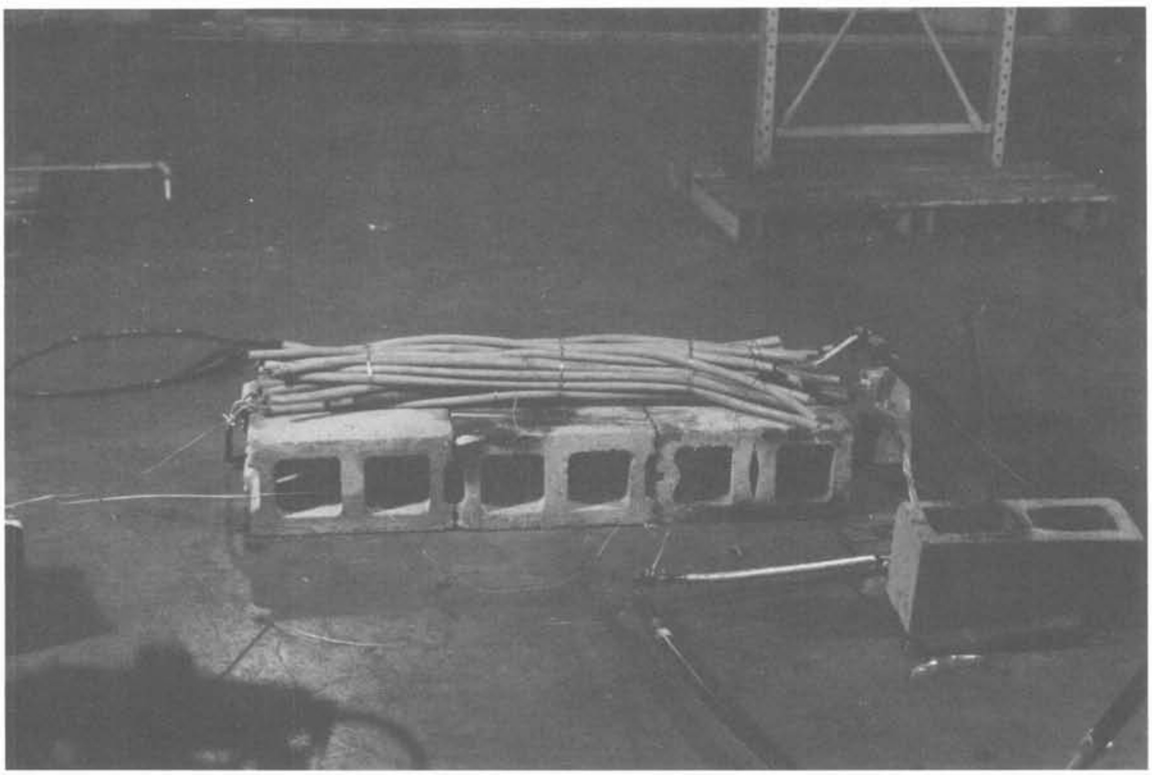


Photograph 72.
Test SS-4, setup showing battery source.

Photograph 64.
Test BX-3, power cable placed on glowing armored cable.

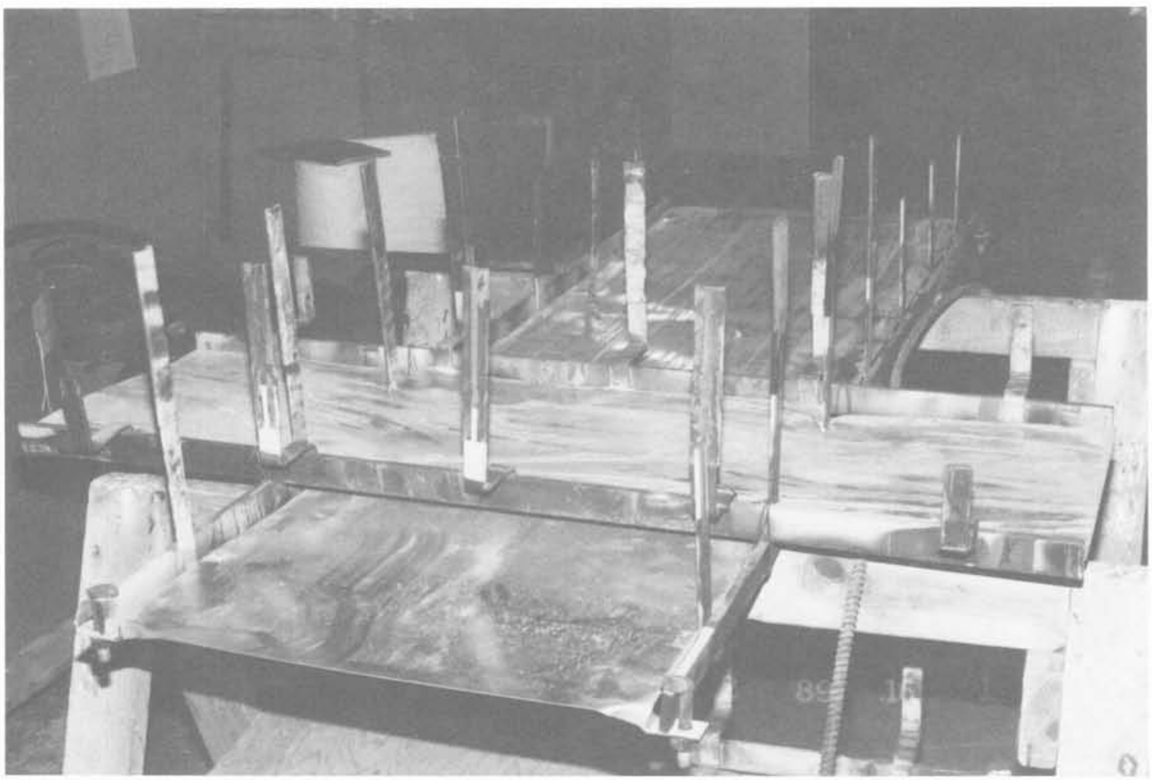


Photograph 4-2.
Test BX-4, Aluminum armor of cable burning.



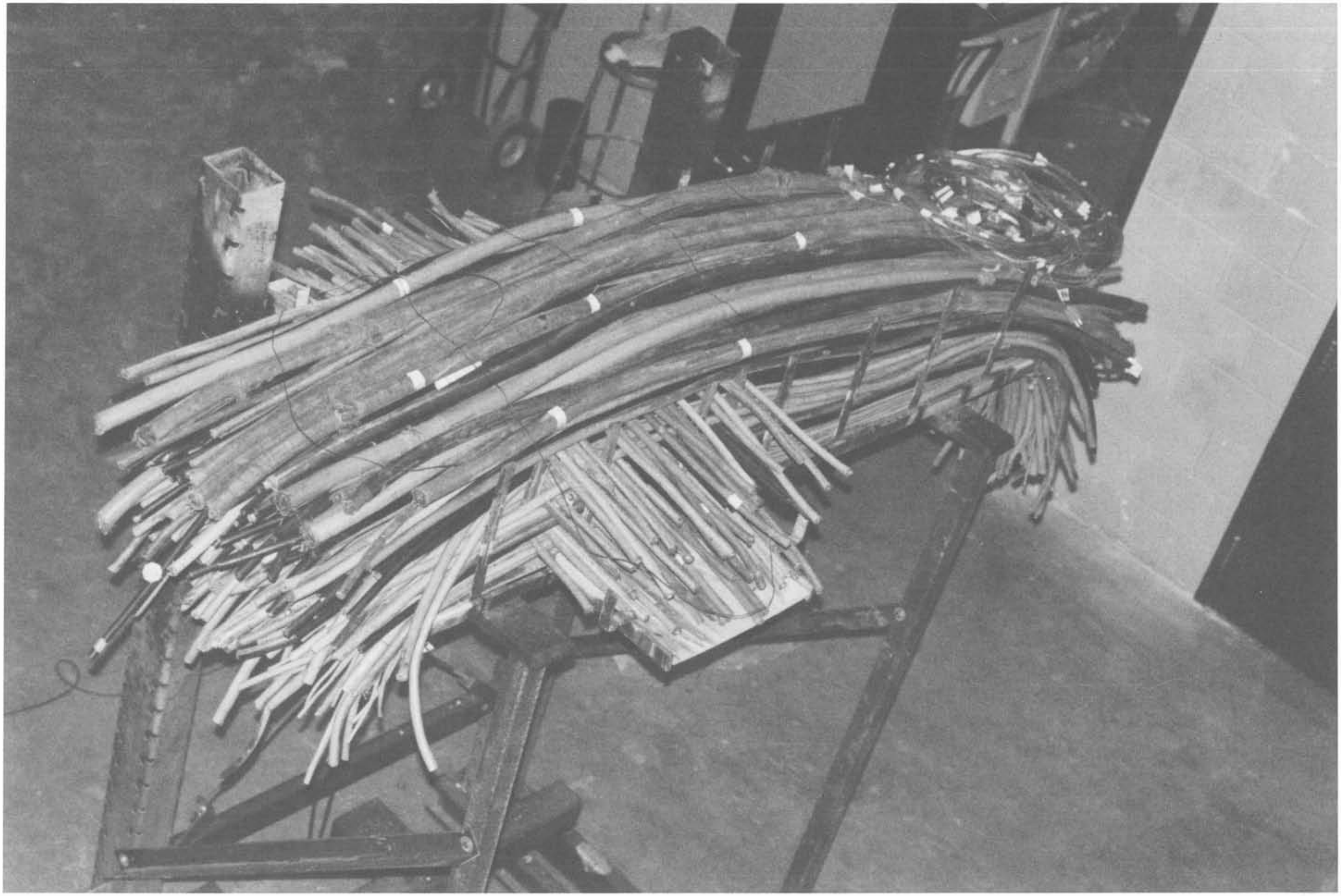
Photograph 75.
Test SS-9, setup.

Photograph 4-6.
Test SS-9, arcing, full involvement of cable bundle.

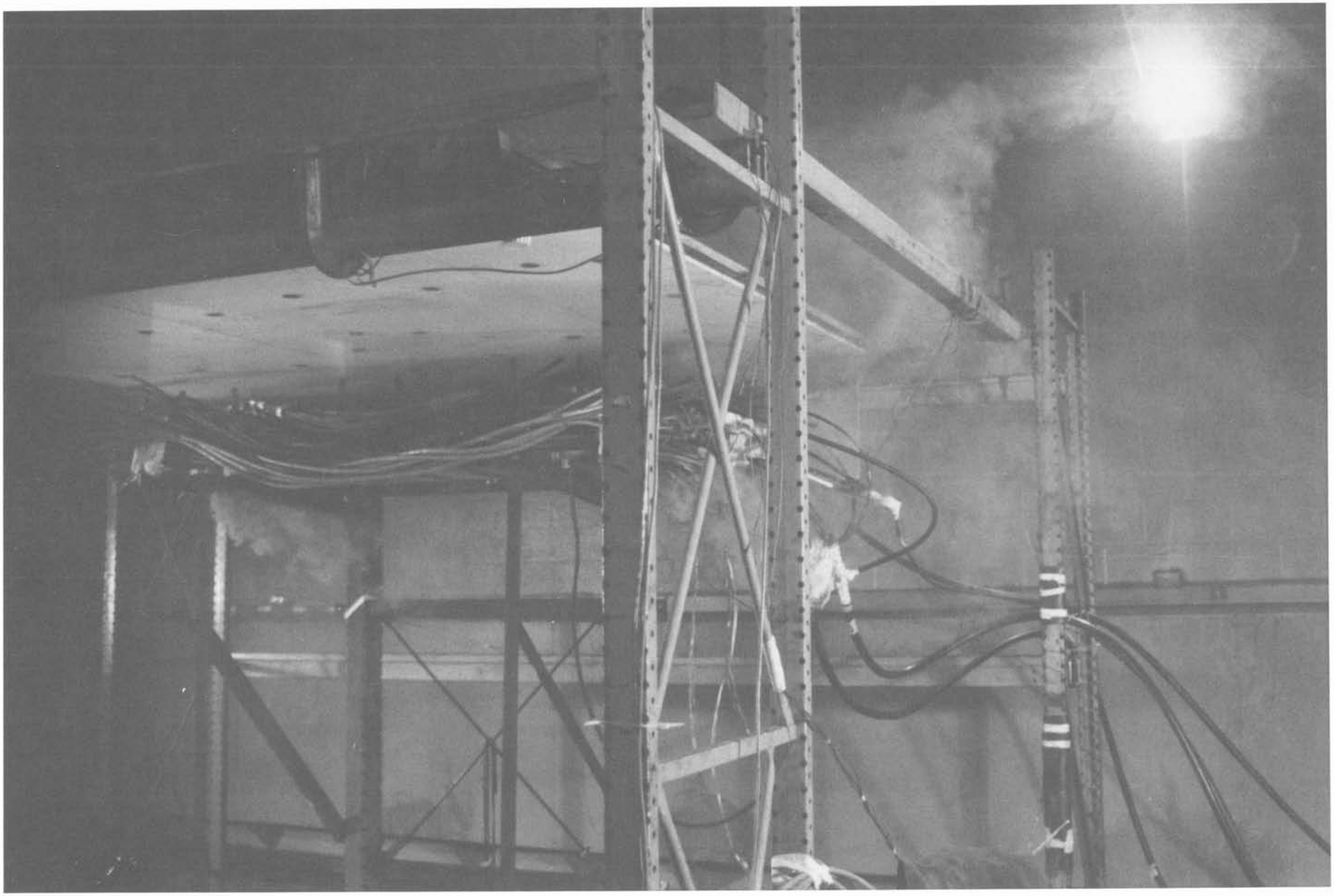


Photograph 4-8.
Typical cable tray frame used for Tests 1 and 2.

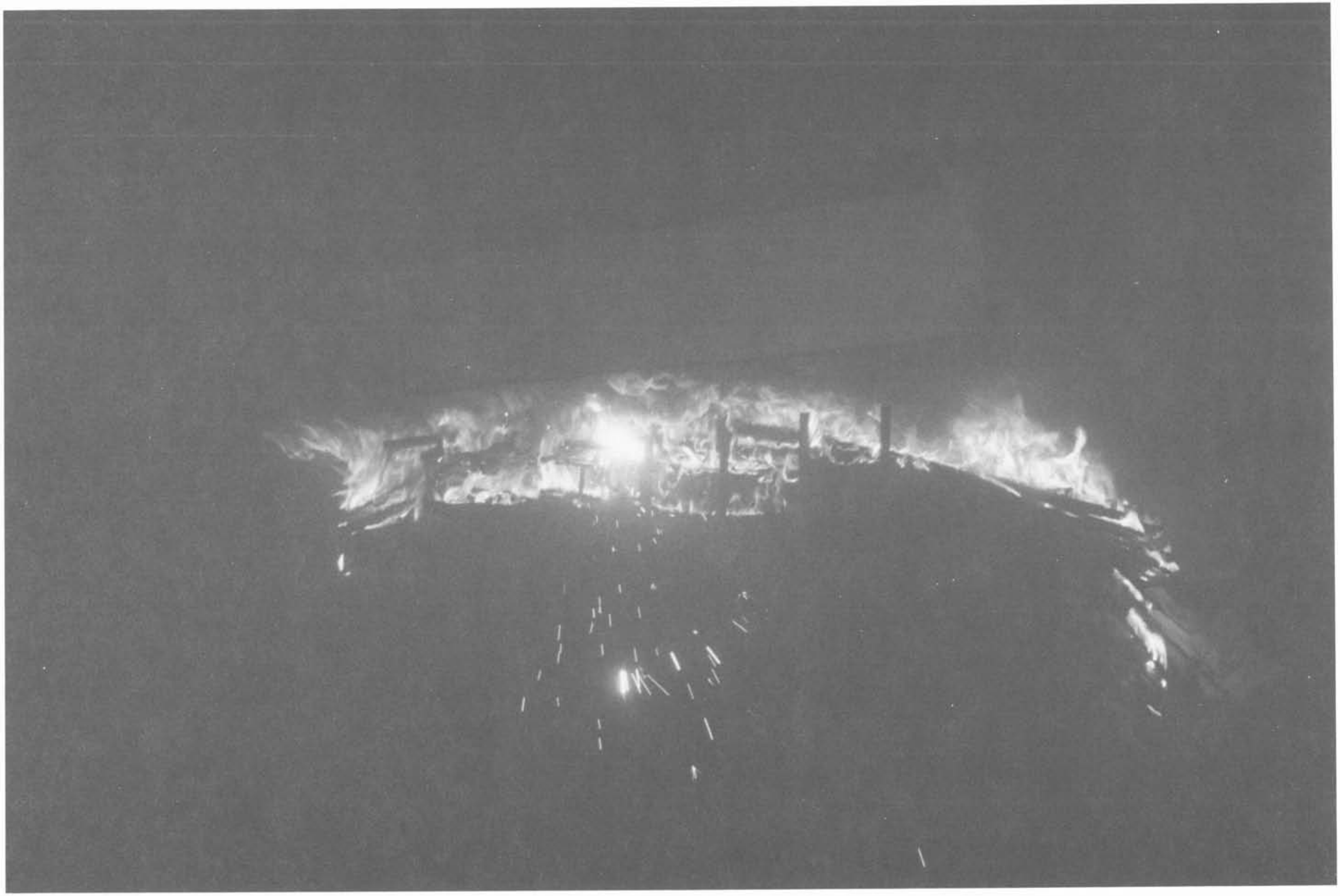
Photograph 4-11
Ignition cable on test tray bundle.



Photograph 4-13.
Test specimen typical ULN-1 and ULN-2.

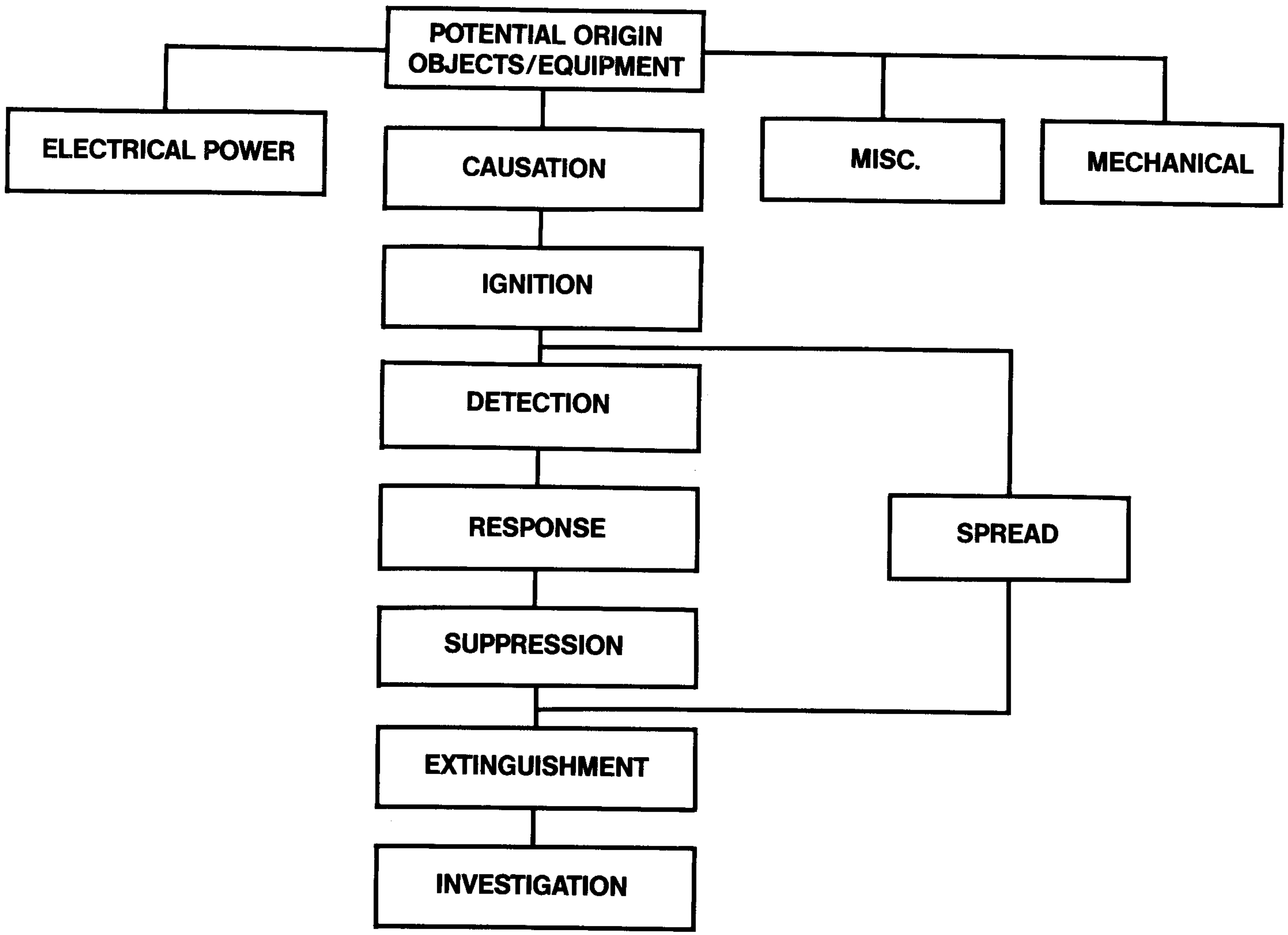


Photograph 4-31.
Test ULN-3 during test.

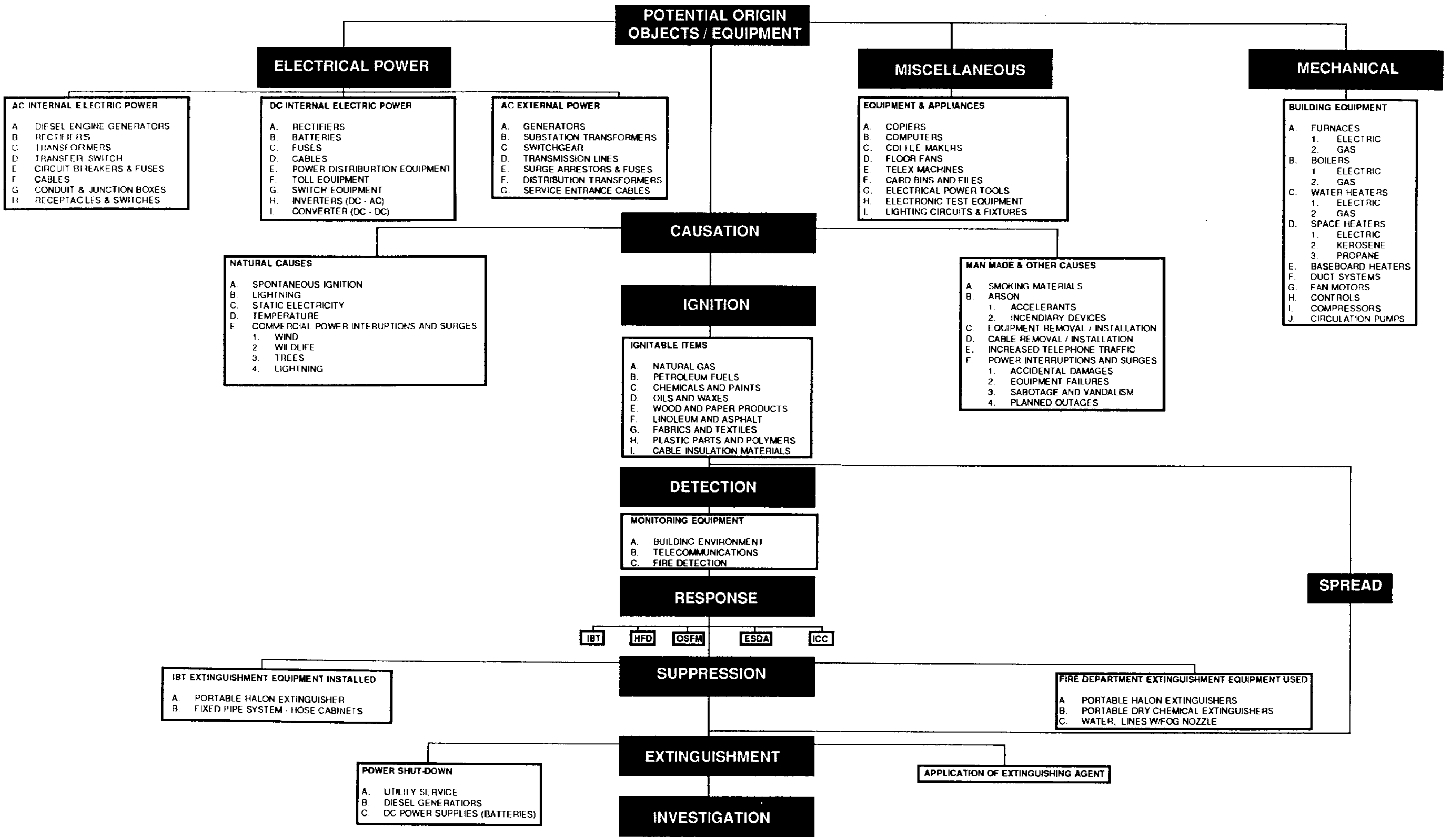


Photograph 4-20.
Fully involved cable bundle; arcing to stanchion, Test ULN-2.

