



JANUARY 1975

NEW YORK CITY TRANSIT AUTHORITY DESIGN GUIDELINES

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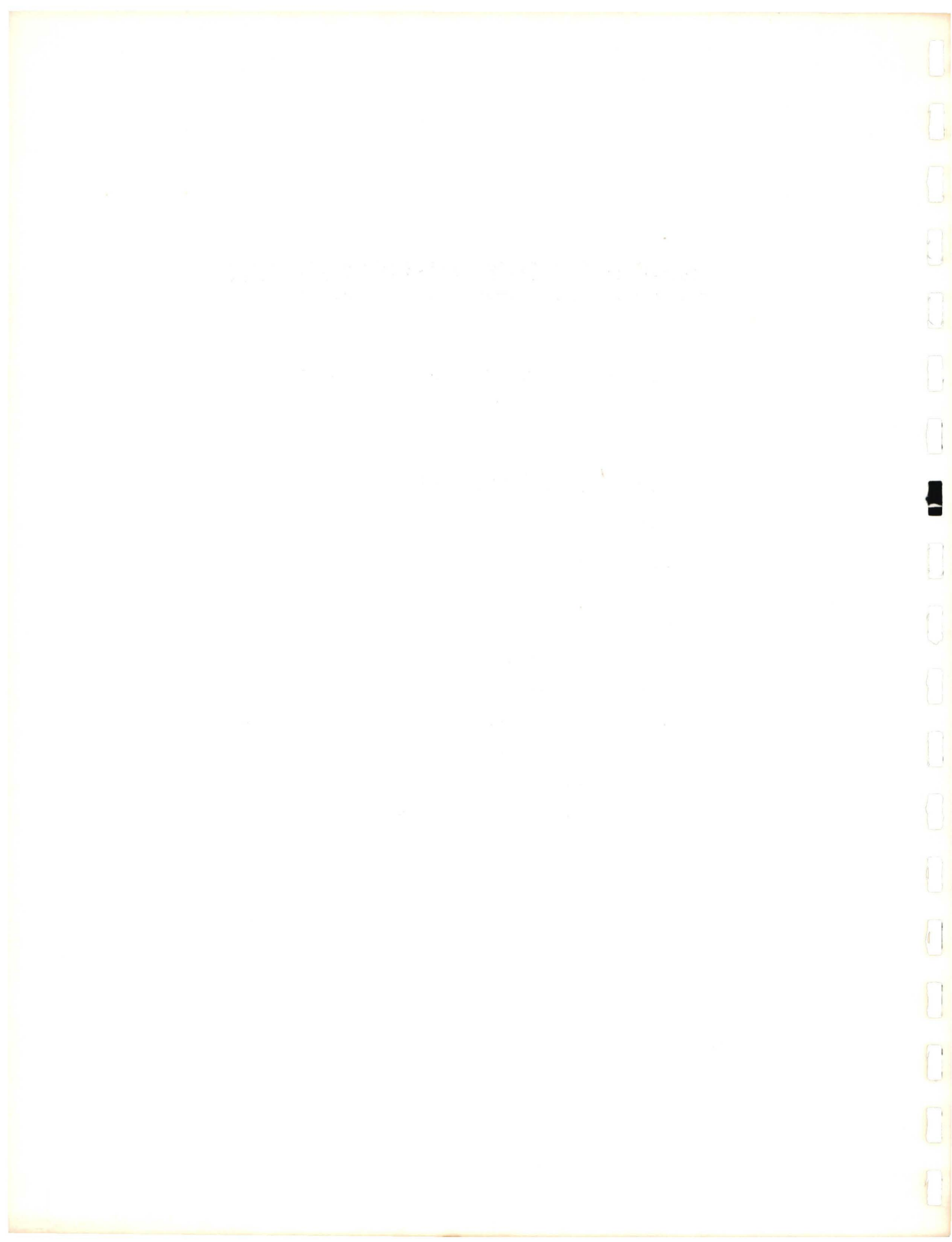
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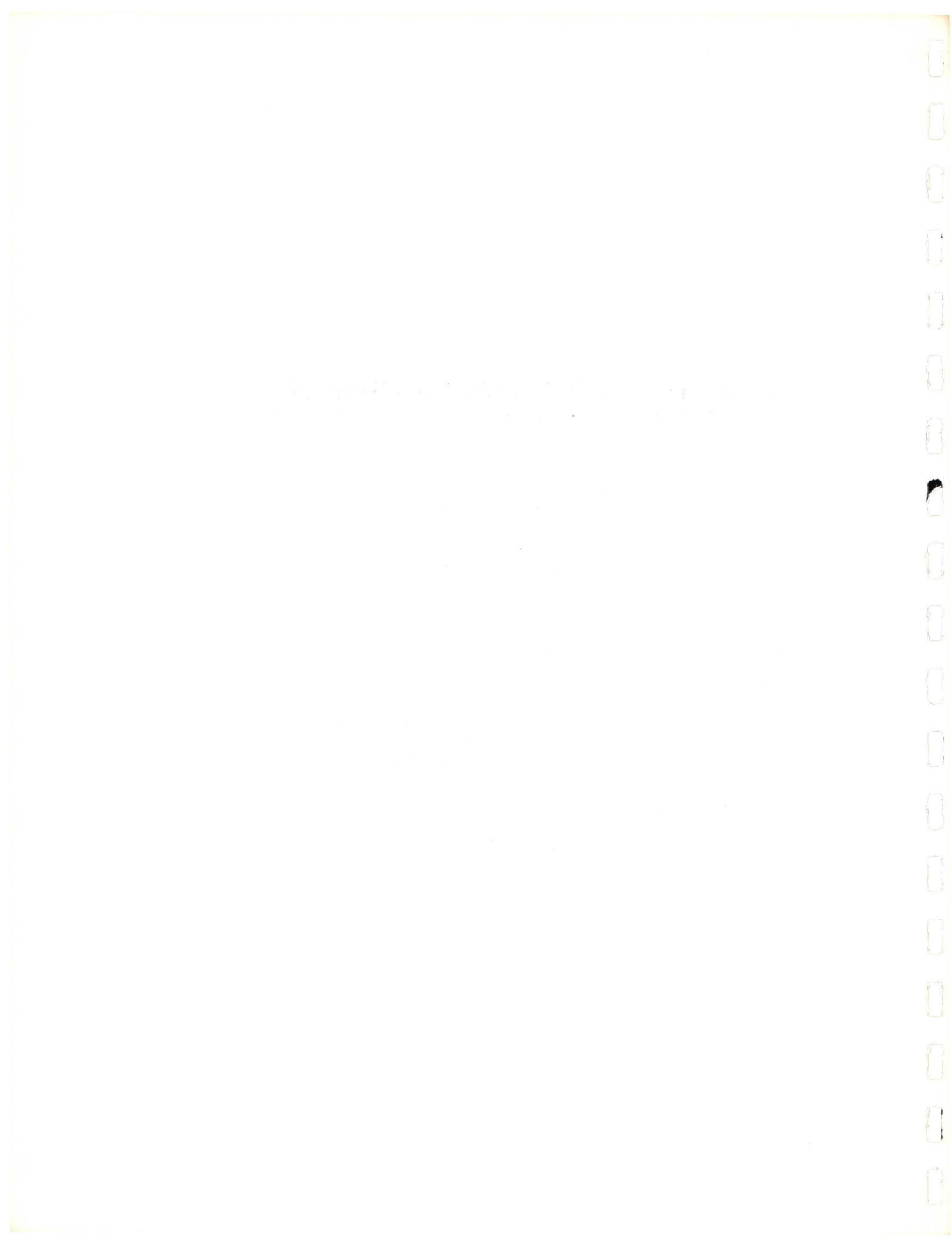
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CONSTRUCTION GUIDELINES



JANUARY 1975

INTRODUCTION

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CONSTRUCTION GUIDELINES

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Construction of subway systems is a complex task in which many factors must be considered in order to determine the method of construction which will best fit any given condition.

The two basic methods of construction are Cut-and-Cover and Tunneling. Both methods of construction have been successfully used in the vast N.Y.C. Transit System network.

With many years of experience in subway construction the Engineers of the N.Y.C. Transit Authority have developed construction standards to be followed as guidelines with sound engineering modifications due to the different local conditions encountered during construction.

It is not the intent to present in these guidelines all the detailed technical information on subway construction, but factors peculiar to these methods of construction within the City limits necessitate that certain rules and regulations be followed.

There are ever changing improvements in construction methods and technology which dictate a certain allowance for flexibility in the application of these guidelines.

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CONSTRUCTION GUIDELINES

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Chapter 1

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Chapter 1

UNDERPINNING

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Chapter 1

1- UNDERPINNING

I - GENERAL REQUIREMENTS

A. SCOPE

Buildings and structures along the route and in the vicinity of the Railroad affected by the construction work, shall be, if necessary, safely and permanently underpinned.

B. DAMAGE TO BE MADE GOOD

Any damage done in performing the work included in this Chapter, whether or not due to negligence or carelessness, shall be made good.

C. APPROVAL OF DRAWINGS

Drawings shall be submitted for approval in triplicate for each and every building indicating the proposed typical and special methods of underpinning or other form of permanent construction in lieu thereof.

D. BUILDING EXAMINATION

Prior to the commencement of work hereunder, an examination shall be made of the interior and exterior of buildings and structures adjacent to the Works in accordance with the Provisions of Chapter 26 of the Administrative Code of the City of New York. The person or persons authorized to make said examinations of buildings shall be approved.

Such photographs as may be necessary or ordered shall be taken to show the exterior surfaces and grounds of each building examined in addition to any special or unique feature or construction methods, and one copy of each photograph, 8 inches by 10 inches in size, and the negatives, shall be furnished.

Samples of records for building examinations on file

may be consulted to assist in the preparation of records for building examinations and to determine the minimum standards for detail and quality of the records to be submitted. The minimum scope of examination of buildings required shall be as provided in the Special Specifications.

E. NEW BUILDINGS

If new buildings are erected in the vicinity of the Railroad after the date of submitting proposals for the work if necessary, said new buildings shall be underpinned.

F. PERMITS

All permits and consents necessary or requisite for underpinning buildings and structures and for the reconstruction thereof shall be secured. Applications for consents to enter buildings for the purpose of underpinning shall state that underpinning is necessary to maintain and support the building in a safe condition during construction of the Railroad. One counterpart of each consent duly signed and acknowledged by the owner or one of the owners, executors or administrators for himself and for his agents, lessees and any other persons who shall have a vested or contingent interest in the building, or notice of refusal if consent is not obtained, shall be filed at least 10 days prior to the commencement of any work which would affect the building.

G. UNDERPINNING IN ADVANCE OF EXCAVATION AND PUMPING

Where underpinning is indicated or directed, it shall be completed before the excavation for the Railroad reaches a depth or width which might disturb the soil supporting the existing structure. Underpinning shall also be completed when ground water is being removed, before soil supporting the existing structure which may be disturbed due to the lowering of the water level.

H. PRELIMINARY WORK

Needling, shoring, grillages, cribbing and posting, as is necessary to ensure the safety of the structure, shall be installed prior to and during underpinning operations.

II- MATERIALS

A. STEEL SHEET PILING

Steel sheet piling shall conform to ASTM Serial Designation: A 328

B. TIMBER

(a) Timber used for underpinning shall conform to the requirements of timber used for sheeting and bracing.

(b) Timber used for underpinning and not removed shall be treated with a 5 per cent solution of Pentachlorophenol in light petroleum solvent to a net retention of 8 pounds per cubic foot of wood in accordance with A W P A Standard Specifications of Recommended Practices.

C. CONCRETE USED IN UNDERPINNING

Concrete used in permanent underpinning or in other permanent construction in lieu thereof shall conform to the requirements for concrete for the Railroad.

III- CONSTRUCTION METHODS

A. UNDERPINNING

(a) By underpinning is meant such method of construction as will transmit the foundation load directly through the underpinning structure to such lower level as is necessary to secure the buildings and which will relieve the adjacent ground and Railroad structure from lateral pressures.

(b) The underpinning shall be designated to furnish a safe and permanent independent support for each building or structure. To accomplish this result, such methods of underpinning shall be used as special conditions may require.

(c) Steel sheet piling, steel or treated timber sheeting and/or steel bracing in connection with the underpinning of buildings shall be provided wherever it is impracticable to remove sheeting or bracing.

B. METHODS

Such methods of work shall be used as are best adapted to preserve the safety and stability of foundations, walls, and other parts of building and structures and to prevent any disturbance or damage thereto. Any damage which may in the course of construction be done to any such foundation, walls, or other parts of buildings or structures shall be made good.

C. DEPTH OF UNDERPINNING

(a) For a building and subway structure in earth above ground water, where the building is more than 6 feet distant from the subway net line, the need for underpinning is determined by assuming a 45 degree slope line from the subgrade of the subway structure at the net line, then extending it upward toward the building foundation. If the bottom of the foundation is above this 45 degree slope line, an underpinning pier or wall is constructed to carry the foundation load to an elevation 1 foot below this 45 degree influence line, without exceeding the safe bearing value of the soil encountered at that level. If the 45° influence line intersects the building line above the foundation, underpinning is not required. In ground water where the net line is more than 6 feet from the building line, the underpinning shall be carried to 1 foot below a 1 vertical to 1-1/2 horizontal slope if in sand or gravel, or 1 to 2 slope if in poorer ground.

(b) Where the building line is less than 6 feet from the net line, and the building and the subway are either in ground water or above ground water, the following criteria should govern:

- (1) Where net line is less than 2 feet to building line, carry underpinning to subgrade of subway.
- (2) Where net line is between 2 and 6 feet from building line, carry underpinning 1 foot below a 1 vertical to 1-1/2 horizontal influence line.

D. RETAINING WALL IN LIEU OF UNDERPINNING

(a) In certain cases, retaining walls in lieu of underpinning may be constructed, provided the safety

of the completed Railroad structure, will not be endangered by improper pressures resulting from the construction of such retaining walls. The use of sheeting and steel piling which is necessary to secure the sides of the excavation for the Railroad and sewers, will not be permitted in lieu of underpinning of buildings.

(b) Wherever the Railroad structure passes so close to private property as to prohibit the use of sheeting methods without encroaching upon the said private property, a continuous concrete retaining wall in underpinning the buildings shall be constructed and such wall shall be carried to such depth as may be necessary for underpinning purposes and to act in connection with the trench bracing to provide lateral support in lieu of sheetings.

E. CONCRETE PIER UNDERPINNING

Approach pits excavated in front of buildings or inside cellars shall be close sheeted, braced and shored. If the sheeting is to be left in the ground, bent steel plate shapes bolted together or timber treated with a preservative shall be used.

Concrete pier underpinning shall be installed and carried to within approximately three inches of the underside of existing footings, leaving sufficient space to properly install steel plates, wedges and dry packing to ensure full bearing of the portion of the footing to be supported. Dry pack material shall consist of one part portland cement and one part sand with a minimum of water sufficient to permit its placing and packing into the spaces between the pier and existing footing.

Where vaults from the building formerly extended beyond the building line, a series of piers with a curtain wall between them shall be installed. If a series of beams is used to span from pier to pier, these beams shall be steel encased in concrete or concrete beams.

IV - UNDERPINNING PILES

A. PILE INSTALLATION

Piles shall be pipe piles conforming to A S T M Designation A 252, Grade 2, and shall be installed open and in such manner as to prevent a "blow" or other loss of ground. The inside of piles shall be cleaned out, filled with concrete, and load tested with final tip elevations at or below elevations indicated on working drawings. Piles shall be installed by jacking means and at pressures which will not damage existing structures or the piles. Jacking pressure shall be maintained within safe limits by alternately cleaning and jacking as required.

B. DEWATERING

Dewatering of the inside of the piles shall be accomplished with caution to prevent any loss of ground. An earth plug of sufficient size to prevent loss of ground shall be left in the tip of the pile, or if necessary, a plug of tremie concrete shall be installed prior to dewatering. After it is safe to do so, the pile shall be dewatered and then inspected.

C. FILLING WITH CONCRETE

After the condition of the pile has been approved, it shall be filled with concrete. Care shall be taken to ensure that the pile is completely filled and without voids. An accurate record will be kept of the volume of concrete deposited in each pile and any deficiency revealed by comparison with the volume of the inside of the pile will be cause for rejection of the pile.

D. LOAD-TESTING

Each pile shall be loaded to 150 per cent of its design load, and shall maintain such load without pile movement for 5 hours. Piles shall be load-tested in such sequence and groupings as to minimize eccentric loadings on the footings and piles. Piles shall be rejaacked and retested if there is a danger of unequal loading.

E. ADDITIONAL REACTION

Should the existing structure fail to furnish sufficient reaction for installation of underpinning piles to the test loads specified, whatever additional reaction is necessary shall be furnished and installed to prevent damage to, or movement of, the structure during installation of piles and to obtain specified underpinning test loads. The additional reaction provided shall not affect detrimentally the previous usage of the building.

F. WEDGING

After load-testing, the pile shall be securely wedged in place by means of steel wedging struts and steel wedges as indicated on the Contract Drawings. Jacks shall not be released until at least 20 per cent of the test load is released by means of wedging. Wedges, plates, wedging struts and piles shall be welded as indicated on the Drawings, upon completion of which the pile head and wedging shall be completely encased in concrete.

G. UNDERPINNING OF BUILDINGS TO ROCK

If building foundations or underpinning are on good sound rock, no other work is necessary. However, if rock is soft or disintegrated, underpinning piers must be carried to sound rock. And, if future excavation is to be made immediately alongside the underpinning and deeper than the surface of the hard rock, and faults or slips exist, steps must be taken to secure the rock face with bracing, rock bolts or other means. In any event, it is essential that the rock be very carefully line drilled in the vicinity of the underpinning to help minimize the danger of overbreakage.

H. SUPPORTING AN EXISTING SUBWAY STRUCTURE

When a new subway structure is to be built under an existing subway, the existing subway shall be supported temporarily as follows:

- (a) The outside wall columns and the center line columns shall be carried on girders and brackets

to a safe distance beyond the influence line from subgrade of cut.

- (b) The reinforced track invert shall be picked up by beams carrying the track ties.

I. SUPPORT OF COLUMNS CARRYING AN EXISTING ELEVATED SUBWAY STRUCTURE OVER A NEW SUBWAY

When a column carrying an existing subway structure is to be supported by a new subway structure, the transfer of load shall be accomplished in the following manner:

- (1) The column shall be picked up temporarily in an approved manner.
- (2) A temporary pier to subgrade of new subway structure shall be erected, and the column load shall be transferred to this pier.
- (3) The column load shall then be transferred to the permanent subway roof structure.

Chapter 2

1970-1971

Chapter 2

DECKING

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Chapter 2

DECKING

I- GENERAL REQUIREMENTS

A. SCOPE

The excavations in the roadways and sidewalks, or elsewhere as required, shall be completely decked. Decking over excavated areas shall be provided, maintained and removed as required. Decking as used herein, includes all surfacing members and those structural supporting members on which they rest.

B. DESIGN OF DECKING AND SUPPORTS

Working drawings showing proposed method of constructing decking and decking supports shall be submitted for approval. The drawings shall show the sequence of placing decking components; details indicating sizes and shapes of girders, beams, soldier piles, other piles and accessories; and methods of assembly and bracing, and of supporting utilities in place.

Working drawings shall show loadings, allowable stresses, and other criteria used in the design including the most severe loading conditions to which it is anticipated the decking will be subjected, including the loads necessary for support of existing utilities.

The working drawings shall be certified by a Civil Engineer registered in the State of New York. Before the decking and the street supporting systems are placed, the working drawings submitted must be approved. All decking in street supporting systems shall be so designed that during installation and removal at least one-half the width of the roadway and sidewalks can be kept open for traffic at all times and as to comply with paragraph, "Installation of Decking."

In excavations covered by decking, a means of illumination must be provided and maintained at all

times, whether work is or is not in progress, so that the supports of the decking may at all times be readily inspected; and as further means toward this inspection, galleries or walkways must be provided beneath the decking, so that inspection of its supports may readily be made when the excavation reaches such depth as to render such walkways necessary.

C. SURFACE OF DECKING

Surface of decking, including steel plates, shall be flush and line up with the existing adjacent street surfaces. Wherever street decking is installed higher than the existing surface, suitable ramps shall be provided.

II - MATERIALS

A. TIMBER AND LUMBER FOR DECKING AND SUPPORTS

All timber and lumber used for decking and the supports for same shall be sound and free from any defects that may impair its strength. All decking used for temporary surfaces shall be hard yellow pine or other acceptable wood, sound, straight and free from all shakes and large knots.

B. STRENGTH OF DECKING AND SUPPORTS

(a) The street supporting system and street decking shall be of sufficient strength to safely support, in addition to its own weight and that of pipes and other subsurface structures supported therefrom, either of the following loadings:

(1) 250 pounds per square foot on any two adjacent 10-foot roadway lanes and 200 pounds per square foot on the remaining area of roadway and sidewalk.

(2) On any two adjacent 10-foot roadway lanes, a single group of four wheel loads of 22,000 pounds each with a consecutive spacing of 7, 3 and 7 feet, placed on any line at right angles to the direction of traffic, and at the center of each 10-foot

area of roadway and sidewalk outside of these lanes, two wheel loads of 10,000 pounds each, spaced 5 feet apart.

The foregoing loads shall be so placed as to produce maximum stress.

(b) Where the loading due to the machinery or equipment is in excess of the above, the street supporting system and street decking shall be of sufficient strength to safely support such machinery and equipment.

TIMBER

Permissible stress, Maximum, pounds per square inch	Short Leaf Pine, White Pine, Spruce	Long Leaf Pine, Fir	White Oak
Tension			
Bending, extreme fibre	1,250	1,600	1,400
Shear	(S.L. Pine 150) (W. Pine 90) (Spruce 90)	150	140
Bearing			
Compression, unit			
Compression, parallel to grain	$1,250 \left(1 - \frac{L}{60d}\right)$	$1,600 \left(1 - \frac{L}{60d}\right)$	$1,600 \left(1 - \frac{L}{60d}\right)$
Compression, perpen- dicular to grain	200	320	560

Legend: L == Length of column, in inches.

R == Least radius of gyration, in inches.

d == Least side or diameter, in inches

STRUCTURAL STEEL

Stresses shall conform to AISC Manual of Steel Construction 7th Edition - 1970.

C. LOADS TO BE RESTRICTED

It is required to restrict the loading on the temporary roadway decking to the aforesaid loadings and display signs, visible at all times, shall be erected and maintained in the streets, and such other measures shall be taken as may be necessary to caution the public against placing excessive loads upon the street decking.

D. STEEL PLATES

Steel plates that may be used to cover small pits and trenches shall be of thicknesses tabulated below:

<u>Plate Size</u>	<u>Maximum Clear Span</u>
1"	4"-0
1-1/4"	4"-6"
1-1/2"	5"-0

III - CONSTRUCTION METHODS

A. INSTALLATION OF DECKING

(1) The excavation of the roadway pavements and sidewalks shall be made in sections to the minimum depth necessary to install decking beams, followed immediately by the placing of the decking. These sections shall be handled in such an order that there will always be available, on one side or the other of a line 15 feet away from each street line, a roadway on which the ladder trucks of the Fire Department or equivalent facilities can operate. Wherever any portion of roadway or sidewalk is opened up, the work to be done must be prosecuted continuously; otherwise the opening shall be decked over. When the decking has been installed, it shall be maintained in proper condition for the use of traffic and for access to adjacent properties until it is removed and the temporary pavement is laid as specified.

Openings may be made in the decking as approved from time to time and as necessary for the prosecution of the work where it is not practicable to do such work under the decking; provided, however, there shall always be maintained on one side or the other of a line 15 feet away from each street line a roadway on which the ladder trucks of the Fire Department or equivalent facilities can operate. Decking shall be replaced over each opening at the end of each workday, or, as soon as the work necessitating access through each opening is completed or, whenever work is discontinued and completion thereby deferred, before such work is completed when it is necessary in the interest of safety or public convenience.

(2) Steel Plates that can be used over pits and small trenches, shall be spiked or otherwise secured to prevent movement due to the vibration caused in the plate from the flow of traffic, and shall be placed flush with the existing adjacent street surfaces. Street shall be cut back as required to permit flush placement of steel plates. Overlapping of steel plates will not be permitted.

(3) Sidewalks within the work site shall be maintained at all times at a minimum width of 5 feet and sidewalks on decking shall be separated from adjacent traffic lanes by timber curbs and shall be raised to curb height above deck grade. Raised portions of sidewalks shall be adequately ramped to lower sidewalk areas.

IV - MAINTENANCE OF TRAFFIC

A. GENERAL REQUIREMENTS

The intent of traffic maintenance requirements is to provide for safe and proper routing of vehicular and pedestrian traffic in a manner that will minimize congestion and delay resulting from the construction operations.

All temporary barricades, guard rails, pavement, decking, bridges, stairs, cones and other devices and necessary facilities shall be furnished, installed and maintained to safeguard the general public and

the work. Such devices and facilities shall be re-located as necessary and, upon conclusion of the need thereof, shall be removed from the site of the work.

The regulations on temporary traffic and pedestrian control by street barricades and channelization as spelled out by the New York City Traffic Regulations under Article XIII, Section 156 shall be strictly adhered to.

B. TRAFFIC ON LONGITUDINAL AND CROSS STREETS AND AT INTERSECTIONS

All necessary facilities shall be furnished for the benefit of street traffic on longitudinal and cross streets. Access for traffic shall be maintained in the blocks and street intersections adjoining the work, except where working shafts are located, shall be kept open at all times.

C. BARRICADES WHERE DECKING IS TEMPORARILY REMOVED

Where the decking is temporarily removed from any part of the street, the opening shall be protected at all times by lighted barricades and bridging. All barricades shall be substantially constructed, neat in appearance and painted as required with approved paint. Heavy timber wheel guards, at least 12 inches high shall be provided along the edges of street decking at openings. The top and the traffic sides of the wheel guards shall be painted in two color stripes in accordance with the Regulation Manual on Temporary Traffic and Pedestrian Control of the New York City Traffic Department. At night, barricades shall be illuminated by flashing yellow lights.

D. FENCES

Whenever a trench is not required to be decked, a solid board fence shall be constructed to enclose the excavation for the protection of the public and prohibit any encroachment upon the site of work.

All temporary fences erected shall be substantially constructed, of new lumber, neat in appearance and shall be painted as required (at intervals not to ex-

ceed 6 months) with two coats of approved paint of colors as directed. Generally, the fences shall be not less than 6 feet high and shall consist of framework of studs and plates, tightly covered.

ILLUMINATION

Whenever by reason of conditions created by constructing temporary fences, bridges or otherwise, illumination by artificial means becomes necessary in order to protect persons and property, as well as to prevent the committing of nuisances, necessary lights for proper illumination shall be furnished and maintained and kept illuminated.

ADVERTISEMENT

The use of fences for advertising purposes is forbidden.

F. ACCESS REQUIREMENTS

1. ACCESS TO FIRE HYDRANTS AND FIRE ALARM BOXES

(a) Wherever the work is being carried on, free access must be given to every fire hydrant and fire alarm box and connection to stand pipe, and when required, hydrants shall be extended by suitable tube or piping to an accessible point as approved and to the satisfaction of the Fire Department. Obstructions must not be piled at any time or place within 15 feet of any fire hydrant or fire alarm box; and where materials are unavoidably piled or placed in the vicinity of a fire hydrant or a fire alarm box, and to such height as to prevent the same from being readily seen, the position of such hydrant or fire alarm box shall be indicated by suitable signals, both day and night.

(b) The wires, cables, ducts, manholes, posts and poles, signals and fire alarm boxes of the Fire Department shall be guarded, maintained and protected. The Fire Department Fire Alarm Telegraph Service shall not be interrupted. No Fire Department wire, cable, ducts, manhole, post or pole, signal or fire alarm box shall be

disturbed except in the presence of a representative of the Bureau of the Fire Alarm Telegraph. In case any such wire, cable, duct, manhole, post or pole, signal or fire alarm box shall be disturbed, it shall be restored to its original condition.

2. ACCESS TO BUILDINGS

Every necessary access shall be provided and maintained for entrance to and exit from adjacent buildings and property at all times. Where access for the delivery or removal of commodities or for the removal of refuse to or from any adjacent property is temporarily cut off owing to the occupancy of the street by the work, every assistance shall be rendered to the owner or occupant in the handling of such commodities or refuse of any description, including all refuse to be removed by the Department of Sanitation, as may have to be taken to or removed from such property; such commodities or refuse shall be taken to or from the nearest accessible point that is convenient for handling.

F. TRAFFIC ROUTING PLAN

Prior to commencing any construction work, working drawings shall be submitted detailing traffic routing and maintenance for approval by the Office of Construction Coordination of the Transportation Administration of the City.

Traffic routing and maintenance drawings shall show but not be limited to the following:

- (1) Vehicular and pedestrian traffic to be used.
- (2) Proposed changes (removals, relocations or temporary installations) of traffic signals and controllers, street and safety lighting standards, fire alarm and police call box facilities, traffic signs, parking meters, pedestrian barricades, railings, trees, loading zones, bus stop zones, and parking regulations or prohibitions.
- (3) Location of traffic signs, pavement strippings and markings, and barricades to control vehicular traffic.

- (4) Designation of storage areas.
- (5) Areas decked during working and non-working hours.

G. STORAGE OF MATERIALS AND EQUIPMENT

Construction equipment shall not be stored and materials shall not be stockpiled in areas other than those designated and approved in the traffic routing plan.

The above designated areas shall be used solely for storage of equipment and materials necessary for the prosecution of the work and shall not be used for parking personal vehicles.

H. GUARDS AND FLAGMEN

Guards and flagmen shall be provided

- (1) when traffic must be routed alternately in a single traffic lane or where traffic is required to change lanes abruptly
- (2) at points where the equipment enters or crosses traffic lanes, crosswalks, and
- (3) at any point where construction equipment may intermittently encroach on any traffic lane or unprotected sidewalk or crosswalk.

I. TRAFFIC STRIPING AND MARKING

Necessary traffic striping and other pavement markings shall be provided as traffic patterns are adjusted during construction.

Pavement striping and markings will be done by City forces. Ample advance notice shall be given for such work; working space shall be provided and areas to be marked shall be clean.

V - TYPICAL DECK STRUCTURE

A. GENERAL

The decking shall be designed so that during installation and removal of decking, the required traffic pattern can be maintained.

B. TYPICAL DECKING SYSTEM

Shall consist of 12" x 12" timbers in 20 ft. length, laid directly on transverse steel decking beams. These transverse beams, usually 10 ft. c.c. shall be supported either directly by soldier piles or if the spacing of soldier piles is different, by a cap (header) beam placed on top of the soldier pile.

C. PROCEDURE FOR DECK INSTALLATION

- (a) Soldier piles shall be driven along net lines of subway excavation to predetermined depth.
- (b) A section of roadway shall be excavated to a depth below the bottom of the longitudinal header beam.
- (c) Tops of soldier piles shall be cut to proper grade and header beam shall be installed.
- (d) Properly braced transverse beam shall be installed across the cut and subsurface utilities to be maintained in place during construction shall be hung.
- (e) 2" x 2" x 3/8 angles shall be welded to the top flanges of alternate transverse beams. This will help keep the 20 long 12" x 12" timbers in place.
- (f) 12" x 12" transverse beams shall be installed parallel to traffic.
- (g) Traffic shall be re-routed onto completed decking section. Next section of roadway shall be constructed in similar manner.

VI - BRIDGES TO BUILDINGS

No building shall, without the consent of the occupant or owner be deprived of means of access thereto; and where streets are open, suitable bridges shall be built and maintained to permit owners and occupants to reach their premises.

VII - VENTILATION OF GASES

Wherever the excavations are decked, or where gases are liable to accumulate, suitable openings, covered with steel gratings, shall be provided for proper ventilation.

VIII - STREET CROSSINGS TO BE KEPT CLEAN

In all cases and at all times, the street crossing on the lines of the sidewalks shall be kept in a clean and neat condition, bridging gutters and low places where water might collect.

Chapter **3**

Chapter 6

Chapter 3

MAINTENANCE, SUPPORT AND PROTECTION OF UTILITIES

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Chapter 3

MAINTENANCE, SUPPORT AND PROTECTION OF UTILITIES

I -GENERAL REQUIREMENTS

A. SCOPE

With the exception of gas and steam mains, operation of utilities shall be maintained in place during the construction of the Railroad.

B. WORK DONE BY OWNERS OR OPERATORS OF EXISTING UTILITIES

In order to reduce to a minimum interference with the practical operation or workings of certain utilities, it will be necessary to have certain work of alteration, reconstruction or change in such utilities and certain services performed by the owners or operators thereof, provided that operation or service shall be maintained with minimum interruption.

C. NOTICE TO BE GIVEN TO INTERESTED PARTIES

Notice shall be given at least one week in advance to all individuals, companies and the proper City officials, owning or having charge of utilities along any part of the work, that operations along such part of the route will commence. Full cooperation shall be given to the proper parties, officers or officials in charge of such structures and they shall be furnished with all reasonable facilities to inspect the methods of caring for their property.

D. WATER DISTRIBUTION AND SERVICES

(1) In case it becomes necessary to cut any connection with any other main, house or hydrant, or in any way to interfere with the continuous and normal flow of water, due notice shall be sent at least 48 hours in advance to the Commissioner of the Department of Water Resources and the consumers, and if so ordered, shall be made to preserve the flow of water while breaking connections.

(2) All connections cut, interfered with or injured shall be restored without delay and in accordance with the rules and regulations of the Department of Water Resources governing such matters, to a suitable condition as good as existed before commencing work.

E. FACILITIES FOR OWNERS TO ALTER OR EXTEND THEIR UTILITIES

Should the owner of utilities or the City desire to make any alterations or additions to their existing facilities, there shall be submitted, by the owners of such facilities three (3) prints, drawings or sketches, together with a statement of facts and supporting data, showing the necessity for such work. Upon approval, said owners or the City, all shall be given reasonable opportunity to perform such work. This shall include only alterations or additions to the existing system necessary for maintaining the usual standard of service or providing additional service required of the owners by applicants.

F. RECONSTRUCTION TO SATISFACTION OF OWNERS

Whenever it becomes necessary to cut, move, change, or reconstruct any utilities, or connections therewith, such work shall be done to the reasonable satisfaction of the owners of such utilities.