HINSDALE CENTRAL OFFICE FIRE
FAILURE ANALYSIS LOGIC TREE



IBT HINSDALE CENTRAL OFFICE FIRE FAILURE ANALYSIS LOGIC TREE



CONCLUSIONS

- General
- Fire cause and origin
- Fire detection and response
- Fire suppression and damage control
- Fire potential assessment
- Central office power system

FIRE CAUSE AND ORIGIN

- The fire was accidental in nature and caused by an electrical fault
- An armored cable contacted a damaged DC power cable
- A DC power cable was most likely damaged at some time during cable mining operations
- An exact point of fire origin was not determined

FIRE DETECTION AND RESPONSE

- The smoke/fire detection system was adequate
- Fire alarm signals required operator interpretation
- Company procedures were not followed completely
- Elapsed time between fire detection and reporting was excessive

FIRE SUPPRESSION AND DAMAGE CONTROL

- Water effectively extinguished the fire after power was shut off
- Cable insulation materials produced large volumes of smoke and corrosive gases
- Damage was primarily due to non-thermal effects
- Vertical fire controls were sufficient
- Horizontal fire controls were limited

FIRE POTENTIAL ASSESSMENT

- Armored cables mixed with DC power cables in the cable trays is potentially hazardous
- Power cables had undesirable fire characteristics
- Communications cables had desirable fire characteristics

CENTRAL OFFICE POWER SYSTEM

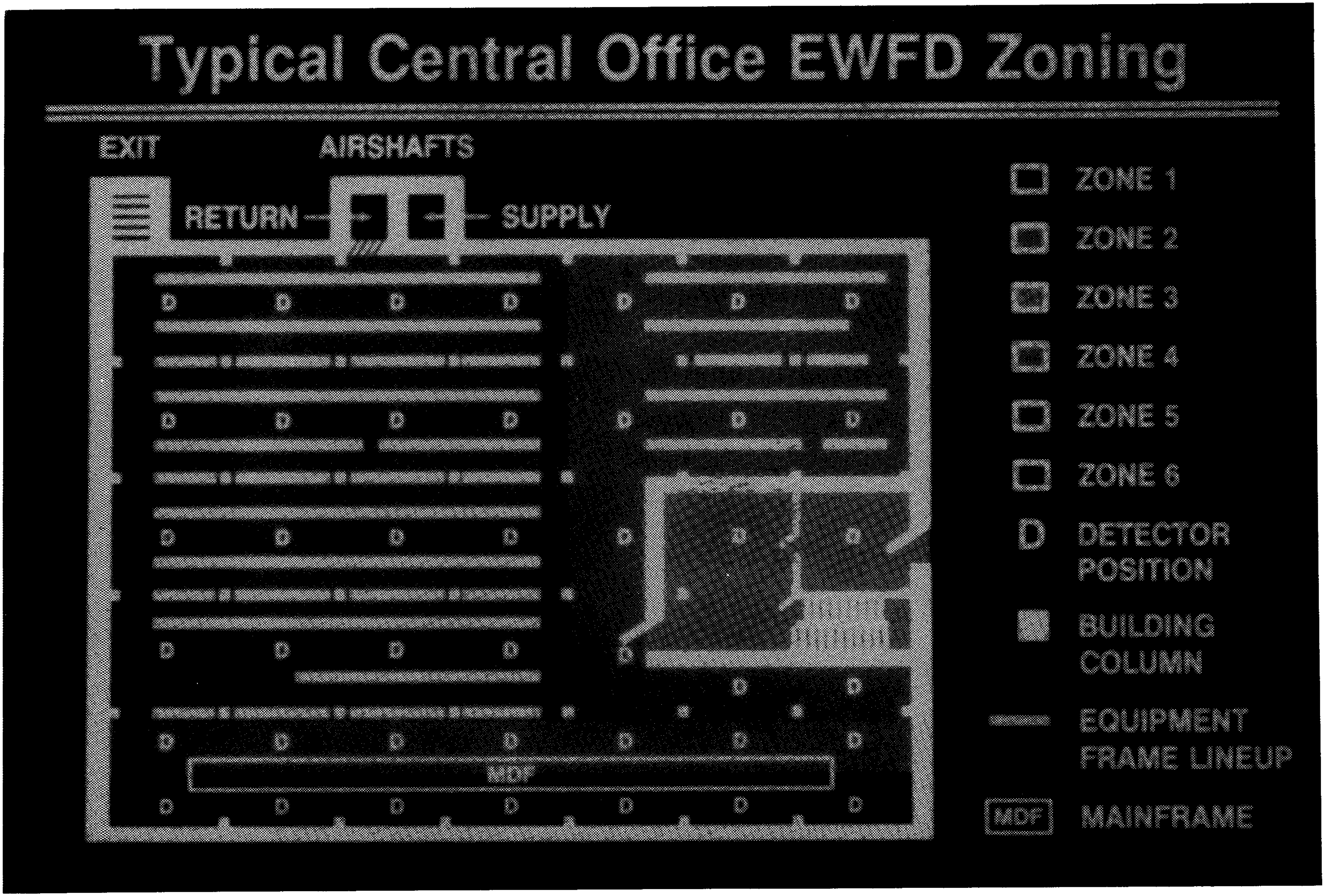
- Cable tray loading was excessive in some areas
- Mining operations damaged cable insulation
- Smaller power cables connected to larger cable bus centers may present a hazard
- The power deenergizing procedure was too complex, and not formalized
- Commercial power was subject to frequent interruptions

FIRE DETECTION, SUPPRESSION AND CONTAINMENT

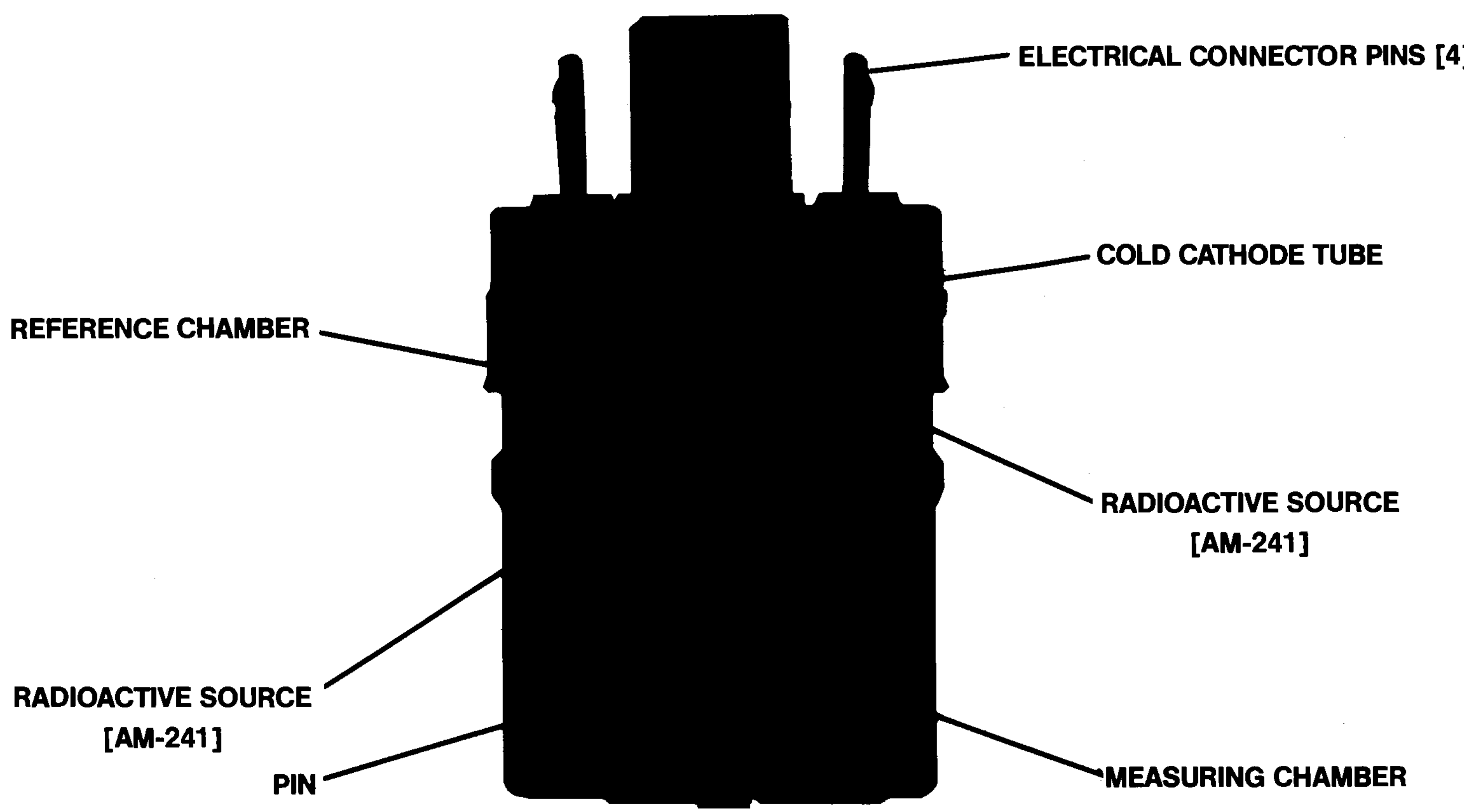
John Simpson
District Manager —
Fire Protection and
Environmental Control
Technology
Bellcore

Early Warning Fire Detection (EWFD)

- Objectives
  - Fast detection of growth fires
  - Response to different fire types
  - Ceiling-mounted spot detection for equipment bays
  - Zoning of detectors
  - Ready site identification
  - Remote monitoring of signals
- Assumes trained fire fighting response


Typical Central Office EWFD Zoning
EXIT
AIRSHAFTS
RETURN
SUPPLY
MDF
ZONE 1
ZONE 2
ZONE 3
ZONE 4
ZONE 5
ZONE 6
D DETECTOR POSITION
BUILDING COLUMN
EQUIPMENT FRAME LINEUP
MDF MAINFRAME

IONIZATION TYPE SMOKE DETECTOR (220 VDC)

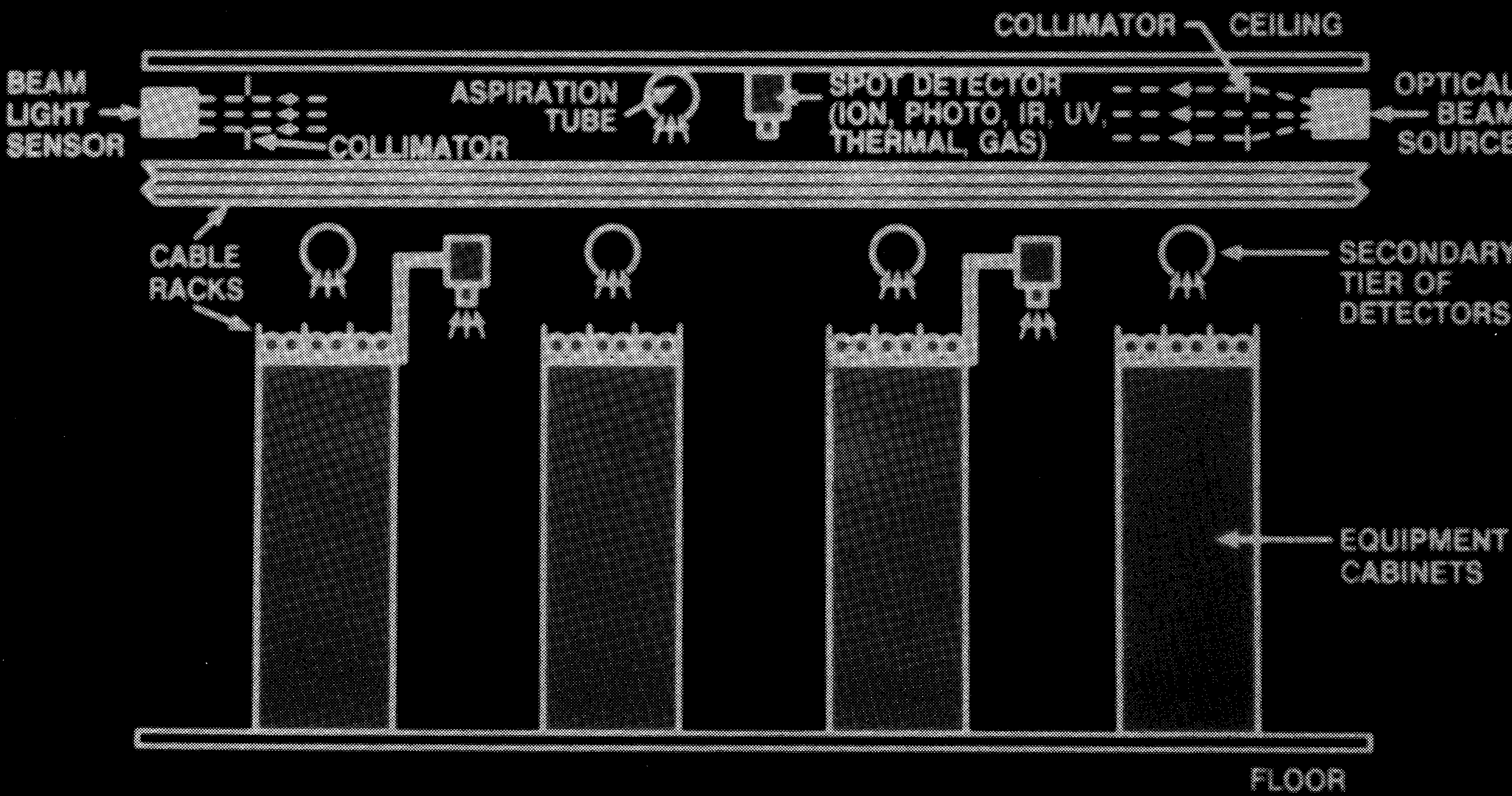


Other Detection Systems

- Spot detection
- Optical beam units
- Aspiration systems
- Specific gas detectors
- Video camera monitors
- Combining different detector types

Diagram Of Location Of Fire Detection Systems

(Elevated View)



Plan View Of Aspiration Detection System

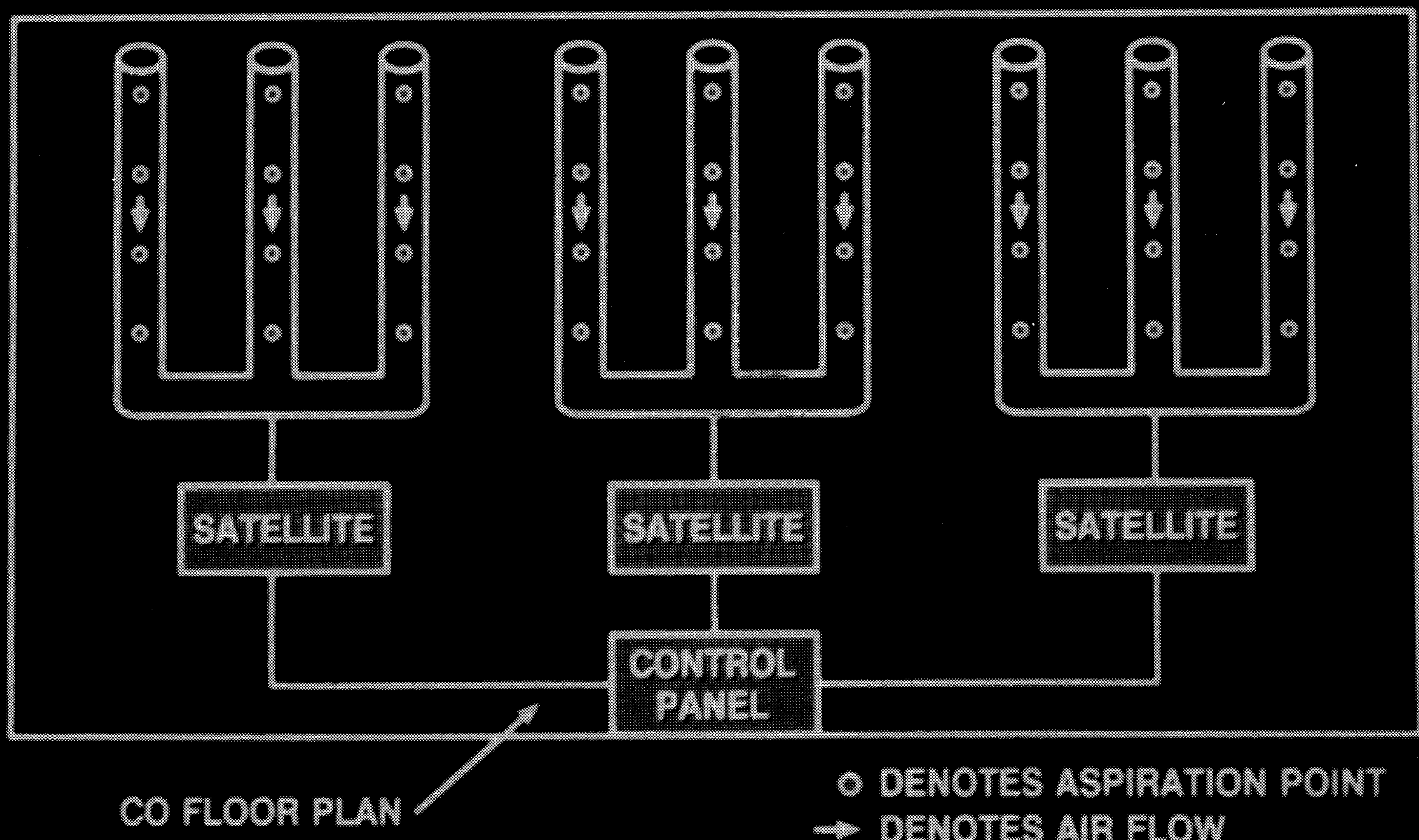
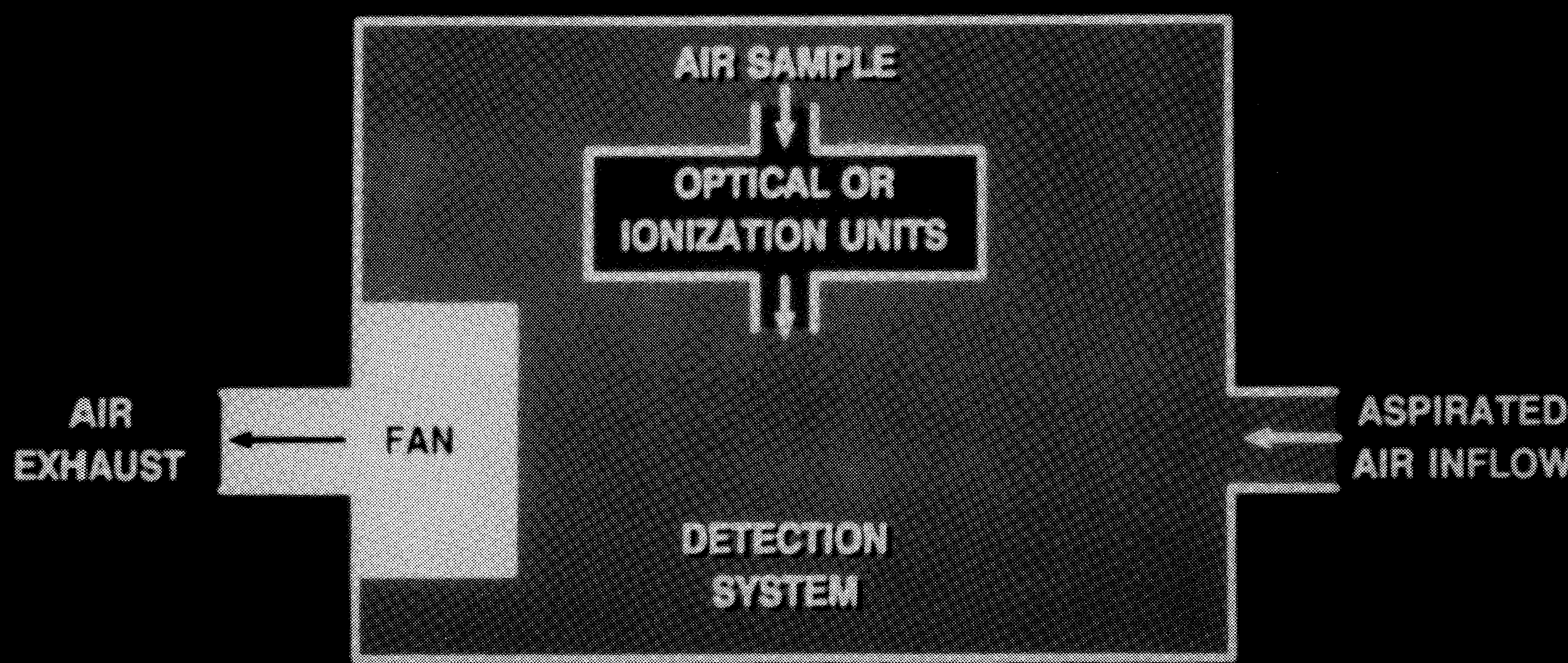
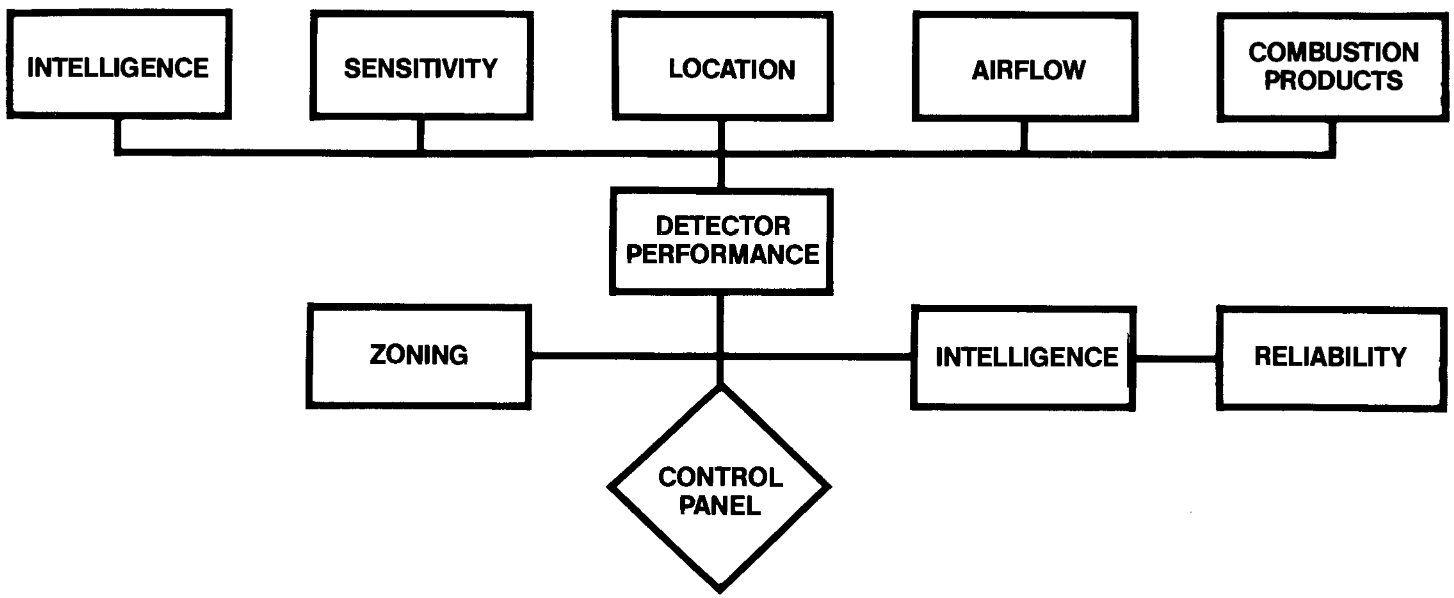


Diagram Of Aspiration Satellite




INTELLIGENCE
SENSITIVITY
LOCATION
AIRFLOW
COMBUSTION PRODUCTS
DETECTOR PERFORMANCE
ZONING
INTELLIGENCE
RELIABILITY
CONTROL PANEL

Future Detection Direction

- Intelligent detection
- Reliable transmission
- Fast fire fighting response

Methods of Fire Suppression

- Manual
- Automatic

Manual Fire Suppression

- Rapid detection
- Requires rapid response
  - Telco personnel
  - Fire department

Automatic Suppression Systems

- Water sprinkler systems
- Halon 1301
- Carbon dioxide

Sprinkler Systems for Electronic Equipment

- Advantages
  - Extinguishes most fires
  - Established technology
- Disadvantages
  - Limitations regarding electrical equipment
  - Electrolytic corrosion on contacts
  - Enhanced corrosivity
  - Risk due to leakage

Halon 1301 Systems for Electronic Equipment

- Advantages
  - Rapid extinguishment
  - Established technology
- Disadvantages
  - Requires sealed space
  - Limited effectiveness in "deep seated" electrical fires
  - Can cause corrosion
  - Environmental considerations

Carbon Dioxide Systems for Electronic Equipment

- Advantages
  - Effective under certain conditions
  - Non-corrosive
- Disadvantages
  - Requires high level of concentration
  - Toxicity
  - Thermal shock

Future Suppression Directions

- Enhanced EWFD
  - Circuit intelligence
  - Detector identification
  - Programmable levels of sensitivity
- Notification to local fire department
  - By control center
  - By EWFD remoting
- Limited utilization of fog nozzle water distribution
- Augment training of fire fighters

Fire Containment

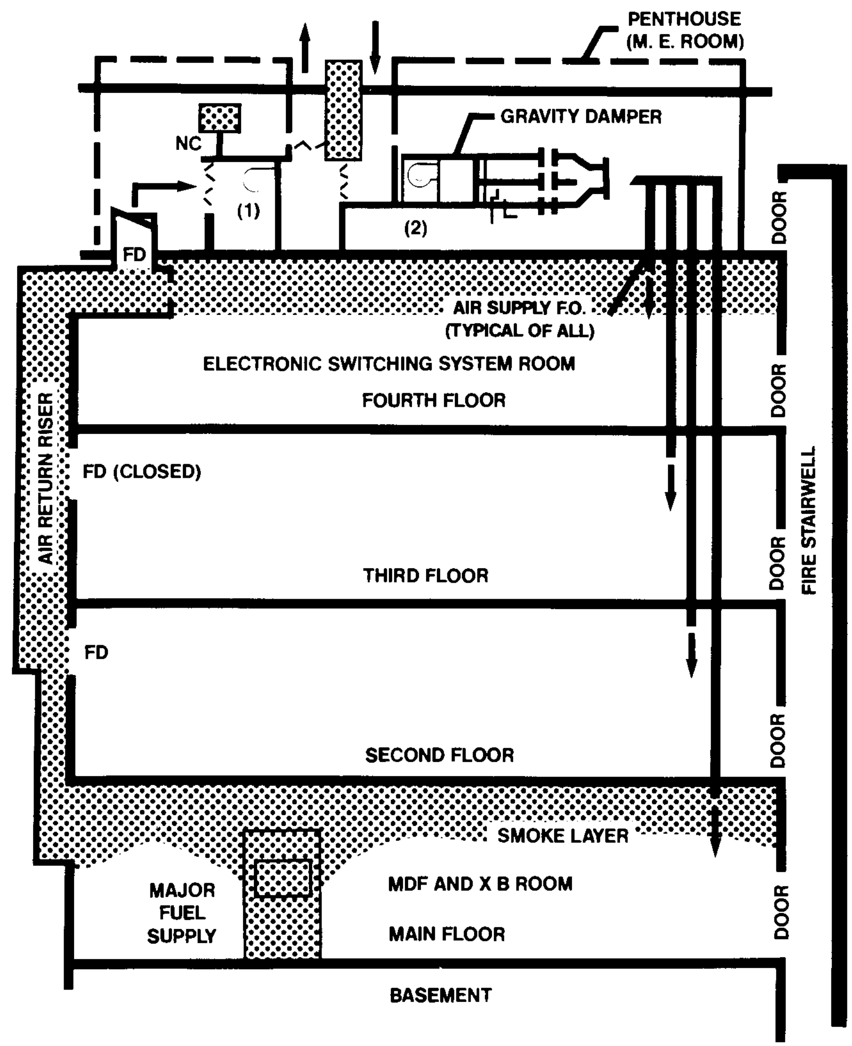
- Compartmentation of equipment by function
  - Cable entrance facilities
  - Administrative areas
  - Power distribution areas
  - Building system equipment
  - Generally open equipment areas
- Firestopped cable and other penetrations