II - CONSTRUCTION METHODS

A. MAINTENANCE, SUPPORT AND RESTORATION

(a) All utilities excepting gas and steam, (including new service connections) and all their appurtenances encountered or affected during the prosecution of work shall be at all times, by suitable bridging, hangers or other supports, be maintained, supported and protected in an entirely safe condition for the usual service and to the reasonable satisfaction of the owners. If the maintenance of such usual service makes it necessary, any such utilities shall be temporarily removed and relayed or reconstructed and the same shall be restored or reconstructed in a new location prior to the completion of this contract.

B. ACCESS

In order that access may be had in emergencies and for routine inspections to gates or valves on water, gas, or other mains and to electric and other service boxes, junction boxes and manholes that are decked over, trap doors of a suitable size with suitable identifying steel plates securely attached thereto, shall be provided at all times in the decking.

C. INSULATING COVERING

Insulating covering consisting of manure, hair felt or asbestos wrappings and boxings or other approved material and construction shall be provided and installed for the protection of exposed water mains and house service pipes as may be necessary to maintain the efficiency of the service within such pipes and to prevent freezing in water mains and house service pipes; to maintain the efficiency of such insulating material or construction, it shall be protected by waterproofed wrappings or boxings or both, as necessary.

D. PROTECTION FROM INJURY

All utilities and all their appurtenances and all surfaces or whatever character along the line of the work shall be protected from injury, and such utilities and all their appurtenances and all such surfaces to, shall be fully restored and shall be left in, as useful, safe, durable and good a condition as existed before construction was begun.

E. MAINTENANCE OF CONDUITS AND DUCT LINES

Generally, vitrified clay, tile, wood, fibre, concrete, plastic or other types of conduit or duct lines, including masonry manholes and service boxes, whether the duct lines contain cables or not, will not be required to be maintained in the trenches during the construction of the Railroad but, wherever possible, iron or steel pipe ducts or conduits (with their cables), and junction boxes shall be maintained in place. In special cases, however, it will be required to maintain such conduit or duct lines in the

trenches during the construction of the Railroad.

F. CONSTRUCTION OF TEMPORARY SERVICE BOXES AND MANHOLES

Whenever an electric service box or manhole containing electric cables has been removed, it shall be replaced at once by a temporary service box or manhole which shall provide the same facilities for racking and supporting the cables as existed in the original manhole. The temporary service boxes and manholes shall be constructed with top, bottom, sides and chimney of 2-inch tongued and grooved matched lumber and shall be put together in a substantial and workmanlike manner so as to eliminate as far as possible, the hazard of an external fire passing through cracks, knotholes, or joints in or between the planks. The temporary service boxes and manholes shall be painted on their outside surfaces with an approved fire retarding paint. Any bonding and fireproofing existing on the cables in the original manholes that may be removed or damaged during the prosecution of the work shall be promptly replaced.

G. PROTECTION OF CABLES

When it becomes necessary to remove the ducts from a duct line, as soon as the ducts have been removed from the electric cables, temporary wooden boxes shall be constructed for the protection of the cables. All wooden boxes for containing cables temporarily shall be constructed of two-inch tongued and grooved matched lumber on bottom, top and sides, reinforced as may be necessary to safely carry the loads to which they are subject; the top to be removable for inspection, installation or removal of cables. The boxes shall be strongly and adequately braced throughout their length so that they will maintain their original dimensions and will not be dependent upon the top cover for support.

The boxes shall be painted on their outside surfaces with an approved fire retarding paint.

Boxes containing power, light, telephone, signal, alarm and other communication cables shall be partitioned as required to provide separation of cables

similar to existing separation, using vertical separators at least two inches thick and horizontal separators at least one inch thick. Boxes containing power and line equipment cables of the New York City Transit System shall, in addition, be lined with transite lining of 1/4-inch thickness over the vertical and horizontal separators. Where necessary, it may be required to place primary and secondary power cables in separate boxes.

H. WRAPPING OF CABLES

Whenever in special cases, wooden boxes are deemed insufficient to protect cables, and the cables have to be removed from their usual conduits then, in lieu of the wooden boxes, such cables shall be covered at once and kept completely covered throughout the entire period of their being removed from ducts by a layer of fabricated asbestos to be covered to a total thickness of not less than 5/8-inch with a fireproofing cement, except that Transit Authority cables shall be fire proofed with two layers of asbestos tape, butt wrapped, with the joints of the two layers staggered approximately one-half the width of the tape. The first layer shall be a 3-inch wide, 1/16-inch thick, untreated asbestos tape; the outside layer shall be 3-inch wide, 1/8-inch thick, asbestos tape, which has been thoroughly impregnated with a highly flame resistant noncombustible, inert compound and properly cured and dried.

Ends of fireproofing shall be severed with 1/16-inch impregnated tying cord, Owens-Corning "Fiberglass", or approved equal. Dust shields shall be secured with tying cord.

Not more than one cable shall be exposed at one time without fireproofing. All cables, bonding, fireproofing, and the permanent and temporary structures in which they are supported shall be maintained in first class condition at all times.

I. REHANDLING OF CABLE AND REMOVAL OF BOXES

During the course of construction and restoration it may be necessary to rehandle, shift or move the cables, and to reconstruct the temporary wooden boxes,

manholes and service boxes in the new locations of the cables. Prior to permanent surface restoration all temporary wooden boxes, manholes and service boxes shall be removed from the ground and disposed of.

J. CONDUIT AND DUCT SEALS

When sections of electric ducts and conduits are removed from duct and conduit runs in areas of existing structures and new construction, the broken or cut ends of the remaining empty and occupied ducts and conduits shall be immediately sealed so as to prevent any inflow of water through the remaining ducts and conduits into the existing structures and new construction. The seal shall be made from approved material and installed in a satisfactory and workman-like manner, due precautions being taken not to damage the remaining existing duct banks and cables. All conduit and duct seals shall be removed after completion of the construction and prior to restoration of the conduits and ducts.

K. WORK AROUND LIVE CABLES

Whenever a duct line containing electric cables is to be broken away or when masonry adjacent thereto is to be removed, the work shall be done with hand labor entirely, using hammer and chisel. Jackhammers, bull points or other power equipment shall not be used. No high voltage or 625-volt positive feeder cable of the New York City Transit System shall be moved or racked while it is alive. Not more than one such cable shall be taken out of service at one time unless otherwise directed.

L. RODDING OF DUCTS AND CONDUITS

Upon the restoration or reconstruction of electric ducts and conduits found in streets, the ducts and conduits shall be rodded by pushing a suitable mandrel through the bore. If obstructions are found which cannot be removed by a cleaner so as to give a clear and smooth opening sufficient to pass the mandrel without damaging the ducts and conduits, the ducts and conduits shall be removed and relaid to the extent necessary. All ducts and conduits during construction and after being rodded shall be plugged

with approved plugs.

M. SUPPORT OF WATER MAIN

Where any movement of the earth adjacent to the Railroad takes place, any water main affected by such movement shall be immediately uncovered, the main moved back into place without cutting off the water, and thereafter the main maintained in place until the movement of the earth has ceased. The main shall be adequately supported by thoroughly consolidated material or by masonry, if required, placed under the pipe and brought up at least to the center of the pipe. All labor and material necessary shall be furnished to safely support the main during the entire period that the main is affected by work on the Railroad.

N. MAINTENANCE, SUPPORT AND PROTECTION OF UTILITIES BY OTHERS

If, at any time during the prosecution of the work, utilities or their appurtenances as hereinbefore provided are not maintained, supported and protected and upon direction so to do, such conditions are not corrected and proper maintenance, support and protection of such utilities not provided for, the necessary work of properly maintaining, supporting and protecting such utilities and their appurtenances may have to be performed by others.

O. MASONRY SUPPORTS FOR WATER AND STEAM MAINS AND SEWERS

In the restoration of water and steam mains and other subsurface structures, approved masonry supports shall be constructed. In special cases, sewers shall be similarly supported.

P. MATERIALS REMOVED FROM EXISTING WATER MAINS

Materials removed from existing water mains, and not required to be re-used shall remain the property of the City and shall be delivered to the environmental Protection Administration of the City of New York Department of Water Resources, Bureau of Water Supply at the site of the work on board Department of Water Resources trucks or shall be disposed of at the option

of the said Department.

Q. MAINTENANCE, SUPPORT AND PROTECTION OF OTHER STRUCTURES

Structures, within net lines or as indicated on plans belonging to various City Departments including but not limited to, street lampposts, traffic posts, fire alarm posts, parking meters and traffic signs, with their attachments, shall be maintained, supported protected, and shall be restored in their original locations in accordance with the Standards and procedures of each City Department having jurisdiction thereof. Said structure shall be made accessible for maintenance at all times. Posts, control and alarm boxes, or other structures removed and not to be reused, shall remain the property of the City Department having jurisdiction thereof, or shall be disposed of with permission of said City Department.

R. OBSOLETE DUCT LINES

In case duct lines of obsolete type are found in the street and the owners of such duct lines request the Authority to provide in lieu thereof duct lines of modern type of construction, the Authority may, by arrangement with the said owners, provide such modern type of construction, and under such arrangement the said owners may furnish the material for the duct lines. In such case, it may be required hereunder to lay the ducts furnished by the said owners or to perform such other portion of the work as may be necessary to complete the duct lines of modern construction.

III - STEAM MAINS

A. MAINTENANCE OF STEAM SERVICE

In order to maintain steam service provided by Consolidated Edison Company of New York, Incorporated (hereinafter called "Edison Company") during the period of construction, portions of the existing steam mains within the limits of trench excavation (and certain portions of steam mains where adjacent thereto) shall be replaced by a system of new steam mains as generally indicated on Drawings.

B. CHANGE-OVER OF STEAM DISTRIBUTION

The transfer of steam distribution from any section of the existing steam main system to the corresponding section of the new steam main shall be undertaken only when the section to which service is to be transferred is completed and ready for furnishing service except for completion of end sections, and shall be done with a minimum of interruption to the distribution of steam, and only during off-peak hours of the nights or on Sundays, in accordance with the usual practice of the Edison Company.

C. NEW STEAM MAINS

The new sections of steam mains will be of the type indicated on the Drawings as "Pre-fabricated Steel Conduit Construction" and consists, in general, of an inner steel pipe (steam main) covered with insulation and housed in an outer steel conduit. All pipe, fittings, expansion joints, anchors, accessories, insulation, housing construction and all other workmanship and material shall comply with the latest standards of the Edison Company. Attention is called to the fact that it may be necessary to field fabricate certain portions of the steam main construction.

D. WORK TO BE DONE BY OTHERS

Arrangement shall be made with the Edison Company, for the jointing of all pipes and accessories where such connections must be made to an active or "live" steam system.

E. REMOVAL OF EXISTING STEAM MAIN

All portions of the existing steam mains (including appurtenances) that are replaced by new steam mains shall be removed and disposed of unless such existing mains may be preserved for reuse in the permanent system.

F. RESTORATION OF STEAM PIPE SYSTEM

The restored steam pipe system (portions of new steam mains, existing steam mains to remain, services, and appurtenances) shall be put in a condition similar

to and equally as good as the steam system that existed prior to the commencement of work hereunder.

G. MAINTENANCE, SUPPORT AND PROTECTION OF EXISTING STEAM MAINS

It will be necessary to maintain, support, protect, underpin (where necessary) and restore portions of existing steam mains where such mains or portions thereof are within the excavation limits. Prior to commencing work in the vicinity of said steam mains, drawings showing proposed method of maintaining, supporting, protecting and underpinning (where necessary) said steam mains shall be submitted for approval.

IV - GAS BY-PASS

Whenever the excavations are decked, all gas pipes, the use of which cannot temporarily be dispensed with, shall be by-passed as directed. Temporary pipes to take their place shall be laid where indicated on the drawings or where ordered.

A. DEFINITION

(a) A gas by-pass shall mean a system of gas pipes, including all required appurtenances, furnished as a temporary substitute for a portion of the existing gas pipe system.

(b) At such time as determined, the gas by-pass shall be removed and the disturbed portions of the existing gas pipe system shall be restored.

B. REMOVAL AND CAPPING

Sections of existing gas mains shall be temporarily or permanently removed from a gas supply system and the remaining "live" pipe ends sealed with caps. It may be ordered that temporary caps shall become permanent caps and that the removed sections of gas main shall not be restored.

C. RESTORATION

Restoration of a gas system shall mean the reconstruc-

tion to original line and grade of that portion of a gas system which has been by-passed or temporarily capped.

At such time as directed, the gas by-pass system or temporary capping shall be removed and that portion of a gas system which has been by-passed or temporarily capped, shall be restored or relocated.

D. RELOCATION

Relocation of a gas system shall mean the permanent rerouting of that portion of a gas system which has been permanently removed and the reconstruction to other than original line and grade of that portion of a gas system which has been by-passed or temporarily capped.

E. CONSTRUCTION STANDARDS

All work in connection with restoration and relocation of gas pipes shall be done in accordance with the latest construction standards of the Consolidated Edison Company of New York, Inc. or the Brooklyn Union Gas Company, whichever is applicable.

F. SERVICE LINES

Service lines shall be supported, maintained and relocated where indicated or ordered to provide continuing service during gas work.

G. WORK TO BE DONE

Main and Service valves shall be connected and disconnected on pipe work and required pipe and fittings including, but not limited to, tees, reducing tees, offsets, crosses, reducing crosses, bends and reducers, shall be provided and attached for the "live" connections to be made by the utility company at the mains.

H. MAIN VALVES FOR GAS BY-PASS

Temporary main valves to control gas by-pass will be provided by the utility company, and returned to the utility company upon completion of gas by-pass. Valves shall be accessible at all times and properly identified.

I. "LIVE" GAS WORK

Arrangement shall be made that the utility company owning or operating a gas supply system perform all required "live" gas work. This work includes such operations as, but not limited to, cutting, drilling, purging, tapping, bagging, capping of mains; removal of temporary caps; the connections and disconnections of main, service and circulator system valves at "live" mains; the turning off and on of main, service and circulator gas valves in the street and the circulator pipe work performed by the utility company.

J. WELDING

All required welding of steel pipes and fittings for gas system work shall be done by persons approved by the utility company as qualified to do such work. Welding shall be done in the presence of a utility company inspector.

K. LIFTING OF GAS PIPES

Cable or chain slings shall not be used to move, lift or place coated pipes and fittings. Only approved, flat-face slings shall be used. Coatings of pipes and fittings damaged by the operations shall be repaired in an approved manner without any additional cost to the Authority.

L. DAMAGE TO GAS WORK

All damages to gas work made during the construction operations shall be repaired according to the procedures required by the utility company.

M. GAS PIPES AND FITTINGS

Gas pipes, fittings and appurtenances shall be of type, quality and design approved by the utility company. All cast-iron pipes and fittings, and steel pipes and fittings which do not have an approved hot coal-tar enamel coating, which are removed from an existing gas system for by-pass or capping work, shall, where required by the utility company, be replaced by approved coated steel pipes and fittings (to be supplied and delivered by the utility company).

Pipe sections temporarily removed and to be reused in the Works shall be purged, sealed and preserved for restoration work. Approved hot coal-tar enamel coated pipes and fittings shall be furnished for relocation work.

Approved insulated couplings shall be furnished for connections of coated steel pipes to existing uncoated steel pipes or to existing cast-iron pipes.

Valves for mains and services shall be of material, quality and design approved by the utility company.

Existing pipes, fittings and appurtenances which cannot be re-used in the Works because they are not in a serviceable condition will be replaced by the utility company.

N. TESTS

(a) All tests required by the utility company shall be performed in connection with the installation of gas work. All such tests shall be conducted in the presence of a representative of the utility company and performed with equipment approved by the utility company.

(b) Radiographic tests of welds shall be performed by persons qualified by the utility company to perform such tests.

(c) The number, type, manner and extent of all tests required in connection with gas work, shall be ascertained from the utility company.

O. EXISTING MATERIALS

The utility company shall be furnished with an itemized list of all materials removed from the existing gas system and those materials removed that are not approved for re-use in the Works or that are not otherwise retained by the utility company shall be disposed of.

P. SAFETY SEQUENCE

In order not to subject the existing gas lines to

excessive vibrations, as the first order of work, all gas by-passing work shall be performed before driving any soldier beams or sheet piling. Soldier beams may be placed prior to by-passing the existing gas lines, provided that a hole shall be auger drilled to sub-grade, and then soldier beams shall be placed in the pre-augered holes.

V - SURFACE BY-PASSES

Gas by-passes shall be constructed as indicated on the drawings or as directed. Where indicated on drawings, surface by-passes shall be protected from roadway traffic by guard timbers, railings, guard pipes and timber housing. Such housings shall be maintained free of snow, ice, dirt and debris. Where surface by-passes are laid on irregular ground surfaces, suitable supports shall be provided as directed. Drips shall be provided at all low points. Expansion joints shall be furnished at the locations indicated or directed.

VI - OVERHEAD BY-PASSES

Overhead by-passes shall be protected from roadway traffic by guard pipes. Overhead by-pass pipe shall be painted with two coats of an approved bituminous paint. All other exposed parts of an overhead system, including tower and other supports, shall be kept neatly painted throughout the life of this contract. Construction, if approved, for the support of the overhead gas pipes other than that indicated may be used.

VII- REFLECTORIZED STRIPING

Reflectorized striping, conforming to the pattern and colors specified for Class I and Class II barricades described in the New York City Department of Traffic "REGULATION MANUAL ON TEMPORARY TRAFFIC AND PEDESTRIAN CONTROL BY STREET BARRICADES AND CHANNELIZATION", shall be provided on the vertical and horizontal pipes of overhead gas by-passes and on all guard pipes.

Reflectorized striping shall be maintained for the duration of this contract and shall be replaced when the reflectorizing quality of the stripes has been lost.

VIII- LENGTH OF BY-PASS

The extent of the gas by-pass system is generally indicated on the drawings, except in special cases governed by local conditions where greater lengths may be necessary.

Gas by-pass pipe shall, in general, be connected to the original system at the nearest practicable point beyond the area of interference with the Railroad; and where the pipe is carried overhead on towers, the pipe shall not be higher than necessary to provide the required headroom. Greater lengths and heights of the gas by-pass and supports may be permitted where necessary to provide clearance.

IX - SERVICE LINES

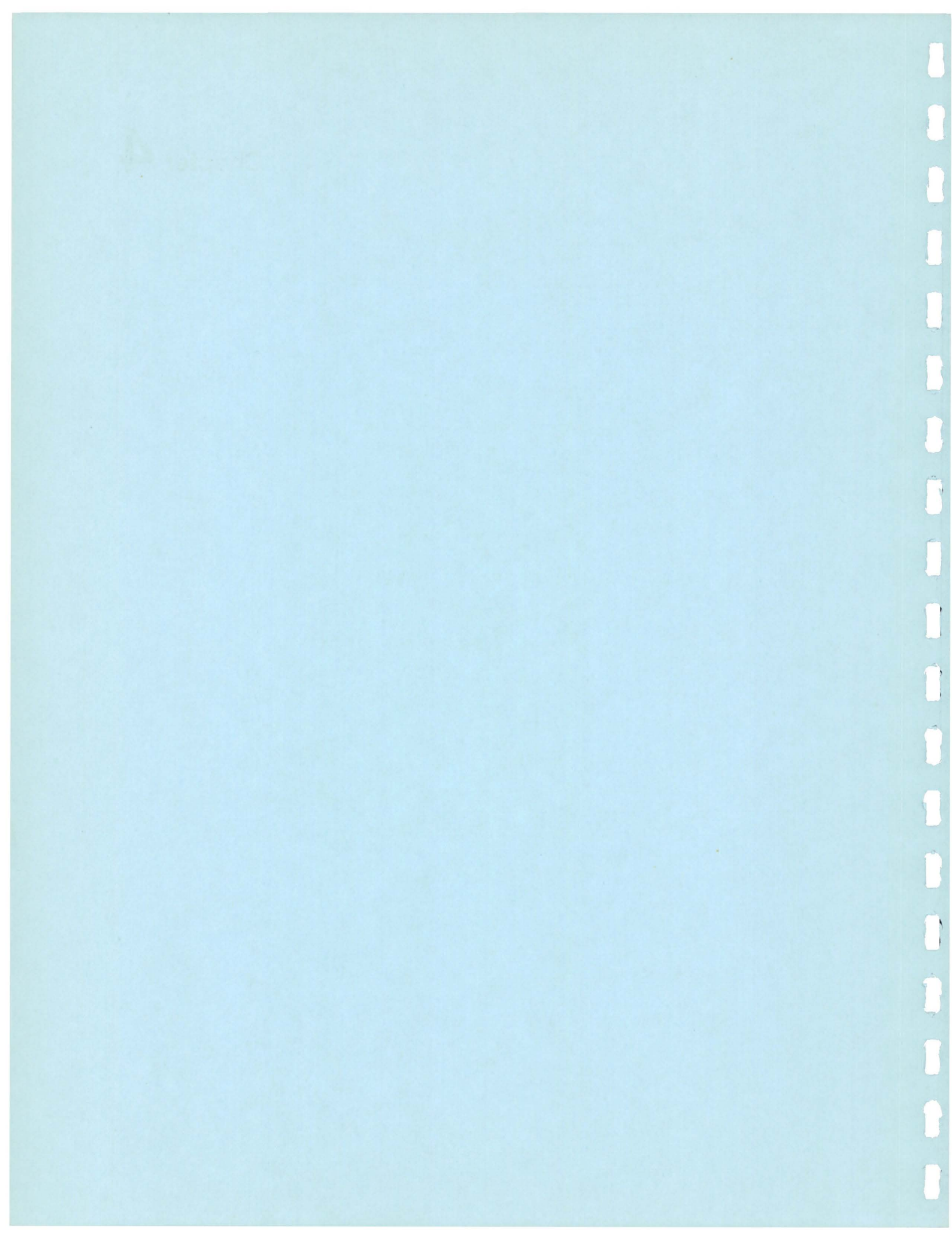
Service lines shall be supported and maintained, or permanently or temporarily relocated, as herein elsewhere provided. An approved shut-off valve shall be furnished in the street for each service line which is permanently relocated or temporarily connected to a gas by-pass, if such a valve does not exist. Valves shall be accessible at all times and properly identified. An "auto-seal" pipe system which runs from a main to a curb or sidewalk box is deemed to be a service line.

X - STORM, SANITARY AND COMBINED SEWER FACILITIES

Operation shall be conducted so as not to interfere with the service provided by existing sewers and laterals from adjoining properties. Detailed plan shall be submitted for the review for temporarily supporting sewers and laterals, or otherwise handling flows in these lines during construction by pumping, fluming or other approved means. Where flumes are used, they shall be fully enclosed and under no circumstances

shall the contents of any sewer or appurtenance be permitted to flow across the surface of any street, property or into any excavation.

Chapter **4**



Chapter 4

EXCAVATION

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Chapter 4

EXCAVATION

I - GENERAL REQUIREMENTS

A. DESCRIPTION

Excavation shall be made from the ground surface to the net lines indicated or otherwise ordered and shall include cut and cover subway excavation, support for excavation, and excavation for existing, new and relocated facilities.

B. EARTH AND ROCK EXCAVATION CLASSIFIED

(a) Earth referring to materials of excavation as classified for payment, shall mean all materials of whatever nature encountered, except rock as defined in paragraph (b) below, and the removal of masonry as defined in Chapter 4, III, Q. The following will, among other things, be classified as earth excavation: filled ground (including rock fill), foundations and vault of buildings, boulders and other materials requiring blasting, trees and shrubs, old timbers and planking, wood, concrete or steel piles, pavements, abandoned street surface railroads (including foundations), abandoned elevated railroad column piers and footings, curb and sidewalks with their foundations, valve chambers, pipe galleries, manholes, gasoline and oil tanks, basins, sewers, ducts and conduits, pipes, tubes and drains. Soft decomposed or disintegrated rock, which, in the opinion of the Engineer, can be removed by means other than blasting, channeling, wedging, barring or other method ordinarily used to remove hard ledge rock, will be classified as earth excavation.

(b) Rock, referring to materials of excavation as classified for payment, shall mean the hard ledge rock in its natural bed, which is removed by the methods, properly used, of blasting, channeling, wedging or barring.

C. TWO SHIFTS MAY BE EMPLOYED ON TRENCH EXCAVATION

Work of excavation, exclusive of tunneling, for the Railroad may be prosecuted for a period of 16 hours each working day, using two 8-hour shifts, during the hours of 7:00 A.M. to 11:00 P.M. only, until the excavation shall have been completed. Such work will include, among other things, trench blasting and removal of excavated trench material.

D. BLASTING

(a) Whenever material requiring blasting is encountered in any excavation, all necessary precautions shall be exercised as required by the ordinances of the City relative to blasting. Explosives shall be used only of such character and strength as may be permitted by the Authority, and the right is reserved that ordinary blasting powder in small charges, shall be used. Blasting shall be done as approved and under such restrictions as may be imposed.

(b) Such magazine and magazines houses shall be provided for the storage of explosives in such manner as may be approved by the proper municipal and/or other authorities in charge of such matters. No larger quantity of explosives shall be removed from the magazine to the site of the work than will be actually required for immediate use and any excess shall be returned to the magazine as soon as the loading of the heading is completed. The amount of explosives kept in any one place shall not exceed the limit permitted by any ordinance of the City or as may be determined by the Authority. Caps and exploders shall not be kept in the same place with dynamite and other explosives. During freezing weather, special precautions shall be taken as to the care and manipulation of dynamite.

(c) Drilling and blasting shall be conducted with all possible care, but in no case shall the peak particle velocity of each blast exceed 2.0 inches per second at the nearest structure. The drill holes shall be placed close together, and light charges shall be used in order not to shatter the rock unduly beyond the net outside line of the Railroad structure nor to endanger adjoining property.

(d) At certain locations where the use of even light charges of explosives for the removal of the rock might undermine, shatter or otherwise endanger adjacent portions of an existing structure, the rock shall be removed by means other than blasting.

(e) When blasting operations are being done in the vicinity of the existing structure, special precautions shall be taken to prevent damage to the existing structure. All necessary apparatus and assistance shall be furnished to permit a continuous observation of the effect, if any, on tunneling adjacent to or under the existing structure. In order that train operation on the existing structure may be properly and safely coordinated with the blasting operations, telephone or other electric communications system connecting all parts of the work shall be furnished, installed and maintained. The system and its installation and the operation thereof shall be subject to approval.

E. SEISMOGRAPH RECORDS

During the time when blasting operations are in progress, seismographic monitoring shall be provided. Individual reports and data for each blast monitored shall be furnished. Two seismograph instruments shall be furnished and installed where directed. The seismographs shall be portable, 3-component photographic recording instruments of the Leet type or equivalent. The services of the seismograph instruments and operating personnel shall be retained for the entire period of blasting operations.

F. RECORDED SEISMOGRAPH DATA

Seismograph reports to be submitted shall include identification of instrument, name of observer, name of interpreter, distance and direction of recording station from the area of detonation, date and exact time of reading, type of ground at recording station, peak particle velocity for all components as well as resultant for all frequencies of vibrations, duration of motion in excess of one-one thousandth of an inch, and a copy of the photographic record of seismograph readings. Seismograph readings and blasting shall be synchronized.

G. OTHER DATA

Other data to be submitted for each monitored blast shall include location and spacing of drill holes, kind of blasting caps, distribution of instantaneous or short period delay blasting caps, or both, delay interval used, order of firing, total amount of explosives per round and per group of delays, date and exact time of firing of blast, name of person in responsible charge of loading and firing, blasting permit number, name and location of project, signature and title of person making report.

H. SEISMOLOGIST

The services of a seismologist whose qualifications are satisfactory to the Authority shall be employed on a consulting basis. He shall submit an analysis of seismograph readings with signed seismograph reports.

I. PROTECTION AGAINST DUST HAZARD

Equipment for the elimination by suction methods of dust and/or wet method of drilling produced by rock or masonry drilling or other operations, as approved by the New York State Department of Labor, shall be installed, maintained and effectively operated for the protection of property against dust and workmen against the inhalation of harmful dust. In the event that conditions are encountered in any area to render the use of suction methods ineffective or impracticable, the work of rock or masonry drilling or other operations in such area shall be performed by other approved methods. If some other device or method is developed that will protect property against dust and the workmen against the inhalation of harmful dust, such device or method, if approved by the said Department of Labor, and the Authority, may be used.

J. DISPOSAL OF MATERIALS EXCAVATED

Excavated materials shall be removed expeditiously and, except as otherwise provided in Chapter 4, I, K., the portion of such material not required for backfilling or filling shall be disposed of in any

place subject to the ordinances and regulations of the City Authorities and other laws governing the disposal of such material and the regulations of the United States Government as to the disposal or dumping of material in and about or near the Harbor of New York. No excavated material shall be stored at the site of the work.

K. MATERIAL MAY BE TAKEN BY CITY

If at any time during the course of construction, the City shall desire for City purposes, any part of the excavated material, not otherwise provided for herein, the Authority may order such material dumped or turned over to the City at a point designated.

L. TEST PITS

If ordered, test pits shall be dug at the locations and to the depths directed alongside the foundations of any buildings to aid in determining the necessity for maintaining, protecting or underpinning the building or for the purpose of determining the location of sewers or other subsurface structures, or for any other purposes.

M. VEHICLES TO BE TIGHT

All trucks, buckets and other vehicles used for the removal of material, shall be tight and so arranged and so loaded as not to spill. Whenever a truck, bucket or other vehicle so used is leaky or unsuitable, it shall be immediately withdrawn from the work.

N. VENTILATION, LIGHTING AND FIRE PRECAUTIONS

To assure the safety of the work and the workmen during construction, safe and adequate ventilation and lighting shall be provided. All reasonable precautions shall be taken against fire and provisions shall be made for the extinction thereof.

II - MATERIALS

A. STEEL SHEET PILING

Steel sheet piling shall be of the continuous interlocking type and shall be of the section best suited for its intended use. Steel sheet piling shall conform to the requirements of ASTM Designation A 328.

B. TIMBER FOR SHEETING AND BRACING

All timber used for sheeting, shoring, bracing, or other temporary purposes, shall be sound and free from any defects that may impair its strength. Timber shall be spruce, Douglas fir, white or yellow Lodgepole or Ponderosa pine, or western hemlock plank, planed on one side and either tongued and grooved or splined. Timber shall not be less than 4 inches thick and lumber shall not be less than nominal two inches thick. The thickness of sheeting and bracing may be increased as ordered. All sheeting and timber used temporarily shall be put in place by competent mechanics, shall be keyed tight by wedges where necessary and so arranged as to be withdrawn readily without endangering the adjoining soil.

C. STRUCTURAL STEEL

Structural steel shall conform to ASTM Serial Designations: A7 or A36.

D. STEEL TIE-BACK CABLES

Steel tie back cables used in connections with temporary construction shall conform to ASTM Serial Designation: A 416.

E. SLURRY

Slurry shall consist of a stable suspension of powered bentonite in water. The powered bentonite shall conform to the requirements of API Standard 13 A, Specification for Oil-Well Drilling - Fluid Materials.

F. SLURRY PROPERTIES

Slurry properties shall be determined by tests described in the API Standard 13 B, "Standard Procedure for Testing Drilling Fluids". During all slurry operations, a full time laboratory technician qualified to perform and carry out the specified tests shall be available and all the necessary laboratory facilities and testing equipment shall be provided. A suitable sampler for obtaining slurry samples from any depth within the holes or slots shall be provided. Tests shall be performed by the laboratory technician. The tests required shall include:

- (a) Slurry Weight (Density);
- (b) Plastic Viscosity and Gel Strength by Marsh Funnel and Viscometer;
- (c) Filtration (Water Loss);
- (d) Sand Content.

G. SLURRY CONFORMITY REQUIREMENTS

Slurry shall conform to the following requirements:

(a) The slurry shall contain a minimum of 0.6 pounds of powdered bentonite per gallon of water. The properties of the slurry may be altered to suit construction conditions by admixtures used for the control of oil field drilling muds. Under no condition will peptizing or bulking agents be allowed.

(b) Density of the slurry at the time of introduction into the holes or slots shall be approximately 65 pounds per cubic foot. At no time during excavation shall the density of the slurry and soil mixture be more than 80 pounds per cubic foot.

(c) Plastic Viscosity at time of introduction into the trench shall be more than 15 centipoises at 20 degrees C, as determined by viscometer.

(d) Water loss (filtration at any time during excavation) shall be less than 20 cubic centimeters in 30 minutes per square foot.

H. SOLDIER PILES

Soldier Piles shall be rolled or fabricated steel shapes conforming to the sections and dimensional tolerances indicated on the Contract Drawings, and shall be of structural steel conforming to ASTM Designation A 36, and A 441 as indicated.

I. TREMIE CONCRETE

Tremie Concrete shall be Class 4000 with 3/4 inch maximum size aggregate.

J. TEMPORARY BACK FILL

Temporary backfill shall be as approved. The backfill shall provide stable support to the ground and displace the slurry. Pea gravel or sand-clay-cement mixture are suitable. An approved bulkhead may be substituted for backfill if it meets the above requirements.

III - CONSTRUCTION METHODS

A. WIDTH AND DEPTH OF EXCAVATION

(a) Special care shall be taken to avoid damage wherever excavation is being done. The width of such excavation shall not exceed the width actually necessary for the proper prosecution of the work. All excavations shall be of such width, in addition to that of the Railroad as shall be necessary, for the proper and expeditious progress of the work and to permit the laying and readjusting of all sewers, mains, subways and other subsurface structures encountered along the route and contiguous to the Railroad.

(b) Excavation shall be carried to such depths as may be necessary to permit the laying of such concrete bed, special foundation or drain pipes as may be deemed necessary.

(c) Excavation below the elevation of the invert of the existing subway structures shall be done by a method insuring against a possible loss of ground

under the existing structure.

B. SUPPORT OF EXCAVATION

(a) The sides of the excavations shall be maintained and secured by a system of supports which shall consist of soldier piles, soldier beams and lagging, sheeting, sheet piling or SPTC wall, consisting of soldier piles or soldier beams combined with tremie placed concrete in slurry filled trench excavation between soldier piles or soldier beams, or other approved method of support, secured in place by means of bracing which may include wales, braces, shores, struts, anchors and similar members, special precautions being taken where there is additional pressure due to the presence of buildings or other structures. The sustaining members in the bracing system shall be designed to furnish sufficient reaction against the side banks to maintain stability in such banks. Such reaction in the members shall be obtained by the use of suitable wedges properly driven into the joints between such members until the necessary reaction is produced against the banks or by such other approved method. Wherever necessary, steel plates and wedges shall be used in driving up the members to produce such reaction. End banks or bulkheads shall be sheeted and braced in such manner that the compression stresses from such banks are transmitted through diagonal braces into sidewalls or the sub-grade, or both, as necessary. Special care shall be taken to assure the stability of the foundations of the vertical supporting posts. In rock cuts and wherever the work is prosecuted by blasting operations, special care shall be taken to so seat and brace the main sustaining members of the bracing and supporting systems that they will not be displaced by blasting shock or by fragments thrown by blasts.