Smoke Containment

- HVAC system dependency on EWFD
- Passive smoke containment; fire/smoke dampers and doors
- Passive/dynamic smoke ventilation
- Dynamic fire room pressurization

Model of Smoke Distribution in a Multistoried Central Office

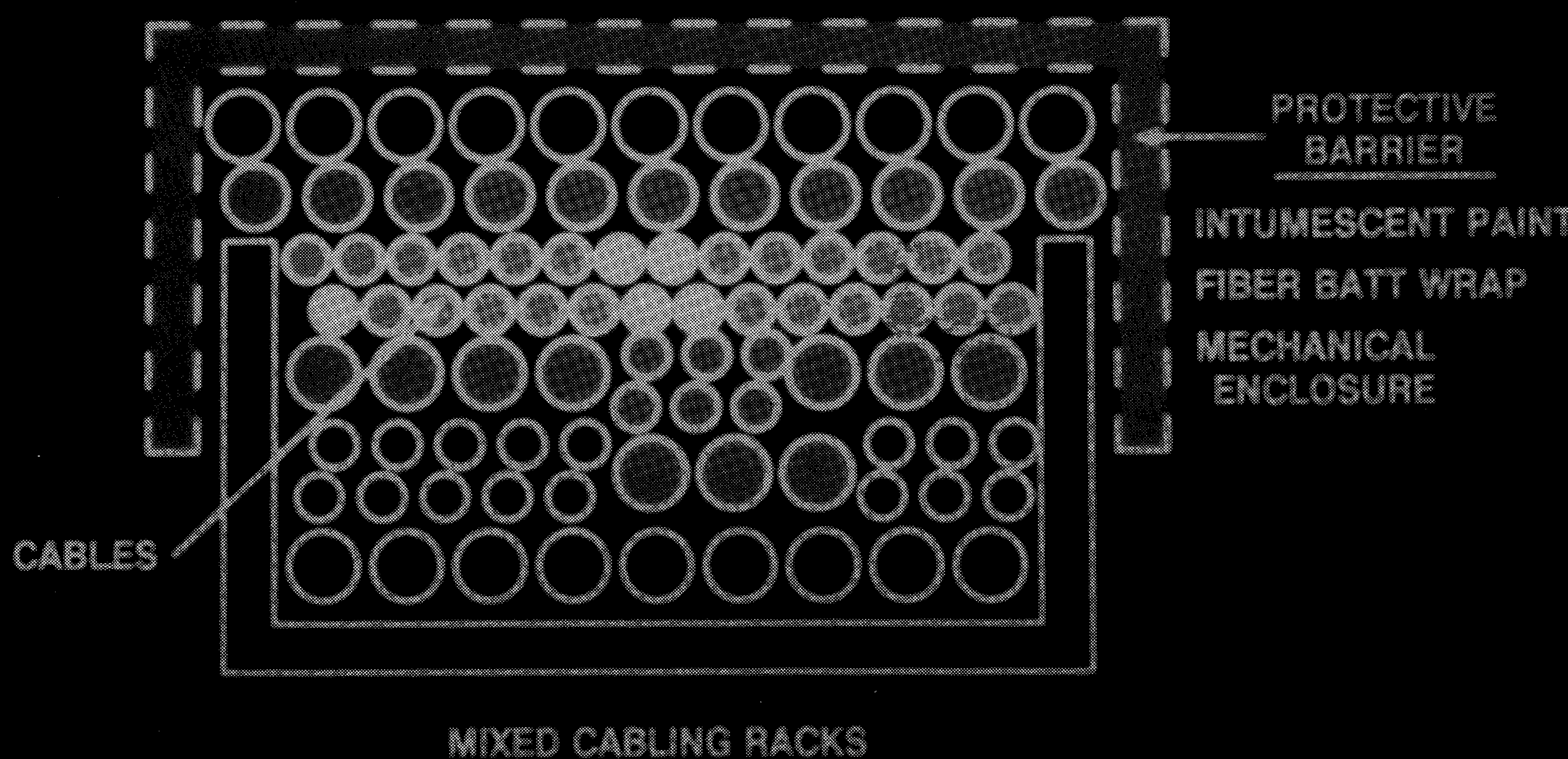
(Early Stages of Fire)

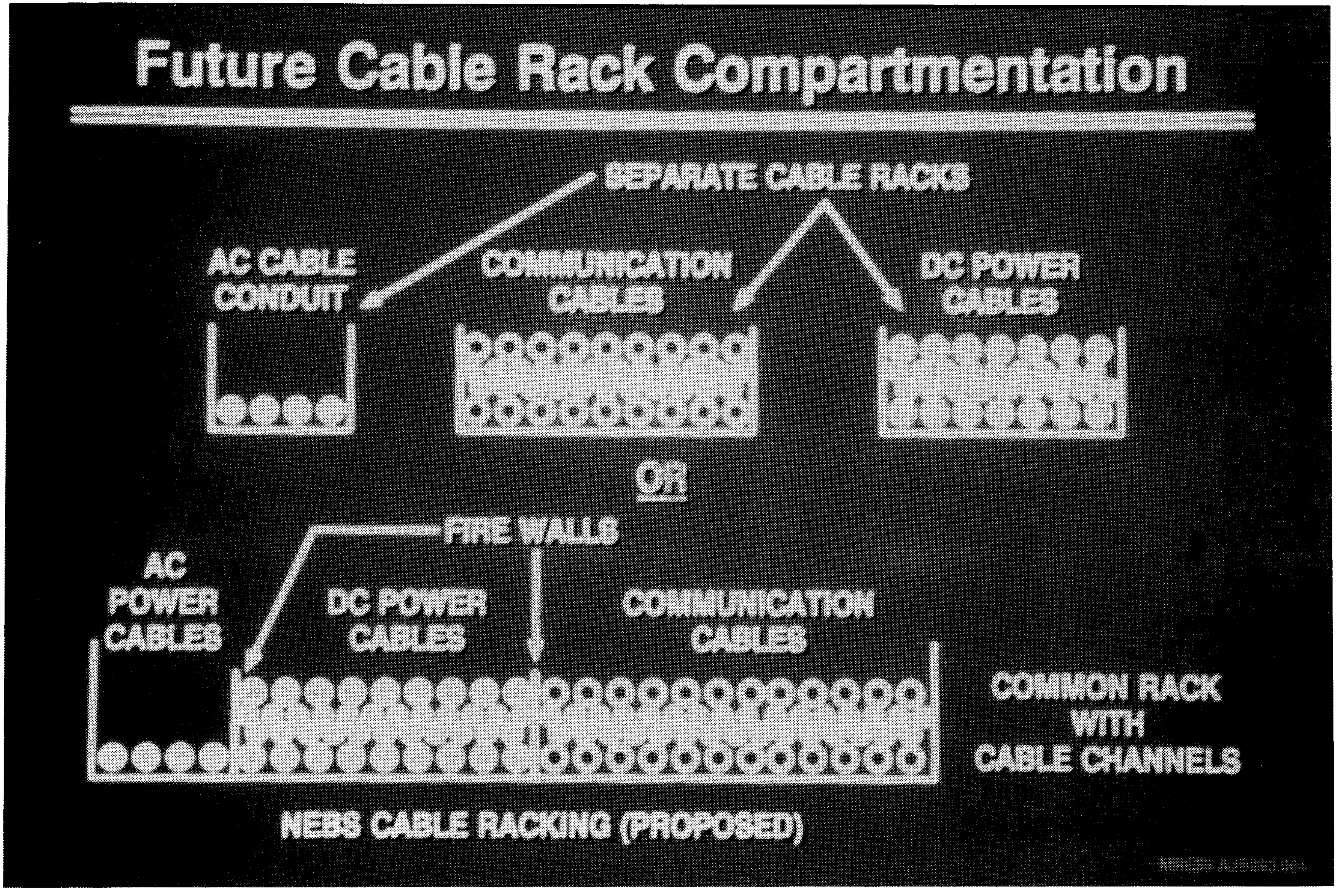


Future Containment Directions

- Enhanced compartmentation
  - Reduced fuel loads
  - Reduced smoke generation
  - Improved sealability
- Enhanced smokestopping
- Modular HVAC systems
  - Exhaust or ventilate fire zone
  - Pressurization of compartments and vertical spaces
  - Complete HVAC system integration
- Cable rack compartmentation

Existing Cable Rack Compartmentation





Future Cable Rack Compartmentation
SEPARATE CABLE RACKS
AC CABLE CONDUIT
COMMUNICATION CABLES
DC POWER CABLES
OR
FIRE WALLS
AC POWER CABLES
DC POWER CABLES
COMMUNICATION CABLES
COMMON RACK WITH CABLE CHANNELS
NEBS CABLE RACKING (PROPOSED)

COMBUSTIBILITY & CORROSIVITY

Barbara T. Reagor
District Manager –
Environmental and
Contaminants Research
Bellcore

COMBUSTION AND THERMAL DEGRADATION

- Products of combustion
  - Volatile gases (inorganic and organic)
  - Carbon soots and chars
  - Molten residues and ash

COMBUSTION AND THERMAL DEGRADATION

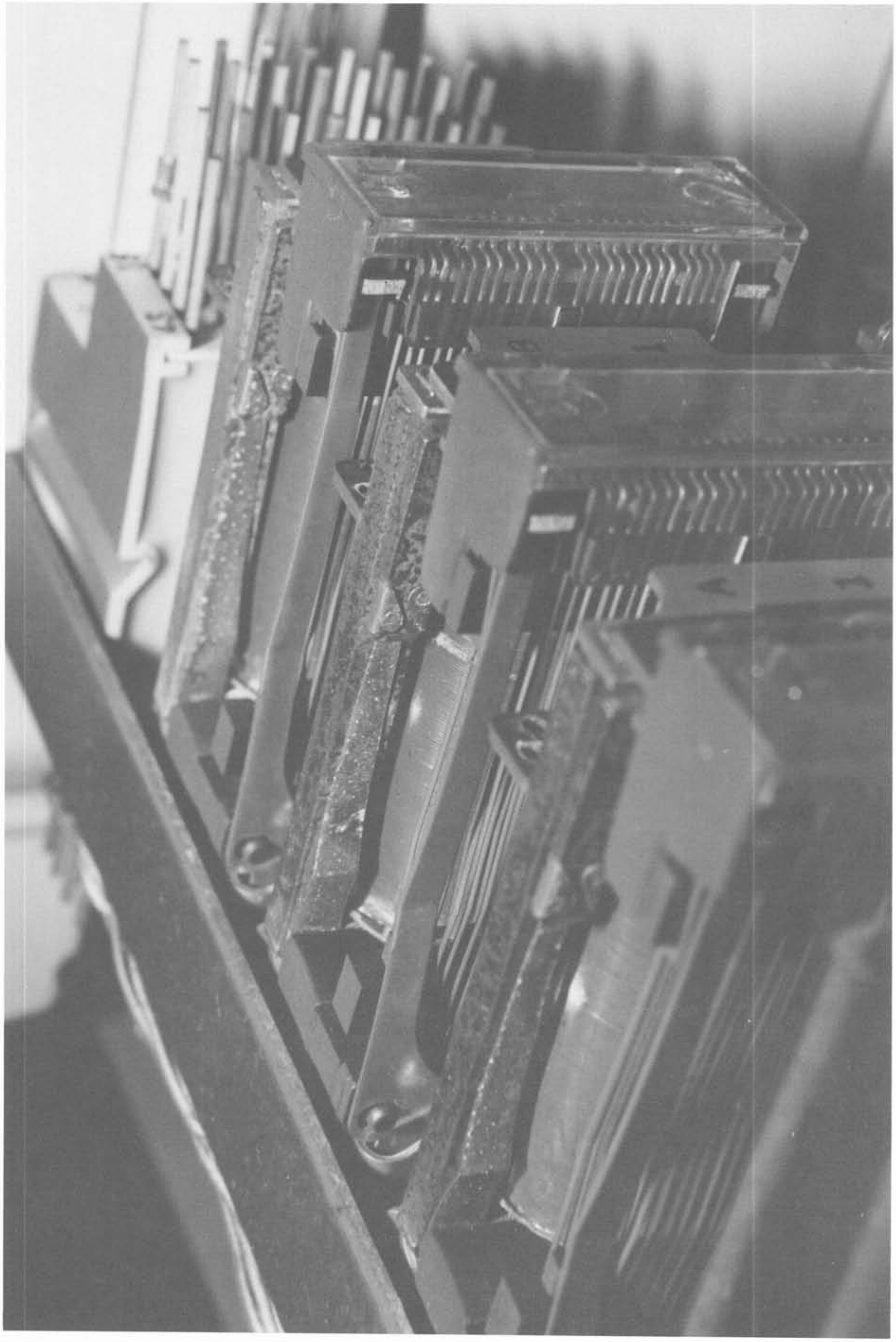
- Low temperature decomposition (smoldering fires)
  - Non-conductive organic soots
  - High particulate levels and deposition
  - Halogenated gases
  - Organic volatiles
  - CO, CO_2, water
  - Molten drips, chars and ash

COMBUSTION AND THERMAL DEGRADATION

- High temperature decomposition (rapid growing fires)
  - Conductive (graphitic) carbon soots
  - Low to moderate particulate levels and deposition
  - Halogenated gases
  - Vaporized metals
  - CO, CO_2, water
  - Very trace amounts of organic volatiles

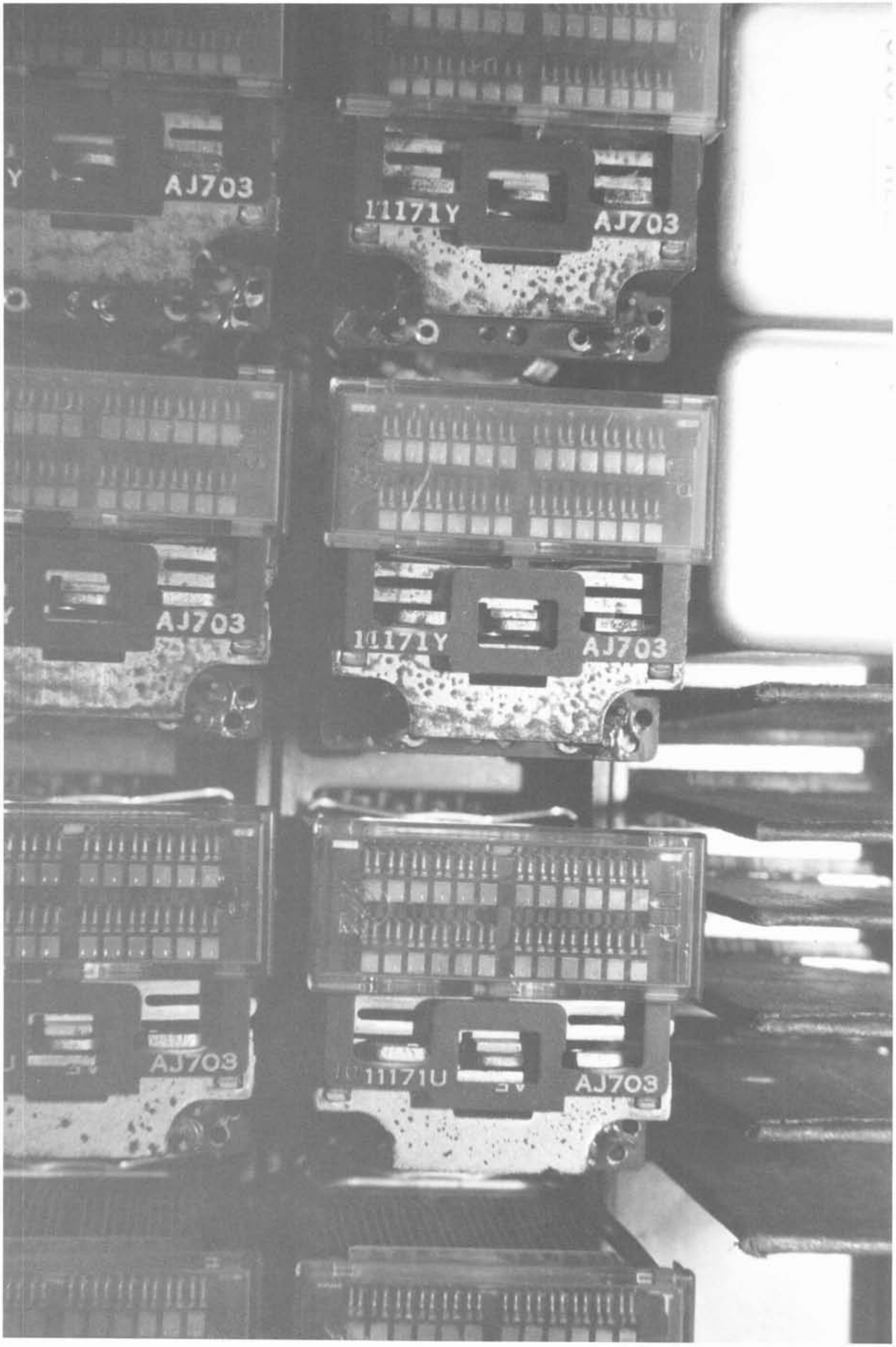
CONTAMINATION IMPACTS

- Soot contamination
  - Organic soot – insulating contact films
  - Graphitic soot – electrical leakage and shorting
  - Both types – contact activation under arcing conditions
  - Both types – require solvent cleaning
- Organic vapors
  - Initiate contact activation
  - Impact human workers



CONTAMINATION IMPACTS

- Metal vapor contamination
  - Electrical leakage and shorting
  - Hazardous waste treatment and protection – (Pb)
  - Impact on restoration cleaning methods
- Halogenated gas contamination (HCl, HBr, HF)
  - Acid gases – metallic corrosion
  - Need for humidity control
  - Major impact on potential of cleaning and restoration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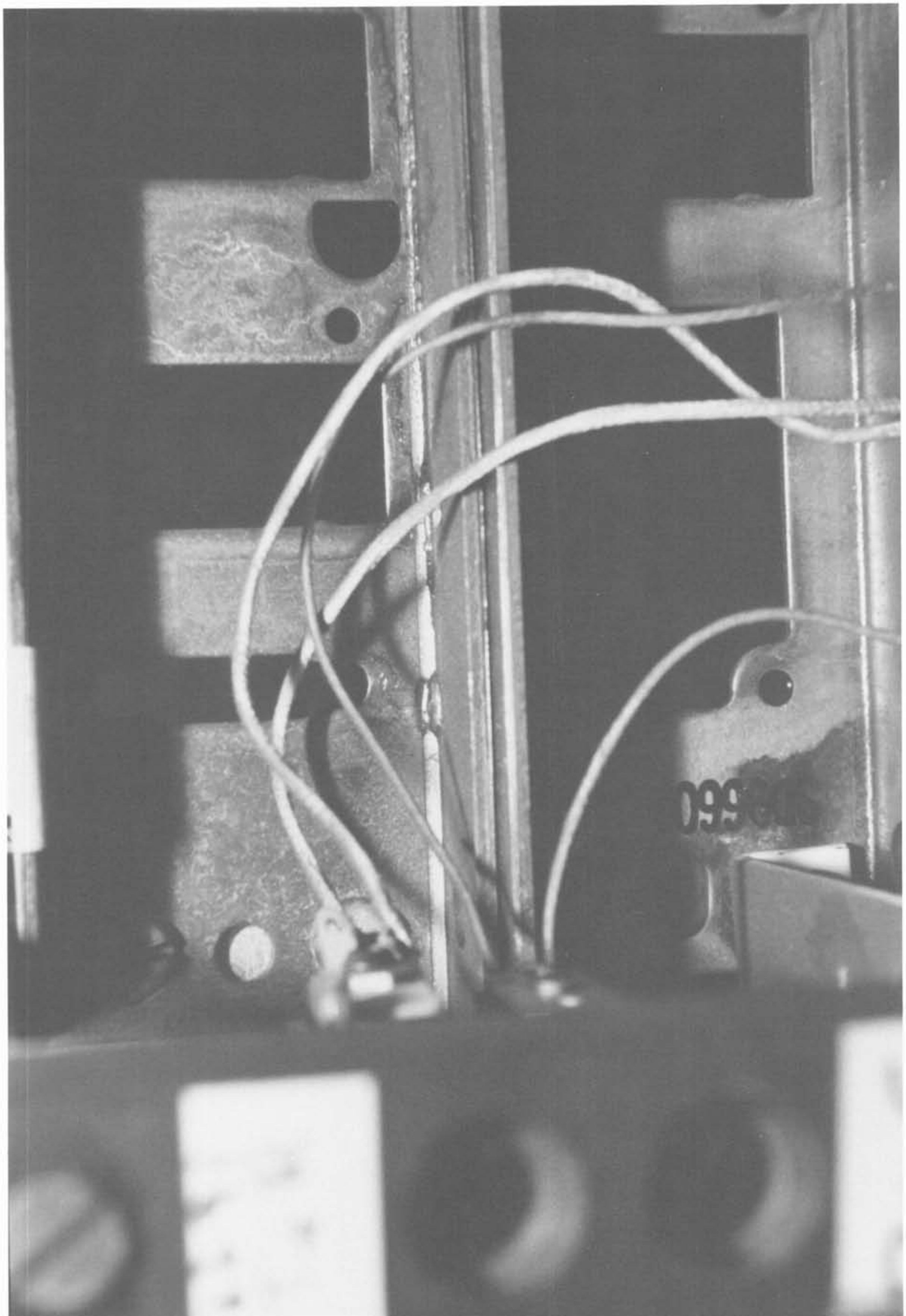
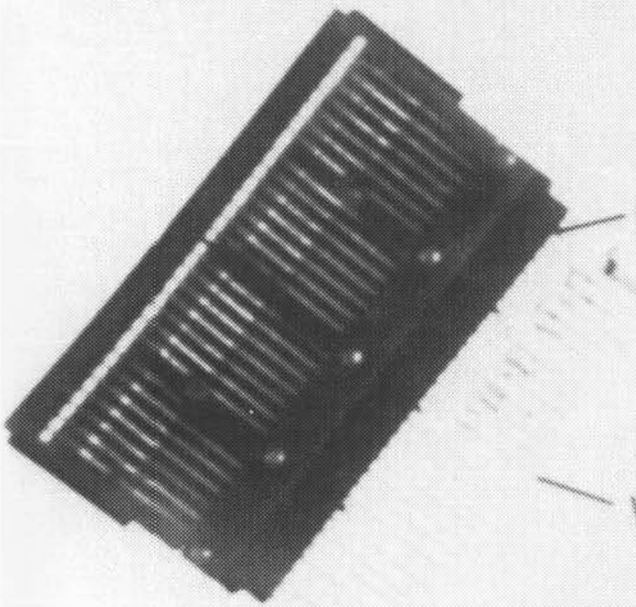


Contamination Problems



INSULATION
RESISTANCE
LOSS

WIRE-WRAP
INTEGRITY
LOSS

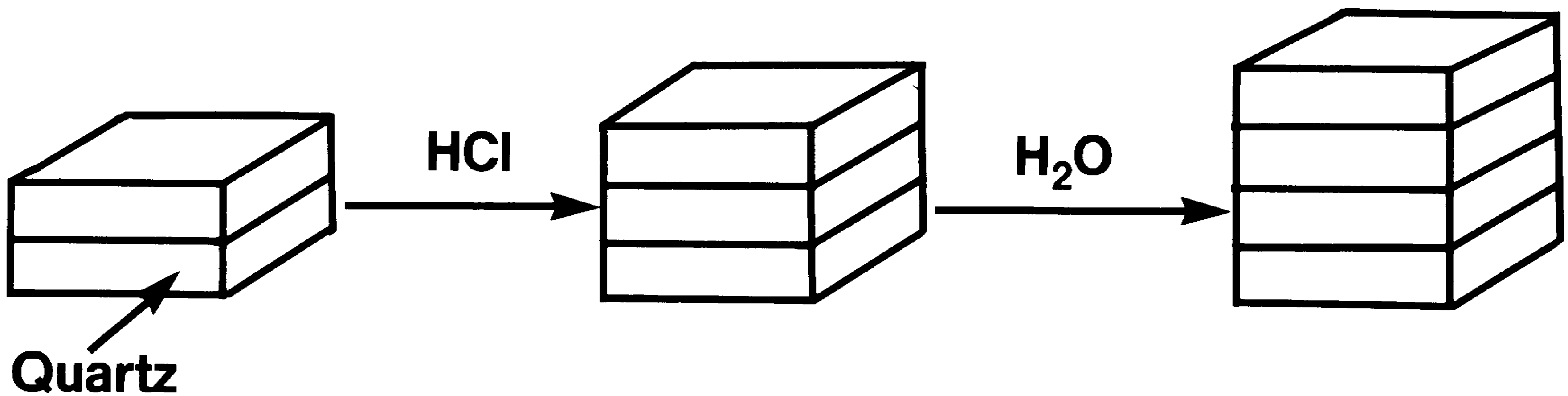
905B CONNECTORS

DETECTION

- Hydrogen chloride sensor
  - Highly specific for HCl
  - DC voltage – RS232 output
  - On-site and remote alarming
- Applications
  - Adjunct to EWFD in a compartment
  - HVAC detector system
  - Hand held sensor for fire fighters