(b) Wherever in connection with the construction of the Railroad in trench, it is advisable to use steel sheet piling, steel sheeting and/or steel bracing in lieu of wood or timber to support the excavation or for any other purpose, such steel sheet piling, steel sheeting and/or steel bracing shall be furnished and installed. Such steel piling, sheeting and bracing shall be left in place unless removal permitted by the written order. Approved precast masonry slabs or

beams, where suitable, will be permitted in lieu of steel.

(c) If so directed, the sheeting shall be left in at any place as may be determined for special reasons.

C. ROCK TRENCHES TO BE COMPLETELY BRACED

Under the provisions of Paragraph B, it may be required to completely maintain and secure the side banks of rock trenches for the Railroad by bracing the side banks regardless of the character of the rock. The size, spacing and arrangement of the members of said bracing system shall be as the nature of the rock may require at any location.

D. SHEETING

(a) The sheeting shall be so designed and placed as to prevent as far as possible the natural ground back of the sheeting from moving and shall furnish a full bearing against the banks, voids behind the sheeting being filled when necessary to obtain such bearing. Sheeting shall be driven or placed as best suited to the local conditions. The excavations shall not be made in advance of or below the bottom of the sheeting. Sheeting shall be started at the surface or, according to local conditions, at such depths below the surface as may be necessary.

(b) Where the excavation is near an adjacent building, the sheeting shall be started before excavating below the foundation of the building, and in every case where the excavation is adjacent to buildings, the sheeting shall be started at such depth in relation to the foundation of each such building as may be necessary to prevent displacement of the soil which supports the building.

E. TIE-BACK ANCHORS, ANCHORED IN ROCK

E.1 Working Drawings

Full details, including design calculations, installation and load test procedures, and detailed working drawings of proposed tie-back anchor system shall be

submitted prior to starting work. The working drawings shall indicate the soil profile for which each anchor is intended, the design load of the anchor for the full excavation condition, size and number of strands per tendon, the preload and the proof test load.

E.2 Test Load

All tie-back anchors shall be tested to a proof load equal to 120% of their design load for full excavation condition. The test load shall be held for a period of 10 minutes and shall then be reduced to 80% of the design load for full excavation condition and maintained at that level until the tie-backs are secured in such a manner that the tie-back anchors will retain the required preload permanently.

During the preloading operation, means shall be provided to measure applied forces to an accuracy of $\pm 5\%$. Loads shall be applied in increments of five (5) tons every 5 minutes up to the required load. The full test load shall then be maintained for at least 10 min. This procedure may be modified depending on the tie-back design and field conditions.

A complete record of all loads and deformations shall be kept, and a copy of this record shall be furnished.

An approved number of tests shall be conducted to demonstrate the adequacy of tie-backs as a support system for typical subsurface conditions. These tests shall be conducted prior to the use of any type of tie-back system for actual excavation support.

E.3 Drilling of Holes

Holes for tie-back anchors shall be drilled to the diameter, depth, line and tolerances specified, an allowance for over-drilling being added to the depth where detritus cannot be removed from the bottom of the hole.

E.4 Post-Grouting Procedures

(a) The tendon shall be inserted into the finished hole.

(b) A grout tube shall be fixed to the made-up tendon or placed later, within 6 inches of the bottom of the hole, and water shall be circulated thru the grout tube until the emerging water is clean.

(c) Grout of the following mix shall be pumped to the dead-end anchor:

two (2) parts of cement
one (1) part "0" graded sand
two (2) pounds of water reducing retarder
per bag of cement.

(d) After the grout is placed, the tendon shall remain undisturbed for a minimum of 72 hours.

(e) As soon as possible after the tendons have been stressed, they shall be grouted solid throughout their entire length.

F. SOLDIER PILE AND TREMIE CONCRETE WALLS

F.1 Description

Construction of trench supporting system utilizing the soldier pile and tremie concrete (SPTC) walls includes the excavation of preparation trenches, drilling slurry filled holes, installation of soldier piles in the slurry filled holes, excavation of slurry filled slots between the soldier piles, placing concrete by tremie in the slurry filled slots between the soldier piles, and temporary back-filling.

F.2 Holes for Soldier Piles

Holes shall be drilled to the depth and tolerances and at locations as indicated or as directed.

F.3 Diameter of Holes

Diameter of holes shall be such as to provide easy driving of the soldier piles and still retain soldier pile outside flange contact with the undisturbed soil at the periphery of the hole. The revised diameter of holes shall be approved as necessary to suit field

conditions and drivability of the soldier piles. Diameter of the holes shall be to, at least, two inches less than the outside flange-to-flange dimension of the soldier piles unless otherwise authorized. At the option of the Contractor, the diameter of the holes may be increased up to six inches greater than the outside flange-to-flange dimension of the soldier pile, provided they are backfilled after installation of soldier piles with approved lean cement-sand mix.

F.4 Filling of Holes

Holes shall be filled during drilling with slurry to within two feet of the top of the hole. The top of the hole is defined as the bottom of the preparation trench. Continuous agitation or circulation of slurry shall be provided to maintain slurry properties as specified and to prevent caving. Slurry movement shall be continued until the soldier piles are installed. If holes are to be backfilled with lean cement-sand mix after the soldier piles are in place, the backfill must be placed by pumping method. The bottom of the placing pipe shall be placed on the bottom of the hole to start placing operations and thereafter must be maintained five feet below the surface of the backfill. The placing of the backfill shall be performed so that the backfill is never more than five feet higher on one side of the pile than on the other.

F.5 Cuttings from Drilling

Cuttings from drilling shall be removed from the slurry and disposed of. Disposal of cuttings into any sewer system or sewer drainage area is prohibited.

F.6 Sequence of Scheduling

In order to provide for the protection of adjacent structures and facilities, construction of SPTC walls shall have certain limitations as follows:

F.6.1 Drilled Holes

Soldier piles shall be installed in the drilled

holes within 24 hours of completion of drilling of the hole. Partially drilled holes shall be completed or backfilled with sand or pea gravel within 24 hours. Within any 50-foot length of wall, no more than two adjacent drilled holes may be left slurry-filled without soldier piles installed. Within any 150-foot length of wall, no more than ten slurry-filled holes with soldier piles installed may be left without excavating slots between and filling with tremie concrete. If soldier pile hole is backfilled with lean cement-sand mix, within 24 hours of completion of drilling and beam installation, one may proceed along the wall in a continuous drilling and soldier beam placing sequence, except that within any 50-foot length of wall, no more than three adjacent drilled holes with beams in place may be left slurry-filled without lean cement-sand backfill in place.

F.6.2 Slot Excavation

Within any 50-foot length of wall, no more than two excavated slots between soldier piles may be left slurry-filled without tremie concrete in place. In addition, there shall be at least one unexcavated slot, or tremie concrete filled slot, between the two excavated slots. Placement of tremie concrete shall be started in the excavated slot within twelve hours of completion of excavating the slot and proceed continuously until completion of concreting.

F.7 Installing Soldier Piles

Soldier piles shall be installed to the indicated tip elevation or, where no tip elevation is indicated, to at least two feet below the bottom of the hole.

Soldier piles shall be centered in the drilled hole during driving. Temporary or permanent pile tip guides or driving points may be used to insure centering. Shop and field splicing of soldier piles shall be done only within areas indicated on contract drawing. Field splicing, where necessary, shall be such that no two adjacent soldier piles shall be spliced within two feet of the same level. All splices shall be assumed to be in tension.

F.8 Slot Excavation

Slot excavation of the slot or spaces between two adjacent soldier piles may be accomplished by combination of drilling, clamming, scraping or other approved means. The means used shall be such as to minimize over-excavation and the loosening and caving of material outside the designated slot width.

The slots between the soldier piles shall be maintained full of slurry to within approximately two feet of the top of the slot during excavation operations and until the tremie concrete placement is essentially completed. Slurry shall be circulated or agitated during drilling and excavating operations and immediately prior to concreting. However, the slurry requirements shall be maintained at all times, including non-working periods and stoppages, and circulation or agitation shall, if necessary, be continuous to meet these requirements.

The inspection tool shall be used to demonstrate that the slot between the soldier piles has been completely excavated and cleaned.

Inspection of the slot excavation with the inspection tool will be made before tremie concreting to insure that settled cuttings and excavated material have been removed. Concrete from previous concreting operations which has flowed into the slots shall be removed.

F.9 Concreting

Excavated slots between soldier piles shall be filled to the indicated elevation with Class 4000 concrete placed by the Tremie method, as specified herein.

The tremie tube shall be placed within one foot of the bottom of the excavation to start tremie concreting operations and thereafter maintained two feet below the surface of the concrete following the initial placement.

The slurry level shall be maintained within two feet of the top of the slot during concrete placement,

unless otherwise authorized. A determination shall be made that the quantity of concrete deposited is not less than the volume of wall occupied thereby.

F.10 Temporary Backfill

The temporary backfill or bulkhead shall be placed above the concrete so as to fill the slots within three hours of completing placement of tremie concrete. Temporary backfill material shall be such as to provide support of ground consistent with construction sequences and shall be easily removed.

F.11 Preparation Trenches

Preparation trenches shall be excavated for the purpose of and in such manner as to discover, preserve, maintain, relocate and restore utilities, and other obstructions in the vicinity of the SPTC walls. Construction methods shall be such that slurry material used during drilling of holes and excavation of slots, installation of soldier piles and placing of concrete by tremie is contained and controlled. Such containment shall prevent leakage and spillage of slurry and excavated materials into adjacent vaults, basements, utilities, streets, sidewalks, structures, or other facilities.

F.12 Equipment

F.12.1 Drilling Equipment

Drilling equipment shall be capable of drilling holes of the required diameter and the location tolerances and depths indicated on the Drawings. Drilling equipment shall be arranged to permit free vertical passage of slurry within the hole and prevent development of suction or pressure due to action of drill cutting or excavation equipment or tools.

F.12.2 Slurry Mixing Equipment

Slurry mixing equipment shall be capable of producing a stable suspension of bentonite and water along with the necessary mechanical agitation. Slurry shall be transported to the drilled holes or slots

by a temporary pipeline or other approved methods.

F.12.3 Slurry Circulation Equipment

Slurry circulation equipment shall be such as to provide circulation and agitation of the slurry throughout the full depth of the drilled holes or slots. Agitation of slurry by air is prohibited.

F.12.4 Slurry Cleaning Equipment

Slurry cleaning equipment shall be such as to remove detrimental quantities of excavated material and other foreign material from the slurry. The cleaned slurry may be recirculated back to the drilled holes or slots if it meets the specified requirements.

This operation shall be continuous regardless of slurry density so as to ensure the use of clean slurry in the trenches at all times.

F.12.5 Driving Equipment

Driving equipment shall be capable of installing soldier piles to the indicated depth below bottom of drilled hole.

F.12.6 Slot Excavating Equipment

Slot excavating equipment shall be capable of excavating the slots to the widths indicated between the soldier piles. Slot excavating equipment shall be capable of removing all material from between the soldier pile flanges and shall be provided with scrapers to clean the inner surfaces of the soldier piles. Slot excavating equipment shall be so arranged as to permit the free vertical passage of slurry within the slots and to prevent development of suction or pressure.

F.12.7 A Slot Inspection Tool

A slot inspection tool shall be designed and furnished. The inspection tool shall be capable of showing that the slots are fully excavated between the flanges of the soldier piles and to the full depth indicated.

F.12.8 Equipment for Measuring Plumbness of Soldier Piles

Equipment for measuring plumbness of soldier piles shall be furnished by the Contractor and shall be capable of demonstrating satisfactorily that the soldier piles are placed within the plumbness and location tolerances indicated.

F.12.9 Concreting Equipment

Concreting equipment shall be capable of placing the tremie concrete at the bottom of the slots and up through the full height of the slot. Concrete may be placed by gravity flow or by pumping. The tremie pipe shall be equipped with a bottom valve, or other approved device to prevent mixing of slurry with the concrete inside of the tremie pipe. Concreting equipment shall be designed to prevent segregation of the concrete.

G. WELDING TEMPORARY STEEL

If field welding of temporary steel members is permitted in connection with the bracing and decking systems, such welding shall conform to the requirements for welding specified in the latest edition of the "Code for Welding in Building Construction", formulated by the American Welding Society, Committee on Building Codes.

H. ROCK TO BE STRIPPED

Whenever rock is encountered in the trench, it shall be stripped of earth in sections, in order that measurements or cross-section may be taken.

I. SUBSURFACE STRUCTURES

Whenever any subsurface structure is encountered in or alongside of the trench, the right is reserved to direct that all rock within 5 feet of the same shall be removed by means other than blasting.

J. EXCESS EXCAVATION IN ROCK TRENCH TO BE AVOIDED

In rock excavation in the trenches for the Railroad, the work must be regulated so as to avoid, as far as

possible, shattering the rock beyond the net lines of excavation, but, on account of the impracticability of excavating rock to an exact line, an allowance will be made for excess excavation in rock on the sides of the trench.

K. EXCESS EXCAVATION

(a) Any excess excavation in the bottom of the trench below the net lines of excavation between supporting walls and columns shall, if the excavation be in earth, be replaced by properly compacted backfill, except where concrete is indicated on the drawings; if the excavation be in rock, by solid materials such as concrete or broken stone properly compacted, except where concrete is indicated on the drawings.

(b) Any excess excavation in the bottom of the trench below the net lines of excavation beneath supporting walls and columns shall, if the excavation be in earth, be replaced by concrete; if the excavation be in rock, all loose rock shall be removed, and the space filled with concrete.

(c) In case any rock core having a width of 8 feet or more and a height of less than twice its width is removed; or, in case the over-breakage of the rock at the sides of the trench shall exceed two feet; in any and all such cases as determined, construction of greater strength and additional waterproofing below water shall be provided in lieu of ramming the concrete to the rock, all as ordered.

L. SAFEGUARDING EXISTING SEWERS

(a) All precautions that may be necessary shall be taken to safely maintain the integrity of existing sewers wherever the flow in such sewers is temporarily maintained in the trenches, and in case any existing sewers so maintained are intermittently subjected to flow under pressure, new sewers or siphons shall be constructed, as the case may be, and the flow diverted into them before the contiguous excavation for the Railroad is removed to a depth where the breaking of an existing sewer might endanger the Railroad or the temporary street supporting and shoring systems.

(b) The exact condition of existing sewers shown on the Supplementary Drawings cannot be determined in advance except at great expense and inconvenience to the public. All sewers may at times flow under pressure. Generally, sewers are not designed and constructed to function when lateral or circumferential support is removed. Whenever any existing sewers are disturbed by the construction operations adjacent to or in the vicinity of such sewers so as to partly or entirely remove their lateral or circumferential support, the sewer may become damaged or broken, causing damage to the Works and to abutting property. It is understood and agreed that before submitting a proposal for the work hereunder, all investigations that are deemed necessary were made as to the general condition of sewers shown on the Supplementary Drawings; and that an allowance was made for any general or special methods of construction or of protecting and securing the sewers.

M. SUBSURFACE DRAINAGE

At all times gutters shall be kept open for surface drainage, and the streets and sidewalks shall be kept clear and free for the passage of vehicles or pedestrians and as otherwise provided in these specifications. All facilities and equipment necessary to maintain surface drainage shall be provided.

N. OFF-LINE TRENCHES TO BE BRIDGED

Where any cross-walk or roadway is cut by a trench for a sewer or other subsurface structure not adjacent to the Railroad, such trench shall be temporarily bridged over to the extent necessary to provide facilities for traffic and to afford access and fire protection to property along the trench. The work shall at all times be conducted so as to cause as little inconvenience as practicable to the public.

O. STREETS TO BE FREE FROM OBSTRUCTIONS

All curb, gutter, flagging, paving and macadam stones, necessary to be removed, which are suitable to be used again, shall be stored in such places as directed, or if unsuitable shall be removed and disposed of. In all cases, a passageway on the sidewalks and in

the roadway shall be preserved free from obstructions.

P. PUMPING

(a) Precautions shall be taken to prevent water from entering upon or flooding the Railroad. The work shall be conducted so as to assure protection against the occurrence of water entering upon or flooding the Railroad, and all materials and the necessary equipment shall be at hand at all times for use in emergency or at times of heavy rainfall.

(b) Whenever water is encountered in the structure or trenches, it shall be removed by bailing, pumping, or other approved means, great care being taken when pumping that the surrounding particles of soil not be disturbed or removed. If necessary to prevent such disturbance, the pumping shall be done by a series of driven wells whose points are protected by fine wire cloths, the rate of flow at each well being made so slow as not to remove the particles of soil.

The discharge from all pumps shall be so arranged as to be readily inspected at all times to ascertain whether the water is free from particles of soil.

(c) Whenever it is permitted to discharge pumps into the City sewers, settling basins or other approved methods shall be employed to keep sewers free from all solid material.

P.1 Removal of Ground Water

For the safe and proper execution of the work, a dewatering system as required at open cut and cut and cover excavation, shall be furnished, installed, maintained, operated and removed. Also observation wells shall be furnished, installed, maintained, operated and removed as indicated and as directed.

P.2 Date to be Furnished

Before starting the construction of any de-watering system, plans shall be furnished showing the method or methods and appurtenances to be used to lower the ground water to the elevations required for the

Construction. Said plans shall show these elevations which also are to be submitted for approval.

Working drawings shall show proposed dewatering system, including general arrangement, procedures to be used, methods of installation, materials, equipment, methods of disposal of all pumped water and procedures for de-activation the system. Methods proposed for removal and disposal of water shall be such as to prevent damage to adjacent property, sewers, pavement, utility installations, and other work.

P.3 Adequate Dewatering System

The arrangement, location, and depths of the dewatering system necessary shall be adequate to accomplish the work and meet the requirements specified herein. Well points and well screens shall be of adequate size and screen openings and sand filter material shall be properly sized to prevent removal of fines from the soil. At all times sufficient equipment, machinery, and piping, including standby pumps of sufficient capacity shall be available and maintained in good working order, to take care of emergencies. At locations where underpinning is to be installed, dewatering operations shall be conducted only to the depths necessary to construct such underpinning work until the underpinning is completed.

P.4 Permits

Whenever deep wells are chosen to lower the ground water, first a permit shall be secured from the New York State Department of Environmental Conservation.

P.5 Pressure Relief

In order to relieve excess hydrostatic pressure in lower lying strata and prevent uplift of the bottom of the excavation, pressure relief shall be provided if necessary. The hydrostatic uplift forces acting on the base of the structure shall not exceed 90 percent of the downward forces consisting of the dead weight of the permanent construction in place, plus the weight of the overlying soil, if any.

P.6 Location

Dewatering facilities shall be located where they will not interfere with indicated utility relocations and construction work to be done by others. Observation wells shall be located as directed. Any dewatering procedure which causes or threatens to cause damage to existing facilities shall be modified as necessary.

P.7 Connection Pipes

(a) Except at street crossings, connection pipe may be laid in gutters adjacent to curbs without protection. The dewatering system shall be so constructed as to not interfere with street drainage or with the entrances to abutting property. Where pipes are laid under sidewalks, about 6 inches of cover shall be provided. All dewatering valves and other such appurtenances of the dewatering system that may be accessible or that project above the street surface shall be suitably housed and protected against tampering.

(b) In case the construction of any part of the dewatering system shall interfere with house service connections or other surface, subsurface or overhead structures, such temporary changes in said structures shall be made as may be necessary to maintain service. Wherever the paved surface of a roadway or sidewalk is removed, and as soon as the connections have been laid and the trench backfilled, a temporary pavement consisting of 3 inches of concrete for sidewalks and 6 inches of concrete for roadways, or other approved temporary pavement shall be laid. Upon removal of the dewatering system, all service connections shall be restored, sidewalks and roadway pavements, and other surface, subsurface and overhead structures affected to a condition similar to and equally as good as existed at the time of commencement of construction.

(c) All connection pipes shall be standard black steel pipes of minimum thickness; the joints to be welded or made with dresser couplings. All pipe for connections shall be new material. Valves and dresser couplings (except gaskets) may be used material, if

in approved condition.

(d) Check valves shall be installed on each pipeline from pumps in order to prevent backflow in case any pump is put out of service. Bleeder taps and shut off valves shall be provided at pockets in all connections from pumps and at any other places in the dewatering system required in order to prevent freezing in event of pumping breakdown.

(e) Discharge lines shall be so arranged as to facilitate taking of water samples.

P.8 Maintenance and Observation

Elevation of the water level in all observation wells shall be observed and recorded daily as long as the dewatering system is in operation and weekly thereafter until the work is completed or the well is ordered removed.

P.9 Removing and Sealing Ground Water Control Facilities

When the ground water control systems are fully deactivated, all wells, sumps and drains shall be sealed for their full length by cement grouting or as directed.

P.10 Panning and Drains

Rock seams carrying water shall be drained as directed. If ordered, sheet metal pans or shields shall be furnished and placed and shall be connected to drains or pipes in order to prevent the water which flows into the trench through the material above or alongside the trench or shaft from injuring the masonry during the placing and setting of same. As directed, these drains or pipes may be required to be connected or drained to the permanent drainage system of the completed structure.

Q. REMOVAL OF MASONRY

Concrete or other masonry (including waterproofing, ducts, steel rods, bars, beams, columns or other steel imbedded in such masonry) of the existing structure

shall be cut out, removed and disposed of as indicated on the drawings and as ordered. The masonry shall be cut to exact lines. Any excess removal of material outside the net lines ordered shall be replaced by new material.

R. REMOVAL OF VAULTS

The removal, where necessary, of all walls and other parts of vaults, areas and coal-holes of abutting property along the lines of the Railroad that are within the ordered net lines of excavation shall be considered as earth excavation.

S. REMOVAL OF FOOTINGS OF ABUTTING BUILDINGS

Where the Railroad passes close to the building line along any street, the footings of abutting buildings may project within the net line of excavation for the Railroad. Such projecting footings may not be shown on the supplementary drawings or they may not be otherwise specifically indicated.

T. CINDER BLOCKS IN BUILDING VAULTS

(a) Wherever vaults of abutting property are broken through or otherwise disturbed, all materials shall be provided for and a cinder block wall laid in Portland cement mortar shall be erected as a temporary partition, on or about the building line, or as directed, that will afford proper protection to the owner or occupant of the adjoining premises. Upon the completion of the work adjacent to the vault, such wall shall, unless otherwise directed, be immediately removed and disposed of.

U. NO ALLOWANCE BEYOND NET OR EXCESS MEASUREMENT LINE

There will be no measurement, allowance or payment made for excavation outside (below, above or wider than) the net or excess measurement lines or payment lines indicated on the drawings or specified. No allowance will be made for any excess excavation caused by slips or slides or for any reason whatsoever, or for any masonry or other materials (except grout, if ordered) necessary to fill the spaces

caused thereby.

V. EXCAVATION BELOW NET LINES

Unsatisfactory material encountered below the indicated subgrade of the Railroad may be required to be excavated. In such cases, supporting walls shall be extended to firm ground, and void spaces between supporting walls and columns shall be replaced with a properly compacted fill.

W. CHANGE OF ROADWAY WIDTH OR STREET GRADE

If it shall be directed that the width of any roadway or grade of any street be changed or when the drawings indicate that the width of any roadway or grade of any street is to be changed, such places shall be filled or excavated to the new width or grade as required.

X. NET LINES DEFINED - TRENCH EXCAVATION

The ordered net lines of the Railroad structure at any location are the lines of intersection of a transverse vertical plane with the outside surfaces of the Railroad structure at the bottom, sides and top of said structure as indicated on the drawings or as ordered, and the area of excavation within said ordered net lines plus any area of excavation vertically above the Railroad structure at said location will govern as to payment for trench excavation for the Railroad at said location. The outside lines at the bottom, sides and top of the total area above defined, governing as to payment for trench excavation, are the ordered net lines of excavation at said location.

Y. NET LINES TO GOVERN

The net lines of excavation which will govern as to widths and depths in the measurements for payment for excavation for the Railroad as aforesaid are, in general, indicated on the Drawings.

Z. EXCESS ALLOWANCE IN ROCK TRENCH

When rock is encountered, because of the impractic-

ability of excavating to an exact line, an excess excavation on the sides of the trench below the elevation of the surface of the rock at the sides of the structure, will be measured to an allowed width of six (6) inches outside the ordered net lines of excavation, except as otherwise indicated on the drawings, whether or not the excavation is made to such width. No excess rock excavation will be allowed below the ordered net lines of excavation at the bottom of the trench.

AA. EXCAVATION FOR PIPES

(a) In the estimate and payment for earth excavation for laying pipes, allowance will be made for a width of trench two (2) feet wider than the interior diameter of the pipe, extending in length one (1) foot beyond the ends of the change, and a depth of six (6) inches deeper than the invert of the pipe, measured from the surface of the street on the line of the trench. Where, the trench for laying pipes thirty (30) inches or more in diameter requires to be close sheeted, allowances will be made in the estimate for payment for earth excavation for a width of trench three (3) feet wider than the interior diameter of the pipe, when the trench is so sheeted.

(b) In the estimate and payment for rock excavation for laying pipes, allowance will be made for a width of trench two (2) feet wider than the interior diameter of the pipe, and for a depth of trench eight (8) inches deeper than the invert of 20-inch or smaller pipe and 12 inches deeper than the invert of pipe of larger diameter, measured from the surface of the rock on the line of the trench. No additional allowance will be made for the removal of rock under the bells to give the required clearance.

(c) For the building of valve chambers and for the setting of valves, valve boxes and hydrants, the total excavation to be allowed will be that within vertical planes one (1) foot outside the outside lines of such structures, valves, valve boxes or hydrants, the depth being taken in earth as the distance from the street surface to the lowest part of the structure or appurtenance.

(d) At the intersection of two (2) trenches at the intersection of a pipe or other trench with an excavation made for any purpose whatsoever, the cubical contents of the intersection will be allowed only once. Under no circumstances will a double allowance be made for any excavation.

BB. EXCAVATION FOR SEWERS

(a) The trenches for sewers and basin culverts to be paid for, both in earth and in rock, where not adjacent to the Railroad, shall have vertical sides and shall be six (6) inches wider on each side than the greatest external width of the sewer or culvert or pipe cradle, but shall be not less than three (3) feet in width. The allowable depth for excavation will be to the lowest part of the structure.

(b) The trenches for sewers and basin culverts to be paid for adjacent to the Railroad, both in earth and in rock, shall be six (6) inches wider than the greatest external width of the sewer on the side farthest away from the Railroad, but in no case will a width be allowed greater than that specified for sewers not adjacent to the Railroad. The allowable depth for excavation will be to the lowest part of the structure.

(c) For manholes and receiving basins or inlets in earth, the excavation to be paid for outside the payment lines for excavation for the Railroad will be six (6) inches wider on each side than the lines of the smallest rectangle that will enclose the greatest exterior dimensions of the manhole or receiving basin, exclusive of the foundation, and shall have vertical sides to the surface, except that where the ordered foundations project more than six (6) inches outside of the manhole or receiving basin, the excavation to be paid for will be extended to include the dimensions of the smallest rectangle that will enclose such foundations.

(d) For manholes and receiving basins or inlets in rock, the excavation to be paid for below the surface of the rock outside the payment lines for excavation for the Railroad will be six (6) inches outside the net outside lines of the manhole or

receiving basin measured at the base and shall have vertical sides to the surface.

CC. EXCAVATION FOR CONDUITS AND DUCTS

In the estimate and payment for excavation for conduit and duct laying and for the building of manholes, vaults, service boxes and their appurtenances, both in earth and in rock, allowance will be made for a width of trench eight (8) inches wider than the duct bank or other structure, except that no trench will be estimated at less than two (2) feet in width, the depth measured on the line of the trench being taken in earth as the distance from the street surface to the lowest part of the structure or to the surface of the rock, as the case may be, and in rock as the distance from the surface of the rock to the lowest part of the structure.

DD. EXCAVATION FOR PERMANENT RAILROAD DRAINAGE

In the estimate and payment for excavation for the permanent Railroad drainage envelope, allowance will be made for a width and depth past the ordered net lines of the Railroad structure to the net payment lines for excavation indicated on the contract drawings for such permanent Railroad drainage.

For drains below the subgrade of the Railroad, measurements for the width of excavation will be to lines six (6) inches outside the net outside lines of the drain structure, including manholes, the depth being taken as the distance from the subgrade of the Railroad to the bottom of the drain structure or manhole as ordered and indicated on the drawings. Individual trenches shall not be less than two feet in width.

Work to be Cleared

The work, Railroad, streets and all public places shall be kept clear of all refuse, rubbish and debris that may accumulate from any source whatever and shall be left in a clean and neat condition.

EE. WASTE MATERIAL

Waste materials will under no conditions be permitted to remain on the site of the work or streets, but must immediately, on its becoming unfit for use in the work, be carted away and disposed of. All rooms, pits, manholes, passageways, trainways and other parts of the Railroad in which the work hereunder is to be done or which are to be used in connection therewith shall be kept thoroughly clean. Such areas shall be protected against unauthorized dumping of waste material by others and such material shall be removed pursuant to the requirements of this paragraph. Waste material shall not be dumped in or on any part of the City's property except by special permission of the Engineer. Concrete mixing trucks shall not be washed out on city streets nor shall the waste material from the washing out of concrete mixing trucks be discharged to any sewer manhole, catch basin, sewer or street.

FF. RIGHT TO HAVE WASTE MATERIAL, ETC. REMOVED

In the event that waste material, refuse, debris and/or rubbish is not so removed from the work, the said waste material, refuse, debris and/or rubbish may be removed by the forces of the New York City Transit System or others.

GG. REMOVAL OF PLANT

As a condition precedent to the acceptance of the work hereunder, all remaining plant, equipment, tools and materials shall be removed from the site of the work and the Railroad, the streets and all public places occupied during construction shall be left in a thoroughly clean and neat condition. In the event that the plant is not removed, the right is reserved to have same removed as provided by and under the conditions set forth in the previous paragraph.

HH. PROTECTION AGAINST FIRE

The utmost care shall be exercised to avoid angles, recesses or pockets in which papers or rubbish may collect and produce a fire hazard. Such covers or

other provisions as may be necessary to prevent or counteract such fire hazards shall be installed.

IV - BACKFILLING AND FILLING

A. DESCRIPTION

Backfilling and filling shall include filling excavations for the Railroad to the lines and grades indicated or ordered.

B. MATERIALS

B.1 Quality of Materials

Backfilling and filling shall be done with sand, gravel or other good clean earth, free from perishable or other unsuitable materials. Solid materials, such as stones, rock fragments or broken masonry of a size which would interfere with the laying of sub-surface structures or prevent proper compacting of the backfilling, will not be permitted. In general, such solid materials will be limited to pieces that will pass through a ring six (6) inches in diameter. In no case shall such solid materials be allowed to collect and remain in layers or nests, but they shall be distributed and separated by finer material as directed.

B.2 Frozen Earth Not Permitted

No filling of trenches with frozen earth will in any case be permitted nor will any filling be permitted over frozen material.

C. CONSTRUCTION METHODS

C.1 Manner of Placing

As the backfilling or filling is placed it shall, except as otherwise permitted, be flushed with water by means of a hose not less than two (2) inches in diameter, in such a manner as to thoroughly saturate the material, to wash it into place, and to fill in voids between stones. Where the backfilling and filling is to support water mains, sewers, gas mains, or

duct banks, it shall be brought up to a level enough above the level at which the subsurface structure is to be placed to allow for 15 per cent shrinkage of the material, and shall be allowed to stand for at least two weeks before any subsurface structure is placed upon it. During this two week period the surface shall be thoroughly flooded with water at least three different times. Backfilling above and around subsurface structures shall be placed in the same manner as that beneath them. When the backfilling placed as above will not insure its being compacted under and around subsurface structures materials shall be reamed and tamped under and above such subsurface structures, using special tools if necessary.

C.2 Subsurface Structures

Subsurface structures shall be so supported that any settlement which may occur will not cause the structure to rest on a timber, rock or other material that might cause a break in the structure. When dumping material for backfilling or other purposes around subsurface structures, such structures must be adequately protected with a timber shield, when necessary, to prevent possible injury by rock or other hard substance in the backfill.

C.3 Removal of Sheeting and Bracing

As fast as the work of filling permits, the sheeting and other timber supporting the sides of the excavation shall be carefully withdrawn and the spaces left by the removal of such material carefully backfilled. If permission is given to leave parts of the sheeting in place, such parts of the sheeting or timber or steel bracing supporting the sides of the excavation be left in place within eight (8) feet of the street or ground surfaces unless directed.

C.4 Filling in Void Spaces

Whenever it becomes necessary to fill in void spaces in vaults or other structures not restored, such spaces shall be filled with material of the same quality and shall be compacted by the use of the

same methods as provided for backfilling, except that filling below the subgrade of the Railroad shall be deposited in layers not exceeding six (6) inches in thickness. Instead of earth filling, it will be required to fill with concrete such void spaces in vaults as are underneath supporting walls and columns of the Railroad and at other locations where required.

Chapter **5**

Chapter 3

Chapter 5

STEEL ERECTION

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Chapter 5

STEEL ERECTION

1 - GENERAL REQUIREMENTS

A. SCOPE

Furnish all labor, material, tools and equipment, and perform all operations necessary for the erection of structural steel indicated on Drawings or specified.

B. MILL ORDERS

It may be required to place mill orders for the steel shown on the drawings issued without waiting for approval of the shop drawings. Mill orders and the material ordered therefrom shall be correct and conform to the shop drawings, except where changes or corrections may be made in the drawings other than the addition of further details.

C. ORDERS AND SHIPPING STATEMENTS

Two (2) complete copies of all material orders and mill shipping statements and four (4) complete copies of all shop shipping statements shall be furnished; if required, additional copies shall be furnished. The shop shipping statements shall show the scale weights of the individual truck shipments.

D. NOTICE OF ROLLING

Ample notice shall be given of the beginning of the rolling at the mill and of work at the shop so that inspection may be provided. No material shall be rolled or work done before an inspection has been arranged.