PIEZOELECTRIC GASEOUS HCl SENSOR

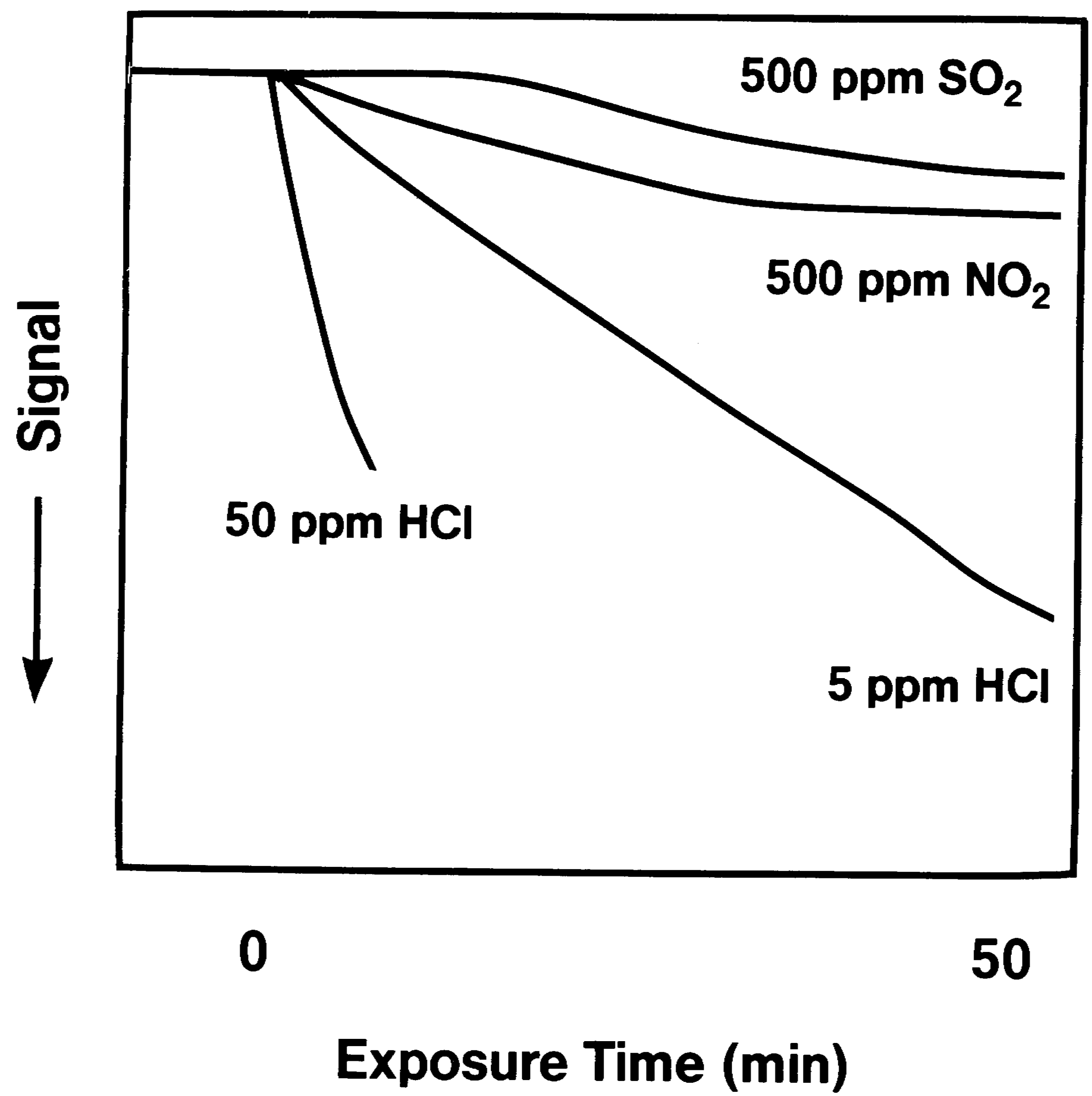
- Oscillator frequency decreases with an increase in mass loading



Freq. = F

F = F − d

HCl SENSOR



Common Indoor Concentrations

Gas	(ppb)
NO_2	200
SO_2	50
HCl	ppb or less


Bellcore
HCl Sensor

FUTURE PROTECTION

- Elimination of halogenated plastics
- Protective coatings
- Smoke and corrosive gas removal
  - Multi-stage air filtration system
    - Particulates
    - Organic vapors
    - Corrosive HCl (other acid gases)

CENTRAL OFFICE DESIGN CONSIDERATIONS

Joseph F. Luby
Assistant Vice President –
Planning & Engineering
Illinois Bell

PRIORITY AREAS

- Training procedures
- Cable guidelines
- Power removal and restoration

C.O. POWER SOURCES

- Commercial power
- Diesel generators
- Batteries

TRAINING INITIATIVES

- Systems diagrams
- Written procedures for disconnecting power
- New signage

ADDITIONAL CONCERNS

- Powering down must be authorized
- Training for local fire departments

CABLE GUIDELINES

- Power redesign
- Review power fusing loads
- Install more flame retardant power cables
- Separate power and communications cables
- Modify cable maintenance procedures
- Infra-red testing
- New cable mining procedures

POWER REMOVAL AND RESTORATION

- C.O. power systems designed to keep service up
- Automatic disconnect systems not the answer
- Restoring service is delicate, time-consuming

NETWORK DESIGN FOR SURVIVABILITY

Robert W. Humes
Vice President –
Operations Planning &
Applied Technology
Ameritech Services

NETWORK SURVIVABILITY STUDY

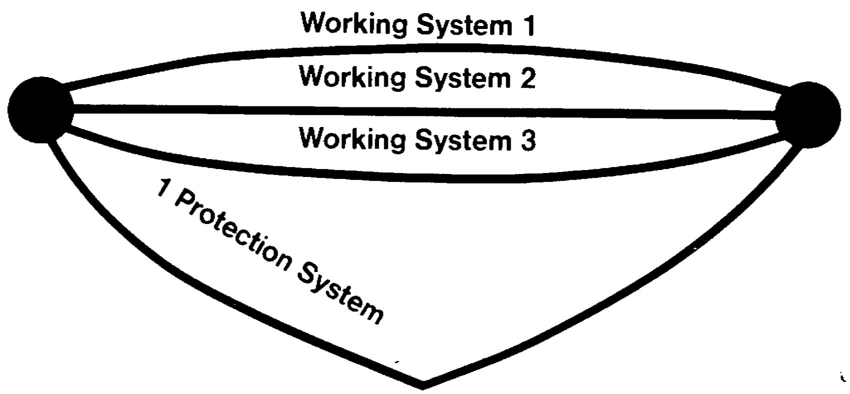
- Focus
  - Physical diversity
  - Facilities network
  - Switched network

NETWORK SURVIVABILITY STUDY

Conclusion: Network has survivability/ diversity

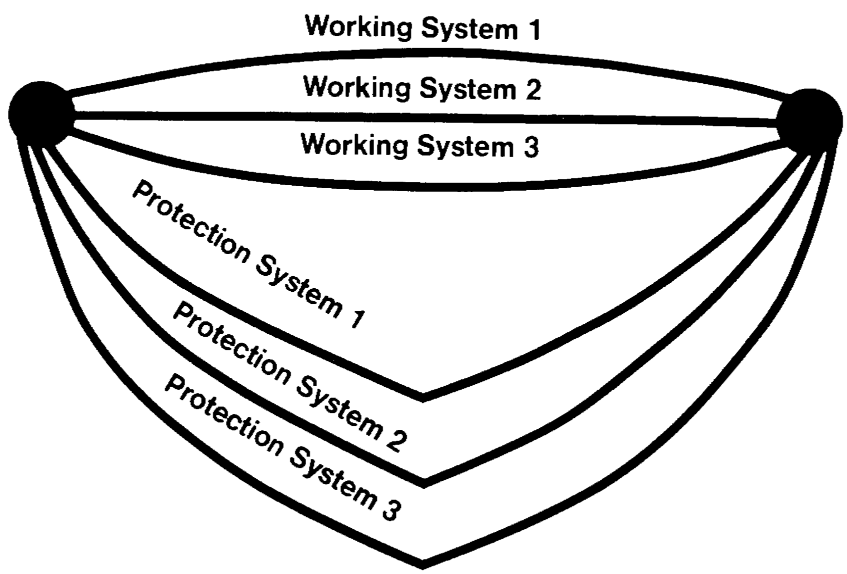
- C.O. Power
- Switching components
- Multiplexing equipment
- Fiber optic equipment
- Laser components
- Fiber diversity

1 x N PROTECTION



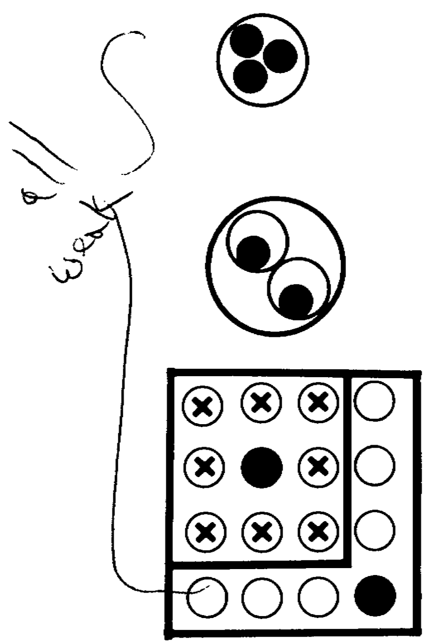
1 x 1 PROTECTION

← moving toward for high traffic concentration

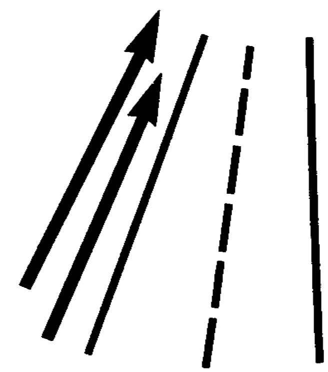


● End Office

LEVELS OF FIBER DIVERSITY

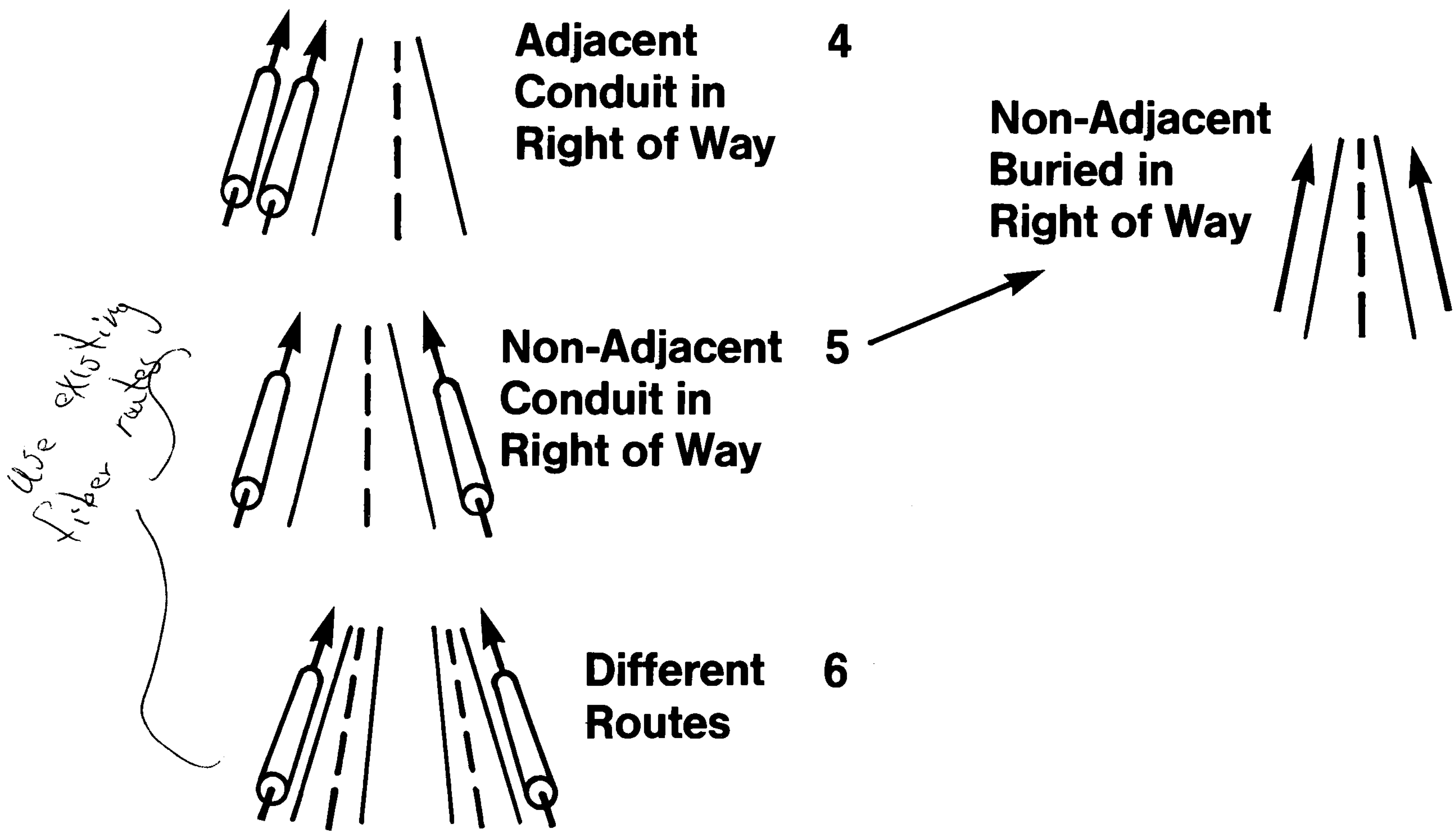


	Level
Same Sheath	1
Adjacent Innerduct	2
Non-Adjacent Ducts	3

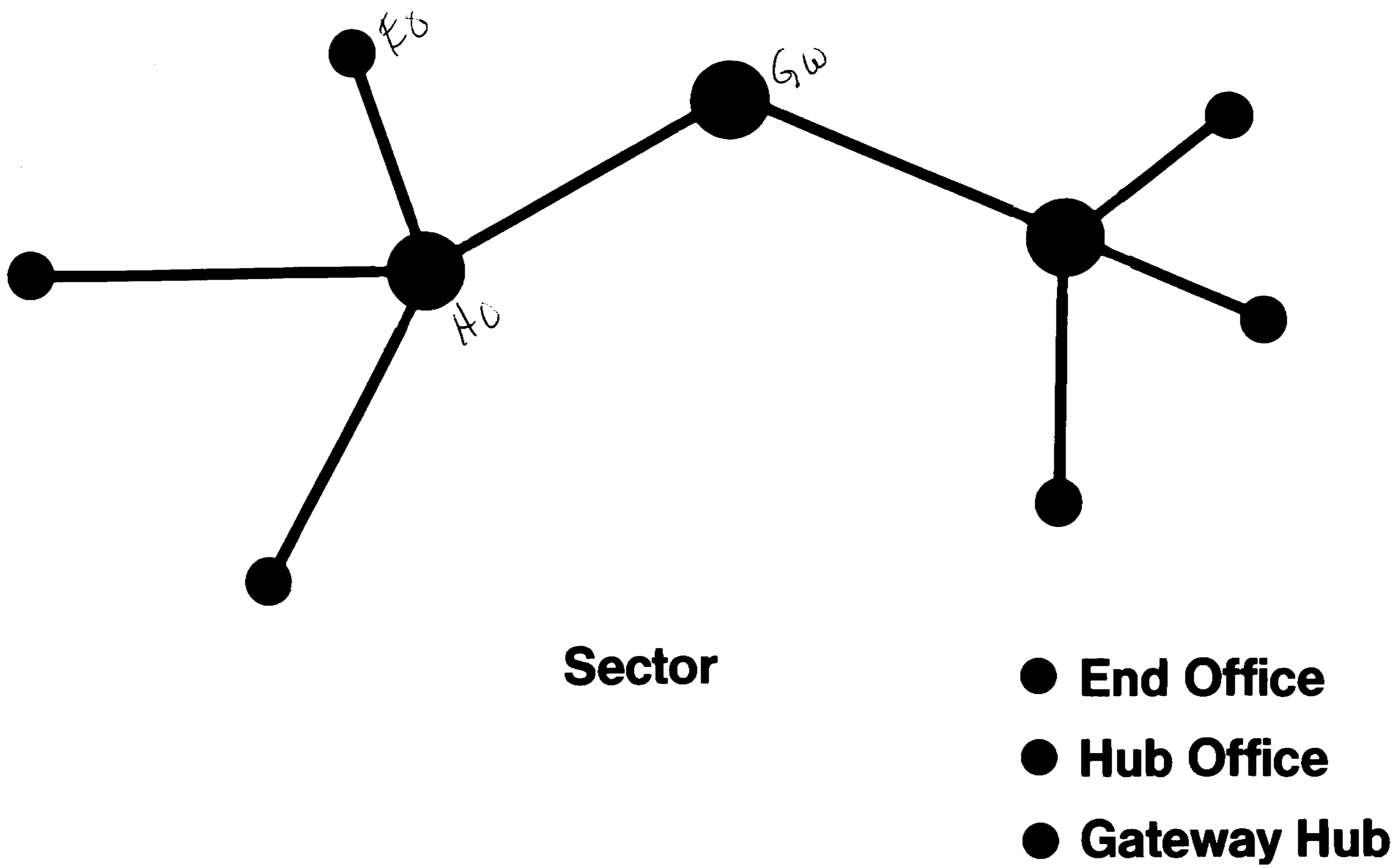


Adjacent Buried in Right of Way

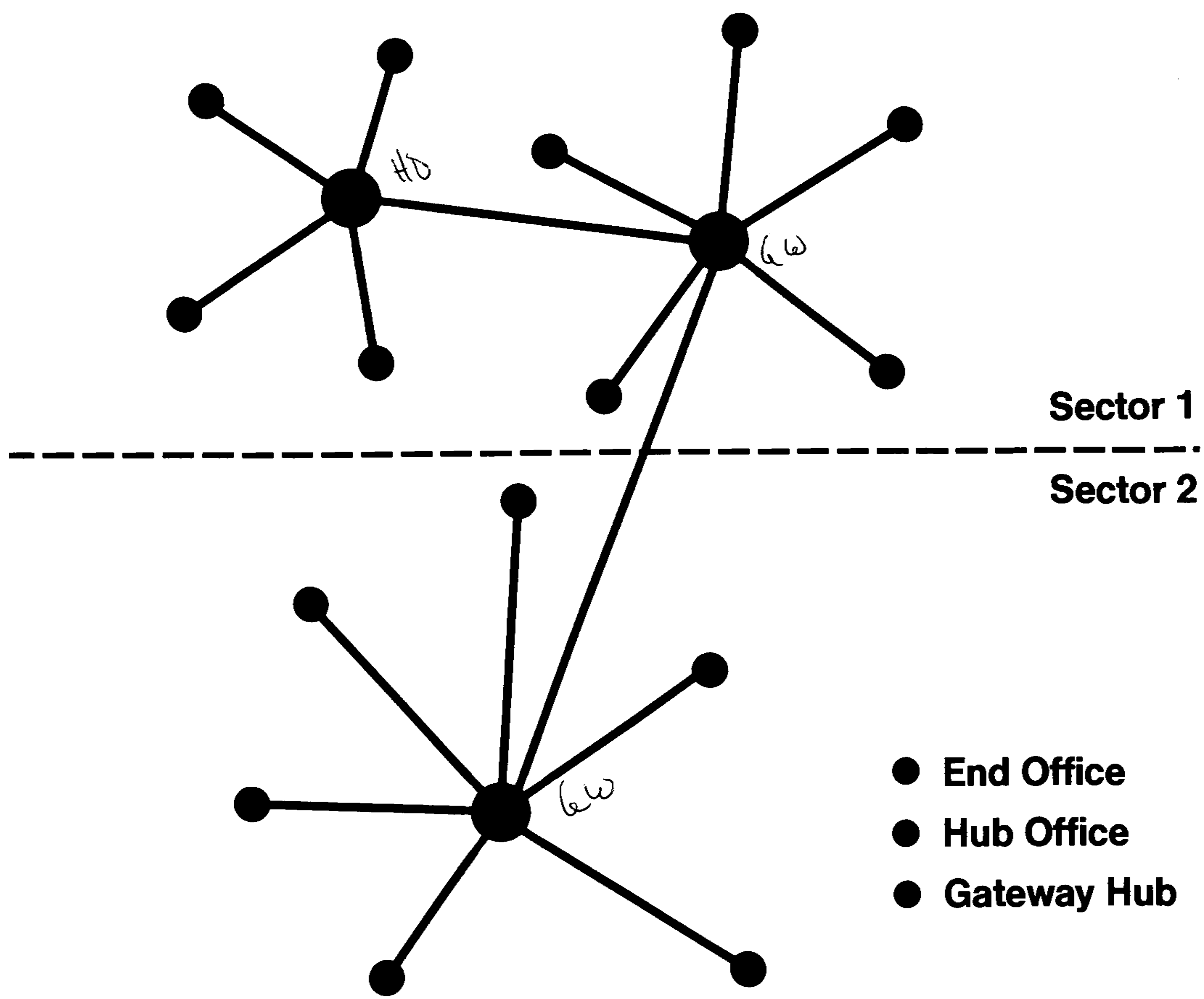
LEVELS OF FIBER DIVERSITY
(Continued)