F. INSPECTOR'S AUTHORITY

The Inspector shall have the power to reject materials or workmanship which do not come up to the requirements of the specifications, but in case of

dispute, his decision may be appealed.

F. ERRORS IN PLANS

There shall be a fixed responsibility for the accuracy of work, including shop drawings, and the approval of such shop drawings shall not be construed as abrogation of responsibility.

G. ACCEPTANCE AND REJECTION OF MATERIALS

The Inspector shall make detailed reports of his inspection and may point out any defects in the material or workmanship. The acceptance of any material or finished members by the Inspector shall not be a bar to their subsequent rejection, if found defective. All acceptances made by him shall be considered temporary and his inspection shall in no way be interpreted as a waiver of responsibility for the character and accuracy of the work. Rejected material and workmanship shall be replaced promptly or made good.

H. HANDLING AND STORAGE

All parts shall be carefully loaded, unloaded and protected from injury during transportation by such means as will be satisfactory to the Inspector. After delivery of materials at the work or in storage, such materials shall be required to be placed on skids at least 12 inches above the ground and such materials shall be kept in good condition. Any piece showing injurious effects of rough handling at any stage before the final acceptance of the work may be rejected.

All bent parts such as brackets, connection and stiffener angles, cap plates, base plates, gusset plates etc., shall be repaired either by straightening or by replacement before erection. Slightly bent details may be straightened by careful hammering, badly bent details shall be cut off and replaced by new ones. Heating of steel for making repairs or for any other purpose shall be allowed only when done under the supervision of the Materials Inspection Division.

I. MARKING AND SHIPPING

Every piece of steel shall have its identification mark painted upon a background of red lead paint applied to the surface of the steel. Members weighing more than five (5) tons shall have the weight marked thereon. Bolts and rivets on one length and diameter, and loose nuts or washers of each size shall be packed separately. Other small parts and small packages of bolts, rivets, washers and nuts shall be shipped in boxes, crates, kegs or barrels, but the gross weight of any package shall not exceed 300 pounds. A list and description of the contained material shall be plainly marked on the outside of each package, box or crate.

II - MATERIALS

A. STRUCTURAL STEEL

Structural steel shall conform to the requirements of A S T M Serial Designation: A 36.

B. RIVET STEEL

Rivet steel shall conform to the requirements of A S T M Serial Designation: A 502, Grade 1.

C. HIGH STRENGTH BOLTS

All high-strength steel bolted connections shall be bearing type connections, with threads excluded from shear planes.

High strength bolts, nuts and washers shall conform to the current edition of ASTM Serial Designation: A 325. Bolts manufactured to these specifications shall be marked on the bolt head with the designation A 325; with the identifying mark of the manufacturer; and, at the option of the manufacturer, with three radial lines 120 degrees apart. Nuts manufactured to these specifications are identified by three circumferential marks 120 degrees apart on the nut face.

D. BOLT DIMENSIONS

(a) Unless otherwise specified, bolts shall be full-body bolts conforming in the dimensions for heavy hexagon structural bolts specified in ANSI Standard B 18.2.1.

(b) In determining bolt lengths, the grip (total thickness of connected materials) shall be calculated the same as for rivets, and the values shown in Table I shall be added thereto. These compensate for thickness of nut, one flat washer, and bolt point. The total length shall be adjusted to the next longer 1/4-inch increment.

(c) If other than the standard thickness of a circular flat washer as given in Table II is used the necessary bolt length shall be adjusted accordingly. Where beveled washers of the dimensions given in Table II are used in lieu of flat washers, an additional 5/32-inch shall be added for each such beveled washer.

TABLE I - BOLT LENGTHS

Bolt Size (Inches)	Add to Grip (Inches)
1/2	27/32
5/8	1-1/32
3/4	1-5/32
7/8	1-9/32
1	1-13/32
1-1/8	1-21/32
1-1/4	1-25/32
1-3/8	1-29/32
1-1/2	2-1/32

E. NUT DIMENSIONS

Nut dimensions shall conform to current requirements for heavy and semi-finished hexagon nuts specified in the A N S I Standard B 18.2.2.

F. WASHER DIMENSIONS

(a) Circular washers shall conform to the dimensions

WASHER SIZE

DIMENSION	To 1-1/2 in. Nominal Bolt Size, Incl.	Over 1-1/2 in. Nominal Bolt Size
Nominal Diameter of hole	-0; + 1/32	-0; + 1/16
Nominal Outside Dimensions	-1/32; + 1/4	-1/32; + 1/4
Flatness; max. deviation from straight edge placed on "cut" side shall not exceed.....	0.01	0.015
Burr shall not project above immediately ad- jacent washer surface more than.....	0.01	0.015

G. STEEL STUDS

Steel studs shall be solid flux filled, cold-finished carbon-steel conforming to A S T M Serial Designation A 108.

III - CONSTRUCTION METHODS

A. QUALITY

The workmanship and finish shall be equal to the best practice in modern bridge shops. Material at the shops shall be kept clean and protected from the weather as far as practicable.

B. MATERIALS STRAIGHTENED IN THE SHOP

All rolled material before being laid off or worked in any way shall be straight. If straightening or flattening is necessary, it shall be done by methods that will not injure the material. After punching and before assembling, the material shall again be straightened if required by the Inspector. Sharp kinks and bends may be cause for rejection.

C. FINISH

Shearing and clipping shall be neatly and accurately done and all portions of the work exposed to view shall be neatly finished.

D. RIVET HOLES

Except as otherwise required in Chapter 5, III, N., if the thickness of the material is not greater than the nominal diameter of the rivet plus 1/8-inch, the holes may be punched. If the thickness of the material is greater than the nominal diameter of the rivet plus 1/8-inch, the holes shall be either drilled from the solid, or subpunched and reamed.

E. PUNCHED HOLES

Full size punched holes shall be 1/16-inch larger than the nominal diameter of the rivets. The diameter of the die shall be as small as required to

punch a clean hole, and shall not exceed the diameter of the punch by more than 3/32-inch. If any holes must be enlarged to admit the rivets, they shall be reamed. Holes must be clean-cut without torn or ragged edges. Poor matching of holes may be cause for rejection.

F. SUBPUNCHED AND REAMED HOLES

Where subpunched and reamed work is required, the holes shall be punched 3/16-inch smaller than the nominal diameter of the rivet, and after assembling, reamed to a diameter not more than 1/16-inch larger than the nominal diameter of the rivet. The diameter of the punch used shall be 3-1/6-inch smaller than the nominal diameter of the rivet and the diameter of the die not more than 3/32-inch larger than the diameter of the punch. Outside burrs shall be removed with a tool making a 1-1/6-inch fillet.

G. ACCURACY OF PUNCHING IN REAMED WORK

In subpunched and reamed work, the punching shall be accurately done. Poor matching of holes shall be cause for rejection.

H. REAMING AFTER ASSEMBLY

Reaming shall be done in accordance with the latest standards of the American Institute of Steel Construction and shall be done after the pieces forming a built member are assembled and so firmly bolted together that the surfaces are in close contact. Before riveting, they shall be taken apart, if necessary, and any shavings removed. When it is necessary to take the members apart for shipping or handling, the respective pieces reamed together shall be so marked that they may be reassembled in the same position in the final setting up. No interchange of reamed parts will be permitted. The use of lubricants in reaming will not be allowed.

I. ACCURACY OF REAMING AND DRILLING

When holes are reamed or drilled, 85 of any group of 100 contiguous holes in the same plane shall, after reaming or drilling, show no offset greater than 1/32-inch between adjacent thickness of metal.

J. REAMED HOLES

Reamed holes shall be cylindrical, perpendicular to the member, and not more than 3/32-inch larger than the nominal diameter of the rivets. Reamers shall not be directed by hand. Outside burrs shall be removed with a tool making a 1/16-inch fillet.

K. DRILLED HOLES

Drilled holes shall be 1/16-inch larger than the nominal size of the rivet. Burrs on the outside surfaces shall be removed.

L. ASSEMBLING FOR DRILLING

Connecting parts requiring drilled holes shall be assembled and securely held together while being drilled.

M. SHOP ASSEMBLING

The parts of riveted members shall be well-pinned and firmly drawn together with bolts before riveting is commenced. The drifting done during assembling shall be only such as to bring the parts into position, and not sufficient to enlarge the holes or distort the metal.

N. FIELD CONNECTIONS

All holes for field connections, excepting those in lateral, longitudinal and sway bracing, and beam connections containing 6 holes or less, shall be subpunched and reamed to a reaming template fitted with bushings, or reamed and match-marked while the connecting parts are temporarily assembled in the shop.

O. MATCH-MARKING

Connecting parts assembled in the shop for the purpose of reaming or drilling holes in field connections shall be match-marked, and a diagram showing such marks shall be furnished.

P. RIVETS

(a) The size of rivets called for on the drawings shall be the actual size of the cold rivet.

(b) Rivet heads, when not countersunk or flattened, shall be of approved shape and of uniform size for the same diameter of rivet. Rivet heads shall be full, neatly made, concentric with the rivet holes and in full contact with the surface of the member. Rivet heads shall not be flattened to less than half the diameter of the rivet, unless countersunk.

Q. RIVETING

(a) The rivets shall be heated uniformly to proper heat and driven while hot. Rivets, when heated and ready for driving, shall be free from slag, scale and carbon deposit. When driven, they shall completely fill the holes. Loose, burned or otherwise defective rivets shall be replaced. In removing rivets, care shall be taken not to injure the adjacent metal, and, if necessary, they shall be drilled out. Caulking, recupping or removing rivets by burning will not be permitted.

(b) Rivets shall be driven by direct-acting riveters where practicable. The riveters shall retain the pressure after the upsetting is completed. Where necessary, special riveting tools shall be used.

(c) When necessary to drive rivets with a pneumatic riveting hammer, a pneumatic bicker shall be used for holding up, when practicable.

R. FIELD RIVETS

Field rivets shall be carefully selected and shall be free from fins on the under side of the head.

S. RIVET SPACING

Distances from center of rivets to a rolled or finished edge shall be not less than 1-1/2 times the diameter of the rivet, such distances to be increased 1/8-inch from a sheared edge. The minimum pitch shall be three times the diameter of the rivet plus 1/4-inch. When the material is subpunched and

reamed or drilled from the solid, such pitch may be reduced 1/4-inch. When 7/8-inch rivets are used in 6-inch angles and placed opposite one another, the distance from the center of rivets to the back of the angle shall be not less than 2-1/4-inches, and the transverse distance between rivets placed opposite one another shall be not less than 2-1/2-inches.

T. REMOVAL OF RIVETS

Rivets shall be removed from the existing structure by knocking off the heads and backing out the rivets. Flame cutting in connection with the removal of either rivets or bolts will be permitted only with the approval and in accordance with given directions.

U. WELDING

Welding of structural steel parts, except where welded connections are indicated on the contract drawings or otherwise specifically permitted, shall be limited to shop welding of stiffener plates on rolled beams, and caps and bases on columns where wing plates are not required.

All welding shall be electric arc welding using a metallic electrode, and the work shall be performed in accordance with the latest edition of the "Code for Arc and Gas Welding in Building Construction," formulated by the American Welding Society, and the Specification for the "Design, Fabrication and Erection of the Structural Steel for Buildings by Arc and Gas Welding" of the American Institute of Steel Construction. Stiffeners shall be welded to the top and bottom flanges and to the web of the beam. Welds on stiffener bearing ends shall not extend closer than 1/2-inch to the outer edge of the stiffener.

V. PLANING SHEARED EDGES

Sheared edges of material more than 5/8-inch in thickness and carrying calculated stress shall be planed to a depth of 3/16-inch. Re-entrant cuts shall be filleted before cutting.

W. LATTICE BARS

Lattice bars shall have nearly rounded ends unless otherwise called for.

X. STIFFENERS

Stiffeners of plate girders carrying stress shall be faced on the ends where the load is applied and brought to a true contact bearing with the flange angles; the other ends of the stiffeners, shall be sheared square and brought to a tight fit with the flange angles. All other stiffeners shall be sheared square and brought to a tight fit with the flange angles to provide full bearing. Web splice plates and fillers under stiffeners shall be cut to fit within 1/8-inch of flange angle on each end.

Y. WEB PLATES

Web plates shall not project beyond the flange angles. The edges of web plates of girders shall not be more than 1/4-inch back of the top and bottom flange angles.

Z. BEARING AND ABUTTING SURFACES PLANED

(a) All abutting surfaces, except abutting ends of roof and invert beams, shall be accurately milled or faced so as to insure even bearing, unless otherwise noted on the drawings. The top and bottom surfaces of base and cap plates of columns, except those surfaces in contact with masonry, shall be milled, or the plates press straightened. Parts of members in contact with them shall be faced to fit.

(b) Sole plates of plate girders shall have full contact with the girder angles. Sole plates shall be milled or press straightened.

AA. FINISHED MEMBERS

Finished members shall be true to line and free from twists, bends and open joints.

BB. SCREW THREADS

Screw threads shall make close fits in the nuts and shall be U. S. Standard and properly annealed.

CC. ANNEALING

Steel, except in minor details, which has been partially heated, shall be properly annealed.

DD. SPLICING AND FIELD CONNECTIONS

When riveting, the erection of all spliced and field connections shall be securely bolted and shall have 50 per cent of the holes filled with bolts and drift pins before riveting. Light drifting will be permitted in order to draw the parts together, but drifting for the purpose of matching unfair holes will not be permitted. Unfair holes shall be reamed or drilled.

EE. HIGH STRENGTH BOLTS

High strength bolts shall be used for field and shop connections except where the drawings indicate that rivets only shall be used. Said bolts shall be of the same size and of the same number basis as indicated on the drawings. The heads of the bolts shall be placed to face the public where possible. Where bolts are used to fabricate built-up columns, the heads of the bolts shall be placed on the faces of the column. The use of button-head bolts will not be permitted.

FF. WORKMANSHIP

(a) Surfaces of bolted parts in contact with the bolt head and nut shall be parallel; except that they may have a slope of not more than 1:20 with respect to a plane normal to the bolt axis if the requirements of the following Sub-paragraph B are observed. Bolted parts shall fit solidly together when assembled and without interposition of gaskets or any other flexible material. Holes shall be punched, sub-punched and reamed, or drilled, as required for rivets and shall be of a diameter not more than 1/16-inch in excess of the nominal bolt diameter.

(b) Contact surfaces, when assembled, shall be de-scaled or carry the normal tight mill scale. They shall be free of paint, lacquer, dirt, oil, loose scale, burrs, pits or defects.

FF.1 ASSEMBLY

(a) Bolts shall be provided with washers under heads or nuts. Flat washers may be used if abutting surfaces adjacent to bolt heads and nuts do not have a slope of more than 1:20 with respect to plane normal to the bolt axis; provided that, in all cases of non-parallel abutting surfaces, the nut shall be torques against a non-sloping surface.

(b) Washers shall be placed under element to be turned.

(c) All nuts shall be tightened to give at least the required minimum bolt tension values given in Table III on completion of the joint.

TABLE III---BOLT TENSION

Bolt Size (in.)	Required Minimum * Bolt Tension (Kips)
1/2	12
5/8	19
3/4	28
7/8	39
1	51
1-1/8	56
1-1/4	71
1-3/8	85
1-1/2	103

* Equal to 70 per cent of specified minimum tensile strengths of bolts, rounded off to the nearest kip.

Note 1--Wrenches should be set to induce a bolt tension in excess of the Required Minimum Bolt Tension as given in Table III.

Note 2--In using a power wrench, the recommendation of the wrench manufacturer should be consulted in

its operation and care should be taken that the machine is maintained in proper working condition and proper calibration.

Note 3--Torque wrenches used for inspection must be calibrated as ordered, and at least three bolts of the same type, size and condition of thread must be checked in the hydraulic tester to determine the average torque equivalent to the minimum required tension.

FF.2 REQUIREMENTS FOR TIGHTENING BOLTS

(a) Nuts shall be tightened with impact wrenches by "Turn-of-Nut" method.

(b) Impact wrenches shall be of adequate capacity and sufficiently supplied with air to perform the required tightening of each bolt in approximately ten seconds.

(c) The impact wrench must be of an adequate size (capacity) to properly tighten the size bolt used. Wrench sockets shall be the bolt clearance type and have hardened inserts to scuff-up the outside nut face. The square and hexagon internal broached surfaces of wrench sockets shall be in good condition. Legible marks, extending from the tightening end back to the drive end, 90 degrees apart and suitably differentiated shall be placed on the outside walls of wrench sockets. The use of universal or straight extension adaptors will not be permitted. Straight extensions built into the wrenches so that there is no power loss, may be approved.

Wrenches shall be properly lubricated and otherwise maintained to prevent variations in proper tightening-up procedure.

FF.3 ERECTION PROCEDURE

(a) Men experienced and competent in the use of tightening procedures by the "Turn-of-Nut" method with high-strength bolts, shall be employed in tightening gangs.

(b) Generally nuts shall be placed on the side of

the connection so that torquing will be against a non-sloping surface. Where conditions at the connection require tightening the bolt head instead of the nut, the head is to be tightened following the same procedure as for nuts. In no event shall nuts or bolt heads be tightened against a sloping surface greater than 1:20.

(c) Each connection when completed shall bear an identifying mark.

(d) Where one or both sides of a bolted connection will be exposed to view, the head of the bolt shall be placed on the exposed side or outer side of the connection.

(e) Washers shall be placed under element to be turned. This is an unqualified requirement.

FF.4 MAKING CONNECTIONS

The connections shall be tightened as follows:

(1) Holes shall be faired up with drift pins, as hereinbefore specified for riveted connections, to maintain dimensions and plumbness of the structure. (Drift pins shall not be removed until the bolts in the balance of the holes have been installed and made snug tight as defined below in paragraphs (2) and (3).

(2) Bolts shall be installed first in the most rigid part of the connection and installation shall proceed toward the free ends. Only hand-tightening is required at this point. (All connected parts must be properly fitted.)

(3) After the remaining holes have been filled with bolts, each bolt shall be torqued up to "snug tight" condition. At "snug tight", all abutting surfaces should be firmly in contact. Drift pins shall now be removed.

(4) Impact wrenches shall be used to tighten up bolts by means of the required turn beyond the "snug tight" condition. Tightening of the bolts in a joint shall, whenever possible, commence at the most rigidly fixed

or stiffest point, and progress toward the free edges, both in the initial snugging up and in the final tightening.

(5) The torque of each initial bolt shall be checked with the impact wrench and further tightened, if necessary.

FF.5 TURN-OF-NUT METHOD

An impact wrench of sufficient capacity for the bolt size shall be employed. The nut of the bolt shall be spun to a "snug tight" condition, and shall then be further tightened at least one-half to three-quarter turn, depending on the grip length, as indicated in Table IV. "Snug tight" is indicated by the wrench when it starts to impact.

TABLE IV

Nut Rotation From Snug Tight Condition

Disposition of Outer Faces of Bolted Parts

Both faces normal to bolt axis, or one face normal to axis and other face sloped 1:20 (bevel washers not used)	Both faces sloped 1:20 from normal to bolt axis (bevel washers not used)
---	---

Bolt length $\nless$ not exceeding 8 diameters or 8 inches	Bolt length $\nless$ exceeding 8 diameters or 8 inches	For all lengths of bolts
1/2 turn	2/3 turn	3/4 turn

* Nut rotation is rotation relative to bolt regardless of the element (nut or bolt) being turned. Tolerance on rotations: 30° over and under. For coarse thread heavy hexagon structural bolts of all sizes and lengths and heavy hexagon semi-finished nuts.

$\nless$ Bolt length is measured from underside of head to extreme end of point.

FF.6 CONNECTIONS

(a) Any connections that do not contain bolts of sufficient length or are not provided with washers or beveled washers under head or nut shall be removed and replaced by the proper combination of bolts, nuts and washers or beveled washers, and all bolts in such connections shall be properly retorqued if necessary.

(b) Upon completion of each connection, it shall be inspected mechanically to see that bolts have been torqued to at least specified minimum tension. A hand torque wrench calibrated for torque at minimum tension may be used. This calibration can be established by torquing a bolt to minimum tension in the hydraulic tester; then torquing the nut slightly tighter and reading the foot-pounds required to turn the nut after the nut has been set in motion. (See Table III, Note 3.)

(c) For field connections, at least 10 per cent of the bolts in any connection and not less than one bolt of each size in each connection shall be checked for tension.

(d) For shop connections, upon delivery at the job site, and before erection, at least 10 per cent of the bolts in any connection, and not less than one bolt of each size in each connection, shall be checked for tension. Should any bolt fail to meet the requirements of this test, all the bolts in that member shall be retightened by properly adjusted power wrenches before the member is erected.

FF.7 TEST EQUIPMENT

An approved hydraulic tester for setting and checking impact wrenches and an approved hand torque wrench (with dial gauge) together with facilities for setting and checking shall be provided and maintained at the site.

GG. STEEL STUDS

(a) Steel studs shall be welded to structural steel where indicated. Welding may be performed in the shop or in the field.

(b) Studs shall be free from rust, scale, rust pits and oil at the time of welding and immediately before concrete is placed. The surface of steel to which the studs are welded shall be free of excessive mill scale, rust, dirt, paint, grease or any other material which might impair the quality of the weld. Welds or studs that are found to form cracks will not be accepted and the stud shall be removed and replaced.

(c) Steel studs shall be automatic end-welded similar to those manufactured by Nelson Stud Welding, Division of Gregory Industries, Inc. of Lorann, Ohio, or by K.S.M. Products, Inc., Steel Welding Division of Merchantville, New Jersey, or approved equal.

HH. REMOVAL AND DISPOSAL OF EXISTING STRUCTURAL STEEL

In connection with the removal and disposal of portions of the existing structure and the framing and fitting of new and old structural steel work, it will be required to remove and dispose of portions of the existing structural steel work. Such steel and iron removed and not reused and waste steel resulting from the remodeling of steel and iron shall, except where otherwise provided, be disposed of.

II. REMODELING EXISTING STEEL

(a) It will be required to remodel certain portions of the steel work of the existing structure generally as indicated on the drawings. For the remodeling work, it will be required to make all necessary shop drawings and the field measurements necessary therefor. Such work will include, among other things, cutting steel shapes and riveted members, reaming, countersinking and drilling holes (round or slotted), reaming and countersinking existing holes, removing old rivets, plugging and welding holes and removing and re-erecting steel of the existing structure. Unused holes in steel to be encased in concrete will not be required to be plugged and welded.

(b) Where existing rivets are in physical interference with new holes to be drilled in the field, the rivets shall be removed and the rivet holes shall be plugged and welded. Where knee braces are removed, rivet heads shall be cut off and shanks ground smooth and flush with the underside of the existing roof beams and with flange of existing columns that are not to be removed.

(c) The use of flame cutting methods for the removal of existing steel will not be permitted where steel which is to remain in the structure might be damaged either in strength or appearance by the flame. In such cases, the steel shall be removed by sawing or other approved method as directed. When necessary to use flame cutting, it shall be done by approved methods as directed. When permitted, the edge of the cut member shall be straight and the distance from the center of the rivets to the cut edge shall not be less than 1-1/2 times the diameter of the rivet plus 3/8-inch.

(d) Where new steel is connected to existing steel, the surfaces of the existing steel shall be cleaned to the bright metal.

(e) In order to connect new steel to existing steel, it will be necessary to remove portions of the concrete of the railroad within lines as directed. Where concrete is removed in order to connect new steel, it will be required to restore such concrete.

JJ. BRACING

All steel structures shall be erected true and plumb and all match marks shall be followed. Temporary bracing shall be introduced wherever necessary to take care of all loads to which structures may be subjected, including erection equipment. Such bracing shall be left in place as long as may be required for safety.

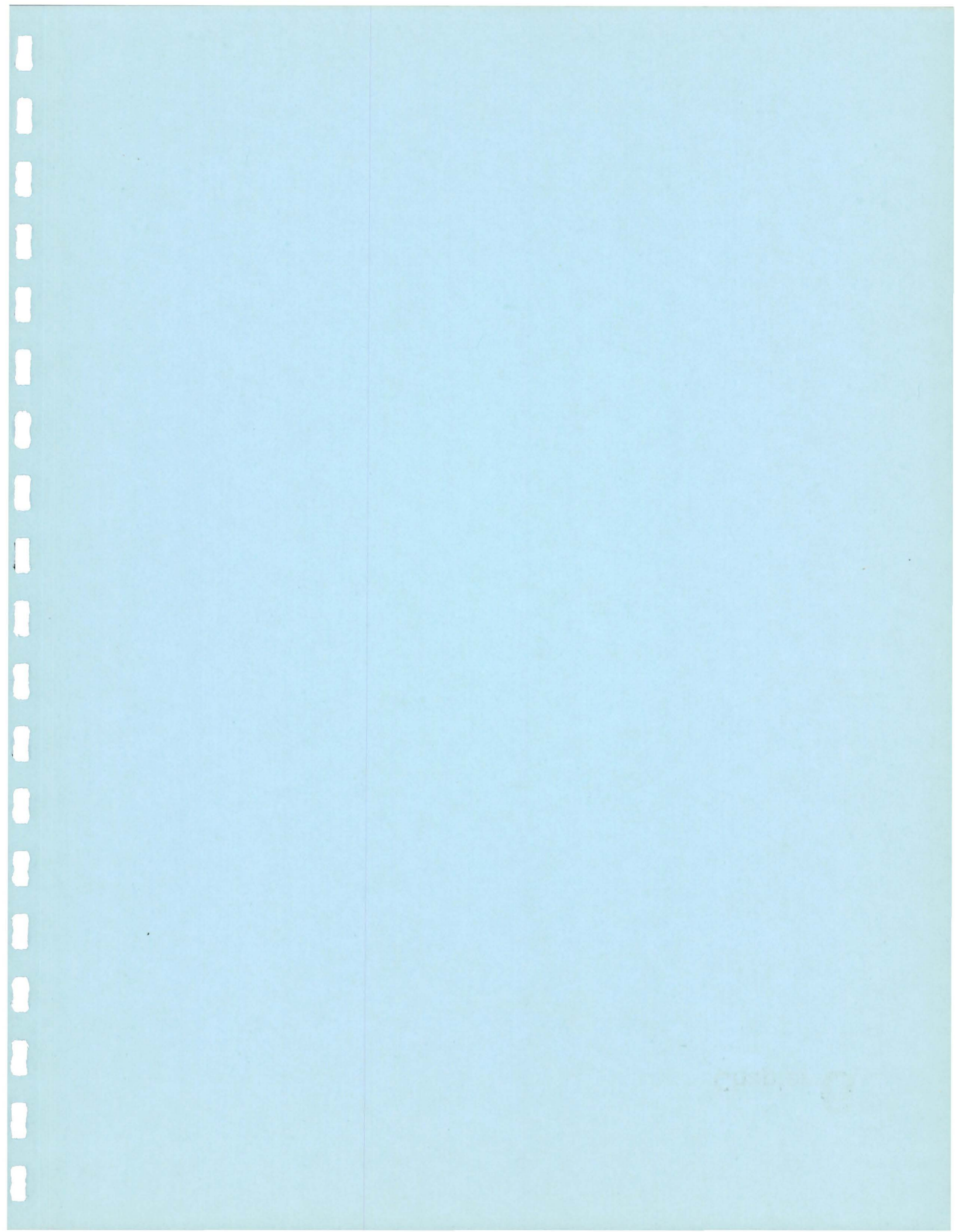
KK. SAFETY

When working on or near tracks of the operating Railroad, an adequate number of flagmen shall cover the work at all times. Working crews shall be made

aware of flagging procedures and instructions.

If a crane is operated in such a location that any part of the crane or of its load in any position of boom or swing may come within 10 feet of a live power line (including the third rail) the power line shall be de-energized, or the power line shall be effectively insulated or isolated, or the crane shall be effectively grounded with a No. 2 AWG or larger single conductor (600 Volt covering, and resistance of 25 ohms or less).

Chapter 6



Chapter 6

RESTORATION

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Chapter 6

RESTORATION

I - GENERAL REQUIREMENTS

A. SCOPE

Furnish all labor, materials, tools and equipment, and perform all operations necessary to restore all surfaces of whatever nature that are disturbed in connection with the construction of the Railroad, in accordance with the requirements of this Section.

B. DEPARTMENT OF HIGHWAYS MAY DO WORK

If, after due notice and within the time specified therein, work of placing a temporary pavement, or work that may be necessary to maintain the temporary pavement is not done, and also sidewalk surfaces are not in a satisfactory condition, the Authority, with the approval of the Board or Officer of the City of New York having jurisdiction, may call upon the Commissioner of Highways' Office to do such temporary paving or maintenance work as may be necessary, and the cost of such work shall be deducted from any moneys due in the first subsequent estimate after the work has been done by the Commissioner of Highways' Office.

C. OTHER FORM OF PAVEMENT MAY BE LAID

(a) Nothing contained in these specifications shall be understood or construed as prohibiting from making any arrangements with the Commissioner of Highways or such other officer of the City as may be in charge of street paving, to lay a better or other form of street pavement in the roadway between curb lines, or to make arrangements with any property owner to lay another style of sidewalk, or other surface covering within curb lines, in place of the sidewalk or other surface covering taken up, provided however, that such other street pavement, sidewalk or other surface covering shall conform to the requirements of the Commissioner of Highways or other municipal officer

having jurisdiction; in which case a copy of a contract with such municipal officer or with such property owner, duly acknowledged in writing by both parties shall be filed with the Authority.

(b) In case the Authority desires to lay a pavement in the roadway between curb lines or a sidewalk or other surface covering within curb lines different from the one removed and shall fail to make satisfactory arrangements for such work or in case the municipal officer in charge of street paving, or other property owner desires to lay a pavement in the roadway between curb lines or a sidewalk or other surface covering within curb lines, affected by this work, different from the one removed and shall notify the Authority in writing that he has failed to make satisfactory arrangements for such work, then in all such cases the Authority in its discretion may arrange to finish and dress the filling over the work to such grade as may be directed, and further arrange to have removed from the area to be restored all material of whatever nature not required to be relaid and to permit another party to lay such roadway pavement, sidewalk or other surface covering, or the Authority may arrange to have furnished and placed a temporary pavement, to maintain the same for a period of 4 months and to leave same in place. In all such cases, the liability shall cease so far as the restoration of said roadway and sidewalk surfaces within net lines is concerned, whenever the instructions of the Authority have been complied with, exactly the same as if the restoration as herein elsewhere provided had been fully completed. The obligation to maintain and guarantee all backfilling and surfaces restored and all other surfaces affected by the work shall remain.

II - MATERIALS

A. TEMPORARY PAVEMENTS

- (a) Temporary roadway pavement shall consist of a foundation course and a wearing course.
- (b) Foundation course shall consist of 1-1/2-inch mineral aggregate.

- (c) Wearing course shall be a bituminous binder mixture consisting of 1-1/2-inch and 3/8-inch mineral aggregate and asphalt.

B. PERMANENT PAVEMENTS

Permanent pavements shall conform to the current requirements of the standard specifications of the New York City Department of Highways.

III - CONSTRUCTION METHODS

A. TEMPORARY PAVEMENT AND RESTORATION

(a) As soon as the structure in any trench or opening made within a street shall be completed and the trench or opening backfilled, a temporary roadway and sidewalk pavement and curb shall be laid and maintained for at least 4 months in a satisfactory condition.

(b) The surface to be paved shall be prepared and compacted so as to form a dry, firm, uniform surface approximately parallel to and the required distance below the finished surface.

(c) The foundation course shall be thoroughly compacted and bonded to a firm, even surface conforming to the grade and crown of the street. The voids in the 1-1/2-inch mineral aggregate shall be filled with screenings or sand before rolling. Where the foundation course cannot be reached by a roller, a concrete foundation course may be substituted for the layer of 1-1/2-inch mineral aggregate, but no additional allowance will be made on account of the concrete foundation course. The foundation course shall be a minimum of 4-inches in thickness after thorough compaction. The wearing course shall be thoroughly compacted by rolling. Areas that cannot be reached by a roller shall be thoroughly compacted by tamping. The wearing course shall have a total thickness of not less than two inches after thorough compaction.

(d) The surface of the pavement shall be hard, dry and even, and shall be maintained at all times in that condition. All depressions shall be promptly

filled in with additional material similar to that used in the wearing course, and reroll until the surface is again uniform and at the required grade.

(e) Temporary pavement for sidewalk surfaces shall conform to the requirements specified for temporary roadway pavement, except that the foundation course of mineral aggregate shall be not less than two inches.

(f) Temporary curb shall consist of sound 12-inch by 50inch or larger timbers of other equally satisfactory curb. Timbers shall be anchored in an approved manner at joints and at intervals of not less than 10 feet between joints.

(g) Whenever after such 4 months the earth shall, have become sufficiently settled, said temporary pavement and curb shall be removed within a reasonable time and the surface shall be restored to a condition similar to and equally as good as that existing at the time of commencement of work hereunder.

(h) The Authority may arrange with the Commissioner of Highways, or other municipal officer having jurisdiction over street and park paving, to have the permanent roadway of park pavement or any portion thereof in any street or park restored by the said Commissioner of Highways, or other municipal officer, and in such case may omit the restoration of the roadway pavement or any portion thereof in any street restored and leave the temporary pavement in place; however, the obligation to maintain and guarantee all backfilling and surfaces restored and all other surfaces affected by his work shall remain.

(i) Street surface over openings made in the streets for the purpose of installing and removing by-passing systems, for rearranging subsurface structures and for building sewers and other structures outside of the main trench for the Railroad shall be restored as soon as practicable, after the temporary pavement is in place, to a condition similar to and equally as good as that existing at the time of commencement of the work hereunder.

(j) Unless otherwise specifically provided, pavements restored shall line up with existing adjacent surfaces and shall be similar to that existing at the time of commencement of the work hereunder, provided, however, that the following requirements are met:

(1) Areas in which the existing roadway pavement is sheet asphalt shall, in general, be restored with a pavement consisting of three inches of asphaltic concrete on a 6-inch concrete base.

(2) Areas in which the existing roadway pavement is brick or block shall, in general, be restored with a pavement consisting of brick or block on a concrete base.

(3) Areas in which existing roadway pavement is concrete shall, in general, be restored with a pavement of concrete at least as thick as that existing. In no event, however, shall the concrete pavement provided be less than 6 inches thick.