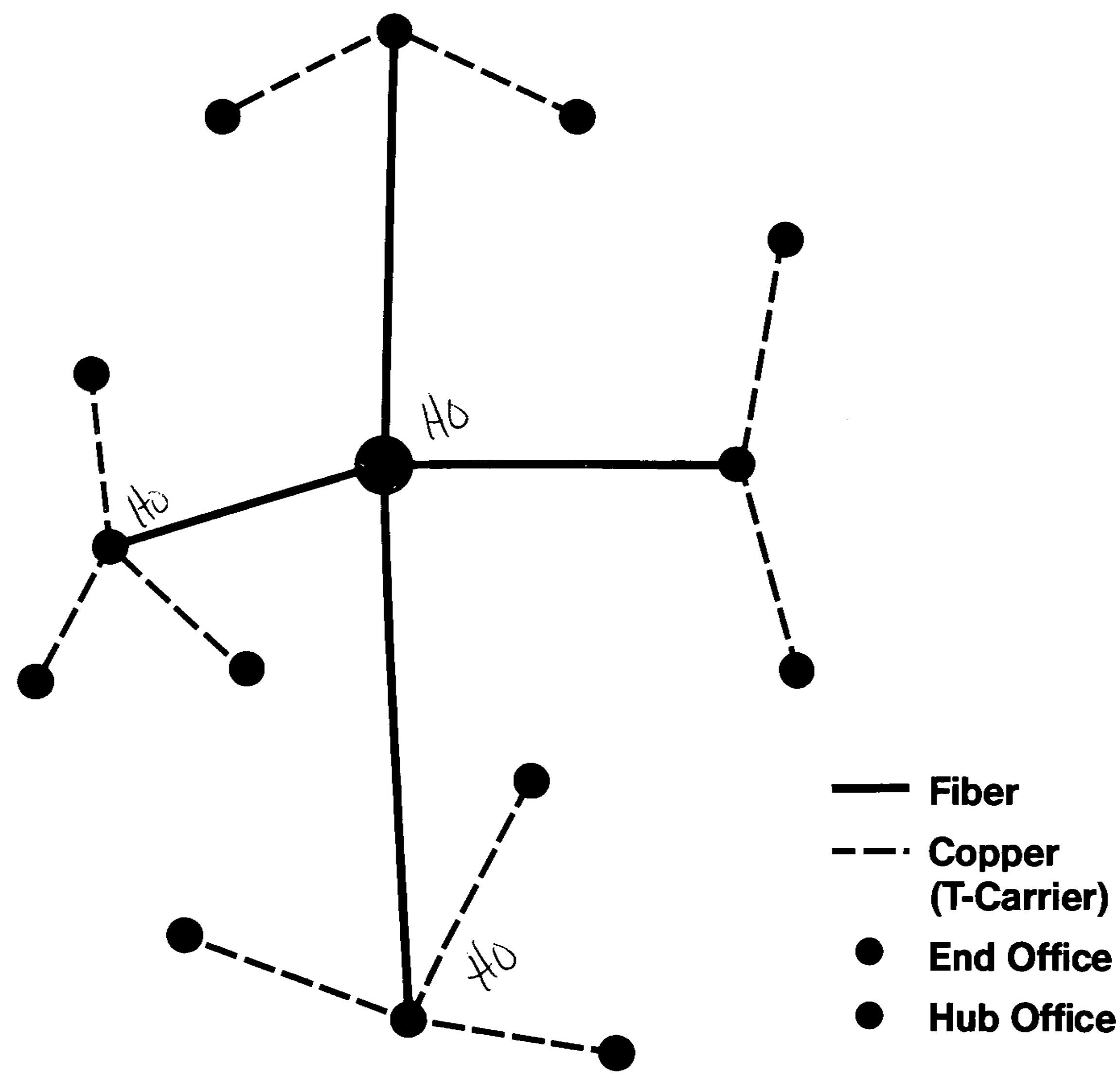
HUB ARCHITECTURE



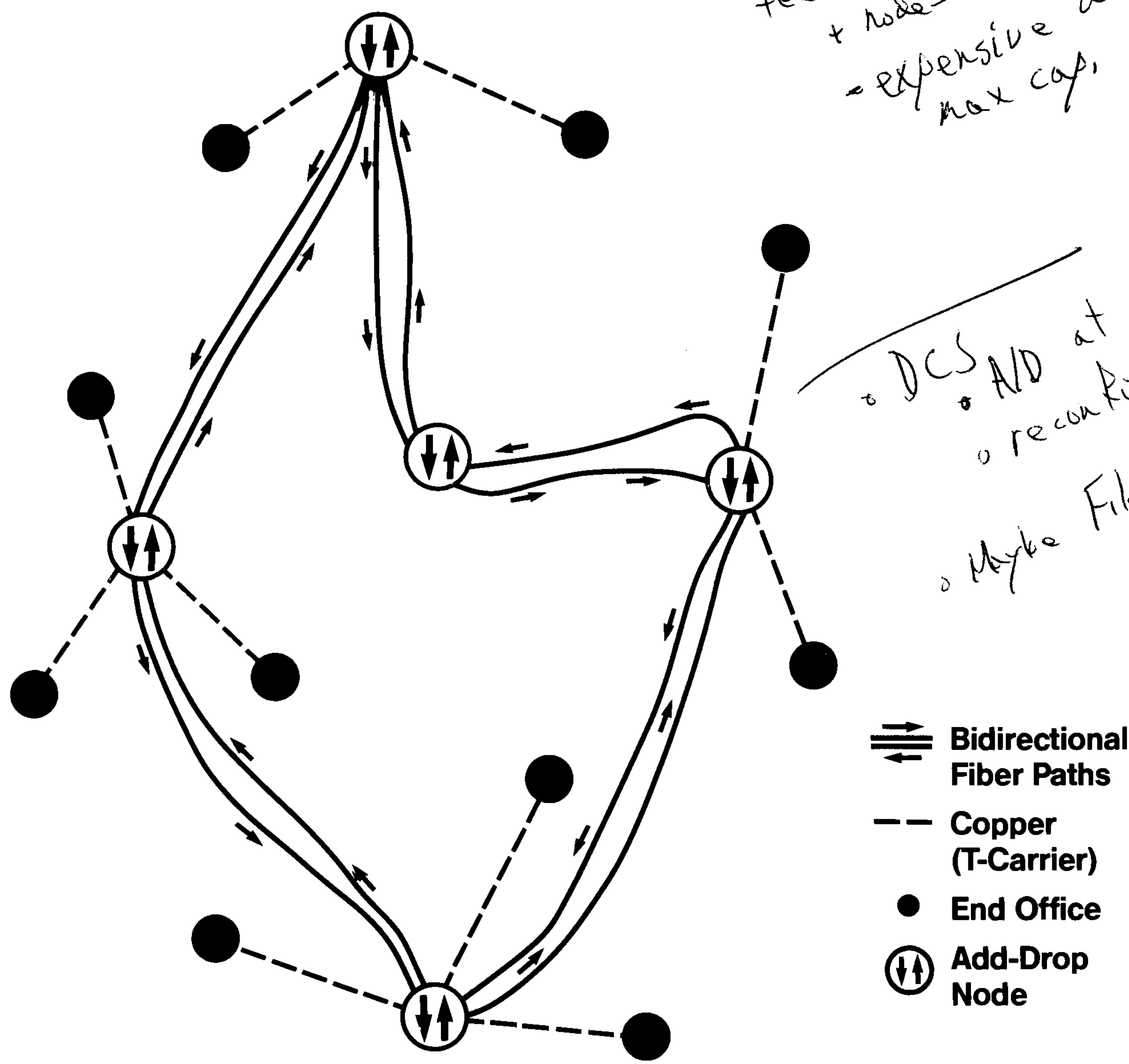
HUB ARCHITECTURE



BACKBONE STAR



RING ARCHITECTURE



Bidirectional feed ring + node/facility protect
- expensive due to max cap,

- DCS
- A/D at nodes
- reconfig. slow now
- Maybe Fiber max

speed a problem

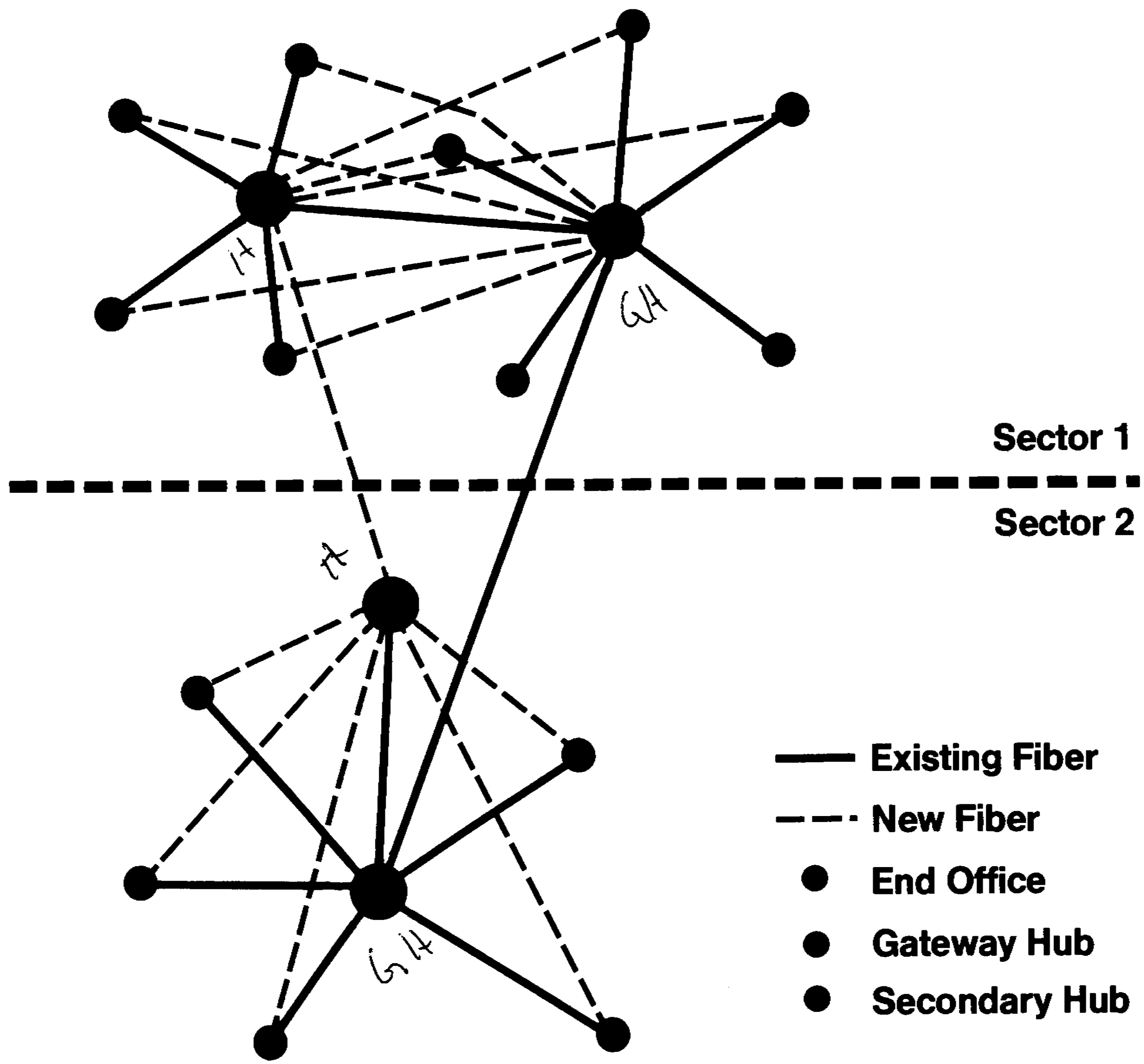
HUB ARCHITECTURE

- Pros
  - Concentrates circuits
  - Minimizes fiber construction
  - Concentrates electronics
  - Allows for efficient use of fiber
  - Centralized control

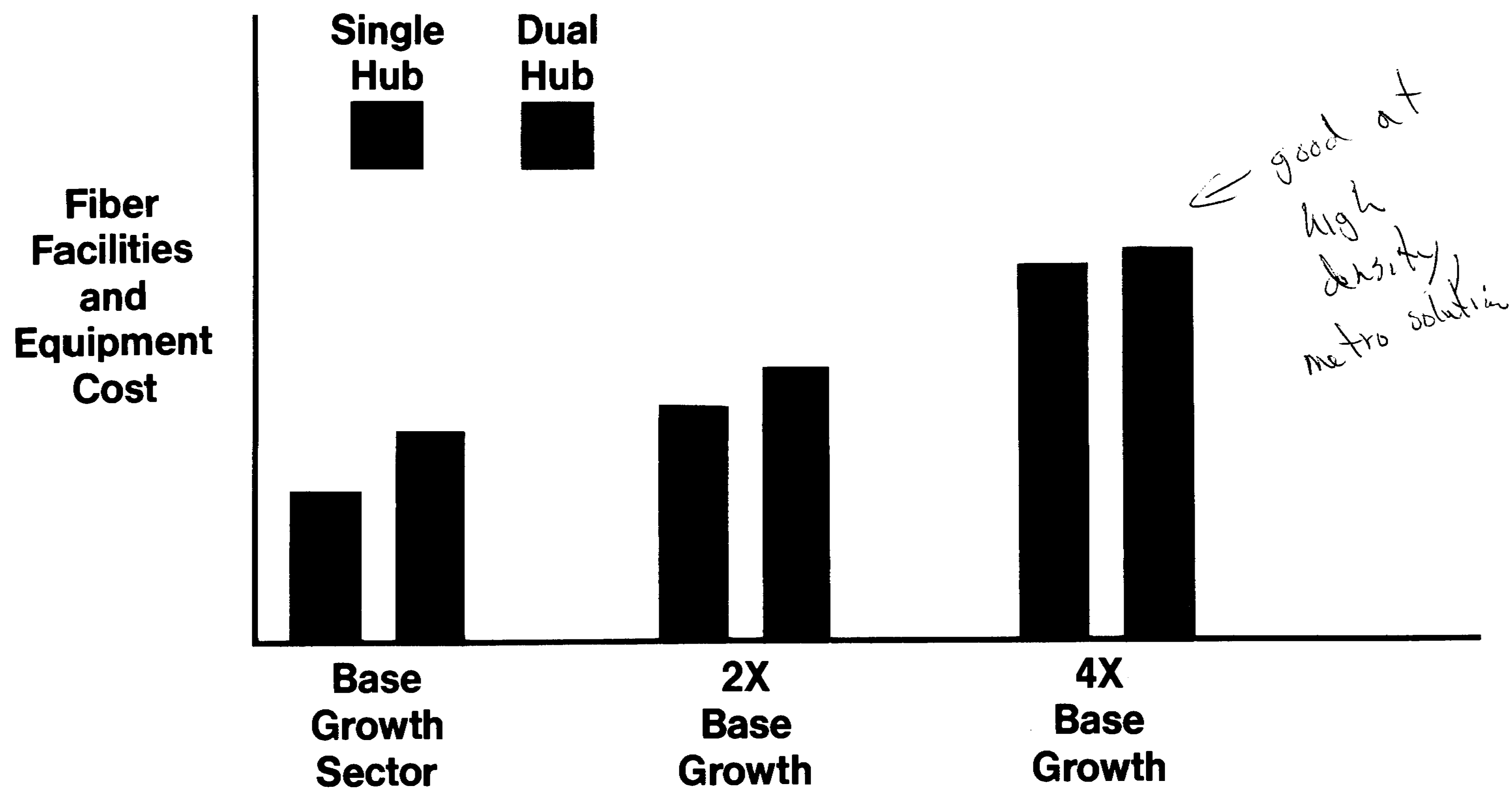
HUB ARCHITECTURE

- Cons
  - Vulnerability

DUAL GATEWAY NETWORK



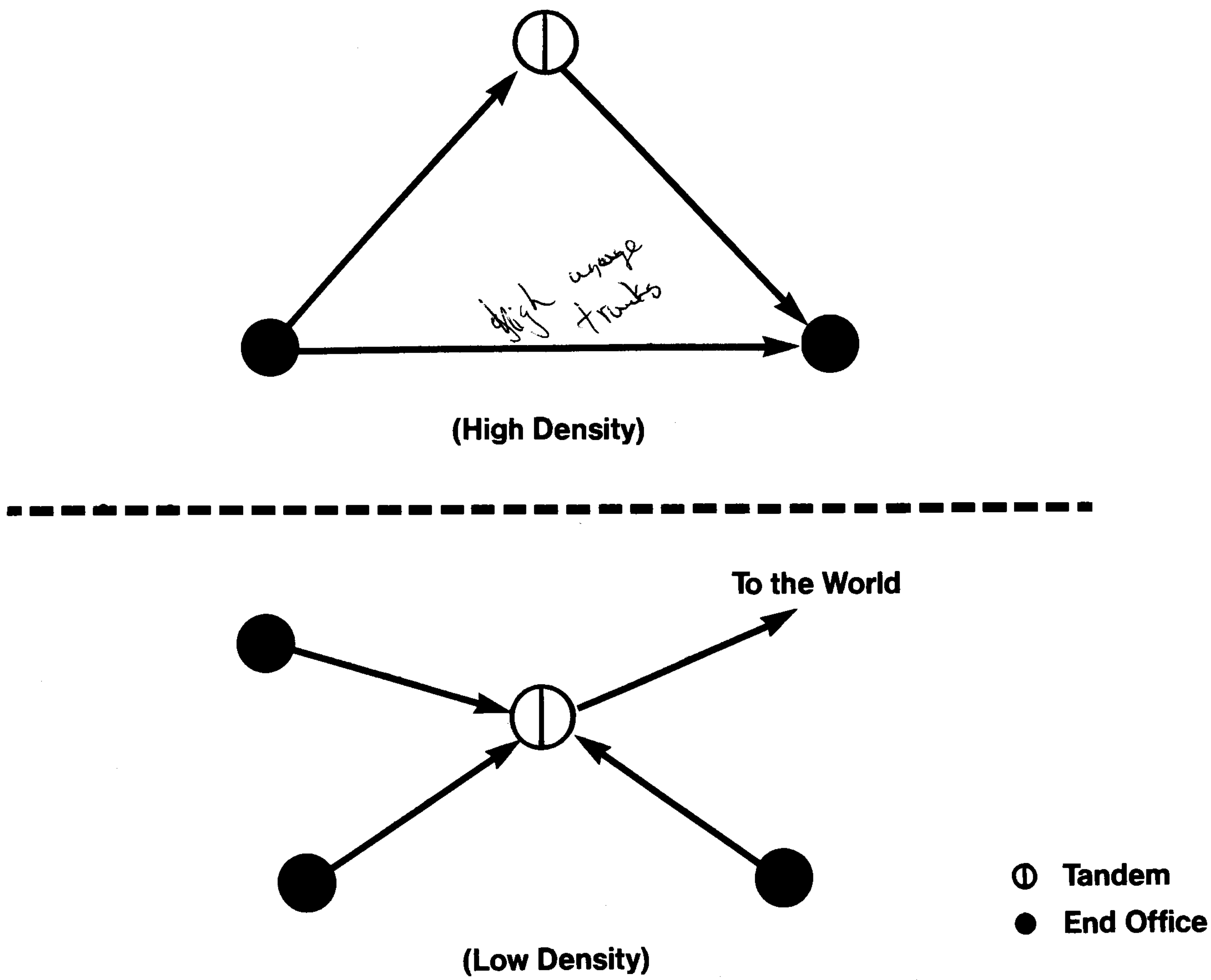
RELATIVE COST COMPARISONS FOR SINGLE VS. DUAL HUBBING WITHIN A SECTOR



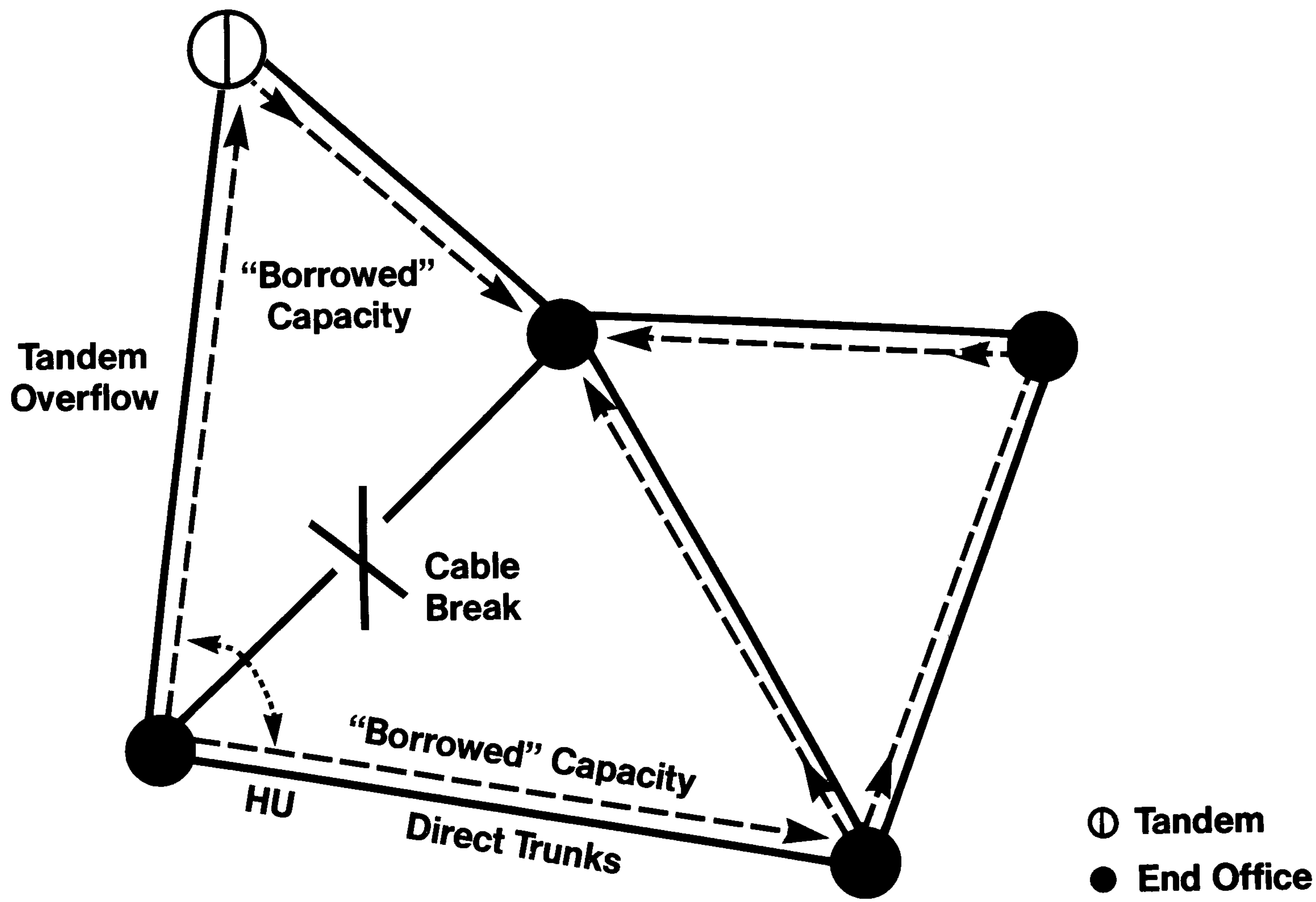
OTHER FACILITIES NETWORK OPTIONS

- Direct connections
- Separate hubs, gateways
- Diversified routes

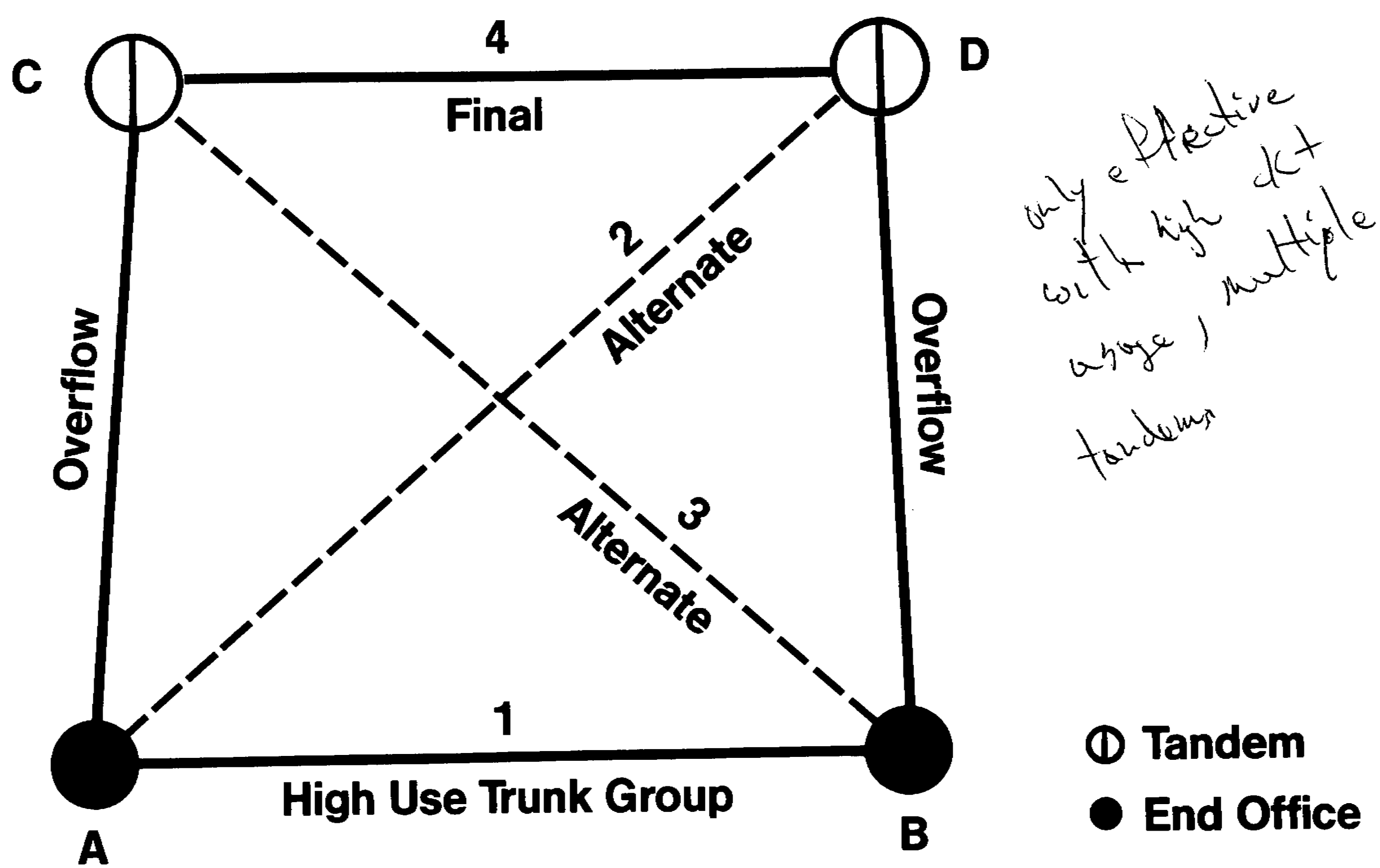
CURRENT ARCHITECTURE



SKIP ROUTING

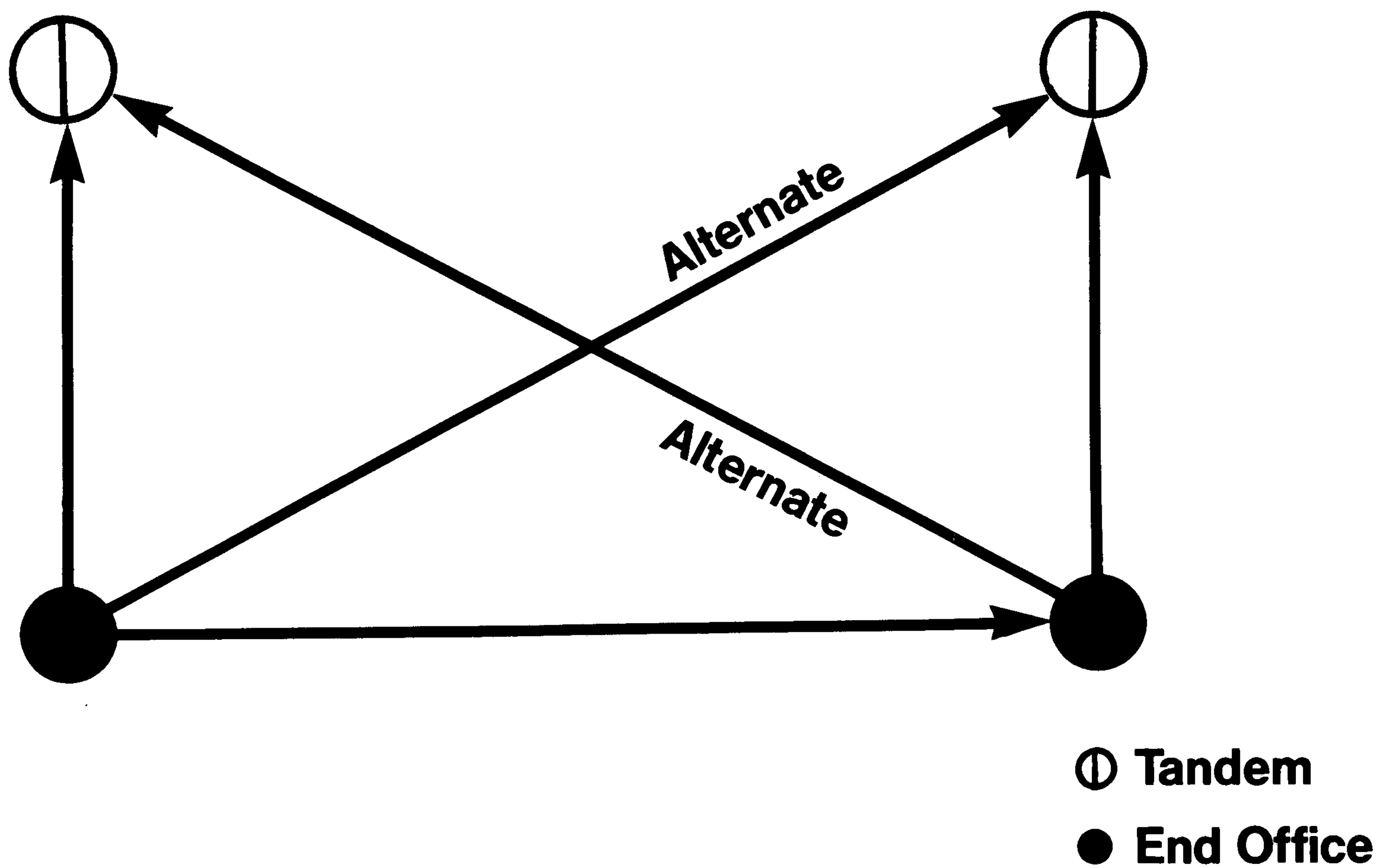


MULTI-ALTERNATE ROUTING



only effective with high ckt usage, multiple tandems

ALTERNATE TANDEMS



SWITCHED NETWORK SURVIVABILITY

- Evaluating placement of network elements
  - Separate buildings
  - Separate within buildings

DESIGN FOR NETWORK SURVIVABILITY

- Physical diversity
  - Level 5-6 diversity
  - One-by-one protection
- Facilities network
  - Diversifying fiber
  - Direct connections
- Switched network
  - Improving routing
  - Adding direct trunks

CUSTOMIZED SURVIVABILITY

Joseph F. Luby
Assistant Vice President
Planning & Engineering
Illinois Bell

ILLINOIS BELL
CONTINGENCY PLANNING

- Established in 1986
- A dozen full-time employees

CUSTOMIZED SURVIVABILITY

- Customer interest growing
- Hinsdale focused attention
- Need for local exchange company to be proactive

CUSTOMIZED SURVIVABILITY

- Giving customers a front door and back door

CUSTOMER CONCERNS

- Duration of outage
- Image
- Critical lines
- Events to plan against

NETWORK ELEMENTS

- Inside wire and equipment
- Local loop
- Local central office
- Dedicated private lines
- Interoffice facilities

GOAL:

- Solutions that are customized

CUSTOMIZED SOLUTIONS

- Usually inexpensive
- Often easy to implement

APPROACHES

- Service from a second central office
- Diversely routed distribution cable
- Switch to back up premises equipment
- Cellular service

ALTERNATIVES COVER A RANGE OF EVENTS

HINSDALE

- Underlined a key problem – loss of gateway hub

AMERITECH NETWORK PROTECTION PLAN

Robert W. Humes
Vice President –
Operations Planning &
Applied Technology
Ameritech Services

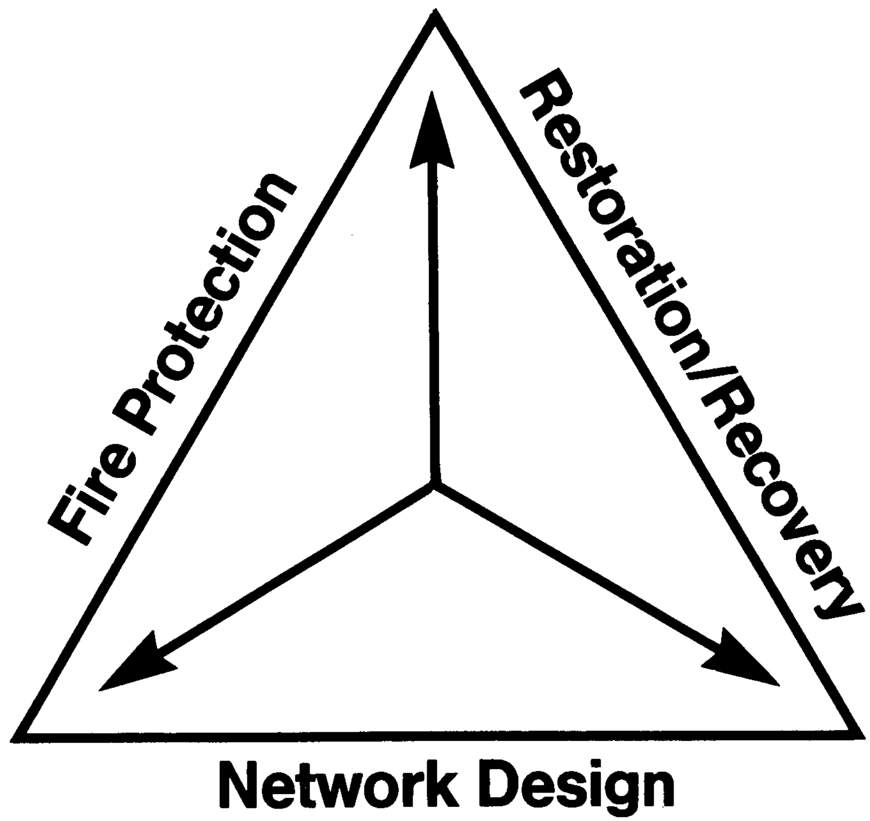
AMERITECH NETWORK PROTECTION PLAN

- Forces
- Goals
- Key issues

AMERITECH NETWORK PROTECTION PLAN

- Goal: Customer Protection
  - Prevent fires
  - Detect fires quickly
  - Respond rapidly, contain, suppress
  - Network survivability
  - Prompt restoration

AMERITECH NETWORK PROTECTION PLAN



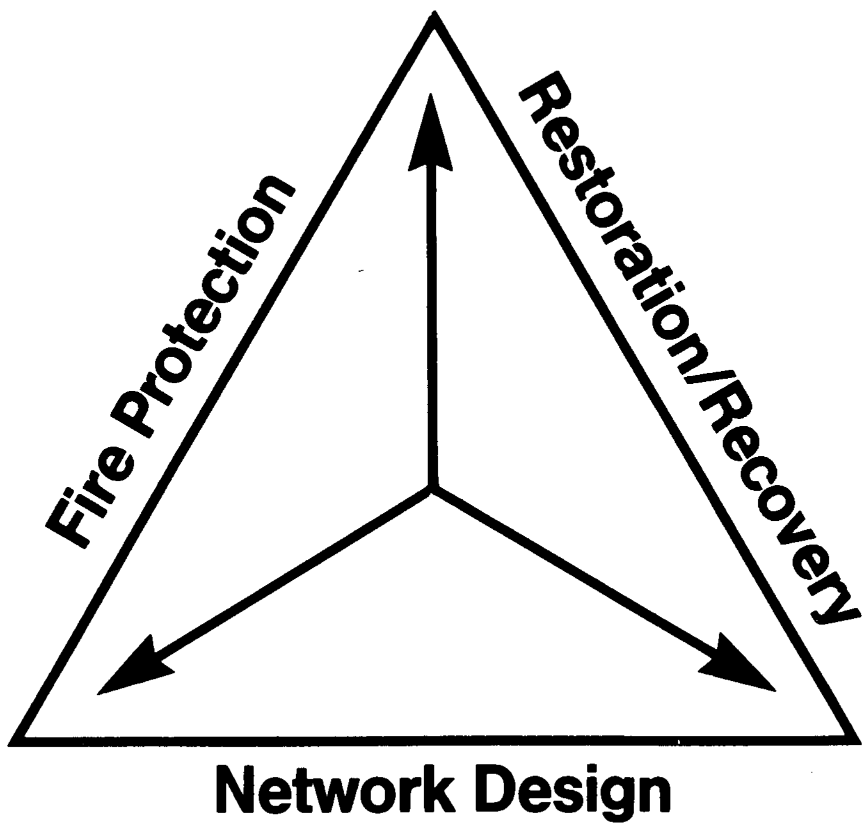
AMERITECH NETWORK

- Built-in survivability
- Opportunities for improvement

AMERITECH NETWORK PROTECTION PLAN

- Prevention is #1 Priority

AMERITECH NETWORK PROTECTION PLAN



FIRE PROTECTION

Issue: C.O. Power

Actions:

- Prevent ignition
  - Inspecting cables
  - Consolidating, downsizing
  - Modifying cable procedures
  - Installing fire-retardant cables
- Quickly remove power
  - Manual removal
  - Improve training

FIRE PROTECTION

Issue: Detection

Actions:

- Analyzing systems, procedures
- Conducting trials of new systems
- Considering direct alarming

FIRE PROTECTION

Issue: Rapid Response

Actions:

- Reviewing monitoring practices
- Evaluating alternate notification avenues

FIRE PROTECTION

Issue: Fire Suppression

Actions:

- Evaluating alternatives to water, halon
- Install sprinkler systems in cable vaults, storage areas

FIRE PROTECTION

Issue: Smoke, fire containment

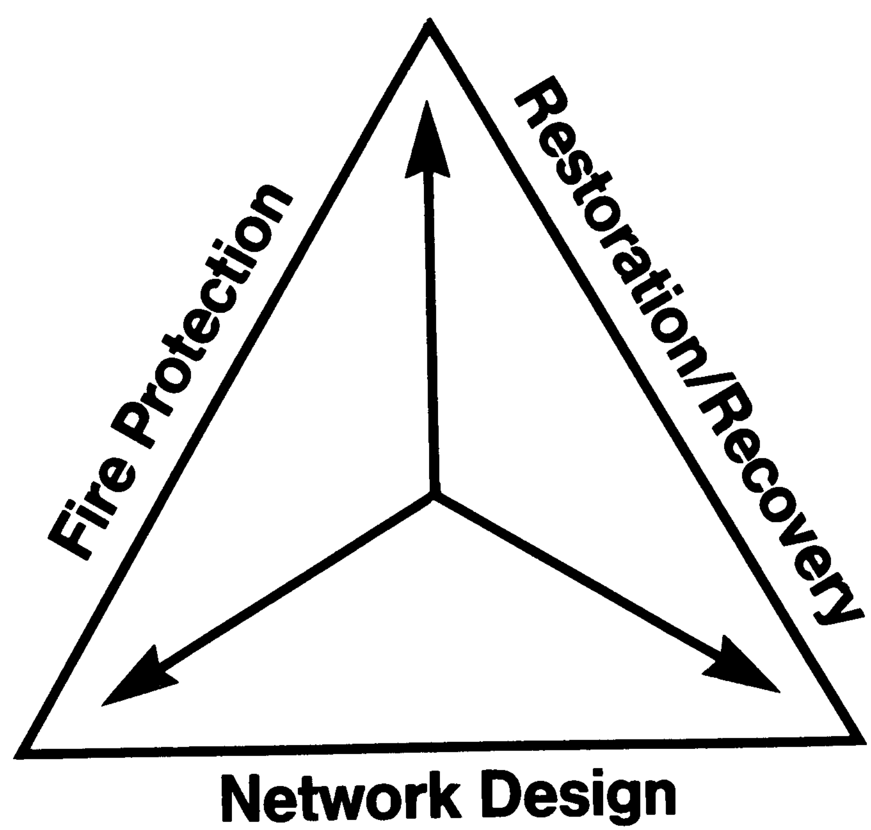
Actions:
- Study smoke control

FIRE PROTECTION

Issue: Fire fighter training

Actions:
- Developing joint training program
- Proactive work with fire departments

AMERITECH NETWORK PROTECTION PLAN



NETWORK DESIGN

Issue: Facilities network survivability

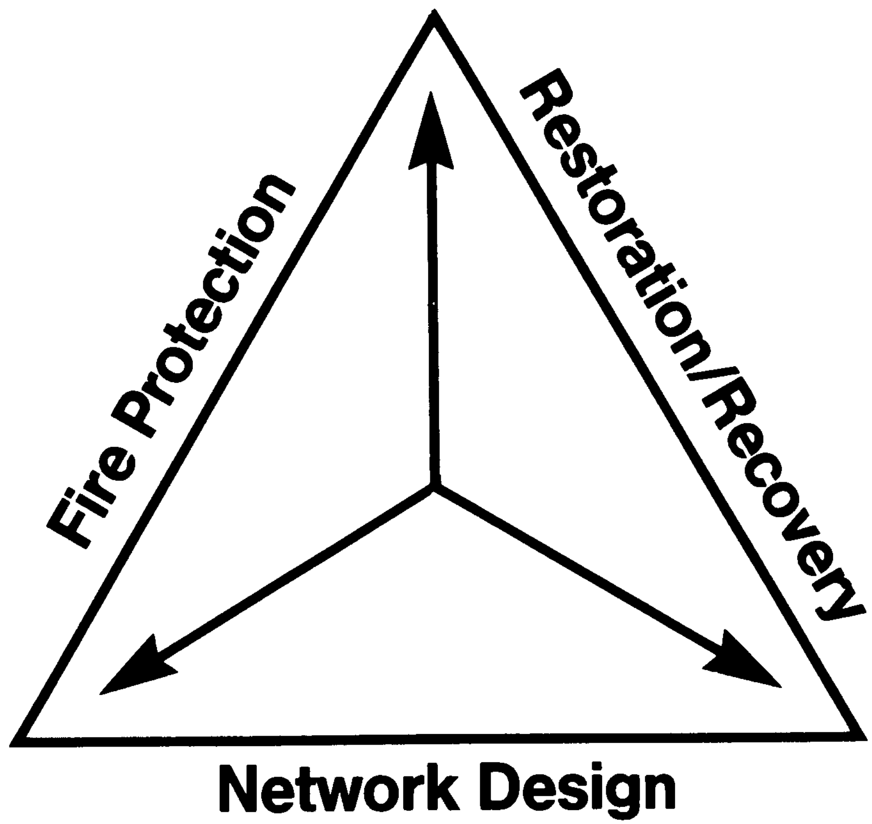
Actions:
- Installing 1-by-1 protection
- Improving physical diversity
- Increasing hub diversity

NETWORK DESIGN

Issue: Switched network survivability

Actions:
- Evaluating call routing

AMERITECH NETWORK PROTECTION PLAN



AMERITECH NETWORK PROTECTION PLAN

- Builds on excellent record
- Sense of urgency
- Tailored to Ameritech customer needs

HINSDALE CENTRAL OFFICE FIRE
FINAL REPORT

EXECUTIVE SUMMARY

Joint Report of:

Office of the State Fire Marshal
3150 Executive Park Drive
Springfield, Illinois 62703-4599

and

Illinois Commerce Commission Staff
527 East Capitol Avenue
Springfield, Illinois 62794-6928

March 1989

Prepared by:

Forensic Technologies International Corporation
2021 Research Drive
Annapolis, Maryland 21401

TABLE OF CONTENTS

LIST OF PHOTOGRAPHS AND FIGURES

FOREWORD

This document presents the main issues and findings found in Volumes I and II of the companion Final Report. Volume I contains the full text, primary graphics, and selected photographs. Volume II contains documents referenced in Volume I, along with test and inspection data, tables, and plots. Additional photographs are provided in Volume II to supplement those presented in Volume I. Although much of the technical details have been omitted in this Summary, all of the pertinent information is included; Section 6, Conclusions, and Section 7, Recommendations, appear exactly as in Volume I of the Report.

1.0 INTRODUCTION

On May 8, 1988, at approximately 4:20 p.m., a fire was detected at the Hinsdale Central Office (HCO) of Illinois Bell Telephone (IBT). The fire burned for approximately three hours but was confined to a 30- by 40-foot area of cable trays on the first floor. These cable trays were suspended from the first floor ceiling and contained both power and communications cables serving the telephone equipment on the first floor. Upon notification at 4:58 p.m., the Hinsdale Fire Department (HFD) responded and found the fire very difficult to extinguish because the electrical power, both ac and dc, was still feeding the burning cables. Heavy smoke also impaired the ability to locate and fight the fire. Other neighboring fire department personnel were called in to provide assistance. All electric power was disconnected from cables in the fire at about 7:15 p.m. At 11:30 p.m., the Hinsdale Fire Department officially declared the fire extinguished. Although the actual burn area was limited, the smoke and combustion by-products from burning cable insulation penetrated the entire building. Smoke was especially thick on the first floor where most of the vital communications equipment was located. This caused the irreparable contamination of much of the communications equipment.

The fire in the HCO, affecting more than one-half million residential and business customers, is now identified as the most serious fire ever encountered by IBT and perhaps one of the most serious in the history of the telephone industry. Personnel from the Office of the State Fire Marshal (OSFM) arrived at the scene on the day of the fire and immediately recognized that, due to the severity of the fire and the number of Illinois citizens affected, it would take responsibility for the formal fire investigation. The staff of the Illinois Commerce Commission (ICC) arrived on the scene two days after the fire and determined that the nature of the fire, and the combined effects of contaminants from the burning of electrical insulation, would make restoration of service most difficult. Since the number of customers without service was so great, it was decided to place initial emphasis on the restoration of service, with the actual evaluation of the cause of the fire to commence after service had been restored by using the essentially unoccupied second floor. Both the Office of the State Fire Marshal and the staff of the Illinois Commerce Commission agreed to this plan.

Soon after the fire, the State of Illinois initiated various efforts to assess the potential consequences of major disruptions in telecommunications capabilities, and to assess the adequacy of both private and governmental programs designed to prevent, or to respond to, such emergencies. Within days of the fire, the Office of the State Fire Marshal engaged outside consulting engineers to assist in its investigation. On May 13, 1988, the staff of the Illinois Commerce Commission initiated its investigation of the fire, seeking recommendations to enhance fire protection and to reduce network vulnerability to any future, similar occurrence. In addition, the Illinois Commerce Commission, at the request of Neil F. Hartigan, Attorney General, opened a formal docketed inquiry into the fire. Governor James R. Thompson recognized that the investigative efforts of the various state agencies should be fully coordinated and asked both the OSFM and the staff of the ICC to work together to report on this incident.

The staff of the ICC and the OSFM recognized the enormous public and private reliance on telecommunications to conduct commerce and industry, maintain personal contact and access emergency assistance. It was imperative that any conclusions and recommendations that may result reflect the cooperative understanding between appropriate state agencies. To this end, the Illinois Emergency Services and Disaster Agency was asked to assist in the review of the potential impacts of emergency response capabilities in light of the Hinsdale Central Office fire experience.

The investigation of an incident of this magnitude must have unquestioned credibility in order to serve the public interest, be of assistance to industry, and serve as a guide for the improvement of service delivery in the future. Therefore, the Office of the State Fire Marshal and staff of the Illinois Commerce Commission agreed to have teams of engineers and scientists, representing Illinois Bell Telephone, Factory Mutual Insurance Company, and Bellcore (formerly part of Bell Laboratories) participate in the process of the state's investigation.

The Office of the State Fire Marshal and the staff of the Illinois Commerce Commission (ICC) retained the services of the consulting firm of Engineering Systems, Inc. and Professor Emeritus Boyd A. Hartley, Chairman of the Department of Fire Protection and Safety Engineering of the Illinois Institute of Technology, to assist in the investigation into the cause and origin of the fire. Further, they were directed to act in a technical oversight capacity with respect to the Memorandum of Understanding, as well as assisting in the formulation of conclusions and recommendations upon completion of the investigation.

The staff of the ICC was on the scene two days following the fire. On May 15, 1988, the Commission staff secured an agreement from Illinois Bell to fund the services of an independent professional investigative firm to serve at the exclusive direction of the Commission staff. Forensic Technologies International (FTI), of Annapolis, Maryland, a nationally recognized consulting engineering firm specializing in fire and failure analyses, was selected to conduct an in-depth investigation into the cause and origin of the fire and to make specific loss prevention recommendations. Due to the complexity of the investigation and the many separate investigative teams, it was determined that a joint investigation would be most effective in discovering the cause and origin of the fire. The joint investigation would serve to eliminate redundant tasks and produce a more cohesive, higher quality investigation process. FTI was directed by the Commission staff to serve as the lead technical investigative firm and to be responsible to both the OSFM and the Commission staff. Figure 1 shows the organization formed by these decisions which responded to investigate the HCO fire.

ORGANIZATION IN RESPONSE TO THE IBT HINSDALE CENTRAL OFFICE FIRE

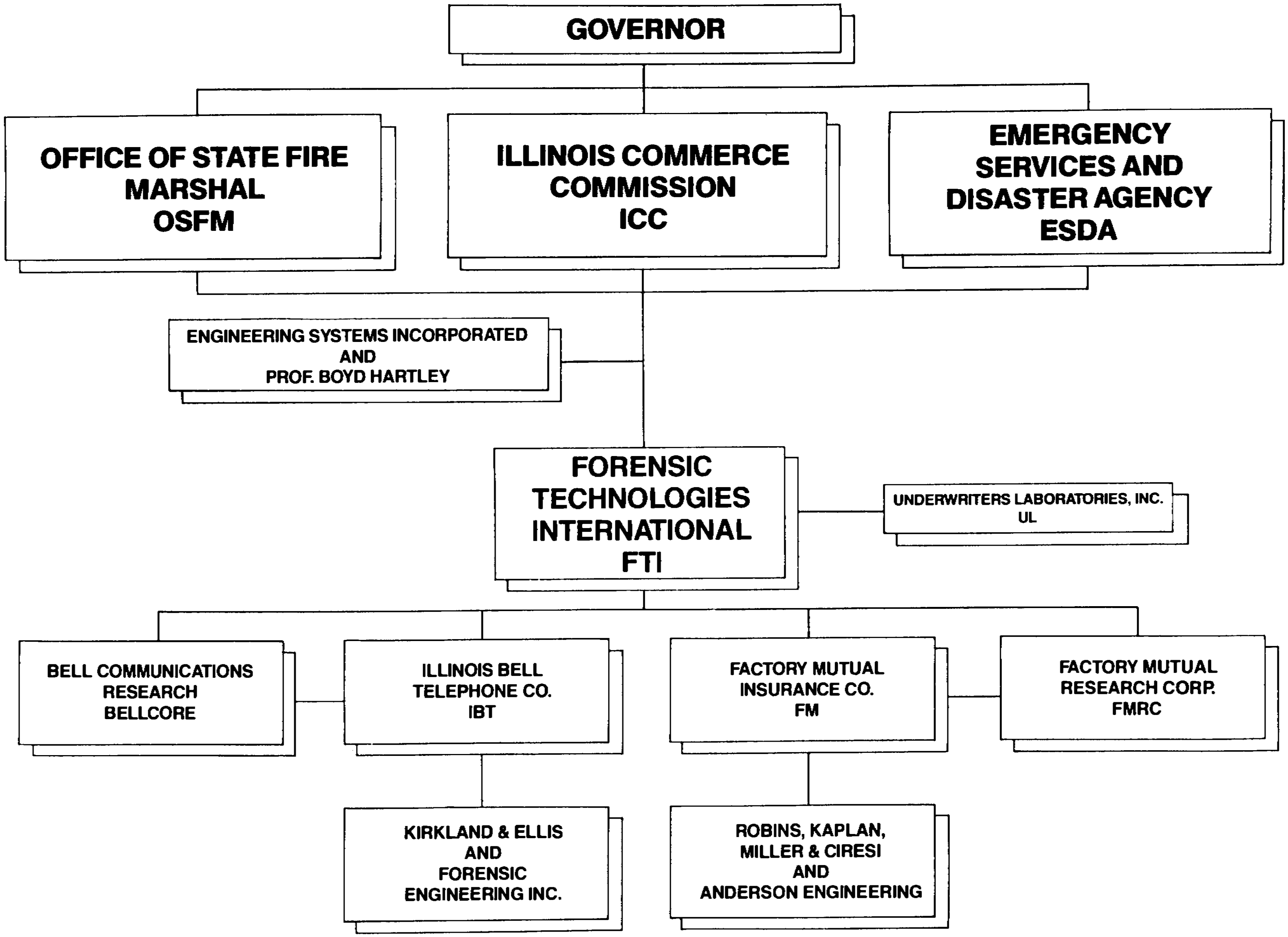


Figure 1

2.0 HISTORICAL BACKGROUND

2.1 Telephone Company Central Office Evolution

In general, telephone company central offices are switching and transmission centers for local and toll communications. Some central offices, such as the Hinsdale Central Office (HCO), are multi-function buildings. There are over 11,500 central offices in the United States which serve as hubs in the telephone network. In addition, there are approximately 9,000 transmission stations located along major transmission lines around the nation. Central offices exist in a wide variety of configurations. Some are as small as 400 square feet, while others occupy over one million square feet. In Illinois, there are approximately 960 telephone central office exchanges, of which about forty-nine provide the same network hub access functions as the HCO. However, the telephone calling volumes of these hubs vary greatly.

An extensive research investigation was conducted in order to acquire a better understanding of telephone equipment fires, specifically, those in a central office location. This research uncovered only two other major central office fires.

The first such central office fire occurred at the New York Telephone Company's (NYT) main switching center on Second Avenue in Manhattan, New York City. The main switching center was located in an eleven-story building with reinforced concrete floors. On February 27, 1975, a fire started in the telecommunications cables in the basement cable vault. The fire remained confined because of the building configuration and the number of walls and partitions.

The second and most recent central office fire occurred on February 18, 1987, at another NYT facility, this one in the Bushwick Central Office in Brooklyn. The fire started in communications equipment on the first floor. One of three NYT employees in the building at the time discovered the fire and contacted the fire department.

In both instances, while the fires were determined to be electrical in nature, the cause and origin of the fires were not determined.

Based upon this information, it appears that major central office fires have thus far been a rare occurrence.

2.2 Hinsdale Central Office Evolution

Hinsdale, Illinois, is located approximately sixteen miles west-southwest of Chicago. Hinsdale shares borders with Oak Brook on the north, Western Springs on the east, Willowbrook on the south, and Clarendon Hills on the west. It is a residential community, with a population of about 17,000 occupying primarily medium to large homes over an area of approximately four-and-one-half square miles. There is no heavy industry in Hinsdale; the light industries include one central business district, two shopping areas, and several office parks. Hinsdale's Fire Department (HFD) employs twenty paid firefighters, three contract paramedics, and ten paid on-call reservists who operate out of one centrally located station. The HFD equipment includes three pumpers, two modular type ambulances, and a quint truck (aerial ladder/pumper). Hinsdale has mutual aid agreements with all its neighbors. Hinsdale is located just to the east of center in the Mutual Aid Box Alarm System (MABAS) District 10, making it easy for mutual aid responses from both the western and eastern members of the district.

The Hinsdale Central Office (HCO) building is located at 120 South Lincoln Street in Hinsdale, Illinois, and occupies the northwest corner of Lincoln Street and Second Avenue. The HCO is shown in Photograph 1 as it appeared during the fire recovery.

The HCO is a major communications center and supplies phone service to approximately 42,000 local lines, operates 118,000 trunks for local and long distance call routing, and supplies voice and data communications services to the communities of Hinsdale, Clarendon Hills, Willowbrook, parts of Burr Ridge, Darien, Oak Brook, Westmont, and the unincorporated areas in south DuPage County, Illinois. The HCO also provides links to AT&T, MCI, and other inter-exchange carriers, as well as cellular phone carriers.

The HCO was monitored remotely by two separate IBT systems, each responsible for different functions. The temperature, humidity, boiler loss, and sump pump were monitored by direct digital control designated as the Building Equipment Status Indicating System (BESIS), which was located in downtown Chicago. The communication equipment alarms and fire alarm systems were monitored by an Illinois Bell Telephone Central Office Technician in Springfield, Illinois, in the Division Alarm Reporting Center (DARC). The alarm system functioned to alert the Springfield facility of fire alarms, power interruptions, and telecommunications equipment malfunctions in the building.

The building was equipped throughout with an ionization smoke detection system manufactured by Pyrotronics which was designed to detect products of combustion released during an

Photograph 1.
The Hinsdale Central Office Building during recovery.

incipient fire situation. In the early stages of a fire, smoke products (both visible and invisible) are normally released into an area before any appreciable heat is released. These detectors were mounted on the ceiling at 20-foot intervals on center spacings. Additionally, smoke detectors were located in the ducts of the air circulating system. These were designed to detect the presence of smoke and shut off the air supply system to prevent smoke from being distributed throughout the building. In special areas not involved in the fire, there were different types of detectors, such as an infrared flame detector in the diesel generator room, and heat detectors in other areas.

There were two diesel-powered generators located in the basement stand-by generator room. One 500-gallon diesel fuel tank, located adjacent to the generators, provided fuel. In the event of utility power failure, the generators would operate under full load for approximately four hours with this fuel supply. In the event of a long term power failure, additional fuel was available from a 10,000-gallon underground fuel tank which had to be manually switched to continue operation beyond four hours. Two banks of large batteries and rectifiers located in the basement constantly supplied dc power to the communications equipment system, ensuring that variations in and/or loss of the commercial power source, did not interrupt the operation of the communications equipment. The battery capacity had sufficient reserve to operate the system under full load for a minimum of four hours after the loss of both utility power and diesel generator power.