(4) Areas to be restored shall include the areas disturbed plus the adjoining pavement that has been damaged or otherwise affected. Such adjoining pavement shall first be broken out. To prevent settlement and secure a proper bond with the new concrete, the concrete base shall be removed to at least 6 inches beyond the outer limits of the subgrade disturbed, and all contact surfaces of the existing concrete shall be cleaned and coated with a grout of Portland Cement. The wearing surface shall be restored over an area extending at least three inches beyond the outer limits of the new concrete.

B. FINISH ON CONCRETE AT STREET SURFACE

The upper three inches of concrete walls or slabs which extend to the street surfaces as at ventilating openings, etc., shall be constructed and finished off as required to form a cement sidewalk.

C. GRASS PLOTS AND TREES

Where any grass plots or trees exist along any street or in any park, parkway or other areas occupied by the work, proper precautions shall be taken to protect them from injury. For every tree removed, injured or destroyed, a new thrifty tree shall be set out either in the old or new location, as required balled and platformed, not less than 15 feet in height and not less than 3-1/2 inches in diameter as measured two feet above the surface of the ground, in such position as the Administrator of the Parks, Recreation and Cultural Affairs Administration shall indicate. The new trees shall be similar in type and size to the trees removed, approved by the Administrator of the Parks, Recreation and Cultural Affairs Administration. All grass plots, shrubbery and other plants removed or affected by the work shall be restored as soon as possible to as good a condition as existed before the commencement of the work. In replanting trees and grass plots, one shall be governed by the reasonable requirements of the Administrator of the Parks, Recreation and Cultural Affairs Administration or by other authorities specially charged with the care of these trees or grass plots, and the nature and depth of the soil to be placed therein must be as approved by such authorities and by the Authority.

D. SURFACES OUTSIDE NET LINES TO BE RESTORED

All streets and other surfaces (including the foundations thereof) outside the payment lines of excavation except as herein otherwise specifically provided for, either adjacent to or not adjacent to the line of the Railroad that may have become damaged, directly or indirectly, as a result of the work shall be restored to a condition similar to and equally as good as that existing previous to the commencement of construction.

E. NEW CURB

(a) When and as required, a new curb shall be furnished and set or constructed at locations as may be required. However, all of the old curbstone removed which is in condition for relaying shall be preserved and restored.

(b) Steel facing for street curbs shall be "Type D" as specified in the New York City Department of Highways" Standards.

Chapter **7**

Chapter 4

Chapter 7

HARD ROCK TUNNELING

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Chapter 7

HARD ROCK TUNNELING

I - GENERAL REQUIREMENTS

A. SCOPE

All labor, materials, tools and equipment shall be furnished and all operations necessary for rock tunnel excavation work shall be performed as indicated on drawings or specified.

B. DESCRIPTION

(a) Tunnel excavation shall be made in rock in free air to the net lines indicated or otherwise ordered.

(b) The requirements for excavation specified in Chapter 4 (incl. blasting, removal of ground water etc.) shall, where applicable, be observed for tunnel excavation.

C. WORK IN ROCK TUNNEL BOTH DAY AND NIGHT

(a) Work in rock tunnel excavations may be carried on with full forces both day and night without intermission, except that it will not be required to prosecute work on Saturdays, Sundays or legal holidays except in case of emergency.

(b) Rock tunnel blasting and removal of excavated material will be permitted to be carried on for a period of 16 hours each working day, using two 8-hour shifts, during the hours of 7:00 A.M. to 11:00 P.M. daily.

(c) In cases of emergencies involving danger to life or property, or where the integrity of the work requires a continuous operation, continuous work with an increased force may be ordered for such time as may be necessary.

D. VENTILATION, LIGHTING AND FIRE PRECAUTIONS

To assure the safety of the work and the workmen during construction, provide safe and adequate ventilation and lighting. All reasonable precautions shall be taken against fire, and provisions shall be made for the extinction thereof.

E. CARS AND TRACK

Cars for transporting materials through the tunnels shall be of substantial design, shall be tight and shall be at all times so handled as to assure safety of operation. Tunnel service tracks shall be maintained at good grade and alignment. A planked walk at least 5 feet wide shall be maintained in good condition at the level of the track floor, extending to the shaft or tunnel entrance, except where the concrete invert shall have been placed and the tunnel service tracks placed on such invert or removed. The system of haulage shall be mechanical and readily controllable.

F. PROBE BORINGS

(a) Probe borings shall be made in the heading before each advance in tunnel excavation. Probe holes may be ordered in advance of the heading at any time.

(b) An accurate record of the character of all materials penetrated by each boring shall be furnished.

G. SCALING

As tunnel excavation proceeds and immediately after each blast, the roofs and walls of tunnel excavations shall be tested by experienced and suitable equipped scalers whose duty it shall be to dislodge all loose or shattered rock which is liable to fall. Previously excavated portions of the tunnel shall be similarly periodically tested. For this work, full time scalers shall be provided and such scalers shall be required to devote all necessary time to the operation of scaling. The roofs and walls of tunnel excavations shall be maintained in a safe condition.

II - MATERIALS

A. STEEL SUPPORTS

Steel supports used in tunneling shall conform to the requirements of ASTM Serial Designation: A 36.

B. TUNNEL TIMBERING

All tunnel timber for blocking and lagging, foot blocks, cribbing etc. shall be sound, well seasoned hardwood timber of rectangular cross section.

C. ROCK BOLTS

(a) Rock bolts shall be of an approved type and shall conform to ASTM Serial Designation: A306-64, Grade 60, or 65 for slotted rods and Grade 80 for headed bolts. Expansion shells shall be made of malleable iron conforming to the requirement, of ASTM Serial Designation: A47-66-T Grade No. 32510 or of forged steel, as approved. Wedges for slotted type rock bolts shall be made of the same steel as the bolts, or from malleable iron castings of approved finish and workmanship conforming to the requirement, of ASTM Serial Designation: A47-66-T, Grade No. 35018. The details of the rock bolts and their anchors shall be as approved, and the efficiency of the bolt anchorage shall be satisfactorily demonstrated. The exposed ends of all rock bolts shall be threaded. Threads shall be smooth, clean, rolled threads, Class 2 fit, of the same diameter as the nominal diameter of the bolt, with the approved number of threads per inch for the size of bolt used. Nuts shall be regular square nuts and shall conform to ANSI Standard B18.2.2.

(b) Each rock bolt shall be tested at the time of installation and retested in accordance with an approved procedure. The testing shall be done with approved calibrated torque or impact wrenches. In addition, approved hydraulic testing equipment shall be made available for testing rock bolts as required. Bolts that do not test at least 200 foot-pounds torque shall be satisfactorily retightened or replaced.

(c) Wire fabric shall be manufactured from approved steel wire having a minimum ultimate tensile strength of 70,000 pounds per square inch. The diameter of the bare wire shall be 0.92 inch. The center to center distance between wires in the fabric shall be 4 inches or more, as approved. Samples of the wire fabric shall be submitted for approval.

(d) Washers, roofplate washers and straps shall be made from open-hearth or electric furnace steels suitable for punching or shearing. Angle washers, roof ties and channels shall be made of open-hearth or electric furnace steels in which the following percentages are not to be exceeded - Carbon 0.40, Phosphorous 0.04, Sulphur 0.05.

D. SHOTCRETE

D.1 Description

Shotcrete is defined as a portland cement concrete mixture containing aggregate up to 3/4" in size, conveyed through a hose and pneumatically projected at high velocity onto a surface.

D.2 Mix Proportions

Proportions of trial mixes shall be developed by laboratory tests and field trials, prior to the actual application of shotcrete forming a permanent part of work. Laboratory mixes shall be made with exactly the same ingredients that are to be used in the work and shall certify that the ingredients comply with the specifications.

D.3 Admixtures

An accelerating admixture, conforming to ASTM C 494 "Chemical admixtures for concrete", shall be used to develop quick set and high early strength as specified. Admixtures shall not contain chlorides or materials corrosive to steel, and shall not encourage other detrimental effects

such as cracking and spalling.

E. CONCRETE

E.1 Composition

The concrete shall be composed of cement, fine aggregate, coarse aggregate and water of the qualities and mixed as herein specified.

E.2 Cement

All cement used in the work shall be true Portland cement, and shall, unless otherwise specified, conform to the requirements for Portland Cement, Type II, of the Standard Specifications of the American Society for Testing and Materials, Serial Designation: C 150-67.

E.3 Fine Aggregate

Fine aggregate for concrete shall be sand having clean, hard, strong, uncoated grains, free from soft or flaky particles, loam, alkali, organic matter, or other deleterious substances. It shall be graded from fine to coarse, and shall not contain any grains which will not pass a No. 4 mesh sieve, and shall not contain more than 6 per cent by weight which will pass a 100-mesh sieve. It shall not contain more than 10 per cent of silt by volume as determined by decantation. Fine aggregate shall be of such quality that mortar composed of one part of Portland cement and 3 parts of the fine aggregate by weight, will have tensile and compressive strength at least equal to those of mortar of the same consistency made from one part of the same kind of cement and 3 parts of Standard Ottawa sand.

E.4 Coarse Aggregate

(a) Coarse aggregate for concrete shall consist of sound, strong, hard, clean gravel or sound, strong, hard, clean, broken limestone, traprock, or other approved stone.

It shall be graded from fine to coarse, and that which is all of one size, or practically so, shall not be used. It shall not contain dust, loam, clay, organic or other deleterious matter. It shall be screened or washed, or both, if required.

(b) Coarse aggregate for concrete for general use in tunnels not lined with cast-iron and in the shafts shall not contain any pieces that will pass through a hole $1/4$ of an inch square and it shall not contain any pieces that will not pass through a hole $1-1/2$ inches square. Coarse aggregate for use as tunnels lined with cast-iron and in thin walls and in form work, where depositing of concrete containing larger aggregate is difficult, shall not contain any pieces that will pass through a hole $1/4$ of an inch square, and it shall not contain any pieces that will not pass through a hole one inch square. In order to place the concrete in and around fibre ducts in the arch of tunnels or elsewhere, a smaller coarse aggregate than that specified above may be required.

E.5 Storage of Aggregate

Concrete aggregates shall be stored on plank platforms or other clean, hard surfaces; the storage of aggregates under conditions which permit of their mixing with earth or other foreign materials will not be permitted.

E.6 Mixing Water

The water used for mixing concrete shall be clean, fresh water; salt water will not be permitted.

E.7 Proportions

The proportions of cement, fine aggregate

and coarse aggregate used in making concrete shall, unless otherwise specified, be by volume as follows:

One part of cement, two parts of fine aggregate and four (4) parts of coarse aggregate.

E.8 Unit of Volume

(a) One bag of cement shall contain 94 pounds net and 94 pounds of cement shall be estimated at 0.875 cubic foot of volume.

(b) For the purpose of measuring and mixing ingredients for concrete, the unit of volume shall be 0.875 cubic foot.

(c) When cement delivered in bags is used, each and every batch of concrete mixed shall contain one unit of volume of cement, or multiples thereof. When cement delivered in bulk is used, it shall be measured by weight for each and every batch of concrete mixed, and the amount of cement for each and every batch shall be computed on the basis of the weight of the unit volume as defined above.

E.9 Aggregate; How Measured

(a) Fine and coarse aggregate shall be measured separately for each and every batch before mixing. Except for batched aggregate, no mixture of coarse and fine aggregate will be permitted to be delivered to the Works.

(b) The proportion of fine aggregate shall be measured by weight on accurate and substantial approved scales.

(c) The proportion of coarse aggregate may be measured either by volume or by weight.

(1) When measured by volume, the proportion of coarse aggregate shall be measured as cast into the measuring container and struck measures shall be used. For this

purpose separate strong, substantial approved measuring containers shall be provided.

(2) When measured by weight, the coarse aggregate for each and every batch shall be weighed on accurate and substantial approved scales.

(d) The capacity of the container for measuring coarse aggregates by volume shall be in the specified proportions to the unit volume of cement as above defined, for each and every batch.

E.10 Amount of Water; How Measured

The volume of water used in concrete shall be exactly gauged for each and every batch, and approved, accurate measuring and controlling devices therefor shall be provided. In no case shall the water for any batch, including the moisture in the fine and coarse aggregates, exceed 6.25 gallons per bag of cement.

E.11 Machine and Ready Mixed Concrete

(a) Whenever practicable, concrete shall be machine mixed. A rotary machine of an approved pattern and mixing only one batch at a time, shall be used. The time of mixing each batch of concrete after all the ingredients are in the mixer shall be determined for each type of machine but the minimum time for any type of machine shall be one minute. The mixing shall be done as close as practicable to the work so as to avoid too great a lapse of time between the mixing and placing of the concrete in the forms, and to avoid segregation. Should segregation occur, remixing will be required.

(b) Ready-mixed concrete may be used where permitted. Concrete may be carried in a truck mixer either in a dry or wet condition. If the concrete is carried in a dry condition

it shall have the ordered quantity of water added at the site of the work and the concrete mixed for at least 40 revolutions for a batch of less than 4 yards, and at least 50 revolutions for a batch between 4 and 5 yards. In addition, the elapsed time between the placing of the dry material in the truck mixer and the depositing of the concrete in the work shall not exceed one hour. If the concrete is deposited in the truck mixer in a wet condition, it shall be kept in agitation from the time it is placed in the truck to its delivery at the site of work and the elapsed time between the placing of the concrete in the truck mixer and the time of its deposit in the work shall not exceed 30 minutes.

(c) All conveyances for transporting and mixing concrete shall be of an approved type.

E.12 Hand Mixed

When concrete is mixed by hand, the coarse aggregate shall be spread on a platform in a bed about 6 inches thick, and shall be thoroughly wet. Fine aggregate shall be spread on a platform and the cement spread on the fine aggregate. After thoroughly mixing the cement and fine aggregate, the dry mixture thus formed shall be spread evenly over the bed of coarse aggregate, wet as above, and the whole turned over until thoroughly mixed, but not less than 4 turnings on the mixing board will be allowed in any case, water being added gradually. Care shall be taken to keep the bed of concrete wet and avoid piling. Concrete shall not be mixed on the surface of the street or on decking.

E.13 Forms

(a) Suitable forms shall be provided to support the concrete while it is being placed. These forms shall be immediately

replaced by new ones as soon as they commence to lose their proper shape. Before being used, they shall be carefully cleaned of cement and dirt in order to insure a perfectly smooth surface on the concrete which is to remain exposed.

The forms shall be made of wood and kept carefully planed; or made of metal sufficiently thick and properly braced.

(b) Forms made of wood covered with metal and of an approved type may be used on exposed surfaces in stations, in certain enclosures between stations, in passageways and wherever a "finished surface" is indicated or ordered. At other locations such forms will also be permitted. They shall be strong and substantially braced. The metal shall be sufficiently thick to resist indentation and deformation, in no case thinner than 18-gauge, and shall be securely fastened to and completely cover the wood forms. The metal surface shall be smooth and regular, neatly finished and free from projecting edges. Wherever practicable, metal sheets of the exact size shall be placed. The lapping of sheets will not be permitted and where joints are necessary, the sheets shall be butted. Used sheets, which after cleaning and rolling regain their original shape, may be re-used. Sheets containing perforations or any unevenness will be rejected for use in the work. The sheets shall be coated with an approved thin nonstaining oil before the concrete is poured on them.

(c) Material, other than metal, shall be of an approved, heavy-body specially prepared material of a type used primarily for the lining of concrete forms to produce a smooth finished concrete. The material shall be nonstaining and shall be fastened to and completely cover the wood forms. The material shall be secured to the forms in such manner as to prevent it from buckling while

the concrete is being place. Material shall be in one piece except that where the form to be covered is larger than the largest size of the material manufactured, then the material shall be joined with a butt joint. Material which has become damaged or torn will not be permitted to be used. Material shall not be reused except where specifically permitted.

(d) The joints in forms shall be watertight. If forms are made of wood, the face of the boards shall be kept carefully planed and shall have tight joints.

If required, the face shall be of tongued and grooved or lapped material.

III - CONSTRUCTION METHODS

A. TUNNELING

Tunneling shall be done by methods best suited to the local conditions and which do not involve any injury to foundations, walls or other parts of adjacent, abutting or overhead buildings, or structures or surfaces, which methods shall be subject to approval before the work is commenced. The methods shall be changed from time to time if local conditions so require. The approval of the methods of tunneling or the failure to call attention to improper or inadequate methods or to require a change in methods will not abrogate the responsibility for the proper execution of the work.

B. ENLARGEMENT OF EXCAVATION MAY BE REQUIRED

If after the excavation for concrete lined tunnels in rock has been made of a certain size, it is found that the nature of the rock is such that the form and dimensions of the structure for which such excavation was intended must be increased, an enlargement of the excavation may be ordered for the purpose of building a lining of greater thickness.

C. STEEL SUPPORTS

Every necessary precaution shall be taken to prevent any settlement or movement of the materials surrounding tunnel excavation and to secure the safety of the work and the workmen in all locations. Permanent and temporary steel supports or other false work shall be used for this purpose wherever necessary. Such permanent steel supports or other false work shall be kept clear of the net outside lines of the Railroad structure. Temporary steel supports shall be removed wherever practicable before placing the concrete lining; where not practicable to remove the temporary steel supports before placing the lining, it shall be left in place until the construction will permit its removal without endangering the work of the workmen and without causing movement of settlement of the material surrounding the excavation. The dimensions and arrangement of steel supports or other supports shall be as the nature of the ground may require and in accordance with prepared drawings; but if there is an opinion, that larger or additional material should be used, such larger or additional material may be used. Sufficient packing shall be used outside the steel supports or other supports to hold the excavation. Steel supports or other supports shall be tightly wedged, securely footed and carefully maintained while in use.

D. TESTS TO DETERMINE NATURE OF ROCK

After the placement of temporary steel, but before the erection of the permanent steel supports, if ordered, tests shall be conducted in order to determine the intensity and pattern of the in situ stress of the rock, the creep rate, the visco elastic properties and mass strength of the rock.

E. TUNNEL TIMBERING

Tunnel timbering in lieu of steel supports may be used in special cases where necessary, in that portion of the excavation which is required to be done in tunnel. The size, arrangement and manner of fastening such supports shall be approved.

F. ROCK BOLT TYPE TUNNEL SUPPORT

(a) Tunnel support of the rock bolt type shall be furnished, installed and tested. Rock bolts shall be installed as close to the heading as work will permit and as soon as possible after blasting. This support shall consist of rock bolts, anchoring devices, plates and nuts, and where directed, wire fabric or straps, and washers. Before ordering the rock bolts and their accessories, drawings showing arrangements and details of the rock bolt type tunnel support, including specifications for the materials shall be submitted for approval. Where wire fabric is used, immediately prior to placing the concrete lining, any part of the wire fabric behind which loose debris is trapped shall be removed. The proposal to begin or end the use of rock bolt type tunnel support shall be submitted in writing. A reserve shall be kept of all materials required for rock bolting ready for use when needed and in an amount sufficient to avoid delays.

(b) Rock bolts shall be anchored in accordance with the manufacturer's recommendations. The depths for anchoring the rock bolts in the rock shall be as approved, but not less than 4 feet.

(c) Rock bolting shall comply with the requirements of the Board of Standards and Appeals of the New York State Department of Labor and shall have the approval of the United States Bureau of Mines.

(d) Holes shall be drilled for the insertion of the rock bolts required for supporting the tunnel excavation. The diameter of the holes shall be that required for properly installing the approved rock bolts.

G. SHOTCRETE

Shotcrete shall be applied to the thickness for the various conditions and at the locations, all as required or as shown on the contract drawings. All shotcrete lining shall be applied by the dry mix process. Shotcrete shall contain approved admixtures suitable to attain quick set and high early strength as specified.

G.1 Placing Equipment

Placing equipment shall consist of a spray nozzle providing for ejection of dry material and water in intimate mixture, separate hoses to deliver dry materials and water to the nozzle, a suitable machine to introduce the dry material to the delivery hose under air pressure, and air and water supply system.

G.2 Compressive Strength

The acceptable compressive strengths shall be not less than 500 psi at 8 hours; 2,500 psi at 72 hours; and 5,000 psi at 28 days. Flexural strength at 28 days shall be at least 15% of the compressive strength.

G.3 Trial Mixes

Trial mixes and preconstruction field test panels shall be prepared, using the same personnel, materials and mixing and placing equipment that is proposed to be used in the work.

G.4 Health Hazard

Some chemicals contained in shotcrete accelerators and hardeners, such as sodium, potassium hydroxide are moderately toxic and can cause skin and respiratory irritation unless adequate safety measures are taken. In applying shotcrete containing toxic accelerators or hardening mixtures, the nozzlemen and helpers shall wear sandblasting hoods supplied with filtered air free of toxic or objectionable material, and other necessary protective clothing.

G.5 Surface Preparation and Application

Surfaces which are to receive an application of shotcrete, shall be cleaned of all loose material, dust, mud, rebound from previously applied shotcrete and other objectionable matter. The surface shall be moist at the time shotcrete is applied. Once started, the shotcreting operation shall be continuous and be completed as expeditiously as possible.

G.6 Shotcrete Reinforcement

Welded wire fabric, for shotcrete reinforcement shall be positioned and held in place by anchor plates furnished with rock bolts or by other approved method.

H. FILLING OUTSIDE OF NET LINES

All space outside the net outside lines of the roof and sidewalls shall be filled with concrete or other approved material.

I. GROUTING

To insure filling all voids behind concrete lining, and for waterproofing rock tunnels, grout consisting of one part sand and one part Portland cement, or of neat cement, shall be pumped in under pressure from time to time, through grout pipes provided for this purpose. Grouting shall be done before the laying of ducts and drains unless otherwise permitted.

J. PANNING AND DRAINS

Rock seams carrying water shall be drained as directed. Approved sheet steel pans or shields shall be furnished and placed and shall be connected to drains or pipes in order to prevent water which flows into the tunnel through the material above or alongside the tunnel from injuring the masonry during the placing and setting of same; the pans and shields shall be properly supported and caulked. Method of supporting and caulking the pans and shields and drain pipes shall be submitted for approval. These drains or pipes, may be required to be connected or drained to the permanent drainage system of the completed structure.

K. LOOSE ROCK TO BE REMOVED AND REPLACED BY CONCRETE AND OTHER APPROVED MATERIAL

All loose or shaky rock whose fall or settlement might endanger the safety of the work or the workmen, or produce an unequal pressure on the masonry lining, shall be removed and the space filled with concrete or other approved material.

L. TUNNEL LINING TO BE CLEANED

Before the concrete lining of the tunnel is placed, the cast iron tunnel lining shall be thoroughly cleaned. A water line shall be kept in the tunnel at all times, and shall be kept available for cleaning the iron or concrete lining.

M. SURFACE TO RECEIVE WATERPROOFING

The surface of concrete to which waterproofing is to be applied shall be made smooth, at the time of placing and shall be carefully protected from injury by barricades or otherwise until thoroughly set. At intersecting surfaces, bevels or fillets of an approved radius shall, if ordered, be used whether indicated on the drawings or not.

N. TIME ALLOWED FOR SETTING

Concrete shall be allowed to set for 12 hours, or more, if so directed, before any work shall be laid upon it; and no walking over or working upon it will be allowed while it is setting. Concrete shall not be flooded with water before it has thoroughly set.

O. CURING CONCRETE

Special care shall be taken to prevent concrete drying too rapidly while setting. Concrete shall be kept wet for a period of at least 3 days after pouring to the extent of flooding it, if required. In dry weather, exposed flat surfaces shall be kept covered for at least 3 days with wet canvas, wet burlap, wet earth or other acceptable material.

P. PREPARING ROCK AND EARTH SURFACES

Rock surfaces against which concrete is to be placed shall be thoroughly cleaned immediately before forms for the concrete are placed, and recleaned, if necessary, before placing concrete. Before laying concrete on earth surfaces the earth shall be wet down and rammed as directed.

Q. BONDING

(a) Wherever a section of concrete is necessarily left unfinished, leaving a surface which will be set before additional concrete can be laid, such dovetails or grooves shall be formed, as may be required, to secure a watertight bond. If deemed necessary, the joints shall be reinforced with steel bars or dowels. Wherever possible, concrete shall be cast complete in one continuous operation. Where this is impracticable, joints shall be made at such points as directed.

(b) In all cases of joining old with new work, the old surfaces shall be thoroughly cleaned and wet, and if required, a coating of mortar or cement shall be applied before placing the concrete and if deemed necessary, at the junction of new masonry with the existing structure dovetails or grooves shall be formed and where necessary steel bars or dowels shall be used to insure a bond.

R. CONCRETE RAMMED TO ROCK

In rock excavation when the rock is shattered beyond the ordered net lines of excavation, the concrete on the sides of the structure shall be rammed to the rock unless otherwise permitted or directed.

S. PLACING OF CONCRETE

(a) Concrete shall be placed continuously in the forms and promptly after mixing in layers of such thickness as may be directed, and shall be thoroughly worked in place, for which special tools may be required.

(b) In excavations not lined with cast-iron, every practicable means, including ramming if required, shall be employed to force the concrete into contact with all the irregularities of the rock or other limits of excavation at the time the concrete lining is being placed, and in excavations made by tunneling where cast-iron lining is not used, and in all other excavations where waterproofing fabric or brick and mastic is not to be used, all seams in the rock through which water might enter (except where the

plans provide for weep holes to be left in the concrete), and all shrinkage spaces and other spaces which it may be impracticable to fill with concrete shall be grouted by means of pipes or channels in the concrete.

(c) Unless otherwise permitted, all concrete during and immediately after depositing, shall be compacted thoroughly by means of internal vibrators, supplemented by spades, slicing rods, forks or treading.

The concrete shall be worked thoroughly around the reinforcement and around embedded fixtures and in the corners of the forms. The vibration shall be sufficiently intense to cause the concrete to flow or settle rapidly into place. Either electric or mechanical internal approved vibrators may be used. The vibration shall be of sufficient duration to accomplish thorough compaction, but shall not be prolonged to a point where segregation occurs.

(d) Care must be taken that no water shall interfere with the proper laying of concrete. Water shall be prevented, where practicable, from entering any excavation at a point where concrete is being placed or while it is setting; or whenever this is not practicable, the water shall be conducted away from the concrete by means of sheet metal shields or pans connected with drains or weepers, all of which shall be grouted after the concrete is set. However, if ordered, such shields, pans and pipe drains shall not be grouted but rather they shall be connected or drained to the permanent drainage system in an approved manner. No concrete shall be deposited under water without permission and then only in strict accordance with directions. In special cases, concrete may be placed by the pneumatic method.

(e) Forms shall be set true to line, firmly secured, and shall be so tight as to prevent water in the mortar from escaping from all joints and bulkheads; they shall be thoroughly wet before concrete is placed and may be removed as soon after the concrete has been placed as may be done with safety to the work. Forms should be so placed and supported as to avoid unnecessary obstructions to the passage of men and materials through the work. Immediately on the removal of the forms, the faces that will remain exposed shall

be carefully examined and any irregularities of the surface corrected; projections shall be removed and voids shall be filled with mortar. If, however, the voids are such as to indicate an excessive loss of mortar, portions of the concrete shall be cut out and the spaces refilled with a rich concrete or mortar.

T. SMOOTH SURFACE

The surface of the concrete that will remain exposed shall be of the smooth and even character produced by the proper use of the best forms. Every precaution shall be taken to construct the forms, to manipulate the concrete while placing it and to remove the forms in such a manner as will insure such smooth and even character of surface.

U. FINISHED SURFACE OF CONCRETE

(a) By "finished surface" is meant a smooth and even surface free from warps, irregularities, voids, lips, shoulders, projections or form marks, at least equal in smoothness to a surface produced by troweling or floating.

(b) Where wood forms covered with metal are used to produce a "finished surface", directly upon removal of the forms, all projecting seams, shoulders and lips left on the surface of the concrete shall be refilled and rubbed down flush with the adjacent surface, leaving a smooth and even finished surface ready for painting. Plastering, troweling or floating will not be permitted. In order to secure a satisfactory "finished surface", the surface of the concrete shall, where required, be rubbed down in an approved manner to the extent necessary.

V. REINFORCING STEEL AND WIRE MESH TO BE FASTENED

Where reinforcing steel or wire mesh is used, satisfactory means shall be provided to maintain it in the exact position it is to occupy in the completed work and to prevent it from becoming dislodged or moved in any manner. For this purpose, annealed iron wire of not less than 18 gauge or approved clips shall be used at all intersections, and the

reinforcement shall be securely supported by metal chairs or hangers.

W. PLACING OF REINFORCING STEEL

(a) Reinforcement bars shall be placed in the exact position shown on the plans and held securely during the placing of the concrete. In general, all reinforcement shall be placed and securely wired and blocked before placing concrete.

(b) No concrete shall be deposited until the placing of the reinforcing steel has been inspected and permission given to place concrete. All concrete placed in violation of this provision shall be rejected and removed.

X. CONCRETE TO BE WATERTIGHT

It is intended that the concrete shall be as nearly watertight as possible and it will be required to exercise every care in mixing, placing, spading and all other operations connected with this work, so as to provide a permanently watertight structure.

To secure a watertight structure, it will be required to grout as required in Chapter 10, IV, E. and F. (Grouting).

Y. CONCRETE IN COMPRESSED AIR

No concrete shall be placed in compressed air when it is practicable to avoid so doing.

Z. TROWELED SURFACES

The surfaces of drip pans under ventilating openings, the tops of duct benches, the floors of duct manholes and other surfaces which require special provision for drainage shall be troweled.

AA. EXCESS EXCAVATION REPLACED BY CONCRETE

Any excess excavation in the floor of the Railroad below the net line of excavation, underneath supporting wall and columns, shall be replaced by concrete.

BB. CAGES AND STAIRWAYS

Cages shall be used in the shafts for hoisting men and materials during the construction of the tunnels. Full precautions shall be taken to insure perfect safety in the use of these cages. These precautions shall include safety catches of best design with bronze or bronze-bushed bearings, landing dogs at all landings, safety dogs on all tracks leading to the cages, and effective devices for the prevention of over-winding. All parts of the hoisting apparatus, cables, brakes, guides and fastenings shall be of the most substantial design, and shall be arranged for convenient inspection. The efficiency of all safety devices shall be established by satisfactory tests before the cages are put into service and at least once every month thereafter and the result of the test certified in writing by the Safety Engineer. Cages shall be provided with strong protective roofs and shall be entirely enclosed on two sides. These sides shall be solid for at least 4 feet above the floor and above that height either solid or wire mesh of not less than Number 8 U.S. Standard gauge, no opening in which shall exceed two inches. The cage openings shall be protected by sliding or lifting gates worked automatically. At the bottom of the shaft there shall be provided a protected walk for the passage of men around the cage way. Effective and reliable signalling devices of an approved design shall be maintained at all times to give instant communication from the foot of the shaft and from the top of the shaft directly to the hoist room. An enclosed stairway shall be constructed in each shaft leading from the top of the shaft to the floor of the tunnel and shall be maintained in good, serviceable condition.

Chapter 8

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MIXED FACE TUNNELING

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Chapter 8

MIXED FACE TUNNELING

I - GENERAL REQUIREMENTS

A. DESCRIPTION

Tunneling in mixed face is defined as tunnel excavation which is partly in earth and partly in rock.

B. APPLICABLE CRITERIA

All relevant criteria as outlined in Chapter 7, I, Hard Rock Tunneling and Chapter 9, I, Soft Ground Tunneling are valid in Mixed Face Tunneling and provisions of these Chapters are applicable.

II - CONSTRUCTION METHODS

A. TUNNEL SHIELDS

Tunnel shields shall be of a design suitable for the work, subject to requirements of Chapter 9, I, Soft Ground Tunneling.

B. GROUNDWATER CONTROL

The saturated ground immediately above the rock shall be at all times controlled to prevent movement of this saturated layer with subsequent loss of ground into the heading.

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Chapter 9

SOFT GROUND TUNNELING

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Chapter 9

SOFT GROUND TUNNELING

I - GENERAL REQUIREMENTS

A. DESCRIPTION

Soft ground tunneling, or tunnel excavation in earth is defined as excavation of materials of whatever nature encountered except rock or mixed face.

B. SCOPE

The work to be performed shall include excavation work for Railroad tunnels and other tunneled facilities in earth to the lines, grades, dimensions and sections shown on contract drawings and shall accommodate the options selected.

The work also includes the disposal of all excavated materials, and the furnishing, operating, maintaining and removal of completely equipped tunnel shields or tunneling machines and/or other equipment necessary to perform the work specified herein. There shall be a choice of method or methods to be used for satisfactorily accomplishing this work. The requirements for excavation specified in Chapter 4 (incl. Blasting, removal of ground water etc.) shall, where applicable, be observed for tunnel excavation. Also requirements for hard rock tunneling specified in Chapter 7 shall, where applicable, be observed for soft ground tunneling.

C. PRIMARY LINING

A primary lining is the lining placed immediately after excavation to maintain and stabilize the opening. Primary linings may be permanent or temporary. Temporary lining must be followed by the application of a secondary lining. Temporary primary lining used for tunnels shall be maintained in position within the specified tolerances until the permanent lining is placed. A permanent secondary lining may be installed without the installation of the primary lining

if the practicality of such a method can be satisfactorily demonstrated. The means of maintaining the position of the primary lining, both temporary and permanent, shall include the use of tie rods, struts or both.

D. SECONDARY LINING

A secondary lining is the permanent lining placed after the temporary lining has been completed.

E. WORKING DRAWINGS

Before beginning work operations, detailed working drawings and pertinent descriptions, data or calculations of proposed facilities, equipment to be utilized, and methods of construction shall be submitted for review. These drawings together with other drawings required elsewhere in this chapter shall cover, but not be limited to, the following: Hoisting plant, tunnel ventilation, lighting and drainage; ground water control methods; details of tunnel shields, tunneling, machines, hydraulic equipment and related equipment; temporary shafts, cuts and tunnels; breakouts; bulkheads; and detailed methods of construction for tunnels and tunnel linings. The details of the hydraulic system shall demonstrate that the jacking shoes will not overload or damage the tunnel primary linings that the tunnel shield or tunneling machine can safely resist the pressure of the working face; and that the tunnel shield or tunneling machine will not move backwards.

II - MATERIALS

A. STRUCTURAL STEEL

Structural steel for steel rib supports, beams, columns and spreader angles shall conform to the minimum requirements of ASTM Designation A 36, Standard Specifications for Structural Steel.

B. CAST IRON TUNNEL LINING

Cast iron tunnel lining shall conform to all provisions of the Section of the Specifications entitled

"Steel and Iron".

C. TIMBER FOR LAGGING

Timber for lagging shall be stress-grade timber in accordance with the National Design Specifications for stress grade lumber and its fastenings recommended by the National Lumber Manufacturers Association and shall be capable of withstanding the applied loading.