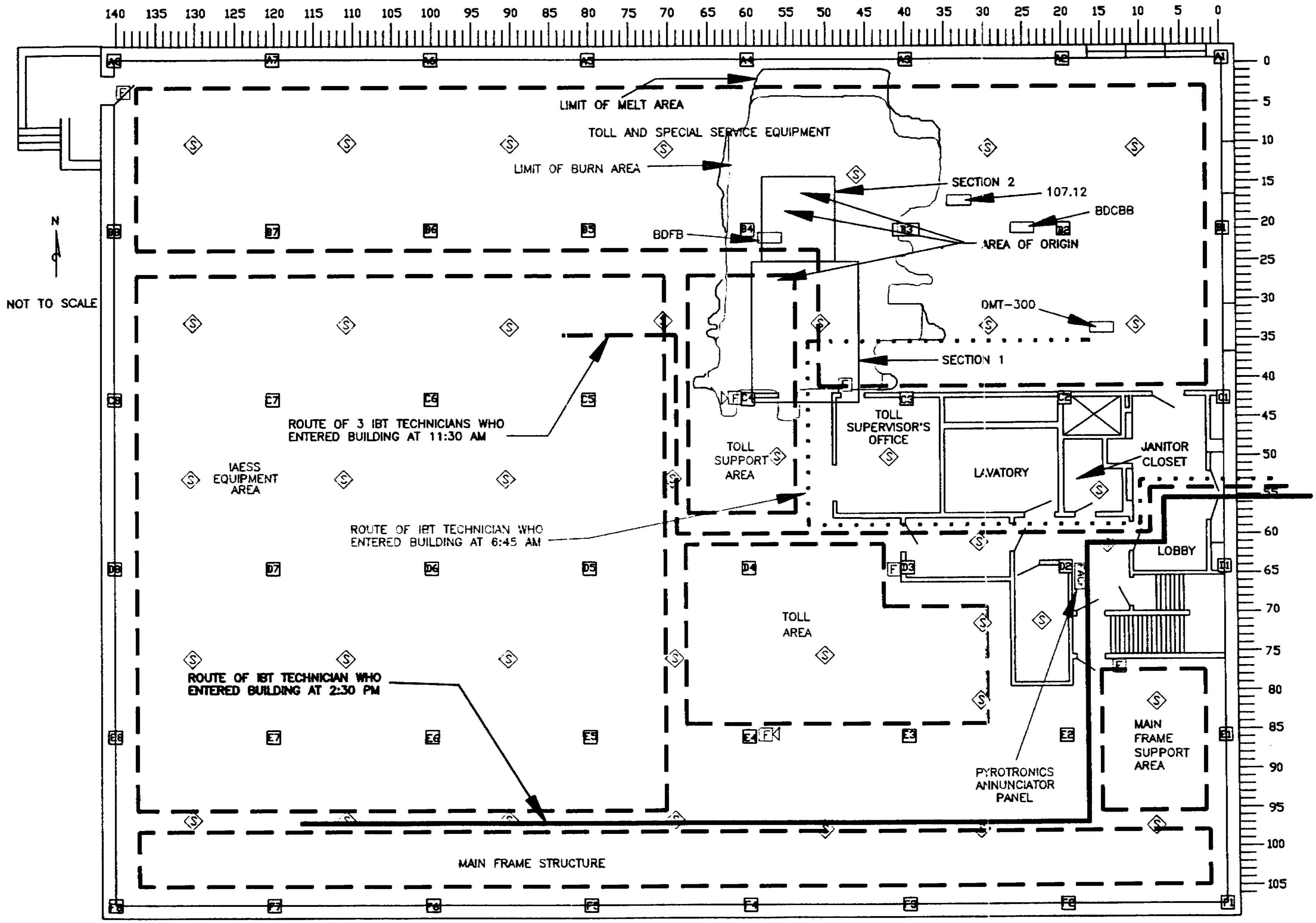
2.3 Hinsdale Pre-Fire Activities and Conditions

During the week, the Hinsdale Central Office (HCO) was normally staffed by several Illinois Bell Telephone (IBT) employees who performed technical repairs, maintenance, circuit installation, and system monitoring. The communications equipment operated without assistance or supervision. Problems with the equipment were reported by customers or by equipment-generated alarm signals. On weekends, the HCO was usually not staffed, although technicians occasionally entered the building to correct reported problems.

Routine fire safety inspections were performed by the HFD at the HCO, and pre-fire plan discussions had occurred between IBT personnel and the HFD. The last fire inspection was performed on March 2, 1988, and the only violation cited was that a door had been tied open.

The last equipment and wiring removal in the HCO occurred in February, March and April, 1988. Garrett and West (G&W), a Knoxville, Tennessee, based electrical contracting company dealing in communications equipment, was contracted by IBT to perform this work at the HCO. Primarily, the contract called for the removal of 66 toll frames and their associated cables in the northeast corner of the first floor. The removal of cables from trays is often referred to as mining of cables. This work began in the middle of February, 1988; it was interrupted due to scheduling conflicts with other work at Hinsdale. G&W left the job as completed at the end of March 1988; however, the IBT Central Office Engineer found that the removal of various patch panels in the toll equipment area had not been performed. G&W returned and completed the job in three days during mid-to-late April.

In March, 1988, while G&W was performing mining operations, two IBT technicians heard arcing, and one of them reported seeing sparks falling from the overhead cable tray. This arcing of cables occurred in the area between columns B3, B4, C3, and C4, approximately ten feet south of the Battery Distribution Fuse Board (BDFB), which can be seen in Figure 2. The IBT technician stated that the G&W employee said that a power cable had been damaged and that he (the G&W employee) had wrapped the damaged cable with electrical tape to correct the problem. It was also reported that a G&W employee accidentally cut an active cable resulting in loss of service. The G&W foreman directing the work at the HCO denied during an interview that his company had caused any damage to or arcing of cables over the course of the contracted cable mining work.



FIRST FLOOR - ROUTES OF ENTRY INTO BUILDING ON MAY 8,1988, BURN/MELT LIMITS AND FIRE PROTECTION SYSTEM

Figure 2

Fli

2.4 Hinsdale Fire, May 8, 1988

In the late afternoon of May 8, the Hinsdale fire and power alarms, and the equipment alarms for the local exchange switch, were being monitored remotely by a technician in Illinois Bell's Division Alarm Reporting Center (DARC) in Springfield, Illinois. It has become standard industry practice for central offices not to be staffed during non-regular work hours and for alarms to be monitored remotely. The sophistication and reliability of modern electronic telecommunications equipment has greatly reduced the maintenance required, and a small number of technicians, called "roamers," can handle the maintenance work in many central office facilities during off-hour periods. Moreover, the sophistication of alarm technology has allowed numerous offices to be monitored remotely from a central location.

Two entries were made into the HCO during the morning of May 8, 1988 by IBT technicians to perform normal work functions and no abnormal conditions were found. The last person in the HCO prior to the discovery of the fire was an IBT customer services technician, who entered the HCO early in the afternoon. A residential phone was reported out of order, which required the technician to perform some work in the central office to correct the problem. He reportedly entered the front door, turned left, and went into the main frame area in the south end of the building as shown in Figure 1. The technician located the particular line with the service problem, disconnected it, and reconnected service to a spare line. He noticed no problems within the building but did not enter the area where the fire damage would later occur. Upon completing his work, he left the building at approximately 2:46 p.m. These activities are illustrated in Figure 2.

The first signs of any unusual conditions at the HCO were an indication of commercial power failure, a fire alarm trouble alarm, a fire alarm, an air dryer alarm and a battery discharge alarm at 3:50 p.m., noted by the DARC operator. The fire alarm trouble alarm is due to loss of ac power and it also sends a fire alarm signal, which will clear if ac power is returned and there is no fire. At 3:53 p.m., these alarms cleared, and signals indicated the diesel generators started as programmed. Power fluctuations occur somewhat frequently and set off this type of alarm combination; the DARC operator interpreted this combination as a power interruption, not a fire. At 3:59 p.m., there was a reported diesel failure, another air dryer alarm, a fire alarm trouble alarm, and a fire alarm. At 4:00 p.m., there was a repeat of the battery discharge alarm, and the previous fire alarm trouble alarm and fire alarm cleared. The battery discharge indicated that the batteries were required to supply electrical dc power for at least a brief period. Once the battery discharge alarm activates, it does not automatically reset, and a technician must be dispatched to reset the alarm. This design was used to ensure that these power alarms would be investigated. At 4:05 p.m. and 4:14 p.m., the DARC operator requested an alarm summary for the HCO. Each time the monitoring system showed the same four conditions.

- Diesel engine failure alarm
- Fire alarm trouble alarm clear
- Fire alarm clear
- Battery discharge alarm

The DARC operator called the Duty Supervisor in Wheaton after the second audit and reported the power alarms at 4:16 p.m. The Duty Supervisor then attempted to contact a Central Office Technician (COT) to respond to the power alarms at the HCO. The DARC operator then started receiving power failure signals from other stations including Oswego, Downers Grove, and Lombard. Although the DARC operator recognized these events as unusual, he did not think that this was a fire situation. These types of alarms were typically experienced when storms and high winds went through the areas monitored by DARC.

At 4:20 p.m., the DARC operator received a fire alarm from the HCO and the first Carrier Group Alarm (CGA) in the interoffice facility system. He called the Duty Supervisor again at 4:21 p.m. and reported the fire alarm. He did not, however, call the Hinsdale Fire Department (HFD) as required by IBT Operating Procedures. At 4:24 p.m., the Duty Supervisor contacted a COT at Downers Grove Central Office and directed him to investigate the conditions at the HCO in response to the DARC power and fire alarms. The COT proceeded to the HCO at about 4:30 p.m. At approximately 4:30 p.m., the Duty Supervisor attempted to contact the HFD and the Downers Grove Fire Department and both phone lines were out of order. At 4:23 p.m., other CGAs and trunk alarms were received indicating that there were severe problems affecting equipment at the HCO. From 4:23 p.m. to 4:56 p.m., the signal he received indicated the HCO equipment was still working, but not well. IBT was experiencing interoffice telephone problems but no local services problems at that time. Alarms continued to be received by DARC, in Springfield, until 4:56 p.m., when all signals from the HCO ended.

The COT arrived at the HCO at 4:52 p.m. and noticed smoke exiting from the north wall vent. He unlocked the main entrance and entered the lobby, turned left, entered the stairwell, and looked through a window in the door to the equipment room. Smoke was evident at the ceiling level. He attempted to use the telephone mounted on the lobby wall to call the fire department, but the telephone did not function. He went out to his car to use his cellular phone, but that was out of service also. At that point, he stopped a passing motorist and asked him to report a fire at the IBT building to the fire station.

The HFD was notified of the fire by the Hinsdale Police Department (HPD). These two departments are located in adjoining buildings approximately five blocks from the HCO. An unidentified citizen walked into the HPD and said that he had seen smoke coming from the IBT building, and an IBT employee had told him to report the fire. The alarm at the HFD was entered at 4:58 p.m., 38 minutes after the DARC operator received the fire alarm signal. Five personnel, a pumper, a ladder truck, and an ambulance were initially sent to the scene of the fire.

The front door area of the HCO was engulfed in heavy black smoke, forcing two firefighters to enter on their hands and knees. After searching two small rooms, fire was initially noticed in several metal bins which were on the floor, in the area of major burning. These bins contained IBT equipment record cards.

The fire was initially thought to be contained in the bins and was extinguished. When a Deputy Chief and another firefighter entered the fire area, they found electrical arcing and popping at the ceiling level and attempted to extinguish the fire which remained in the overhead cable trays. The smoke in the area on the first floor was very heavy and black. The smoke in the basement was described as being thirty percent of that found on the first floor, and the second floor smoke was fifty percent of the density on the first floor. Firefighters reported the cable tray fire was then approximately six feet in diameter and the flames were described as blue or bluish-green, with lazy movement. Repeated attempts were made to extinguish the fire with water spray. Each time water was applied, the flames appeared to be extinguished but reignited and seemed to spread.

The HCO's electrical power system with its built-in redundancy capabilities to maintain operational telephone service continued to supply power to the ac and dc cables in the overhead cable trays. After forty-five minutes of efforts to extinguish the fire, it was decided to shut off the electrical power since the rekindling of the fire appeared to be the result of electrical arcing. A firefighter was instructed by IBT personnel on how to turn off the power to the building; he then entered the building and went to the basement to turn off the diesel generators. He found a fire department lieutenant and another man already there turning handles and pulling fuses on an electrical panel. The firefighter found the Commonwealth Edison panel and turned off two main breakers. He also shut down the two diesel-powered generators. These actions failed to shut off all electrical power because all fuses were not removed from the battery powered sources.

During the entire firefighting effort, the burning appeared to spread from the initial area of flames, outward and mainly northward. Burning was confined to an area approximately forty feet by thirty feet. The fire consumed the majority of the wire insulation around both power and communications cables housed in the overhead cable tray in this area, as shown in Photograph 2. Although there was burning of other combustible items in the ceiling area, minimal direct fire damage occurred to associated telecommunications equipment located below the cable trays, as depicted in Photograph 3. Significant smoke and corrosion damage was incurred throughout the first floor.

The fire was extinguished immediately after all the electrical power was cut off at about 7:15 p.m. to the cables in the overhead trays. The fire was officially extinguished at 11:30 p.m. The Special Agent of the Division of Arson Investigation of the Office of the Illinois State Fire Marshal on the scene, released the building to IBT at 3:00 a.m., on May 9, 1988. IBT security monitored access and materials to and from the HCO during the first day and were supplemented by contract security for the remainder of the investigation. The fire area was quickly sealed off and all access and evidence handling was under the control of the OSFM.

Photograph 2.
Fire damaged cable trays suspended from ceiling in the Toll Equipment Area of the first floor

Photograph 3.
Fire damage below cable trays shown in Photograph 2.

2.5 Impact and Restoration of Service

The damage caused by the switching station fire affected voice and data communications for more than one-half million resident and business customers in Hinsdale and surrounding Chicago-area communities. Local service was disrupted for 38,000 customers in Hinsdale, Clarendon Hills, Willowbrook and parts of Burr Ridge, Darien, Oak Brook, and Westmont. The outage affected special service lines and local, long distance, and cellular calls because Hinsdale served as a communications gateway for the fiber optic network.

Restoration of service began with the rerouting of interoffice traffic around Hinsdale on available working circuits and the temporary installation of a microwave link between the Hinsdale switching center and the LaGrange switching center. Service for police, fire departments, and hospitals was given first priority for restoration.

The number of local customer lines served by the Hinsdale office totaled 41,455.

While the damaged switching equipment gradually was returned to temporary service, simultaneous efforts were made to install and test a new 5ESS digital switching system. This equipment, already enroute from the manufacturer to another telephone company, was diverted to Hinsdale.

The new switching system was placed in service in two stages. The initial stage was completed May 26, 1988, and 19,500 customer lines were transferred to the new equipment from the old. The first to be transferred were fire, police, and hospital lines.

The remaining customers were transferred June 5, 1988. At this point, all service was delivered, installed, tested, and in service four weeks after the fire.

3.0 INVESTIGATION

The thorough investigation and comprehensive report are the results of the excellent cooperation of the investigation team members, identified in the Introduction, and the support of the state agencies and IBT. The steps and results of the process are detailed in Volumes I and II of the Report.

The investigation consisted of a broad range of activities expanding over a nine-month period. Included in these efforts were:

- Site inspection to determine the scope of the fire and resulting damages.
- Interviews with numerous persons extending over a period of more than six weeks.
- Examination of evidence utilizing ultraviolet scanning, X-rays, and dissection techniques.
- Analysis of ac and dc power supply systems.
- Analysis of cable damage patterns.

Damage to both communication and power cables was found during the examination of evidence. Extraneous materials were found in the cable trays. Areas where cables were being crushed against portions of the supporting trays were also found.

A total of eleven sections of cable trays containing cables which were damaged during the incident were dissected and each cable carefully examined. Sketches, photographs and videotapes were made during these tear-downs to allow subsequent analysis to be conducted. Radiographs of Sections 1 and 2, the sections most heavily involved in the fire, provided information as to the location of interior damage.

As the investigation proceeded, it became clear that fire research testing would be required to reach conclusions as to the cause and spread of the fire.

4.0 TESTING

Extensive testing was performed on undamaged cables that were in use at the HCO on May 8, 1988, to determine the physical, mechanical, chemical, and electrical characteristics of the cable as well as their performance under actual fire conditions. These are detailed in Volumes I and II of the Report.

Physical and electrical tests were performed at Forensic Technologies International Corporation (FTI), in Annapolis, Maryland. The chemical tests were performed by Bellcore at the Navesink Research and Engineering Center, located in Red Bank, New Jersey. The mechanical and electrical testing was done by Underwriters Laboratories (UL) at its Melville, New York, facility. Large-scale burn tests were performed at the UL, Northbrook, Illinois, where adequate facilities were available. All UL testing was performed under contract with and at the direction of FTI.

The tests verified the primary deduction of the investigation that the grounded sheath of an armored cable in contact with the conductors of an energized, insulation-damaged power cable will provide a reliable and repeatable ignition of cable insulation.

Through testing, it was possible to duplicate repeatedly a chain reaction of power cables shorting, arcing, and overheating. Specifically, one or two power cables would short to a smaller cable causing it to overheat and burn. This fire would then cause the insulation breakdown (through heating and melting) of adjacent power cables which would fail and perpetuate the fire growth. Low-voltage multiconductors and coaxial cables would readily ignite and add fuel to the fire. The high power densities and synergistic effect of cables can only be simulated through realistic large-scale fire tests. Large-scale fire tests of non-energized cables in trays would not provide relevant data for the HCO fire scenario. Without the chain reaction effect of energized cables failing in the fire, the cause and spread scenario for this incident cannot be relevantly analyzed. As far as can be determined, fire tests of this scale, utilizing cables energized to high power levels, have never been done before. Therefore, the results provided not only a great deal of insight into the HCO incident, but also contributed to the general knowledge of fires developing in energized cable trays.

A significant finding from all cable tests that ignited was the burning mode for these cable assemblies. Irrespective of ignition source location, the fire would ignite the top layer of cables and spread the length of the tray. A combination of thermal radiation from the flame and burning, melted insulation dripping down into the cable stack were the downward fire spread mechanisms. This flaming material was observed to be capable of igniting card bin materials below as well. The longer the fire was allowed to burn, the deeper the fire damage to the tray cross-section. Fire spreads fairly rapidly to those areas directly exposed to air, such as the sides of the cable bundle, both ends of the longitudinal sectional, and the exposed cross cables. Even with a twenty-five-minute fire exposure, the jacket materials in these areas were heavily consumed. A general observation is that the thermal radiation from the fire-heated ceiling enhanced the flame spread and resultant growth of the fire.

5.0 ANALYSIS

A complex investigation to reach a supportive conclusion requires that all possible causes be addressed and either confirmed or eliminated as the cause. Use of the FTI Failure Analysis Logic Tree (FALT) process provided a disciplined approach to the investigation aiding comprehensiveness, thoroughness, and manageability. Using the FALT, a logic tree structure, engineers from numerous areas of expertise determined eight main areas related to the potential causes of the fire. These eight areas were as follows:

- AC Internal Electric Power
- DC Internal Electric Power
- AC External Power
- Equipment and Appliances
- Building Equipment
- Ignitable Items
- Natural Causes
- Man-made and other causes

Within each of the eight main areas, more detailed potential causes were listed, as shown on the FALT for this fire, Figure 3. This logic tree method was used by the investigating engineers to isolate all possible contributing factors at the scene of the incident and to determine their relationships to the cause of the fire. Each potential cause listed on the FALT was thoroughly addressed and analyzed during the investigation and either discarded for good reason or followed to a conclusion.

HINSDALE CENTRAL OFFICE FIRE
FTI FAILURE ANALYSIS LOGIC TREE

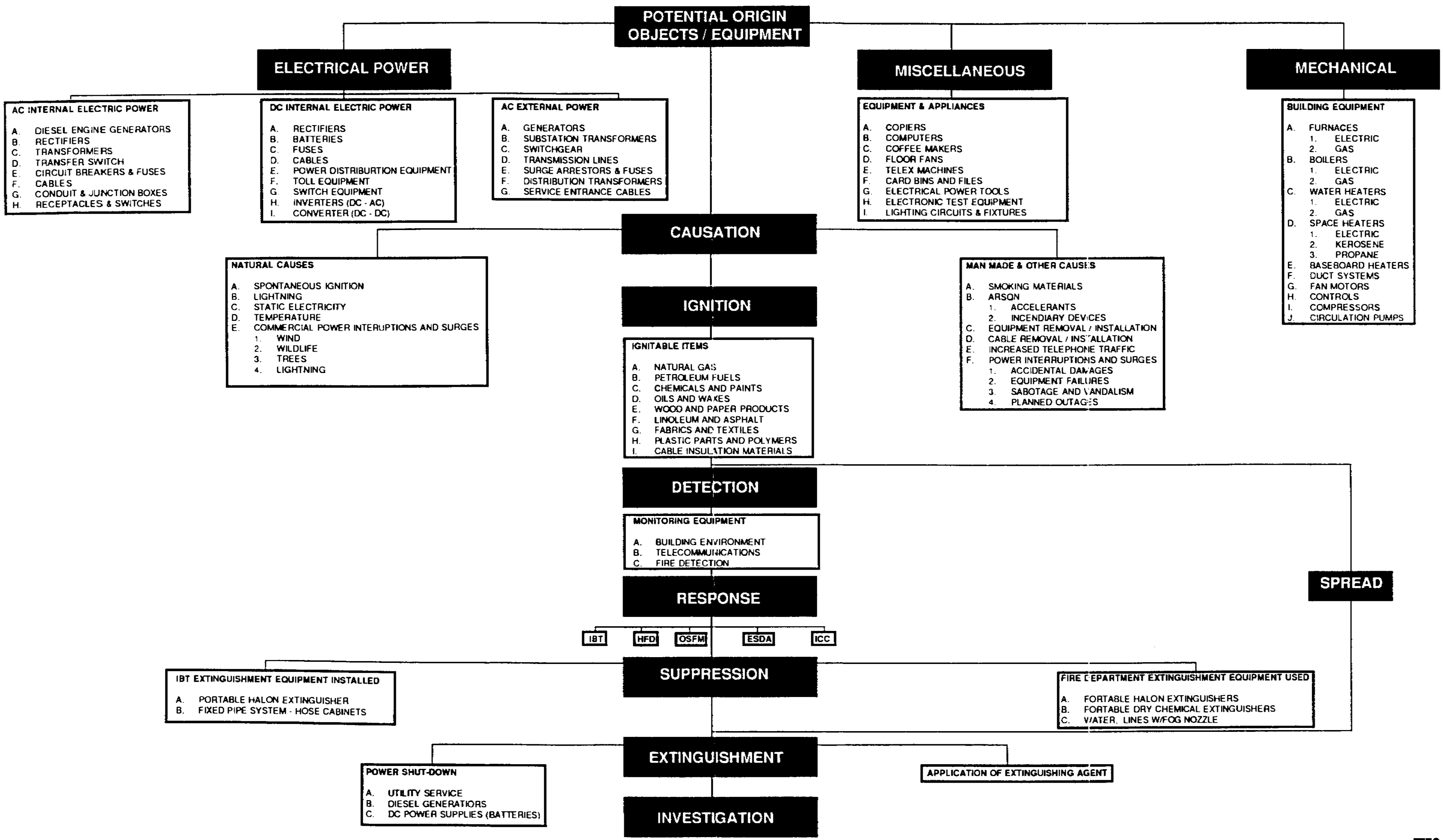


Figure 3

FTI

6.0 CONCLUSIONS

6.1 General

The following information highlights the essential conclusions reached in the report, followed by a brief review of factors relevant to each conclusion. Further data supporting the conclusions may be found in various sections of the report and in Volume II, Appendices.

6.2 Fire Cause and Origin

- The fire was accidental in nature and caused by an electrical fault.
- An armored cable contacted a damaged dc power cable.
- A dc power cable was most likely damaged at some time during cable mining operations.
- An exact point of fire origin was not determined.

The Hinsdale Central Office (HCO) fire of May 8, 1988, was accidental in nature and caused by an electrical fault. A unique combination of circumstances resulted in an electrical fault in the cables of the cable tray extractions identified as Sections 1 and 2. The initial electrical fault probably involved an armored cable sheath which became energized when it contacted a damaged dc power cable. This contact was caused by cable movement in the trays produced by the combined effects of electrical, mechanical, and thermal forces. The degree of motion was small, but sufficient to result in contact. Other types of cables were involved in electrical faults but are considered less likely to be the cause. Damage to the dc power cable most likely occurred during cable mining operations in Section 1 and 2, at sometime prior to the fire. The exact point of the fire origin has not been determined; however, three areas within Sections 1 and 2 are possible origin locations. The results of the fire research studies, when compared to the actual fire evidence, corroborate this cause and origin determination.

Contributing causation factors were: the increasing and cyclic ambient and cable temperature variations, building vibrations, and the commercial power interruptions which may have resulted in cable motion. These factors would have had no causal effect if the dc power cable insulation had not been damaged.

6.3 Fire Detection and Response

- The smoke/fire detection system was adequate.
- Fire alarm signals required operator interpretation.

- Company procedures were not followed completely.
- Elapsed time between fire detection and reporting was excessive.

Based on the equipment alarm logs, the system performed as designed, and there is not reason to suspect that the smoke detection system was slow in reacting to the fire. However, fire tests conducted at UL suggest that fire in cables, in some cases, can slowly smolder at first, and the suddenly erupt into flames. A more sensitive and sophisticated detection system may have reacted and identified the fire earlier.

On the day of the fire, fire alarm trouble alarms occurred as follows: 3:50 p.m., alarm activates; 3:53 p.m., alarm clears; 3:59 p.m., alarm activates; 4:00 p.m., alarm clears. A fire alarm trouble alarm is activated when commercial power is interrupted; it is cleared when the emergency generators come on line. A fire alarm trouble alarm is again activated when the diesel generators disconnect and the commercial power returns. At each of these times, a brief ac power outage occurs to prevent paralleling the emergency and commercial supplies. The fire alarm signal was wired to activate each time the fire alarm trouble signal was activated. Thus, this interruption in ac power supply causes transmission of several signals to the Division Alarm Reporting Center (DARC), including power failure signals, a fire alarm trouble signal and a fire alarm signal; these fire alarm signals could lead to misinterpretation and delay.

At 4:20 p.m., a fire alarm signal alerted the DARC technician to an actual fire. Fortunately, this operator was not confused by previous multiple signals. Unfortunately, he did not call the Hinsdale Fire Department (HFD) (as required by Illinois Bell Telephone [IBT] operational procedures) but called the IBT Duty Supervisor. This may have contributed to the 38 minute delay before the HFD was alerted to the fire.