D. TIMBER FOR BLOCKING

Timber for blocking shall be an approved soft or hardwood and shall be in accordance with the National Design Specifications of the National Lumber Manufacturer's Association.

E. BOLTS AND NUTS

Bolts and nuts for splicing and connections shall conform to ASTM Designation A 307, Standard Specifications for Low Carbon Steel Externally and Internally Threaded Standard Fastener, grade A, C1018 Bolts, C1010 Nut and thread 60-degree stub.

F. TIE RODS

Tie rods shall be hot rolled Merchant Bar Quality M10120 and the threading shall conform to ASTM Designation A 307, QA series, 7 threads per inch.

III - EQUIPMENT

A. TUNNELING MACHINES

Appropriate tunneling machines for performing tunnel excavation shall be used. If a tunneling machine is proposed, the design, specification, methods of operation, and other pertinent data shall be submitted for review prior to the use of such machine in the work. Tunneling machines shall be of such type as will prevent the loss of ground ahead of and around the machine and provide for the erection of the specified tunnel linings within the machine. Tunneling machines shall conform to the requirements of Tunnel Shields.

B. SHIELD

(a) Excavation in soft ground shall be made by means of a shield of an approved type, substantially proportioned in all their parts, and their design shall make adequate provision for the safety of the workmen and for the application of safe methods for protecting the face of the heading. The rear overhang or tail shall be long enough to extend 12 inches back of the joint between the last two rings erected when the shield is in position to erect another ring. The shield shall be built to a true circle and riveted as far as practicable. The annular space between the tail and the cast-iron lining shall be as small as current practice indicates as advisable. The shield shall be equipped with hydraulic jacks or rams and these jacks or rams shall be of sufficient number and so placed as to distribute their reactions safely against the tunnel lining and shall be of sufficient power to move the shield along the line and grade shown on the drawings. The hydraulic system for the shield shall be provided with a fail safe system in the event any single failure in either the shove or breast circuit should occur all other components within each circuit shall automatically maintain their integrity, thereby keeping the shield in a fixed position until the failure is located and repaired or bypassed. The fluid medium used in the hydraulic system of the shield shall be composed of a minimum of 97 percent water and if required a maximum of 3 percent water soluble oil. Petroleum based hydraulic fluids, phosphate esters, water glycols or other synthetic hydraulic mediums will not be permitted in the tunnel. The shield shall be equipped with at least one suitable erector arm for erecting the cast-iron lining. The hydraulic pumps for operating jacks shall be located in the power house on the surface. The drawings for the shield shall be submitted prior to their construction.

C. SAFETY OF EQUIPMENT AND OPERATIONS

All equipment utilized shall be of safe design and of sufficient capacity for the intended work. All equipment shall be at all times maintained in sound working order and safe condition. Equipment shall not be operated in excess of its design capacity or

in violation of the applicable safety regulation. If at any time, the use of a method of construction is likely to result in hazard to life or property, such method shall be modified immediately. If necessary corrections are not made, the work may be stopped until the required corrections are made. In any case, operations must be conducted in a safe manner.

IV - CONSTRUCTION METHODS

A. EXCAVATION METHODS

Tunnel excavation shall be performed in a manner that will minimize movement of the ground in front of and surrounding the tunnel, and subsidence of the surface, structures, and utilities above and in the vicinity of the tunnel. During all stages of tunnel excavation, the ground shall be continuously supported and controlled in a manner that will prevent loss of ground, and will keep the perimeters and faces of the tunnel passages and bottoms of the shafts stable. Roof protection will be a requirement during excavation and setting of temporary supports. Tunnels shall be excavated using shields or tunneling machines or other approved methods. Whenever there is an emergency, or the stoppage of work is likely to endanger the excavation or the adjacent structures, the work shall be carried out with full forces for 24 hours a day, including weekdays and holidays, without intermission, until the emergency or hazardous conditions no longer influence the stability and safety of the work. During these periods, an increased force may be ordered for such time as may deem necessary.

B. SHIELD OPERATION

(a) Where the shield is erected in a shaft, tunnel or trench, satisfactory means shall be provided for their support and to take the pressure of the shield jacks and distribute it against the sides of the shaft, tunnel, or trench in such a manner as to cause no injury to the permanent work. In compressed air tunnels as soon as practicable after the shield has been erected, bulkheads and locks shall be installed in the tunnels.

(b) The greatest care shall be used, in advancing the shield and to keep it under control at all times without binding or imposing excessive loads on the tunnel lining. In compressed air tunnels, operations at the shield shall be conducted so as to avoid excessive escape of air or inflow of materials, particularly at the face of the heading and through the space between the tail of the shield and the tunnel lining, all suitable means to this end shall be employed, such as polings, breast-boards, clay or other suitable materials. Gravel packing, grout or other approved material shall be ejected through the last ring outside the shield while the shield is being advanced. The grouting outside of the tunnel lining, where required, shall be kept close to the shield, as hereinafter provided.

(c) The shield shall be driven and the tunnel built as nearly as possible to the alignment and grade shown on the drawings. Such methods of excavation shall be employed, such use of jacks and such other means as may be necessary to secure this result. Any work which is not so built, shall be removed and replaced or otherwise corrected as may be directed.

(d) All necessary steps for the guidance of the shield shall be taken to overcome any tendency toward a variation from the required line and grade.

(e) Following the erection of the tunnel lining behind the shield, this tunnel lining shall be maintained in its proper position, using the necessary loading bracing or such other means as may be necessary, as well as doing the necessary caulking shall be done to prevent leakage.

C. SURVEILLANCE OF HEADINGS

Whenever tunnel excavation is suspended or shut down, (such as over the weekend), watchmen shall be maintained on duty to observe conditions which might threaten the stability of the heading. Acceptable monitoring devices may be substituted, such as closed circuit television, which will enable continuous monitoring of the conditions at the face by observers from outside the tunnel.

During shut down periods, the face of the excavation shall be supported by positive means; and no support shall relay solely on hydraulic pressure. When required, and in all cases when the face is untouched for more than 48 hours, the face shall be closely boarded and grouted and the shield or machine shall be shoved tightly against the ground face.

D. EXCAVATION BY BLASTING

Whenever material requiring blasting is encountered, blasting and related operations shall be performed in accordance with the requirements of Chapter 4 Excavation.

E. MINIMUM DISTANCE BETWEEN HEADINGS

No tunnel heading shall be advanced to a previously excavated tunnel until primary or permanent secondary lining in the first tunnel has been fully installed the voids behind the lining completely filled, and all tendency of the primary or secondary lining to distort has ceased. The longitudinal distance between two adjacent tunnel faces being excavated at the same time shall not be less than an approved distance.

F. TUNNEL BREAKOUTS

Tunnel Breakouts shall be excavated and braced in accordance with the working drawings.

Prior to the beginning of work, detailed working drawings shall be submitted for review indicating proposed method for excavation and bracing at the tunnel breakouts connecting shafts to the tunnel tubes. The method proposed shall provide the immediate and adequate support of the ground, adjacent structures and other facilities. Working drawings shall include proposed temporary bracing system including bracing in the tunnel tubes as well as in the breakouts connecting the tunnel tubes with shafts.

During all stages of excavation, the ground shall be continuously held firm in a manner that will prevent loss of ground and will keep the bottom of the shafts and the perimeters and face of the passages stable. No breakouts from shafts and tunnels shall be started

until suitable supports have been installed around all structures likely to be affected by the excavation and such supports shall remain in place until 7 days after concrete placement.

G. OTHER OPENINGS

Other openings shall be excavated and supported in accordance with the requirements of Chapter 4, Excavation. When no longer required for the work, such openings shall be completely sealed as shown on the contract drawings or as directed.

Before backfilling, positive steps shall be taken to preserve the required tunnel shape and form of the section within the specified tolerances. Backfilling shall not be started until the concrete has reached its design strength.

H. DISPOSAL OF EXCAVATED MATERIAL

Excavated material shall be removed expeditiously and, except as otherwise provided in paragraph I, the portion of such material not required for backfilling or filling shall be disposed of in any place selected, subject to the ordinances and regulations of the Authorities and other laws governing the disposal of such material and the regulations of the U.S. Government as to the disposal or dumping of material. No excavated material shall be stored at the site of the work.

I. MATERIAL MAY BE TAKEN BY CITY

If at any time during the course of construction, the City shall desire for City purposes any part of the excavated material, not otherwise provided for herein, the Authority may order such material dumped or turned over to the City at a point designated, without cost to the City.

J. TEMPORARY BULKHEADS

Temporary bulkheads, if required, shall be constructed at the locations shown on the contract drawings. Bulkheads shall be capable of resisting the lateral earth and hydrostatic pressures involved and shall

be watertight, and capable of being removed without damaging the permanent lining. The temporary bulkheads shall remain in place as long as required.

K. DETECTION OF MOVEMENT

A system of points or indicators shall be established and maintained as shown on the drawings, for the detection of vertical and horizontal movement of the ground, tunnel, structures and utilities adjacent to his work.

L. SUBSURFACE INDICATORS

Subsurface settlement indicators shall be installed at the locations shown on the drawings. This shall represent the minimum number to be installed. It may be required to install additional indicators at other critical areas, where directed. Indicators will be located directly over each tunnel and shall be extended to 5' above the crown.

The indicators shall consist of a 2-1/2 in. I.D. Steel casing and an inner 1 in. diameter deformed steel reinforcing rod. The casing shall be advanced and cleaned out to the elevations spacers, located as directed, shall be lowered to the bottom of the casing and then driven 4 to 6 feet below the bottom of the casing. The 2-1/2 in. casing shall be cut off 5 in. below ground level and the inner rod shall be cut to project 1 in. above the casing. An approved access box shall be placed over the casing and rod, flush with the ground surface.

M. TEMPORARY ELECTRICAL FACILITIES

Temporary electrical facilities shall be furnished, installed and maintained, including light fixtures, power circuits and related equipment during the life of the job, in accordance with the requirements of the Section on Electrical Work. Where required, electrical facilities shall be left in place in operating condition at the completion of the Contract.

N. PRIMARY CAST IRON TUNNEL LINING

N.1 Erection of Tunnel Lining

In erecting the lining special precautions shall be taken to preserve the circular form of the tunnel and to preserve the plane of the face of the ring. The machined surfaces of the segments shall be cleaned before being taken into the tunnel and when in contact shall be perfectly free from sand, cement or other material preventing a uniform bearing. Grommets shall be placed under the washers at the head and nut of each bolt at the time the segment is being bolted. Each segment shall be bolted immediately upon being placed, with a sufficient number of bolts to hold it closely and firmly in contact with adjacent segments before the succeeding segment is placed. The segments in the invert shall be fully bolted and all bolts made tight before the remainder of the ring is erected. Each ring shall be fully bolted, all bolts made tight and all the bolts of the two preceding rings, including those under the floor retightened before the shield is shoved for the next ring. Tunnel ring bolts shall be tightened in accordance with ASTM A 325. Permanent tie rod assemblies, as indicated on the drawings, shall be installed in the tunnel rings and shall be tightly drawn up, all while the tunnel rings are within the shield. If required or ordered, temporary tie-rods, provided with turnbuckles, of sufficient strength to prevent distortion of the tunnel lining, shall be attached to the flanges by means of clevises and shall be kept tightly drawn up to prevent distortion of the ring. These temporary tie-rods shall be placed on any diameter and shall not be removed until all tendency to distortion disappears, and should such tendency reappear at any time, they shall be replaced immediately. The segments in the successive rings shall break joints as fully as possible.

Before any ring is erected, the last ring erected will be carefully examined and any broken or cracked segments shall be replaced by sound ones. Any segments subsequently found broken or defective shall be removed and replaced, or, in lieu of such replacement it may be required that the segment be repaired in place or otherwise strengthened and reinforced to satisfaction.

N.2 High strength structural bolts and nuts

(a) High strength steel bolts and nuts shall be used for the joints of the cast-iron tunnel lining.

(b) High strength bolts and nuts shall conform to the requirements of ASTM A325-64.

N.3 Washers for tunnel lining bolts

(a) Each bolt shall have a washer under the head and nut. Where clearance is necessary, washers may be clipped on one side to a point not closer than $7/8$ of the bolt diameter from the center of the washer.

(b) Circular washers shall be flat and smooth and their dimensions shall be as indicated on the drawing. Washers shall conform to the material, chemical and mechanical requirements of ASTM A325-64 as hereinbefore specified in this Chapter.

N.4 Permanent steel tie-rod assembly

(a) Permanent steel tie-rod assemblies, located in the cast-iron tunnel ring section diametrically across the tunnel shall consist of two lengths of alloy steel eye-rod, one alloy steel turn-buckle, 4 structural steel finger plates, high-strength structural bolts, steel nuts and washers, and grommets, all as indicated on Drawings.

(b) All permanent tie-rod assemblies shall be installed as indicated on the drawings and tightened as directed, all while the tunnel rings are within the shield. Additional tightening of the tie-rods, after the rings have left the shield will be done as directed. The springing line and crown deflection must be checked at intervals as directed.

N.5 Concrete cradle to support shield or cast-iron lining

Where the bottom of the cast-iron lined tunnel is in rock, a concrete cradle as required shall be built to the required line and grade and shall be placed for the purpose of supporting the shield or

cast-iron lining. Steel rail or plates upon which to slide the shield shall be embedded in the concrete. Where the rock is not of sufficient width to permit an adequate width of cradle, other satisfactory construction shall be used.

O. PROVISIONS RELATING TO WORK IN COMPRESSED AIR

All work shall be in conformity with the provisions in the latest Rules and Regulations Relating to Work in Compressed Air of the Industrial Code of the Labor Department of the State of New York.

O.1 Work in compressed air

The work of excavating those portions of the Railroad to be built by tunneling methods shall, where the tunnels are in earth, and where required in part earth and part rock, and where required in rock, be conducted in compressed air, and those parts of the tunnel shall be made as nearly watertight as is practicable before the air pressure is removed.

O.2 Plant to be adequate

An adequate air-compressing plant shall be furnished. The plant shall include air-compressing, hydraulic and electrical machinery, hoists, pumps and all other necessary apparatus, all parts of which shall be suitable for the work to be performed. The capacity of the plant shall be sufficient to meet not only usual conditions but emergencies, and to afford at all times a sufficient margin for repairs.

O.3 Plant to be approved

Before any portion of the air-compressing plant is purchased, delivered or installed, a complete and satisfactory description of such plant and any drawings shall be submitted including compressor manufacturer's performance data and other information that may be necessary to enable to judge of its efficiency, fitness and suitability, and if the plant which is proposed to be furnished is not deemed to be suitable and satisfactory, another plant which shall be furnished fully complying with the requirements.

0.4 Capacity of air-compressing plant

(a) The air compressing plant shall be housed in a suitably fireproofed building. The building shall be of steel frame construction with walls and roof of corrugated iron, hollow tile or other approved fireproof material. The air-compressing plant shall include air compressors for supplying both low pressure and high pressure air, hydraulic pumps for operating the shield jacks and erectors, together with the necessary motors, switchboards, engines, piping, etc., and other equipment necessary for safe and efficient operation. The low pressure air compressors shall be capable of furnishing an air supply sufficient in volume and pressure to enable work to be done as nearly as practicable in the dry and to afford the degree of ventilation herein specified. The Plant shall be capable of furnishing at the heading sufficient quantity of free air at a sufficient pressure above atmospheric pressure all as specified.

The high pressure air compressors shall be capable of furnishing at all points of the work, including compressed air chambers, a sufficient air supply at a pressure of 100 pounds per square inch above atmospheric pressure for operating grouting machines and other appliances requiring high pressure air. The manufacturer's maximum permissible piston speeds of other suitable compressors must not be exceeded in operation of the compressors.

(b) The plant shall be so arranged that the air for compressors shall be drawn from pure outside sources, the inlets being at least 20 feet above the surface of the ground and care must be taken to keep the air from being fouled by smoke, lubricating oil or other impurities. The necessary air receivers and cooling apparatus shall be provided so that an even supply of air at a moderate temperature can be provided in the tunnels when the plant is operating to full capacity and at all other times.

(c) There shall be a sufficient number of separate units of machinery and equipment within the air-compressing plant to allow for the cutting out of

certain machines or equipment for repairs without interfering with the requirements of the work.

0.5 Power for air-compressing plant

There shall be at least two independent sources of power capable of supplying power to compressors supplying low pressure air to the tunnel and decompression chamber, water pumps and the lighting system. Each source of power shall be sufficient to supply power for the entire plant and all temporary buildings and offices. By independent sources of power is meant that the power is derived from electric supply lines from Con Edison and from an approved diesel-operated plant. The diesel-operated plant shall be maintained in working condition at all times for immediate emergency use. The diesel-operated plant shall be provided with an automatic control and switching system so that in the event of an emergency, the diesel-operated plant will be automatically started to provide power to all the construction site circuits including all temporary buildings and office circuits. It shall be tested at least once during every 24-hour period and a log of such tests shall be made. Before any contract for supplying electricity for operating the air-compressing plant is made, the sources of supply, the supply cables and their routing and the switching and other operating arrangements by which either power source can be thrown in, must receive approval.

(b) Before any contact is made for supplying electricity for lighting or for operating any plant or equipment other than air-compressing plant, the source of supply, the supply lines, etc., shall receive approval.

(c) Every reasonable effort shall be made to minimize noise and annoyance to the public in connection with the operation of the plant. Air intake lines for compressors shall, if required, be equipped with silencers.

0.6 Records of air-compressing plant operation

Continuous records shall be kept of the operation of each compressor, including the output and the

pressure supplied by the hydraulic machinery for the movements of the shield, and shall furnish the Engineer each day a copy thereof. The pressures in the tunnel heading and in other parts of the work where compressed air is used, shall be registered continuously. Tests of air compressors or other operations of the plant shall be made and additional records of plant operation kept to determine the net output of the plant and the actual distribution to the heading.

0.7 Precautions against fire in the tunnel

(a) The utmost precautions shall be observed at all times in regard to fire in compressed air. Smoking in compressed air shall not be permitted.

(b) The tunnel shall be provided with a water line extending into the working chamber and to within 100 feet of the working face. Such line shall have hose outlets with 100 feet of fire hose properly attached and maintained as follows: one at the working face; one immediately inside of the bulkhead of the working chamber; and one immediately outside such bulkhead. In addition, hose outlets shall be provided at 200-foot intervals throughout the length of the tunnel, and 100 feet of fire hose shall be attached to the outlet nearest to any location where flammable material is being kept or stored or where any flame is being used.

(c) At least two approved fire extinguishers shall be provided in the working chamber as follows: one at the working face and one immediately inside the bulkhead (pressure side). Extinguishers in the working chamber shall use water as the primary extinguishing agent and shall not use any extinguishing agent which could be harmful to the persons in the working chamber. The fire extinguisher shall be protected from damage.

0.8 Workmen's quarters

Suitable and approved quarters shall be provided, suitably fireproofed, for superintendents, foremen and workmen. These quarters shall be well lighted and heated and plentifully provided with running hot

and cold water, showers, tubs, toilets, clothes lockers, and facilities for resting, drying clothing and providing the men with hot coffee.

O.9 Hospital room and lock

These quarters shall also contain a completely equipped hospital room which shall include in its equipment an approved hospital lock with two compartments where men could be subjected to the working or higher pressure if attacked by caisson disease. Such lock shall contain cots, telephones, lights, clocks, air gauges, and arrangements for ventilating and heating, and shall be kept in a thoroughly sanitary condition. There shall be a standing arrangement for the immediate removal and hospital treatment of any employee who may be injured or who may become ill.

O.10 Medical and surgical attendance

Whenever men are employed in compressed air, the services of one or more physicians shall be retained who are licensed to practice medicine in the State of New York and acceptable to the Authority, who shall have had satisfactory experience in the treatment of the physiological effects of compressed air and who shall care for the health of the employees and supply them with whatever treatment and medicines as may be needed because of injuries and sickness received or contracted in the performance of their duties on the work. Whenever men are employed in compressed air, one of the said physicians shall be in attendance at all times while work is in progress.

O.11 First aid treatment for Authority's employees

This physician and medical staff shall give first aid treatment to the employees of the Authority whenever required.

O.12 Daily statements

Daily statements shall be furnished of the number of decompressions and the number of cases of the "bends" among employees. In every case of compressed air illness of any employee, statement of such illness shall be immediately furnished in the form

prescribed in the latest Rules Relating to Work in Compressed Air of the Industrial Code of the Labor Department of the State of New York. In addition, a statement shall be furnished giving the time of return to work of the employee affected, and if said employee does not return to work in compressed air, a statement shall be furnished of the man's physical condition at the time of the last medical examination made after the onset of the illness.

O.13 Accidents

In case of accidents either within or outside of the compressed air chambers, full written data shall be immediately furnished relative to such accidents.

O.14 Medical examination

(a) No person shall be employed in compressed air until such person has been examined by a physician and found to be fit to engage in such work. If an employee is absent from the work for 10 or more successive days, he shall be re-examined before being permitted to resume work in compressed air. In any event, each compressed air employee shall be re-examined every three months as to his fitness to continue work under compressed air.

(b) A medical record shall be kept of every man employed under compressed air, which record shall contain dates on which examinations were made and a clear and full description of the person examined; his age and physical condition at the time of the examination; also a statement as to the time such person has been engaged in like employment. These records shall be kept on suitable examination record forms and shall be available when required.

O.15 Sanitary precautions

Care shall be taken to keep all parts of the tunnels in a thoroughly sanitary condition and free from refuse or decaying matter.

O.16 Bulkheads and locks

(a) Working chambers shall be formed in the tunnel

by bulkheads of concrete or of steel plate diaphragm construction according to an approved design. The bulkheads and air locks shall be of sufficient strength to sustain with safety resigned pressure.

(b) The bulkhead separating the working chamber from areas of lower pressure shall be of sufficient strength to withstand safely the maximum pressure to which it may be subjected. Where there is a possibility of rapid flooding of the working chamber, the bulkhead shall be located sufficiently close to the face or shield to permit escape of the workers in case of emergency but in no case where there is such possibility shall such distance be more than 1,000 feet.

(c) Air locks shall be of approved design and shall be firmly set and anchored in the bulkhead and shall include two or more main locks and an emergency lock. The main locks shall be not less than 6 feet in diameter. The emergency lock shall be located as high up in the bulkhead as practicable, shall be not less than 5 feet in height and shall be large enough to hold the entire heading force. The emergency lock shall be kept open toward the heading and shall be ready for instant use at all times. The lock or locks regularly used for taking men in and out of compressed air shall be heated and ventilated and provided with seats.

0.17 Lock equipment

Lock doors shall operate easily and shall be provided with gaskets fitting truly and tightly against the jambs. A heavy glass bull's-eye shall be set in each end of each tunnel lock. A sufficient number of air valves of approved size and design shall be provided for the safe and proper operation of each lock in use. In the man lock, air valves shall be so arranged that the pressure may be controlled from both the inside and outside of the lock. The muck lock in the tunnel bulkhead shall be so connected to the main air line that it may be locked in from the outside.

O.18 Air gauges

(a) The man lock in use in each tunnel bulkhead shall be provided with an air gauge and a clock for the use of the locktender; in addition, there shall be provided recording air gauges, connected, respectively, with each of the above mentioned man locks that are in use with a dial of such size that the amount of change in the air pressure in the lock within any 5 minutes will be readily shown. These gauges shall be enclosed in waterproofed boxes which shall be kept locked. An 8-1/2-inch air gauge shall be placed in an acceptable position on the outer side of each bulkhead in use.

(b) To the tunnel heading under compressed air, until the air pressure is finally removed, there shall be connected an approved recording air gauge. These gauges shall be located in the field office, where directed. There shall be one such gauge for each working chamber or heading. These gauges and their piping shall be disposed of upon completion of the work.

(c) Gauges shall be regularly tested and kept in accurate working order at all times.

O.19 Locktender

There shall be a competent locktender on duty outside the man lock and in full control thereof at all times when any individual is in the working chamber or in the man lock. No person employed as a locktender shall be suffered or permitted to undergo dangerous periods or repetitions of pressure or decompression. A watchman familiar with compressed air work shall also be on duty, in addition to the locktender, in the compressed air heading whenever work is suspended.

O.20 Air supply

(a) The supply of fresh air to the tunnel shall be sufficient to permit work without danger of discomfort; and where work is in compressed air (working chamber; special decompression chamber or man locks) such supply shall be sufficient at all times and

places to prevent the accumulation of carbon dioxide to a greater amount than one part in 1,000 in volume. A foul air vent pipe, at least 6 inches in diameter, shall be carried back from the heading under pressure to normal atmosphere and shall be provided with suitable regulating valves so placed as not readily to be tampered with. The compressors shall be run so as to maintain at all times a change of air through the regulation valves.

(b) The air supplied to the heading shall be delivered through pipes of such capacity that the drop in pressure under regular working conditions shall not be excessive. Two pipes, at least 10 inches in diameter, shall be used for delivering the air supply from the power house to the tunnel heading.

(c) The air supply lines shall be kept close to the shields and so provided with valves that at all times the fresh air will be discharged both at the heading and just inside the bulkhead nearest the heading.

(d) Each supply pipe shall be provided with a pressure regulating valve and shall be provided with suitable valves arranged for by-passing at a convenient point between the power house and the heading and shall also be provided with suitable plapper valves at the points of discharge. All pipes shall be standard lap welded.

0.21 Safety screen

In each tunnel heading where compressed air is used, when the heading extends beyond the shore line, safety screens as specified shall be installed when necessary. These screens shall be made of steel plate at least 5/16 inch thick, shall have airtight joints, shall be substantially braced, shall extend at least 12 feet below the inside clearance line of the roof of the tunnel, and shall be of approved pattern. These screens shall be installed in such locations and at such intervals as may be required and as may be necessary to properly protect the men in the tunnel. There shall be a door opening in the screen with gasket and lock for purposes of extending line and grade.

O.22 Runways

In each compressed air driven tunnel, a substantial runway at least three feet wide shall be provided above the springing line of the tunnel leading from the heading to a platform at the emergency lock. Each runway shall be provided with a hand-rail and, at intervals, with steps or ladders for access from the track level. Runways shall be kept clear at all times. In areas under pressure the runways, stairways and ladders, including railings, shall be of incombustible material.

O.23 Special decompression chamber

(a) Where required. When the working period in compressed air is of such pressure as to require a total time of decompression exceeding 75 minutes, a special decompression chamber shall be provided and used for the final stage of decompression.

(b) Capacity. The special decompression chamber shall be of sufficient size to accomodate the total number of workers to be decompressed at the end of a shift. The rated capacity shall be based on the required minimum space per worker, and the maximum number of workers permitted in the chamber shall be posted at the entrance to the chamber. Posted capacity shall not be exceeded except in case of an emergency.

(c) Design. The special decompression chamber and passageway shall be designed for an operating pressure of 20 pounds per square inch gage pressure.

(d) Size and capacity.

(1) Vertical clearance. The minimum vertical distance from the floor of the chamber to the ceiling shall be 7 feet in the area where persons are required to stand.

(2) Volume. The inside dimensions of the chamber shall be such as to provide a minimum of 50 cubic feet of air space per worker.

(3) Floor area. The minimum total horizontal floor area per worker shall be 7 square feet, of which three square feet shall be seating area. Lavatory and toilet areas shall be excluded in computing this required minimum area.

(e) Equipment. The chamber shall be provided with equipment as specified for man locks.

(f) Automatic Control. The chamber shall be provided with an approved automatic control which, through taped program or cams or other acceptable means, shall automatically regulate decompressions. The control shall be equipped with a timing device and such manual control as necessary to enable the lock attendant to override the automatic control in the event of an emergency.

(g) Sanitation.

(1) Toilets. One water closet in a screened or enclosed space shall be provided in the chamber for each 10 occupants or fraction thereof. The water closet shall be vented to the outside of the special decompression chamber.

(2) Wash basins. One wash basin with hot and cold running water in a screened space shall be provided in the chamber for each 10 occupants or fraction thereof.

(3) Clothes change area. A clothes change area shall be provided for the persons in the special decompression chamber. The area shall be screened for privacy and shall be provided with lockers or other suitable means for proper protection and storage of employees' clothes.

(4) Drinking water. An ample supply of clean and potable drinking water shall be available in the chamber during occupancy, together with an adequate supply of disposable cups.

(5) Towels. An ample supply of disposable towels shall be provided in the chamber.

(6) Maintenance. The chamber shall be kept clean. Fire resistant enclosed receptacles for used cups, paper towels or other combustible refuse shall be provided.

(h) Location.

(1) Where practicable, the special decompression chamber shall be situated adjacent to the man lock on the atmospheric side of the bulkhead. When located adjacent to the man lock, a passageway shall be provided connecting the special chamber with the man lock to permit workmen in the process of decompression to move from the man lock to the special chamber without a reduction in the ambient pressure from that designated for the initial pressure of the final stage of decompression. The passageway shall be so arranged that it does not interfere with the normal operation of the man lock nor with the release of the occupants of the special chamber at atmospheric pressure upon the completion of the decompression procedure.

(2) Under unusual circumstances or in an emergency and only with the express permission of the designated physician, decanting procedures may be used to facilitate the movement of men at atmospheric pressure from the man lock to the special decompression chamber for the final stage of decompression.

(i) Fire protection and prevention. The decompression chamber shall comply with requirements for fire protection and prevention.

O.24 Telephone connection

A telephone connection shall be provided and maintained in service at all times from the tunnel heading and emergency lock, to the power house and to the office of the Engineer at the site of the work.

P. PROTECTIVE BLANKETS FOR SUBAQUEOUS TUNNELS

A clay blanket shall be placed on the bed above the proposed subaqueous tunnel route where soil cover is shallow.

(a) An initial blanket and a temporary (movable) blanket of approved clay of sufficient width and thickness shall be provided and maintained where necessary and where indicated on the drawings, to counteract the unbalanced air pressures and to counteract buoyancy of the tunnel. The temporary (movable) blanket may be required to be protected from erosion with a rip-rap covering. A portion of the initial blanket shall remain in place and shall be used as part of the permanent blanket as indicated.

(b) Initial Blanket. The initial blanket shall be made by depositing good clean approved clay between mounts of rip-rap as indicated on the drawings. The rip-rap shall consist of good clean approved stone, of such size and gradation as will be approved with no piece larger than two feet in any dimension. Stones or boulders shall be clean, sound and durable, and of established weathering qualities.

(c) The initial blanket shall be completed in advance of tunnel operations in that part of the river, and shall be maintained until the permanent blanket is ready to be placed.

(d) At such time as the permanent blanket is ready to be placed, portions of the initial blanket (clay and rip-rap) shall be removed as indicated on the contract drawings.

(e) Temporary (Movable Blanket. In order to prevent erosion and scouring of the temporary (movable)

blanket due to swift currents or otherwise, it may be required to furnish and place an approved rip-rap protection covering on and over the temporary (movable) blanket.

(f) When a heading extends beyond the shore line, unless such heading is protected by a sufficient rock cover, daily soundings shall be taken where and as directed and a copy of the records shall be immediately furnished.

(g) If, during the progress of the work, soundings indicate that portions of the initial blanket have been eroded, scoured, washed away, or disturbed, whether due to the operations of moving the temporary (movable) blanket or otherwise, the initial blanket shall be immediately restored to the original condition, elevations and cross sections as approved and as directed.

(h) The provisions of the Permit of the Department of the Army regarding the placing and removal of such initial and temporary (movable) blankets shall be strictly complied with.

O. PERMANENT BLANKET

(a) A permanent blanket is to be provided over the tunnel, as shown on the drawings.

(b) At such time as the construction of the tunnel permits as indicated on the drawings, portions of the initial blanket shall be carefully removed to the lines and grades indicated on the drawings. If any portion of the initial blanket that is to remain in place as part of the permanent blanket is disturbed or removed, the blanket shall be restored to the lines and grades as indicated. In order to complete the construction of the permanent blanket, rip-rap shall then be placed over the portion of the initial blanket to remain in place, all as indicated on the drawings. The rip-rap shall consist of good clean approved stone of such size and gradation as will be approved, with no piece larger than two feet in any dimension. Stones or boulders shall be clean, sound and durable, and of established weathering qualities. Rip-rap removed from the initial blanket in order to

complete the permanent blanket may be used. All excess material not used to construct the permanent blanket shall be disposed of.

(c) All work in connection with the placing and maintaining of the blanket must be conducted in strict accordance with the requirements of the Permits of the Department of the Army. The permanent blanket shall be maintained and guaranteed not to scour, wash away, erode, or disintegrate within 5 years from the date of the completion of the job.

R. SOUNDINGS

(a) Soundings shall be taken in the river when required and as directed. For the purpose of taking soundings, it will be required to provide a boat, all sounding equipment, and all personnel for the operation of the boat and equipment.

(b) The boat shall be equipped with an approved recording survey type echo sounding device and with such other sounding devices (lead line) as may be required.

(c) Accuracy is of the essence. The echo measuring sounding device provided must be capable of producing results consistently accurate to within one per cent of the depth to be sounded.

(d) All sounding devices shall have their accuracy and calibrations checked periodically as may be required.

Chapter **10**

Of course

Chapter 10

PRESSURE GROUTING AND GRAVELING

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Chapter 10

PRESSURE GROUTING AND GRAVELING

I - GENERAL REQUIREMENTS

A. SCOPE

(a) Grouting will be done to fill voids behind concrete lining or cast-iron tunnel lining, for waterproofing rock tunnels not lined with cast-iron, for filling voids between interior concrete lining and the cast-iron tunnel lining, and for other purposes as required.

(b) Pea gravel will be used in lieu of grout or in conjunction with grout, as hereafter specified to fill voids outside cast-iron tunnel lining.

II - MATERIALS

A. GROUT COMPOSITION: PROPORTIONS

(a) Grout shall be either neat Portland cement or it shall be mixed in proportion by volume of one part of Portland cement and one part sand, and shall be mixed with clean, fresh water. For purposes of defining the mixture and for payment, 376 pounds of Portland cement shall be estimated at 3.5 cubic feet of volume and will be considered a barrel. The proportional volume of sand shall be as cast into the measuring box.

(b) Sand for grout shall be of the quality specified for fine aggregate for concrete, but of such fineness that it will all pass a sieve having 64 openings per square inch. For special purposes, finer sand may be required.

III - EQUIPMENT

A. GROUTING EQUIPMENT

The arrangement of the grouting equipment shall provide for continuous circulation of grout in the system and shall permit accurate pressure control. The machine used shall be of the type which will mix the grout continuously until discharged from the mixer and permit the application of a pressure of 60 pounds per square inch in excess of the external water pressure. Machines that will safely operate under pressure up to 300 pounds per square inch may be required for grouting to secure watertightness in tunnels not lined with cast-iron. Care shall be taken not to continue the excess air-pressure after the grout is discharged from the mixer.

IV - CONSTRUCTION METHODS

A. CONTRACTOR'S RESPONSIBILITY

Unless otherwise specified herein, grouting mixes, pressures, pumping rate and the sequence in which the holes are drilled and grouted, will be determined in the field. During operations of filling voids, controlling water flow and consolidating the natural ground, the desired results shall be accomplished without damage to underground utilities and structures. Any such damage shall be repaired.

The amount of drilling and consolidation and seal grouting to be performed will depend upon the nature of the materials encountered as the work proceeds in the tunnels.

All measures necessary shall be taken for the control of inflow of water into tunnels, shafts and adits.

B. KEEPING RECORDS

An accurate log of all drill holes shall be maintained and a copy of same shall be furnished including: description of all materials of whatever character encountered in the drilling and their locations in the holes; the location of special features, such as

mud seams, open cracks, soft or broken ground, points where abnormal loss or gain of drill water has occurred; groundwater levels; and any other items of interest in connection with the grouting. The fact that an inspector may or may not be present, and is keeping a record of the drilling, shall not preclude the necessity for maintaining an accurate log as described above.

An accurate record shall also be maintained and furnished of the time of each change of grouting operations, pressures, rates of pumping, changes in ingredients and mix proportions, and such other data as may be required.

D. SUPERVISOR TO BE NOTIFIED

All graveling, washing of grout holes, and grouting operations, shall be performed in the presence of supervisor.

At least one week of advance notice shall be given of the time grouting operation is to begin and subsequent grouting schedules shall be made available.

D. METHOD OF GROUTING

Voids outside the tunnel lining shall be wholly or partially filled with grout as hereinafter more particularly specified. Grouting shall be commenced at the bottom of a ring or section and shall proceed uniformly upward unless some other order of grouting is directed or permitted. Each plug shall be removed, if required, and in the cast-iron lining, the grout mixing machine shall be connected to the grouting hole by means of a hose and a nipple cut to the same thread as the screw plug. When the grouting or graveling through any hole in cast-iron lining is completed, the threads of both hole and plug shall be cleaned, the plug replaced for its full length in the hole and screwed tight. The plugs in cast-iron lining shall completely fill the hole.

D.1 Grouting in Rock

(a) Where the cast-iron tunnel lining is erected in rock, by use of a shield, the voids outside the lining

shall be filled with grout containing Portland cement and sand. Grout forced through the lower holes of the lining must show at the upper holes before connection is made to the latter for grouting. Such pipes shall be placed in the upper holes or elsewhere as may be required to determine the extent or progress of the grouting and to serve as vents.

(b) Where the excavation in tunnels is wholly in rock, circumferential dams or bulkheads shall be built around the cast-iron lining, where used, at intervals not exceeding 50 feet to confine the flow of grout subsequently introduced. It may also be required to build dams in the space to be grouted over the arch in tunnels not lined with cast-iron, if it appears desirable to prevent the flow of grout over too great a length of the arch. These dams or bulkheads shall be built of a one to one mixture of Portland cement and sand in small bags and will be paid for as one to one grout on the basis of the number of barrels of cement used. The bags may be omitted in the case of tunnels not lined with cast iron, if conditions so warrant.

D.2 Grouting in Earth

Grout ejected through the cast-iron tunnel lining in earth shall contain neat Portland cement or one part Portland cement and one part sand, as directed. Where the excavation is wholly or partly in rock, or in hardpan or other material firm enough to keep its form after the shield passes until grouted, enough grout shall be used to fill the voids between the tunnel lining and the undisturbed material. Where the excavation is in sand or other moving material, actual voids around the lower three-fourths of the tunnel shall be filled with grout, but the upper one-fourth shall not be grouted, except as provided in Paragraph D.3.

D.3 Additional Grouting

In addition to that herein specified, grout will be permitted to be ejected through the tunnel lining or in the face of the heading or to fill voids between the interior concrete lining and the cast-iron tunnel lining, or elsewhere as he may deem advantageous in the prosecution of work.

E. VOIDS TO BE ROUTED

Voids between the interior concrete lining and the cast-iron tunnel lining shall be grouted with neat Portland cement. Voids between the concrete tunnel lining and the rock or other limits of excavation where cast-iron is not used shall be filled with one to one Portland cement grout or neat Portland cement grout or both as directed. In all cases, proper vents shall be provided to permit all such spaces to be properly filled. Initial grouting pass shall be made for purposes of filling voids between the concrete tunnel lining and the rock or other limits of excavation at such times as approved. Prior to the initial grouting pass of filling voids between the concrete tunnel lining and the rock or other limits of excavation, drawings shall be submitted for approval indicating proposed grouting procedure and pattern. Grouting pressures up to 50 pounds per square inch shall be used if required. For this grouting, a very fine quartz beach sand may be required. If required while placing the concrete in the arch in cast-iron lined tunnels, approved grout and vent pipes shall be placed in each segment and key of the cast-iron lining for use in grouting between the interior concrete lining and the cast-iron tunnel lining. Where grouting is required in tunnels not lined with cast-iron, the necessary grout and vent pipes must be placed at, or before, the time of placing the concrete.

F. GROUTING TO SECURE A WATER-TIGHT STRUCTURE

(a) Upon completion of the initial grouting pass, of grouting and filling voids between the concrete tunnel lining and the rock or other limits of excavation, as required in Chapter 10, IV, E., additional grouting operations shall be performed when ordered in order to secure a watertight structure. All places where water is leaking through the rock in tunnels where cast-iron lining is not to be used, except where the plans provide for weep holes to be left in the concrete, shall be properly panned with metal shields and provided with proper grout and vent pipes and, if required, shall be thoroughly grouted with neat Portland cement grout to stop the water, at such time after the concrete lining has

been placed as may be directed. At locations where ordered, the panning shall not be grouted but rather shall be drained to the permanent drainage system in an approved manner.

(b) If leaks appear on the surface of the concrete at any time after it is set, the concrete through which the leakage takes place shall either be removed, stop the leak, the waterproofing or cast-iron lining, bolting, or caulking, shall be repaired and the hole shall be refilled with sound concrete, or where waterproofing or cast-iron lining is not used and leaks appear after the grouting herein specified has been done, the leaks shall be stopped by injecting grout through holes drilled in the concrete, or, in any case, steps shall be taken that may be considered practicable to secure watertightness. Any concrete which is found to be defective, before the final completion and acceptance of the work, shall be removed and properly rebuilt, or if damaged during such time shall be properly repaired or replaced, as required.

G. PEA GRAVEL EJECTED THROUGH CAST-IRON TUNNEL LININGS

G.1 Scope

It will be required, if directed, to fill the voids outside the cast-iron tunnel lining by ejecting pea gravel or pea gravel and grout under pressure, through grout holes provided in the cast-iron tunnel segments.

G.2 Method of Placing

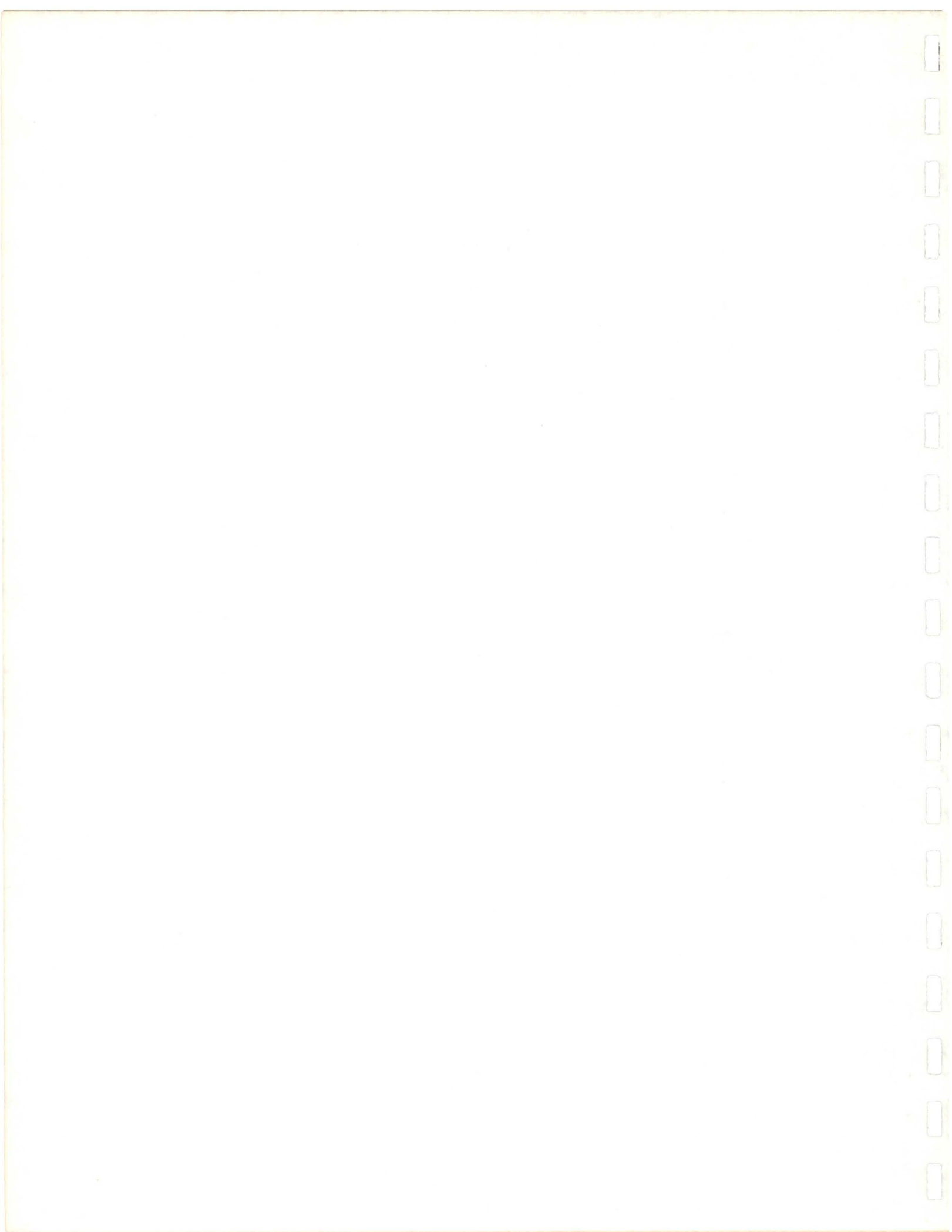
Gravel shall be ejected through the cast-iron tunnel lining, while the shield is being advanced for the erection of each ring and shall be ejected through holes near the upper quarter-point on both sides of the tunnel simultaneously, or through such other holes as may be directed. The machine used for ejecting gravel shall be of a type which will permit the application of a pressure of 100 pounds per square inch. All voids around and above the tunnel lining where the excavation is in hard-pan or other material firm enough to keep its form after the shield passes,

shall be filled as completely as possible with pea gravel. Where the excavation for cast-iron lined tunnels is in sand or other moving material, actual voids around the lower 3/4 of the tunnel shall be filled with pea gravel, but the upper 1/4 shall not be filled with gravel in such cases, except where structures exist which require protection.

G.3 Grout Following Graveling

In places where gravel has been placed around the entire circumference of the tunnel lining on account of the tunnel being in hard-pan or other material firm enough to hold its shape after the shield passes, it may or may not be required that grouting shall be done to fill any remaining void outside of the lower 3/4 of the tunnel lining, but no grout shall be placed outside the upper 1/4 of the tunnel lining.

All grouting through gravel packing shall follow the erection of the cast-iron lining as closely as it deems practicable, and effective means must be employed to confine the grout so as to prevent its return into the shield.



SIGNALS AND COMMUNICATIONS GUIDELINES



JANUARY 1975

INTRODUCTION

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SIGNALS AND COMMUNICATIONS GUIDELINES

INTRODUCTION

Signal construction work is normally performed shortly after, or concurrently with general construction work and the track work. The work of the Power Division and of the Equipment Division is normally performed at approximately the same time as signal construction.

The main purpose of signaling is to provide safety and headway for Rapid Transit operations. This is accomplished by installing and interconnecting thousands of components of signal equipment into a coordinated functioning system that, in all phases, stresses safety.

There are three (3) main classifications of signals: automatic signals, approach signals and home signals. The automatic signal is the predominant one and its aspect (appearance to the motorman) is automatically governed by the position of the trains on the section of track (block) being protected by the signal.

Lengths of track are sectionalized into blocks by means of insulated rail joints. The length of the signal block varies depending upon whether the track is level and tangent, is curved, or is on an up-or down-grade. The maximum attainable speed and the required braking distance are governing factors in the location of signals. The location of stations and track switches is another important factor in the location of signals. Longer blocks are utilized on level tangent express tracks; shorter blocks are used where it is necessary to more closely control the movement of trains, such as on curves, downgrades and approaching stations.

Under modern signal systems, automatic signals function in the following manner:

When a train has passed through the block, the signal is RED and the tripper arm of the automatic

train stop. A valve in the compressed air train line is opened and the brakes are applied bringing the train to an emergency stop.

The heart of the signal system is the track circuit. This circuit detects the presence or absence of a train in a signal block and by means of interconnected controls, positions the automatic train stops, and displays the proper signal aspects for the series of signals in such a way as to protect the movements of a train following behind a preceding train on the same track.

The signals are so spaced that if a motorman attempts to pass a RED signal (even at the maximum attainable speed at that point in the Railroad), his train will be tripped by the automatic train stop and brought to an emergency stop. In general, a margin of safety of approximately 35 percent of the braking distance required, for the maximum speed that he could possibly be traveling at, is designed into the spacing of most signals. This prevents rear-end collisions.

At interlockings, home signals and approach signals are installed so as to safely permit the movement of trains through interlocking territory over switches and onto other routes. The circuits controlling home signals are the most complex in the art of railway signaling and provide safety features and safety checks for all possible contingencies. These circuits and the signal equipment they control are so interconnected as to prevent head-on collisions, side-collision, derailments and other accidents, in addition to providing protection against rear-end collisions. The equipment for automatic and approach signals is housed along the wayside in instrument cases or housings, or in centralized enclosures. Most of the equipment for home signals is housed in relay rooms which are adjacent to, or part of, signal tower buildings. Thousands of relays are housed on specially designed racks in relay rooms. (Approximately 70 relays are used to protect a single crossover in a typical modern interlocking). Cables interconnecting all the components of the signal system are installed along the right of way, suspended from messengers, installed in ducts, or buried in trenches.

Given the required number of trains per hour that will operate within a given territory, mathematical calculations are utilized to determine the optimum spacing and locations of signals. These calculations involve the determination of the maximum allowable speeds for trains running from station to station, the required headway between trains, and involves the plotting of speed-distance and time-distance curves on graphs for each track. The track layout, alignment, grades, curves, stations, interlockings and other pertinent data are also drawn on these graphs. From these graphs and other engineering data, including the operating characteristics of the train equipment that will be operated on the line, the required braking distances at various operating speeds and the necessary factors of safety are determined. It is then possible to choose the optimum location of each signal in the layout required to accomplish the desired movement of trains. The number of signals in particular section of track depends on many factors, primarily safety and headway, but also includes such special factors as protection on grades, curves, special conditions at interlockings, closing-in signaling at stations and other transit requirements. In general, the greater the headway, the less will be the number of signals required for a given section of track.

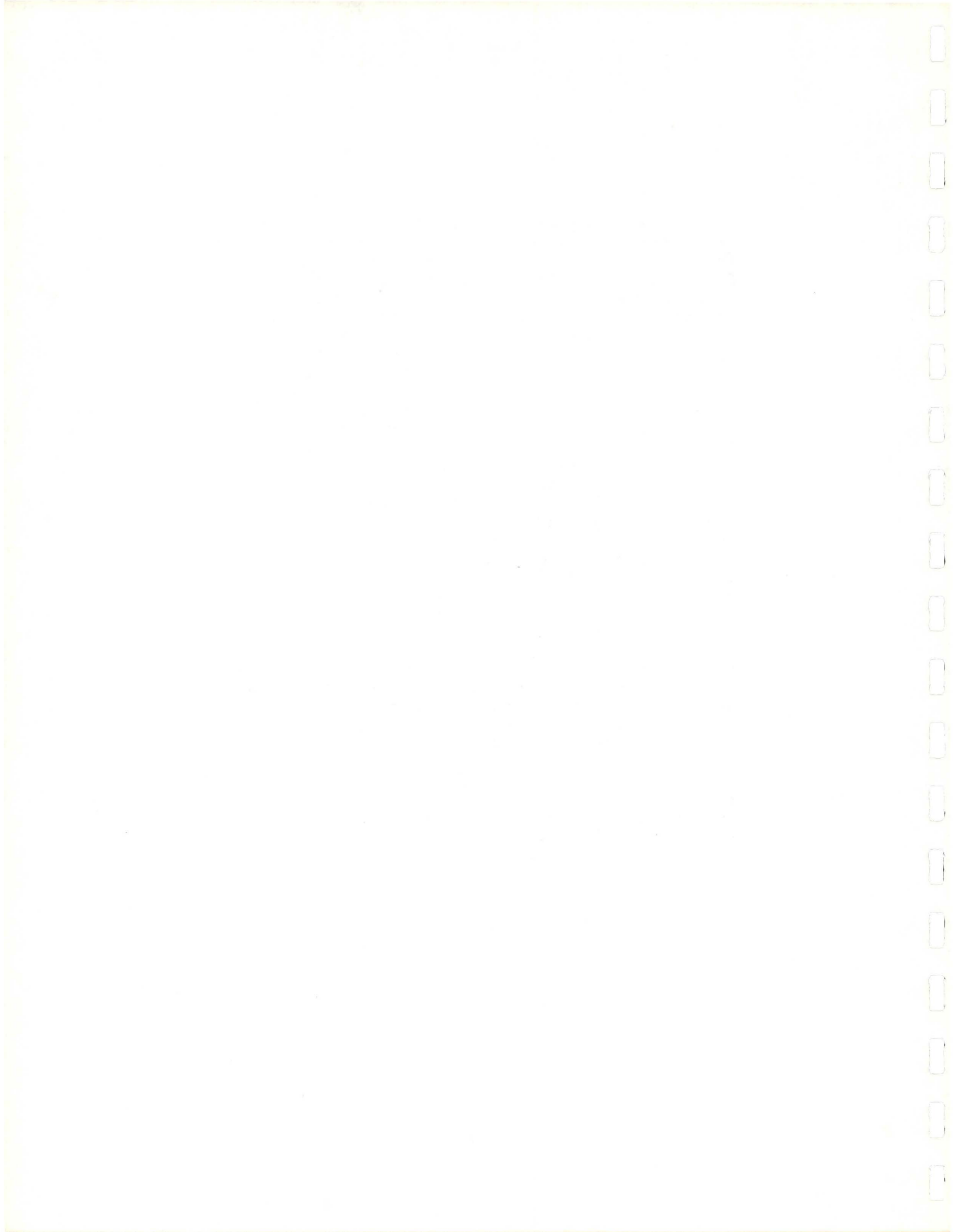
The purpose of the following information is to assist in standardizing the procedures involved in furnishing and installing of equipment to establish a signal system that will accomplish the intent outlined above.

DIVISION ENGINEER

SEYMOUR DORNFELD

AUTHOR

ERWIN FRIEDMAN



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SIGNALS & COMMUNICATIONS GUIDELINES

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Chapter 1

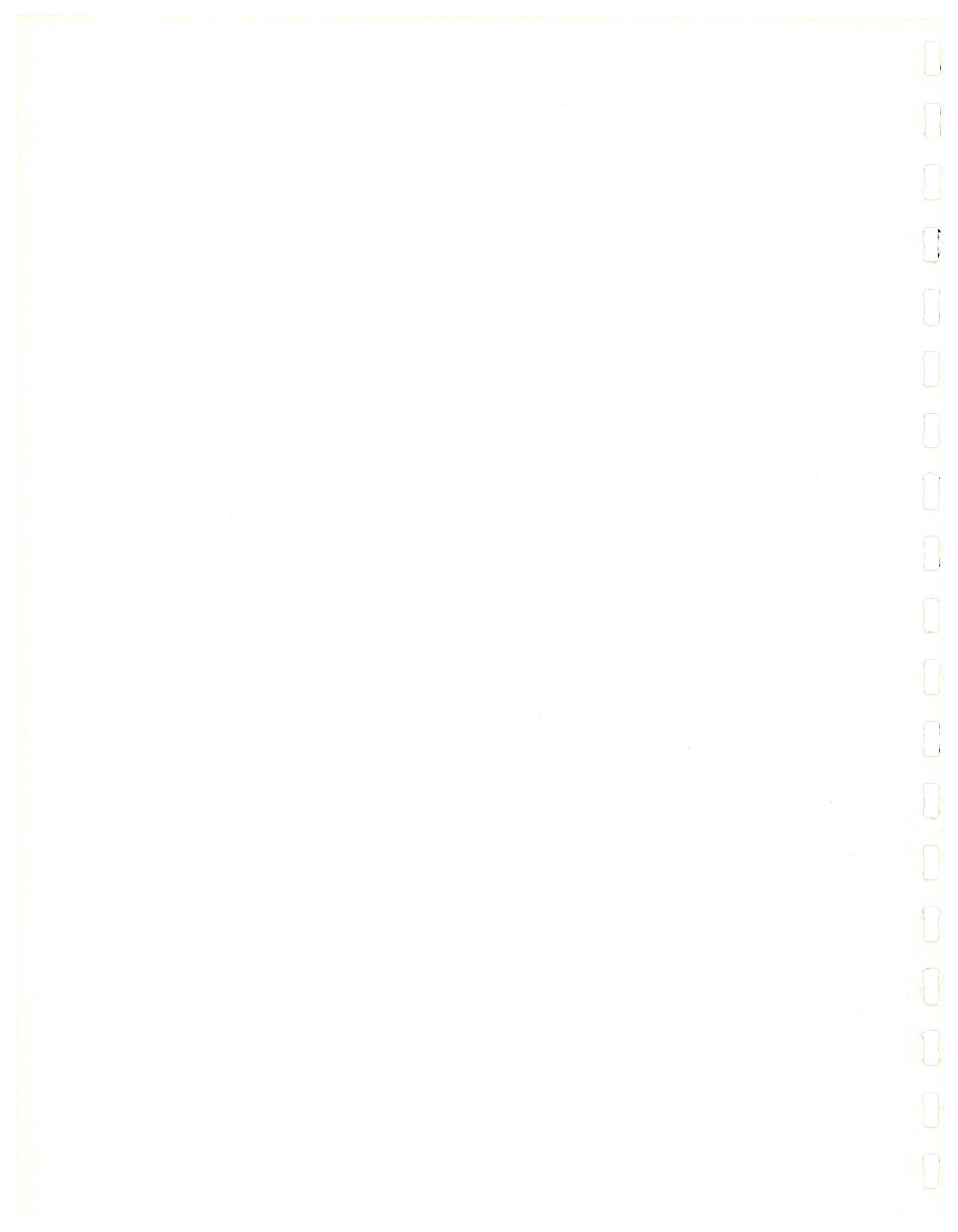
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Chapter 1

LOCATING OF BLOCK SIGNALS FOR RAPID TRANSIT RAILROADS

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Chapter 1

LOCATING OF BLOCK SIGNALS FOR RAPID TRANSIT RAILROADS

Block signals for rapid transit lines can be, and are, accurately located on paper, without the necessity of going out in the field, and regardless of the type of signal equipment used. This is accomplished by combining all of the known factors, which affect the location and spacing of signals, on one "Working Diagram" or set of "Operation Curves", for each run between stations.

In order to accurately compute and plot the "Operation Curves", and to intelligently locate the signal, the following facts must be known and considered:

1 - CHARACTERISTIC CURVES OF MOTOR EQUIPMENT

The characteristic curves of the motor equipment show the speed of the train, in M.P.H., and the gross tractive effort developed by the inputs to the motor. Speed and tractive effort are plotted as ordinates, against current as abscissae.

These are obtained from witnessed or certified tests, made by the motor manufacturer, and submitted by him for approval.

These curves are the basis for all speed-time, speed-distance, and time-distance curve computations. However, in order to make these computations accurate, the following additional information must be obtained from the car equipment department:

(a) Rate of "straight-line" or controlled acceleration on tangent level track in M.P.H.P.S.

(b) Speed at which "straight-line" acceleration ends and "motor-curve" acceleration starts, at the assumed average load per motor, on tangent, level track.

(c) Whether the rate of "straight-line" acceleration depends on the load, or is automatically kept

constant at all loads.

II - BRAKING CHARACTERISTICS

The braking rate of a train, for emergency and service applications, depends on the design of the brake equipment, the speed of the train, and the profile and alignment of the roadway. The rate of service application also depends on the person applying the brakes.

For signal location purposes, the rate of service braking is used only to determine whether the distance from which a signal can be sighted is great enough to bring a train to a stop when operating under normal conditions. In this way, it sometimes determines whether a repeater signal should or should not be installed.

The emergency braking distance, however, is continually used, and is nearly always the factor that finally determines the length of block. There must always be sufficient emergency braking distance past a signal displaying a "Stop" indication, to bring a train to a stop before it collides with the preceding train. This is at least 135% of the emergency braking distance required, when the following train is operating at maximum speed.

The emergency braking distance required to bring a train to a stop is obtained from actual tests made in the field. The tests are made on tangent, level track, or on grades as nearly level as it is possible to obtain, for various speeds.

From these test data, the braking distance required to bring a train to a stop from various speeds, and on various grades, are computed by means of the following formula:

$$D_1 = \frac{V^2 D}{V^2 + 30 GD}, \text{ where,}$$

D = Braking distance to stop on level track, in feet,
(Test Date)

D₁ = Braking distance to stop on desired grade.

V = Speed, in M.P.H. at which braking begins.

G = Desired grade expressed as a decimal, and is preceded by a plus (+) sign if the grade is up, and by a minus (-) sign if the grade is down.

III - PROFILE AND ALIGNMENT OF ALL TRACKS

(a) GRADES: Grades affect the speed of a train, an up-grade having a tendency to reduce the speed, and down-grade having a tendency to increase the speed. A one-percent grade (one foot rise or drop per one hundred (100) feet of track) is equivalent to a tractive effort of twenty (20) pounds per ton of train weight, which must be added to, or subtracted from the tractive effort developed by the motor, depending on whether the grade is down or up. Grades also affect the braking distance required to bring a train to a stop from any given speed; an up-grade reduces the braking-distance, and a down-grade increases it.

The speed of a train, and the braking-distance required to bring it to a stop, in turn affect the lengths of blocks and the location of block signals.

(b) CURVES: All curves tend to reduce the speed of a train. The resistance of a curve to the motion of a train (curve-resistance) is equivalent to a negative tractive effort of four-tenths (0.4) to one (1) pound per ton, per degree of curvature, and is always subtracted from the tractive-effort developed by the motor. Aside from the curve-resistance, the speed of trains around short-radius curves must always be limited for fear of derailment, and for the comfort of the passengers.

Since curves affect the view of signals, they may determine the location of signals (if nothing else is affected); and when signals are located on curves, the direction and degree of curvature may dictate the location of repeater signals.

IV - LOCATION OF SPECIAL-WORK

The locations of interlocking signals are always determined by the locations of special-work, and the location of these signals may determine the locations of other signals.

V - LOCATIONS OF ALL PASSENGER STATIONS, LENGTH OF EACH PLATFORM, AND STATION STOP

The distance between passenger stations is one of the factors that determines the maximum and average speeds that a train can attain, and these speeds affect the location of signals. In general, the longer the run, the greater is the permissible distance between signals, other conditions being the same.

The length of platform, and the length of time of station stop are factors in determining the number and locations of closing-in and speed-control signals required at stations.

VI - WEIGHT OF TRAIN INCLUDING LIVE-LOAD, NUMBER OF MOTORS PER CAR, COMPOSITION OF TRAIN

This information is necessary so that the total load (weight of train plus live-load) can be properly divided among the motors in the train. If a train is composed entirely of motor cars, the average load per motor can be obtained by dividing the average load per car (car weight plus live-load) by the number of motors per car. If a train is composed of motor and trailer cars, the load per motor is obtained by dividing the total weight of the train, (train weight plus live-load) by the total number of motors in the train.

It is necessary to know the load per motor in order to compute the speed and time-distance curves, since the operating characteristics of the motor are modified by the load.

VII - TRAIN RESISTANCE

Train resistance consists of the rolling friction of the wheels or the tracks, wind resistance, motor bearing and brush friction, etc. It is one factor that cannot be accurately determined because of all the variables which enter into it.

The resistance between wheels and rails depends on the weather, atmospheric conditions, physical condition of rails and wheels, weight of the train, and the composition and weight of the rails. Bearing friction depends on the kind of lubricants used, the composition and physical condition of the bearing parts, and the load on the

bearings.

Direct wind resistance depends on the area and shape of the front end of the car, and side resistance or "skin friction" depends on the length of train and the design of the sides of the cars.

When a train runs in the open, the wind resistance changes with the weather and atmospheric conditions; in the subway, the design of the structure, whether tube, open column, curtain wall, will affect the wind resistance, and it will vary as the train moves from one type of construction to another.

All of these resistances vary with the speed of the train.

In computing speed-and time-distance curves, it is not necessary to consider each of the preceding items individually, and in practice, all are combined as a single item of train resistance.

Various authorities have developed formulae, as the results of actual tests, to determine train resistance, but it is difficult to verify any of them because of the extreme difficulty, and almost impossibility, of duplicating all of the conditions of the tests.

It has been customary to use the data that most closely approximate the conditions to be met, and to plot a curve of Train Resistance vs. Speed, from these data. The values of train resistance read from this curve are used in computing the speed-and time-distance curves.

VIII - MINIMUM HEADWAY

The minimum headway, or maximum number of trains per hour that must be operated, is one of the deciding factors in the spacing of Signals between passenger stations, and in conjunction with the maximum speed, the station stop, and the length of platform, determines the number of closing-in and speed-control signals which must be installed approaching a passenger station.

IX - MAXIMUM LENGTH OF TRAIN

The maximum length of train is a big factor in determining the length of blocks. As a rule, the length of a block should always be at least a few feet more than the length of the longest train to be operated. However, deviations from this rule are sometimes necessary because of other conditions such as long station stops, close headways, interlocking plants, sharp curves, etc.

The length must be known in computing speed-and time-distance curves, since changes in grades and curvature are considered as not having any effect on the speed of a train until one-half of the train has passed the point of change. This method of considering the effect of a change in grade or curvature is not exact, but gives the average effect of the changes and is sufficiently accurate for all traction purposes.

X - CHARACTERISTICS OF SIGNAL EQUIPMENT

The operating characteristics of the signal equipment have an effect, though small, on the location of signals, particularly on time-controlled signals. The time required for a change from one aspect to another (relay operation) and for operation of the automatic stop, and the ease of identification of the indication conveyed, all have their effect, which must always be borne in mind when locating signals.

XI - HUMAN ELEMENT IN OPERATION

The human element introduces variables which cannot be reduced to mathematical terms, but must be constantly borne in mind when locating signals.

The aforementioned factors must be given due consideration when locating signals, according to the judgement and experience of the engineer making the signal layout.

Chapter 2

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Chapter 2

CIRCUITS AND LOCKING FOR A FAIL SAFE SIGNAL SYSTEM

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Chapter 2

CIRCUITS AND LOCKING FOR A FAIL SAFE SIGNAL SYSTEM

I - CIRCUITS AND LOCKING

The design of preliminary circuit drawings and cable plans for the equipment to be furnished is a prime requisite for the development of a fail safe-signal system.

The circuits will consist of all circuits necessary to apply the signal manufacturer's particular type of equipment to the signal system.

The following description of the circuit and equipment requirements is given as information for the design of the signal equipment, final circuit drawings, wiring diagrams and for the development of the circuits required for the Contractor's particular type of equipment.

II - ALL RELAY INTERLOCKING

(a) The locking for the switches and signals shall be accomplished by means of relays so interconnected and controlled through a control panel that a signal permitting a train movement over any route within the limits of the interlocking plant cannot be cleared until all switches in the route are properly set and locked and all signals governing conflicting movements over the same route or any part of it are electrically locked or controlled to display a "Stop" indication.

The control circuits of the route interlocking will be so designed that to initiate a route, the operator need only to press the button on the control panel at the entering end of the route. An indication shall be returned to the control panel showing the routes that are available. When no route is available the effect of the pressing of the button shall not be stored, either electrically or mechanically. To complete a route, the operator is required to press the exit button located at the leaving end of the desired route. Where exit buttons are provided solely for the purpose of establishing an exit for a route, such exit

buttons shall be electrically checked to insure that operation of the exit button prior to operation of the entrance button shall not establish an exit.

The operation of the entrance and the exit buttons of a route shall cause the various switches of the route and those switches within the extended control limits of the signal to be operated to their correct positions for the route. Indications shall be returned to the control panel showing that the switches in the route are out of correspondence or in transit.

When a route has been selected, no other conflicting route shall be set up or stored for future operation. While route selection storage will not in general be used, the selection of a route containing a switch or crossover that is locked electrically by a signal, the overlap control of which includes the electrically locked switch or crossover, may, under certain conditions, be stored. When all of the switches within the route have operated in accordance with the route selected and the route has been locked an indication shall be returned to the control panel in the form of a white "line-of-light".

The route from an approach signal or from an interlocked home signal used as an approach signal shall be established by operating the initiation or entrance button only.

When a route has been established in accordance with the above, the signal or signals governing the route shall have the indications changed in accordance with the limits of the signal controls as shown on the drawings, without any further action by the operator. When this occurs, the signal light indication at the entrance button which displays red upon initiation of the route shall be changed to yellow.

Establishing a route shall be understood to mean the conditioning of switches for the clearing of a signal for train movement from one signal to the next signal. Through-routing shall be understood to mean the conditioning of switches for the clearing of two or more consecutive signals through a section of interlocking plant by the manipulation of the initiation button at the entrance of the section and the exit button at the leaving end of the section without the necessity of manipulating the intervening buttons.