Use of an alternate emergency communications system and reinforcement of existing operating procedures between DARC and the HFD could have shortened the fire response time. A fully staffed, localized IBT alarm center would be more accessible to emergency operations of local monitored facilities and participate more fully in preplanning and training activities.

If the HCO had been staffed, it may not have affected the detection time, but it could have shortened the reporting time. Since the fire was confined to the first floor and the HCO was compartmentalized vertically, an observer on the second floor or basement would probably not have sensed the fire before the 4:20 p.m. fire alarm.

6.4 Fire Suppression and Damage Control

- Water effectively extinguished the fire after power was shut off.
- Cable insulation materials produced large volumes of smoke and corrosive gases.
- Damage was primarily due to non-thermal effects.
- Vertical fire controls were sufficient.
- Horizontal fire controls were limited.

Water was the most effective extinguishing agent once all power was disconnected. However, the use of water can introduce additional irreversible damage to sensitive electronic equipment. This is not to say that an alternate agent would be less effective given a different set of circumstances.

Halon® is not necessarily the agent of choice for several reasons. Halon® functions by breaking up the chemical reaction of the combustion process, thus suppressing the fire. It does not directly work to reduce the temperature. The application of a Halon® system is designed to hold the required concentration of Halon® for a minimum of 10 to 20 minutes in order to be effective. Energized high current circuits such as in the HCO would need to be deenergized prior to the release of the Halon® and then the concentration must be maintained in the area until the fire is extinguished. Unless the HCO was subdivided into smaller, controllable zones, a Halon® system would be ineffective. Further, because of the growing international concerns regarding the depletion of the ozone layer of the earth from compounds such as Halon®, a Halon® system of a size needed for the HCO, plus other central offices to comparable importance, would be environmentally unacceptable, due to its potential adverse effects. Carbon dioxide (CO_2) and dry chemical agents, with their relatively low penetrating power, are not completely compatible to this type of fire and location. These concerns apply particularly to existing facilities with their limitations of access and interior volumes.

Based on the examination of cable tray installations in several central offices and observations made during the UL testing program, it is doubtful that traditional sprinklers would be completely effective in extinguishing cable tray fires in existing central offices.

Cable insulation materials produced large volumes of smoke and corrosive gases. The extent of damage was primarily due to non-thermal effects. Lack of smoke-control features in the HCO allowed for the rapid and total spread of corrosive by-products throughout the first floor.

Although the horizontal controls for smoke and fire were very limited on the first floor, the vertical controls between floors were adequate.

An active smoke control system may have been partially effective in limiting the spread of smoke on the first floor, but it is unlikely to be of benefit without horizontal compartmentalization.

6.5 Fire Potential Assessment

- Armored cables mixed with dc power cables in the cable trays is potentially hazardous.
- Power cables used in the HCO had undesirable fire characteristics.
- Communications cables used in the HCO had desirable fire characteristics.

The presence of armored cables mixed with dc power cables in the cable trays elevated the risk of fire to a serious and unacceptable level. Two factors had to be present to initiate the HCO fire: armored cable and a damaged dc power cable in close proximity in a cable tray. The resistance heating of the grounded sheath of the armored cable was the most probable ignition source of the fire.

The insulation of the power cables used in the HCO had undesirable fire characteristics and contributed to the spread of the fire. The power cables did not meet the normal desired burn limits in comparison tests.

The insulation of the communications cables used in the HCO had desirable fire characteristics in that they were self-extinguishing and, thereby, helped to limit the spread of the fire.

Cable trays were often fitted with a cross trays containing vertical retainers or stanchions. As cables were loaded into the main tray, they often rested on top of these metal bars, crushing the insulation. During the fire, at least four dc power cables were in this position and with the addition of heat, failed electrically, causing various degrees of arcing. These events were not the cause of this fire but were secondary sources of ignition which aided the fire spread.

6.6 Central Office Power System

- Cable tray loading was excessive in some areas.
- Mining operations damaged cable insulation.
- Smaller power cables connected to larger cable bus centers may present a hazard.
- The power deenergizing procedure was too complex, and not formalized.
- Commercial power was subject to frequent interruptions.

Cable tray loading was excessive in some areas and probably contributed to the difficulty in mining or removal of cables.

Mining operations were conducted in such a manner as to damage insulation on cables to the point of exposing energized conductors.

Established dc power cable distribution methods created many unfused, smaller cables connected to larger cable bus centers, rendering the smaller cables unprotected. The dc power plant systems were very reliable and rugged. The combination of a weak and damaged dc power cable system and an extremely reliable source of dc power accelerated the chain of events.

An efficient, straight-forward de-energizing procedure and system for the ac and dc power systems would have enabled extinguishment of the fire up to two hours earlier. However, in this case, the non-thermal fire damage had most likely reached all parts of the first floor by the time firefighters entered the HCO, shortly after 5:00 p.m.

Surge protectors were not found in the power distribution system; however, their absence did not appear to contribute to the fire.

Commercial power delivered to the HCO has been less than reliable as evidenced by the relatively high number of service interruptions caused by: the use of a bifurcating switch on the 3614 feeder; the lack of a paired service; and, the increased vulnerability to contact along the heavily wooded distribution feeder route to the HCO.

7.0 RECOMMENDATIONS

7.1 General Intent

The real benefit from the exhaustive and comprehensive analysis, which this report represents, is the opportunity to develop plans for preventing similar incidents.

These recommendations are focused on the primary objectives of fire protection engineering; prevention of ignition; detection of combustion at an early stage and notification to assure a minimum response time; suppression as quickly as possible and in the most effective manner; and containment of the fire and its by-products to minimize the spread and extent of damage.

Not all recommendations may be appropriate for all central offices; the objective should be the implementation of an effective, reasonable fire protection plan addressing the unique characteristics to be found in various facilities.

Recommendations are not limited to those which would have been effective in preventing or limiting the Hinsdale Central Office (HCO) fire. Rather, it addresses fire protection generally and seeks to anticipate other potential causes and consequences of fires based upon an analysis of the enormous amount of data acquired through this investigation.

Each recommendation is followed, where appropriate, by a brief discussion of the philosophy, logic, and facts supporting the position. In addition, many recommendations are followed by a discussion of the problems which may be encountered or created by inflexible implementation of the recommendations. Recommendations of a technical nature should be modifiable when prevailing conditions warrant, providing the intended safety and reliability levels are achieved.

An original task of this investigation was to provide estimated costs associated with the various recommendations. However, due to the complexities and interrelationships of many of the recommendations, this was determined to be both unmanageable and inappropriate for this report.

7.1.1 Fire Protection and Risk Management Characteristics of Telephone Communication Facilities and Systems

An IBT Office of Fire Protection and Investigation should be created at an effective level of management to assume company-wide authority for control

and planning in this critical area. Telecommunications experts should be supplemented by independent consultants to provide a balanced and effective team.

A telephone exchange is not unlike other facilities that can suffer high consequences from a low probability fire event. The same can be said for high-tech electronics manufacturing facilities, nuclear plant cable vaults, hospitals, and other critical occupancies and sites. However, the high concentration of increasingly sensitive electronic equipment, the engineered reliability of power systems, and the unique construction of IBT central offices present special concerns.

The evaluation of needs in this area can only be carried out by a number of extremely knowledgeable and sometimes highly specialized individuals pooling their knowledge. However, the activity must be controlled by an individual with broad management ability and experience, and some technical understanding. It is most important that the position in the organizational structure is high enough that recommendations from the group will be given careful consideration.

7.1.2 Risk Assessment

A risk assessment survey should be coordinated by the responsible state agencies in cooperation with the telecommunications utilities to determine which facilities and/or operations are to receive priority. Each such facility and equipment/storage/functional area of operation must be evaluated for this purpose.

Based upon the philosophy of continuous and reliable communications service to the subscribers, the highest priority should be given to those "target hazards" which are identified and isolated as having the potential for unsafe or adverse impact to facility employees, the public, and the business community when an interruption occurs.

Some basic questions to ask include:

- How long can a given facility reasonably be out of service?
- What areas and components are critical (relative necessity of the area or component to the continued operation of the facility as compared to the level of protection provided) to the continued operation of the facility.

- What degree of fire damage can specific areas and components tolerate? What would be major damage? What would be minor damage?
- To what degree can operations and facilities be modified to continue operation in the event of partial loss of a facility?

Much of these criteria would be based on telecommunication operational requirements, while answers to some of the questions would be generated through fire risk analyses (defining the importance of an area and evaluating the probability of fire initiation and resultant damage) of specific facilities.

7.1.3 Fire Department Education and Pre-Fire Planning Program

The appropriate state agencies should initiate a multi-discipline committee to establish a fire department education/pre-fire planning program which would address the problems unique to the telecommunication carriers regulated for intrastate service.

The preparation phase should include input from both the fire service and personnel involved with central offices. Implementation should include, to the highest degree, central office personnel working directly with the fire departments in their area.

7.1.4 Emergency Communications

A state system should be developed that would not have total reliance on a telephone cable network and that would have sufficient routings to ensure uninterrupted completion of emergency communications.

There is a dangerous potential that a situation could arise whereby a remote alarm-monitoring site could not communicate to appropriate fire departments during certain fire scenarios. Virtually all of the State's emergency communications systems, including the low-band state-wide radio network, the National Warning System, the Nuclear Accident Reporting System, and the Federal Emergency Management Agency System are dependent, to a degree, on telephone transmission.

7.1.5 Telecommunications System Considerations

An improved network of interoffice cable trunking should be developed to provide alternate routing in the event of a major malfunction at critical sites.

Major offices should have more than one communication route to other offices and long distance carriers in the event of a disaster. The cable network architecture should be redesigned on a priority basis to avoid the isolation of emergency communications systems and customers.

7.2 Fire Protection of Existing Facilities

7.2.1 Compartmentalization

Central offices should be compartmentalized into functional areas where feasible. The size of compartments can only be determined by a study of each building arrangement. Only general guidelines can be expressed in this document. The barriers installed for separation must be of recognized fire protective ability.

The widespread smoke damage experienced during the HCO incident highlighted the need to evaluate the use of compartments to limit the spread of fire and contaminants. The barriers establishing structural division must be substantial enough to prevent passage of fire for extended periods and also limit the spread of smoke. The fire-resistive integrity of the barrier must be preserved when openings through floors and walls are created for inter-compartment access, whether doors and stairways for people or holes for cables, pipes, and HVAC ducts.

Many professionals in fields other than fire protection oppose compartmentalization for such reasons as interference with a production process, whether it be installation of a factory production line, or cable trays and communication equipment frames, inconvenience, or cost. Subdividing a building into compartments complicates the heating and cooling process such as requiring more capacity, ducts, and control equipment to maintain controlled conditions in each room.

At present, some equipment and/or operations are commonly isolated such as cable rooms, emergency generator rooms, battery rooms, and transformer rooms. Vital equipment should be isolated where possible.

Essentially a compromise decision must be made to establish, within the maximum compartmentalization allowed by existing codes, the degree of separation that is feasible and effective for each facility and operation.

7.2.2 Detection Systems

All central offices should have sensitive fire alarm and smoke detection systems, which detect products of combustion at the earliest possible stage of a fire.

There have been many advances in the fire and smoke detection field in recent years because of the advances in science and engineering; these should be explored. Particular attention should be paid to systems which sample ambient air for products of combustion, such as CO and CO_2, and those which react to airborne contaminants peculiar to telecommunications equipment under thermal stress, such as polyvinyl chloride and rubber. These systems may not be limited only to the fire protection field but may have been developed for other uses. For example, a fire in the Holland Tunnel in New York City in 1948 was first detected by the carbon monoxide monitoring system designed to automatically adjust the ventilation capacity as automobile exhaust fumes increased or decreased.

7.2.3 Standards

The appropriate state agencies should review and determine the adequacy of existing codes and standards applicable to fire alarm and smoke detection systems.

There is a need for state agencies, the fire service, and the regulated industry to review system applications with respect to the established standards. The best possible system must be designed mindful that it may be necessary to interpret the actual wording of the relevant codes while still maintaining the intent. Current standards do not consider the implications of public safety when telecommunication facilities are disabled.

7.2.4 IBT Reporting Center Notification

Fire alarm, other alarm, equipment supervisory, or trouble signals should be transmitted to the IBT DARC facility by equipment and circuits which will provide the highest degree of reliability.

Ideally, an alarm circuit to a receiving center should be direct, not used for any other purpose, not susceptible to damage, monitored so that those in authority will be immediately advised of any failure or threat of failure, and be duplicated to provide an alternate transmission route that is not subject to the same incident affecting the first route.

7.2.5 Division Alarm Reporting Center (DARC), Springfield

The DARC facility and operation should be reviewed to determine its suitability for continued operation, at the same scale and location, as a center for receiving alarms. The operational procedures, particularly those relating to fire emergencies, should be reassessed. DARC technicians should be trained in the operational procedures and a program instituted to ensure compliance.

DARC supervises (receives equipment alarm and trouble signals and initiates appropriate responsive action) 280 unattended central offices throughout the state; the operator responsible for monitoring the HCO was responsible for forty-one of these unattended central offices.

The potential for impaired efficiency exists whenever a work load is too great, a normal level of activity is significantly increased, the required attention span is too broad, or productive time is adversely affected by lengthy delays in routinely contacting other individuals. To some extent, each of these conditions may have existed on the day of the fire. On May 8, 1988, the DARC technician did not call the Hinsdale Fire Department as required by IBT's procedure manual.

IBT should analyze the work load of the center and of each operator to determine the levels of stress to be expected during days and shorter time divisions of maximum traffic conditions and other obligations. Analysis of traffic has the potential for reducing the number of signals received with relatively minor circuit or equipment arrangements at central offices. At the HCO, for example, transfer of power supply from commercial service to diesel generator transmitted four signals: a fire alarm, a fire trouble alarm, an air dryer alarm, and a battery discharge alarm, the last locking in until manually reset. Transfer of power supply from diesel generator back to commercial service caused transmission of all four signals again (the battery discharge was locked on the display board but received by the computer and printed out) in as little as ten minutes. The only actual change in condition was the variation in the ac power source, for which information was given by the transmission of those signals directly.

7.2.6 Subdividing DARC Operations

Consideration should be given to subdividing at least part of the DARC operation and transferring it to a new Reporting Center in the western suburbs of Chicago, with personnel on duty at all times at the Center.

The Springfield (DARC) facility is located over 200 miles from the site of the Hinsdale fire and, therefore, familiarity with the local area and fire department response operations may not be adequate. Another issue in the distance involved is the relationship between the monitoring personnel and the local fire departments.

7.2.7 Transmission of Alarms to Fire Departments

Fire alarm signals received by DARC should be immediately transmitted directly to fire department receiving stations by equipment and circuits which will provide the highest degree of reliability. This transmission should be confirmed over the commercial telephone system.

Such circuits should be used only for alarm transmission. The circuits should be as direct as possible, entering central offices only for cross-connection purposes. Alternative circuits, such as microwave or radio, should be explored.

7.2.8 Direct Connections to Fire Departments

Fire alarm signals transmitted by central office detection systems could be transmitted directly to fire department alarm-receiving locations, when desired, or required by local governments.

Although direct alarm transmission to the fire department has the advantage of immediate notification, such a system is susceptible to numerous false alarms. When the transmittal of alarms is required, IBT should ensure that fire alarms, and not equipment alarms, are transmitted to the fire department. Some communities in Illinois have required homeowners with automatic telephone transmissions of fire and burglar alarms to disconnect the system because of this problem.

Although not required by the NFPA Standards for Proprietary Signaling Systems (NFPA-72D), a direct connection from a central office to the nearest fire department would mean an earlier response when a fire occurs.

7.2.9 Automatic Fire Suppression Systems

The installation of automatic fire suppression systems should be reviewed by IBT, but no recommendation for a complete building installation can be made at this time.

There has been much public comment that a total flooding Halon® system or a complete automatic sprinkler system be installed in central offices. Because of the unusual arrangement of central office telecommunications and power distribution equipment in large open spaces, neither system is completely practical.

Halon® is a heavier-than-air gas so its utility would be limited when the fire is in cable trays about two feet below a ceiling which is fourteen feet high unless the entire volume of the room is filled to the required concentration level. Even then, the Halon® would have to be continually replenished as it settled and leaked from the space, limiting its effective time to extinguish the fire. Also, the penetration ability of Halon® is limited and may be ineffective after the single-shot application.

An automatic sprinkler system would apply cooling water to the fire area. It would, also, thoroughly wet down all the electrically energized equipment in the area, whether exposed to fire or not, greatly increasing the size of the loss of a small fire.

Forty years ago, a large, well-ventilated, and air-conditioned room was required to house the computer capacity that can now be held in one hand. As the telecommunications industry moves toward that goal, it can be anticipated that automatic suppression equipment will be more practical and more widely used. Until then, the appropriate approach is to isolate limited sizes of equipment by function, where large volumes or important customer services are affected, or by cost, where highly specialized and expensive equipment is in a small room. Where possible, equipment should be so isolated and suppression equipment installed.

7.2.10 Commercial Power Supply

The IBT should consult with Commonwealth Edison to establish a system design criteria for a maximum level of service continuity.

An examination of Commonwealth Edison's operating log for 3614-X, the feeder which supplied Hinsdale, showed a large number of interruptions. Although not directly associated with the fire, the variations of the dc power system associated with ac power system interruptions can contribute to problems in the dc system. Commonwealth Edison should consult with local IBT officials when determining the best routing of power service to central offices, whether through the use of buried cable or improved tree trimming programs along cable routes.

7.2.11 Equalizing Center Design

The use of the equalizing center design to distribute dc power in the central office should be reviewed.

The practice of tapping smaller power cables from large power cables creates the possibility of unprotected sections of cables. This condition was noted in the examination of the HCO cable trays which disclosed a number of burned-off smaller conductors. These cables cannot be protected by a 600-ampere fuse because they will burn off before the 600-ampere fuse fails. Battery distribution boards, of either fuse or circuit breaker type, serving as the distribution point for the sub-circuits to the individual loads, will provide the capability for providing proper protection for the sub-circuits.

There exists significant lengths of inadequately protected conductors. This tapping of smaller conductors from larger conductors leaves the smaller conductor unprotected as the protective device on the larger conductor is normally too large to sense faults on the smaller conductor. The installation of a fuse on the smaller conductor at the tap point would remedy this condition; however, maintenance of the fuses must be considered in the placement location. The length of unfused taps should be limited to as short a length as is practical.

7.2.12 Surge Protection

The surge protection programs for telephone central office power systems should be reviewed.

Although no evidence of over-voltage surges was found during the examinations of the HCO electrical/electronic equipment, there was a feeling among some of the investigators that this condition could exist. The resultant high impact that surge damage could impose on the cable systems makes it prudent to examine the practicalities of installing surge protection. The installation of high capacity arresters, such as thyrite air-gapped arresters, at the origin of the power cables, in conjunction with the installation of metal oxide varistors, which have lower voltage discharge characteristics but also lower current handling capability, at the equipment terminals, would provide adequate surge protection for the majority of surges that could be expected to appear on the system.

7.2.13 Protective fuse and breaker settings for all power cables should be reviewed.

It was apparent that protective devices, fuses or circuit breakers, on power cables did not de-energize the faulted circuit soon enough to prevent the ignition of insulation on adjacent cables. A load study should be performed on all systems in an attempt to improve the system protection while maintaining performance margins. Both sizes and types of protective devices available should be considered in this study. The minimum setting which will provide the capacity required and the sensitivity to detect damaging faults should be used.

7.2.14 Master Power Switch

Central office power supply equipment should be redesigned to enable a practical, safe disconnection of all interior circuits using as few switches as practical and installed at a single location.

The experience of firefighters at the HCO demonstrated the criticality of shutting down all the ac and dc power feeding the cable tray fire before the fire could be extinguished. Powering down proved difficult because central offices have been designed for extreme reliability of service and no consideration has been given to providing a safe method for quickly powering down the system. At the HCO, the power could be shut off only by individually pulling the in-line fuses for the power cables feeding the equipment.

Clearly identified primary control switches should be installed in the dc power supply to allow the complete and quick deenergization of the dc system by the operation of a small number of controls. This equipment should isolate both the rectifiers and the batteries from the dc cable system. This system must be engineered with a power-down procedure for safe operation both for the employees and the equipment. The capability to isolate portions of the system would lessen the need for shutdown of the complete system.

It must be realized that the complete removal of power in a central office puts all customers served by that office out of service. Even an undamaged electronic switching system can only be restarted through a careful sequence of events that may take several days. The risk of premature, inadvertent, or deliberate power shutdown must be weighed against the requirement for expeditious shutdown procedures in the event of a fire.

It is essential that the fire department preplanning education program include a specific procedure for safely disconnecting all electric power to the central offices to which a particular fire department will respond; central office personnel must also be re-educated in these procedures.

7.2.15 Armored Cable

All armored cable, flexible metal conduit, and any other cable with an exterior metallic or conductive surface should be removed as expeditiously as possible from cable trays in central offices.

The tests performed to analyze the cause of the HCO fire showed that the failures, which resulted in wide spread burning, required the presence of damaged dc power cables, bare grounded-sheath cables, and communication cables. Examination of the cable trays from the HCO showed that all three elements existed.

7.2.16 Power Cable Isolation

Wherever possible, power cables should be physically separated from communications cables.

Separation can be achieved by installing parallel cable trays. Limiting the number of cables in the tray and isolating the power cables would significantly reduce the probability of damaging conductors during removal operations.

7.2.17 Cross Tray Stanchions on Overlapped Cable Trays

Cross tray stanchions should be removed whenever possible; when removal is not possible, they should be insulated. In extensions and retrofits, butt joints should be used.

Cross tray stanchions (vertical posts on each side of the tray) were often observed to be covered by cables at the HCO. Those cables lying directly on the stanchions were frequently observed to have damaged insulation due to contact with the stanchion. This condition could lead to arcing of an energized cable to the grounded stanchion. Although ignition scenario testing indicated that this was not a likely cause of the fire, it is still an undesirable possibility. This issue can be avoided by the use of butt joints rather than overlap joints where cable trays intersect. Both types of joints were observed at the HCO. In an overlap joint, the cables in the lower tray must be laid over the cross rails of the upper cross tray. This, coupled with the weight of the cable stack, was observed at Hinsdale to cause deep impressions in the insulation of the bottom cables. In a butt joint, however, both trays are at the same height; thereby eliminating this problem.

7.2.18 Fire Performance Characteristics of Cable Insulation

Cables meeting the most recent standards for fire resistance and retardation should be used when extending a telecommunication system or replacing cables within it.

The insulation on the cables at the HCO burned readily and produced large amounts of smoke and hydrochloric acid. These resulted in permanent damage to surrounding equipment which had not been directly involved in the fire. Cables are now available with insulation that is fire retardant or resistant and produces reduced quantities of smoke and hydrochloric acid.

7.2.19 Cable Installation Management Program

A more comprehensive cable installation management program should be instituted to minimize the possibilities of overloading cables and cable trays and to survey conditions of existing cables.

During the investigation of the HCO fire, there were several occasions when it was necessary to determine the run of power distribution in particular cables. Because some records were incomplete, the only method for tracing was to physically follow the cable. Any modifications to the equipment in the central office may also require knowledge of particular cable runs. A comprehensive and accurate record of cable data, including such information as size, length, source, fusing, termination, date and method of installation, is desirable.

An inspection program should be developed to examine the condition of the insulation on the power cables. Although no deteriorated insulation was found in the HCO, the consequences of damaged insulation are so great that reasonable measures should be taken to minimize this possibility. Employees should be required to report damage to cables whenever observed.

7.2.20 Use of Infrared Scanner

All equipment and cables should be regularly inspected, with an infrared scanner to detect hot spots.

Hot spots, indicative of an area of increased resistance and a potential source of ignition, may have been present in the HCO dc system for some time prior to the fire. Regular inspection with an infrared scanner would detect hot spots in areas such as the cable trays, fuse and breaker boards, and system buses.

7.2.21 Cable Mining

Careful consideration should be given to the selection of future sub-contractors to perform cable mining. Any such operations should be monitored very carefully ensuring the appropriate tools and methods are employed.

Examination of cables removed from the HCO showed evidence of cable damage; interviews, where statements described arcing during cable removal, further support these findings. Detailed procedures and standards should be established for all cable mining and rerouting, cable tray loading, and installation. Procedures and standards which may currently exist should be reviewed, expanded, and updated on a regular basis. The review should recognize the difficulties encountered in removing cables from heavily loaded trays. Effective management of the subcontractor conducting the removal operations is essential.

7.2.22 Fire Stops

Fire stops placed, both horizontally and vertically, at regular intervals in the cable trays should be considered.

The HCO fire travelled substantial distances horizontally. A fire stop system would limit the ability of this type of travel as demonstrated in the final full-scale horizontal burn Test 3A at UL, Northbrook.

7.3 New Central Offices

The recommendations to improve existing central offices are equally applicable to new central offices. However, before implementation, the latest techniques unique to central office building safety should be considered for inclusion

during the design stage to be certain they are still valid and also to determine if there is any need of updating; these should be reviewed by the appropriate state agencies.

7.3.1 Isolation of Cables

A high degree of separation of critical spaces and equipment should be maintained by modifications to past designs.

The HCO fire and test experience clearly demonstrate the desirability of dividing a building into compartments for the control of smoke and fire spread. The most critical of these is the separation of power cables from communication cables. In addition, all cables should be separated from equipment to the highest degree possible. This will allow the use of specialized fire detection and suppression systems.

Consideration should be given to such possible arrangements as:

- Installation of cables on separate floors with connection to equipment being through fire-rated floors and ceilings close to the point of use.
- Separation of cables and equipment by fire-rated walls with connection to equipment being through fire-stopped openings close to the point of use.
- Separation of cables and equipment by a fire-rated false floor or ceiling, giving consideration to cooling needs or possible derating of cables.
- Use of fiberglass cable trays which are fire-resistant and non-conductive.
- Installation of power cables in a bank of cable trays above trays reserved for communication circuits.

7.4 Coordination

Development and implementation of recommendations of varying degrees of technical complexity require a methodology which will recognize the need for immediate action, phased response, and future study. To facilitate the development of reasonable actions, legislation has been introduced in the Illinois General Assembly to establish rule making authority among three State agencies most directly responsible for telecommunications, fire prevention, and emergency services; respectively, the Illinois Commerce Commission, the Office of the State Fire Marshal, and the Illinois Emergency Services and Disaster Agency. This legislation would enable them to: (1) establish protective mechanisms to prevent major interruptions of telecommunications services; (2) provide for proper emergency response following a telecommunications failure; and (3) provide a communication capability ensuring continuity of emergency services.