The control circuits for the route interlocking shall be so designed as to permit "fleeting" when the initiation button is pushed and turned in the direction of the route. Under this condition the signal shall again be cleared for all following train movements, without any further manipulation of the buttons, after each train has passed beyond the limits of the signal control. In general, fleeting shall not be provided for moves against traffic or for reverse moves and for such other locations as may be designated.

When the route is operating on the non-fleeting basis, the route shall be automatically cancelled by the train movement past the signal. When a route has been established under the above condition, cancellation may also be effected by pulling the initiation button.

When the fleeting is in effect, cancellation shall be obtained by turning the initiation button to the position opposite that used for fleeting the signal, under which conditions the route will be cancelled by the next train movement past the signal. Fleeting shall also be cancelled without train operation by pulling the initiation button.

(b) The circuits and equipment may be designed to provide indications on the interlocking control panel as hereinafter described.

(1) LINE-OF-LIGHT-TRACK INDICATOR LIGHT.

(A) The "line-of light" sections shall normally be dark.

(B) EXIT LIGHT. When an entrance button is pushed, a steady white light shall appear in the light section at the exit end of every available route. When a route is selected by pressing an exit button, only the exit light for that route shall remain lighted. All other exit lights which may have been displayed shall be extinguished.

(C) ENTRANCE LIGHT. When an exit button is operated and the operation of the selection circuits is completed, a steady white light shall appear at the entrance end of the route selected.

(D) ROUTE LIGHT. When a route has been completely established and the switches have been locked in position,

the "line-of-light" from the beginning to the end of the route selected shall show a continuous line of steady white light. This line of white light shall remain displayed until the route is accepted or, if cancelled, until the approach locking for the route is released. The end of the route selected shall be understood to mean the next interlocking signal in the same direction or, in the case of leaving signals, the next interlocking signal in the opposite direction controlled for this panel.

(E) TRACK OCCUPANCY. When a section of track is occupied, a steady red light shall appear in the "line-of-light" unit or units representing the section of track occupied. The red light shall remain as long as the section of track is occupied. This indication shall supersede any other indication which would be in conflict, except the switch-out of correspondence light.

(F) SWITCH OUT OF CORRESPONDENCE. Whenever any switch or crossover is in transit or out of correspondence with its controlling devices, a flashing red light shall appear in the reverse light unit of that switch or crossover and shall continue to flash until the switch or crossover is locked in the position corresponding to its controlling devices. This indication shall supersede any other indication for that switch.

(G) AUXILIARY SWITCH CONTROL. When a switch or crossover is controlled by means of the auxiliary switch control button, a steady white light shall appear in the light unit or units representing the position of the switch.

(H) OVERLAP LOCKING AND INDICATION. When a route is initiated which includes a switch or crossover previously electrically locked by a signal, the overlap control of which includes the electrically locked switch or crossover, a flashing white light shall appear in the light unit or units representing the position of that switch, and light indicator for the signal locking the switch or crossover shall be flashed. The flashing light shall be red or yellow depending upon the indication displayed by the signal.

(I) SWITCH POSITION INDICATION PUSH BUTTONS. Switch position indication push buttons on the control panel when operated, shall cause an indication light for each switch of the associated interlocking area to be illuminated, indicating the positions of all the switches within that interlocking area.

(2) SIGNAL INDICATOR LIGHTS. The normal condition of the signal indicators shall be dark.

(A) INITIATION. When a route is initiated by pushing the entrance button, a steady red light shall appear in the associated light indicator and shall remain until the signal clears or the route is cancelled.

(B) CLEAR SIGNAL. When a signal governing the route clears, a steady yellow light shall appear in the associated light indicator and shall remain lighted so long as the signal is clear.

(C) CALL-ON SIGNAL. When the towerman displays a call-on signal, a flashing yellow light shall appear in the corresponding associated light indicator and shall continue to flash until the stop release has been operated by the motorman and the automatic stop operated to the clear position at which time the light will become a steady yellow.

(D) FLEETING. When a signal is fleeted a steady green light shall appear in a separate associated light indicator, triangular in shape, and shall remain until the fleeting is cancelled.

(3) TRAFFIC INDICATOR LIGHTS. Traffic indications shall be in the form of two (2) direction indicating arrows, each equipped with a red and white lamp. The following indications shall be provided:

(A) A steady white light shall indicate the established direction of traffic when the block is unoccupied.

(B) A steady red light shall indicate the established direction of traffic when the block is occupied.

(C) A flashing red light at the exit end shall indicate that the traffic lever, or button has been moved out of correspondence with the established direction of traffic while the traffic is locked.

III- INTERLOCKED SWITCH CONTROL

(a) The operation of the switch control relays shall be automatic for route selection and they shall be provided

with an auxiliary control over buttons located on the control panel. The switch control circuits shall be so designed that the operation of the interlocked switches can be accomplished only when the route is unlocked and conflicting routes have not been established.

The switch control relays shall be D.C. biased neutral relays of the plug-in type and shall be operated from a constant source of power.

(b) Switch control circuits shall be so arranged that the crossing of any wire of a switch control circuit with any other wire or the plugging in of a removed relay or relays cannot result in an improper operation of the switch.

(c) Each switch shall be equipped with a switch circuit controller which, with its circuits and auxiliary equipment, shall control all signals governing movements over said switch, and shall indicate that the switch assumes and remains in the position corresponding to that of its controlling devices.

(d) Means shall also be provided which will effectively prevent all power operation of the switch when the corresponding track or route relay is de-energized, or when the signal or automatic stop at the entrance of any route to the switch is clear, and the means shall be effective regardless of the position of the mechanism in a cycle of the operation or the position or subsequent operation of its controlling devices.

(e) Where the two (2) switches of a crossover are operated as a unit, the circuits will be so arranged that it will be necessary for both switches to operate properly before permitting the clearing of a signal for a train movement over either or both of them.

IV - BLOCK SIGNAL CONTROL

The limits of control of block signals should be indicated on drawings. Automatic block signals shall be controlled by appropriate circuits and have associated automatic train stops. They shall indicate "Stop" when any portion of the track within the control limits, as shown on the drawings, is occupied. They shall also

indicate "Stop" when the stop arms of their automatic stops are in the stop position, even though the tracks within the limits of the control of the signal may be unoccupied. They shall further be controlled by traffic control relays, if the route is in traffic controlled territory, in such a manner that the proper direction of traffic must be established before the signal can be cleared. Automatic block signals shall indicate "Proceed, Prepared to Stop at Next Signal", when the portion of track within the said control limits is unoccupied, the automatic stop arm is in the clear position, and the next signal indicates "Stop". Automatic block signals to which an illuminated "S" and/or "D" is attached, shall indicate "Approach at Allowable Speed" when the portion of track within the said control limits is unoccupied, the automatic stop arm is in the clear position and the next signal, which has "speed limit" control, indicates "Stop" only because such speed control devices have not operated. Automatic block signals shall indicate "Proceed" when the portion of track within the said control limits is unoccupied, the automatic stop arm is in the clear position and the next signal or signals indicates either "Proceed with Caution" or "Proceed".

Signals if equipped with a lunar white aspect shall indicate "Proceed with Caution at Allowable Speed" when the portion of track within the control limits of the signal is unoccupied and the signal is displaying "Stop" only because the speed control device has not operated.

As indicated on the drawings certain signals which are located within, or in the approach to, station time control territory shall be equipped with an "Allowable Speed Limit Indication" in the form of an illuminated numeral. The numeral, when illuminated, shall indicate that the signal is indicating "stop" due to track occupancy within or adjacent to the station limits and that the signal will clear if the train, while in the block approaching such signal, does not exceed the speed indicated by the illuminated numeral. The numeral shall be illuminated only when required.

V - INTERLOCKING HOME SIGNAL CONTROL

Interlocking home signals shall be controlled by appropriate circuits and have associated automatic train

stops in the same manner as the block signals and, in addition, shall be controlled from the control panel by the manipulation of the route buttons, as required. They shall be controlled in such a manner that all of the switches in the route and within the limits of the caution control must be in their proper positions and locked before the signal can be cleared. They shall further be controlled by traffic control relays, if the route is in traffic controlled territory, in such a manner that the proper direction of traffic must be established before the signal can be cleared.

A home signal shall indicate all routes within its control limits, and the control by track circuits, as above described, shall be effective on the particular route set up except for train movements permitted by call-on signal indication. After a home signal indication, other than a stop indication, is one displayed, it shall not be possible to change to a call-on indication without first cancelling the signal.

VI - CALL-ON SIGNAL CONTROL

Call-on signals used in connection with interlocking home signals shall be controlled by pushbuttons on the control panel, as required. The controlling circuits shall be so designed that the call-on signal cannot be displayed unless the route has been established and all switches in the route are locked, the home signal indicates "Stop", and the track circuit or track circuits in the approach to the signal are occupied. They shall further be controlled by traffic control relays, if the route is in traffic controlled territory, in such a manner that the proper direction of traffic must be established before the signal can be cleared. The call-on signals, as a rule, shall have no other track circuit control. Provisions shall be made to permit a call-on signal to be given instead of a home signal when the track circuits in the caution control of the signal are unoccupied. After a call-on signal is once displayed it shall not change to a home signal indication until the approach track circuit or circuits are cleared, or the route is cancelled manually. Movement from a home signal against the normal direction of traffic shall be governed by the call-on signal indication.

VII - YARD SIGNAL INDICATION

The "Yard Signal" aspect, consisting of three yellow lights, shall be displayed by home signals to indicate a third route; this signal shall not be displayed unless a route has been established and all switches in the route are locked. It shall not have a less restrictive indication for this move. When a yard signal indication is displayed, train movements shall be made without the necessity of stopping and releasing the automatic stop. After a yard signal indication is once displayed, it shall not change to a less restrictive home or to a call-on signal indication until the route has been cancelled and again established.

VIII - APPROACH SIGNAL CONTROL

Approach signals shall be controlled by appropriate circuits and have associated automatic train stops in the same manner as automatic block signals, and in addition, shall be controlled by route buttons, as required, on the control panel. They shall further be controlled by traffic control relays, if the route is in traffic controlled territory, in such a manner that the proper direction of traffic must be established before the signal can be cleared.

IX - TIME CONTROL OF SIGNALS

Certain signals shall have in addition to the control above described, special control by time-element relays. The time setting of the time-element relay shall be confined to the track section by which it is controlled. The return of the time-element relay to its normal position shall be checked by controlling the signal in approach through a contact closed in the de-energized position of the time-element relay.

X - SIGNAL CONTROLS

General. (a) A signal located at or near the leaving end of a switch detector circuit of a facing point switch or crossover shall be so controlled as to indicate "Stop" when the diverging route is set and the signal is not included in the route.

(b) Signal controls shall be D.C., and in general shall obtain their energy from the A.C. power mains by the use of transformer-rectifiers.

(c) Track repeater relays repeating remotely located track relays shall have double break controls. In general, track repeater relays which are locally controlled within the case, enclosure, etc., shall have single break controls.

(d) Stop repeater relays shall have single break controls.

(e) All other D.C. repeater relays shall, in general, have single break controls.

(f) All stick relays used for signal or stop control or electric locking shall be checked in both positions.

(g) All signals having associated automatic stops shall have the light circuit checked through a clear-signal repeater relay which effectively checks the position of the stop mechanism. Clear-signal repeater relay controls shall have a double-break over the automatic stop circuit controller.

XI - AUTOMATIC STOP CONTROL

(a) Automatic stops at block, home, and approach signals shall have the same control as the respective signals with which they operate, except that the stop arm must be retained in the clear position until the entire train has passed over it. The stop arm at a home signal shall assume the stopping position as soon as the rear end of a train has passed it. The control of automatic stops at interlocking home and approach signals, except as noted below, shall be so arranged that the stop will be cleared automatically for any legitimate reverse movement, but not until the signal button or device controlling such movement has been cleared. If the track circuit beyond the stop is occupied, the stop shall not clear until the train has entered a designated track circuit in approach thereto.

(b) When an automatic stop is used in conjunction with a marker signal, the stop control may be a duplication of the automatic stop control of the opposing interlocking signal, except that the retaining circuit shall

be so arranged as to cause the stop to assume the stopping position as soon as the rear end of a train moving in the normal direction of traffic has passed it.

(c) The return of all stop arms to the stopping position for automatic stops in the direction of traffic shall be checked for each train movement past the associated signal.

XII - RELEASES FOR AUTOMATIC STOPS

Automatic stops at block and approach signals shall be so located with reference to the insulated joint at the entrance of a block, that when a train approaches a signal indicating "Stop" and stops at the signal, the first wheels of the train will have passed the insulated joint and the circuits will be so arranged that this will cause the stop arm to assume the "Clear" position, and the train will be permitted to proceed according to rule. This arrangement is in lieu of a push button or key release.

At interlocking home signals, the relation between the signal, automatic stop arm, and the insulated joint shall be such that the train stopping at the signal will not have passed the insulated joint and the stop arm will be located in relation to the insulated joint in accordance with Authority's guidelines. A manual release shall be provided in the approach to home signals. After the call-on signal has been displayed, the operation of the manual release by the motorman shall clear the automatic stop permitting the train to proceed according to rule.

XIII - APPROACH AND TIME LOCKING

(a) Electric locking shall be provided for all interlocking signals and shall be so arranged that a route can be cancelled at any time, but will not be released until the control relays of all signals of the route have responded to the cancellation and have assumed the stop position.

(b) Approach locking shall be provided for each home and approach signal. The limits of the approach locking sections are to be shown on drawings. The locking shall be so arranged that when the route push buttons have been operated to establish a route for a home or approach signal

and the particular signal or signals have changed from stop to proceed, the route shall be electrically locked in such a way that it cannot be released after a train has entered the approach locking section except by the cancelling of the signal and then only after a predetermined time has elapsed or until the train has entered the track circuit or circuits beyond the home signal. The signal or signals controlling the route may be restored to "Stop" indication at any time.

In order to prevent nullification of approach locking of the interlocking signals, or any other locking involving time release, due to restoration after a momentary loss of power, power-off stick relays and associated auxiliary relays and associated auxiliary relays shall be furnished for each set of A.C. buses feeding release track circuits. The power-off stick relays once having been de-energized shall not be energized again, when the power is restored, until a predetermined interval of time has elapsed. Front contacts of the power-off stick relay shall be included in the approach lock relay circuits to make the quick release ineffective at the instant that the power is restored.

Where there are two (2) or more interlocking signals on one (1) track and controlled by the same push button at an interlocking plant, one (1) approach lock circuit will, under certain circumstances, be used for all of the signals, in which case the approach locking circuits shall be so arranged that the locking of each signal or group of signals governing a switch will be released when the front end of the train passes the last signal protecting the switch.

(c) Time locking only shall be provided for certain interlocking signals as shown on the drawings, where the character of train operation will be such that approach locking will not be necessary and shall be so arranged as to delay the release of the route a predetermined time.

XIV - APPROACH LOCK RELEASE

A time release shall be provided in connection with each approach locking circuit and shall consist of a time element relay, adjustable as to time. The control of this release shall be so arranged that if a train has

entered an approach lock section of a home or approach signal, or both, as above described, and the signal controlling the route have been restored to the "stop" indication, the time element relay shall start to operate, and at the end of the time for which it is set, shall release the route. The return of the time element relay to its normal position shall be checked by controlling the signal through a contact closed in the de-energized position of the time element relay.

XV - DETECTOR LOCKING

All switches shall be electrically locked in the normal and reverse positions. The electrical locking shall be controlled by the track circuit or circuits in which the respective switches are located, and also by all track circuits, if any, between the switches and the automatic stops at such signals. Where there is more than one (1) switch in a route, electric locking of each successive switch shall not be released when the rear end of the train has passed it.

XVI - SWITCH REPEATER RELAYS

Switch repeater relays shall be furnished for each of the switches and crossovers. The switch repeater relays shall be D.C. biased-neutral plug-in type and shall be controlled over contacts of the switch circuit controller and switch machine. Power shall be supplied from separate transformer-rectifier units.

XVII - TRAFFIC LOCKING

(a) The method of control of traffic locking, in general, shall be in accordance with the latest guidelines.

The traffic relays shall be electrically interlocked with their respective signal controls in a manner such that it will not be possible to permit the entrance of trains into the controlled section in opposing directions. The relays of the traffic control shall be electrically locked so that, when traffic is set for moves in one direction of traffic it cannot be changed to the opposing direction until all track circuits in the controlled

section are clear and the signals governing moves into the section are returned to normal.

(b) Lights shall be provided on the control panels, to indicate the established direction of traffic control.

XVIII - CONTROL EQUIPMENT FOR TRAIN STARTING LIGHTS

Provision shall be made on the control panel and locally, for controlling train starting lights. The controls from the control panel shall, in general, be in multiple with the controls from the respective local point.

XIX - TRAIN ORDER SIGNAL CONTROL

Train order signal aspects shall be controlled by approved controlling devices located on the control panel and on the Dispatcher's indicator panel. Train order signal indicator lights shall be installed on the control panel and on the Dispatcher's indicator panel.

XX - PROTECTION OF CIRCUITS

Nonrenewable fuses and fusetrans of suitable capacities to protect the respective apparatus, shall be incorporated. Where reference is made to fuses, they shall be an approved fuse or a fusetrans as required by set standards. Each individual load tapped off the signal power buses shall be fused. In general, fuses in the relay cases along the track and at central instrument locations shall be as shown on drawings. In the interlocking tower and the interlocking relay rooms the final arrangement shall be determined by the nature and requirements of the circuits of each interlocking, with the intention that the blowing of any fuse shall give the maximum of protection and the minimum of interruption that it is possible to obtain with a group fuse arrangement. In general, all new fuses in the relay room and central instrument rooms shall be self-indicating and, where required, shall also operate a tower alarm when a fuse is blown. Fuses, where required for markers, signs, etc., shall be separate from those for the signal circuits.

Indicating fuses in the relay room shall, in general, be mounted on a separate rack adjacent to the power rack or racks. This rack shall also have power buses at the top portion so arranged that all secondary voltages of the track transformer and signal lighting transformer will be available and it shall be possible to change the voltage supply to any individual function without disturbing any connection other than the one being moved. Fuse alarm relays and relating equipment may be provided on this rack.

Working drawings of the equipment and the detail wiring plans should show which fuses will be required.

Where required, resistors shall be furnished with approved mounting blocks. Where a number of 12-24 volt D.C. relays receive energy from one (1) transformer-rectifier unit, resistors are required for the individual control circuits to prevent excessive drop in rectified voltage in the event that one of the branch circuits becomes short-circuited. Individual current-limiting resistors shall also be provided to protect all 12-24 volt D.C. circuits which break through equipment located in the trackway.

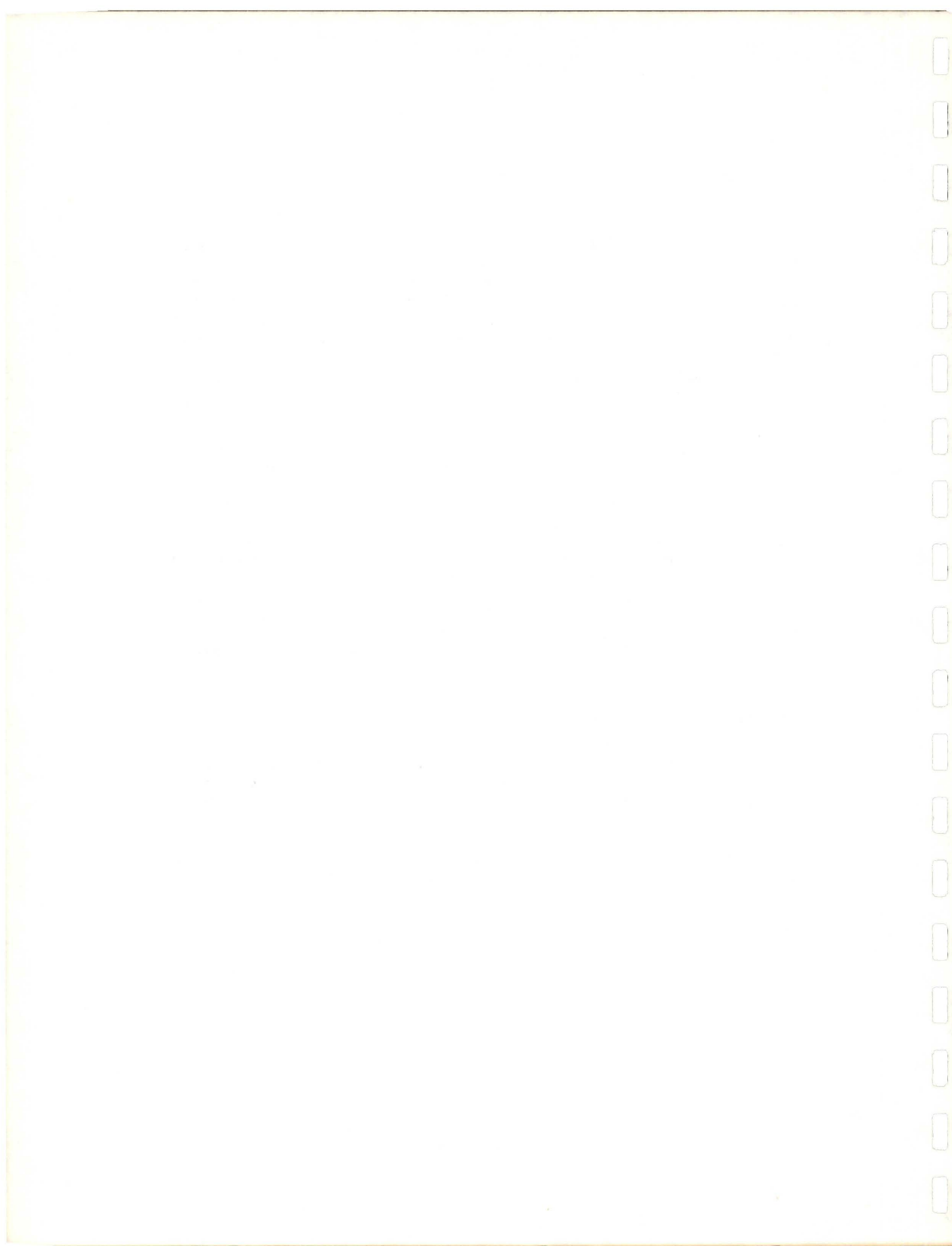
XXI - MISCELLANEOUS CIRCUITS

At certain locations shown on the drawings, special circuits to meet unusual conditions are called for; in these cases, furnish the equipment which is necessary to meet these conditions.

Indicator and alarm circuits of various kinds shall be in accordance with specified requirements.

XXII -CAPACITANCE

All equipment required to neutralize capacitance effects due to 60 Hz A.C. circuits in the cable runs should be provided.



Chapter 3

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Chapter 3

SIGNALS

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Chapter 3

SIGNALS

I - FURNISHING SIGNALS

A. GENERAL REQUIREMENTS

The signal layouts should be shown in symbol form on the general signal arrangement plans. The symbols, with their indications and aspects should be listed on these drawings.

Signals shall be similar to and interchangeable with the latest type of signals installed elsewhere on the railroad system. Signals shall be adaptable for mounting either on columns, on concrete walls, on ceilings, on terminal compartments, on cases, on pedestals or horizontally from the station canopy, as required.

All signals shall be completely equipped with lamps, lamp receptacles, lenses, transformers, terminals, terminal boards, number plates, end plates, poles, ladders or pole steps, and bases, as required. The signal light cases shall be cast iron or cast aluminum. The signals shall be internally wired so far as possible and practicable. All signals shall be equipped with a hinged door on the back. Each signal head shall be ventilated by two (2) openings in the door. These openings shall be covered by a fine mesh brass or copper screen for cast iron cases and aluminum mesh for cast aluminum cases and these openings shall be hooded to prevent entrance of moisture. Doors shall be capable of being secured by padlocks or snap hooks and the locking arrangement of the doors shall be such that the door cannot be locked until fully closed. All doors for signal heads shall have a stop that will prevent them from swinging out where they may be struck by a passing train. Lamp compartments in signal cases shall be separated from each other by partitions which will prevent the passage of light between compartments. Compartments shall be of such size as to provide ample space for lamps, lamp receptacles, transformers, and such adjusting devices as are necessary in connection therewith. All signal shall be designed with regard to voltage and power ratings of the lamps and shall have such lens arrangements as will provide satisfactory indications. Enameled number plates one-sixteenth (1/16)

inch thick shall be furnished complete where required. All unused threaded openings on signals shall be suitably plugged with pipe plugs.

Signal lenses for subway-type signals shall be A.A.R. Signal Section Standard, not less than five (5) inches in diameter. All signal lenses shall be secured to the signal head in a manner such that their removal will not affect the adjustment of lamp receptacles. Signals shall be equipped with back lights approximately one-quarter (1/4) inch in diameter. The back lights shall be placed opposite the respective lenses and shall be frosted white glass behind the green and yellow lenses and red glass behind the red lens.

Signal lenses for outdoor type signals shall be A.A.R. Signal Section Standard, not less than five and one-half (5-1/2) inches in diameter with doublet lenses not less than six and three-eighths (6-3/8) inches in diameter, and shall be secured to the signal head such that their removal will not affect the adjustment of lamp receptacles. All lens openings and openings for "GT", "ST" and "Track Indicator" indications shall be equipped with approved hoods to prevent, so far as possible, interference from the sun's rays. Hoods shall be the standard four (4) or nine (9) inches long. A smaller hood shall be provided for the call-on unit at home signals and on any other units where the standard hood interferes with the motorman's view of the lens. Signals shall be equipped with back lights approximately one-quarter (1/4) inch in diameter. The back lights shall be placed opposite the respective lenses and shall be frosted white glass behind the green and yellow lenses and red glass behind the red lens.

In general all signals, except marker signals, shall have a full complement of lenses, lamps, lamp receptacles and transformers. Blank out, in an approved manner, unused lens compartments. Marker signals shall be equipped with lenses, lamps, lamp receptacles and transformers in the upper and lower lamp compartments only. The middle lens space of marker signals shall be blanked out in an approved manner.

B. AUTOMATIC BLOCK SIGNALS AND INTERLOCKING APPROACH SIGNALS

Automatic block signals and interlocking approach signals shall have openings for three (3) lenses and shall

be equipped with an enameled number plate in the front. The three-light cases shall contain red, yellow and green lenses.

Approach signals shall have an enameled plate one-sixteenth (1/16) inch thick, bearing the letter "X" over its interlocking control number. The plate shall be fastened to the track side of the signal when vertically mounted, and to the underside when horizontally mounted.

In general, the enameled plate bearing the location number shall be mounted on the front of the number plate compartment of each automatic and approach signal. At signals equipped with allowable speed limit indicators, as described elsewhere, the number plate shall be mounted as shown on the drawings.

Automatic block or interlocking approach signals shall be adapted for suspension horizontally from a beam or the subway ceiling if they are located over a station platform. Signals adapted for horizontal suspension shall be designed for clamping to the beam or shall be furnished with either two (2) inch elbows and plates for holding the signal in an upright position, or two (2) inch flanged elbows mounted on the ends of the signal unit. In addition, each signal adapted for horizontal mounting shall be equipped with a ladder support bracket fastened securely to the signal unit. Horizontally mounted signals shall have door hinges equipped with pins and cotter pins and should have doors hinged on top so the door opens upward.

C. INTERLOCKING HOME SIGNALS

Interlocking home signals shall be made up in the form of two (2) three-light cases and one (1) one-light case having a yellow lens for call-on or special route indication. The three-light cases shall be the same as the automatic block signal described above and the one-light case shall be similar thereto in design and arrangement of interior fittings.

In general, the enameled plate bearing the location number shall be placed under the lower lens in the upper three-light case. At signals equipped with allowable speed limit indicators, as described elsewhere the number plates shall be mounted between the two (2) three-light cases.

An enameled plate bearing the letter "X" and its interlocking control number shall be placed under the lower lens in the lower three-light case.

The interlocking home signal when used for a single route shall be made up in the form of two (2) three-light cases and one or more one-light units. Both of the three-light cases shall contain red, yellow and green lenses.

Provisions shall be made for the mounting of a stop release contactor for each interlocking home signal, except home signal repeaters.

D. MARKER SIGNALS

Marker signals shall be similar to automatic signals except that the lens combination shall be upper lens red, middle lens compartment blank, and lower lens red.

An enameled number plate containing the letter "X" shall be mounted in the space under the lower lens.

In addition, an enameled number plate containing the location designation shall be fastened to the track side of each marker signal.

E. REPEATER SIGNALS

Repeater signals shall be of the same design, and shall repeat all of the aspects of their respective principal signals. All doors of repeater signals shall be equipped with ninety (90) degree door stops.

F. GRADE TIME CONTROL

Certain signals shall be equipped with grade time (GT) control and shall have an additional indication referred to as a "Special Signal Indication". Where the grade time signals have two (2)- block control, this adjunct to a principal signal shall consist of an illuminated letter "S" and/or "D", and shall be of such design that when illuminated it will provide a distinct indication at a distance of five hundred (500) feet, and when the

lights are not illuminated the letter "S" and/or "D" shall be as nearly invisible as possible.

If so indicated on the drawings, grade-time signals having single-block control shall be equipped with an illuminated "lunar white" lens which shall provide a distinct indication for the same distance required for the lenses of the principal signal and shall be mounted in a housing similar to that furnished for the call-on signal unit.

G. STATION TIME CONTROL

Certain signals shall have station time (ST) controls and shall be equipped with allowable speed limit indicators in the form of an illuminated numeral. The allowable speed limit indicators shall be located in the space normally occupied by the signal location number plate and shall be of such design that, when illuminated, they will provide a distinct indication at a distance of three hundred (300) feet, and when not illuminated, the indication shall be as nearly invisible as possible. The numeral shall be an easily replaceable stencil. Two (2) lamps shall be located in the compartment behind the stencil in the same manner as the lamps behind the lenses. The stencil shall be protected by a glass plate.

H. TRAIN ORDER SIGNALS

Train order signals shall have the following indications: Upper compartment, blanked out or used for call-on indication, as required. Middle compartment, double lunar white. Lower compartment, double red. Number plate compartment lettered as shown on the drawings.

Train order signals shall be used in conjunction with automatic or interlocking signals and shall utilize the stop employed by these signals. Train order signals may be mounted with the associated signals.

The lenses in the train order signals shall be of such design that when illuminated, they will provide a distinct indication at a distance of five hundred (500) feet. Signal lenses for train order signals shall be of an approved diameter. The sign in the number plate

compartment shall provide a distinct indication at a distance of one hundred (100) feet and when not illuminated the indication shall be as nearly invisible as possible.

The illuminated sign shall be similar in construction to that described for the allowable speed limit indicators.

I. SIGNAL LAMPS, LAMP RECEPTACLES, LENSES AND TRANSFORMERS

The type and arrangement of all lamps and lamp receptacles to be used behind lenses shall be as follows. Two (2) lamps shall be mounted behind each lens. Current for the signal lamps shall be taken at approximately 7 volts from individual transformers for each lamp compartment mounted in the signal head. Lamps for the indoor signals shall be 5 watt, 10 volt, bayonet base, and 25 watt, 10 volt, bayonet base for outdoor signals. Each signal should be fully equipped with the required number of lamps.

Lamps shall be mounted in receptacles so designed that proper relation of lamps to lens can be readily made and maintained. Receptacles shall be so designed that they will prevent the lamps from coming loose due to vibration or any other cause. Lenses shall be uniform in hue and saturation for the respective colors. The lens arrangement of the signals shall be such that from an approved height above base-of-rail, a distinct and unmistakable aspect will be given by each lens under the most adverse operating conditions prevailing on the railroad at a distance of one thousand (1,000) feet in the case of automatic block, home and approach signals and five hundred (500) feet in the case of dwarf and marker signals.

The sighting distances required for special signals shall be given under their respective descriptions.

All material, including shims or special offset brackets, required to properly focus and align the signals both horizontally and vertically in order to obtain the proper sighting distances shall be utilized.

The type of transformer furnished and the manner of

mounting the transformers in the lamp compartments shall be as approved. The transformer shall be furnished without voltage taps, shall be rated for operation on 60 Hz energy, and shall have a voltage ratio of 120/10. Lamp transformers shall be fused. These fuses shall be in centralized locations.

J. SIGNAL NUMBER PLATES

Number plates for signals shall be enameled sheet steel. The enamel shall be of the best quality and the colors shall be guaranteed fast. The enamel shall be baked on the sheet steel in such manner as to insure that every part of the metal has a smooth, durable and permanent covering, free of any imperfections. Number plates of repeater signals shall bear that portion of the number which refers to the station location of the repeated signal under the letters "REP".

All number plates which are an integral part of signals and are fastened to the signal, shall have black letters or numbers on a white background.

Signal number plates shall be provided for all signals furnished.

Enameled number plates to be attached to the front of the number plate compartment or the side of the signal shall be installed in the factory.

K. SIGNAL LADDERS AND POLE STEPS

Ladders or pole steps shall be provided for all signals installed, where the center line of the uppermost lens is more than six (6) feet above base-of-rail. A portable ladder shall be furnished at each station platform where signals are located over a station platform.

L. MOUNTING ON TERMINAL COMPARTMENTS AND CASES

Signals mounted on cases or terminal compartments shall be suitably equipped at the bottom to fit the top of the terminal compartment or case. If required, the top of the signal unit shall be equipped with an end cover plate suitable for ladder support.

M. PEDESTAL MOUNTING

The support for pedestal mounted signals shall consist of an approved steel pipe post suitably equipped at the top to accommodate the signal unit and provided at the bottom with an approved base. If required, the top of the signal unit shall be equipped with an end cover plate suitable for ladder support.

II - INSTALLING SIGNALS

(a) All signals and, if required, their repeaters shall be installed at locations approximately as shown on the drawings. The signal layouts should be shown in symbol form on the general signal arrangements plans. The symbols, with their indications and aspects are to be listed on drawings. The exact locations of the signals will be designated in the field by the Engineer. Signals shall be mounted at a height in accordance with Guidelines, or as approved. Marker signals at bumping post locations shall be installed three (3) feet in approach to the fixed stop.

Install all required materials to properly mount signals as mentioned hereafter.

The signal lamps may be shipped separately and installed after the signal heads have been installed in the work. The enameled number plates, intended to be attached to certain signal heads by means of brackets, may be shipped separately and installed after the signals have been installed in the work.

The enamel plate bearing the letter "X" over the interlocking control number for approach signals shall be fastened to the track side of the signal when vertically mounted, and to the underside when horizontally mounted.

Install the required fuses for signal lamp transformers in centralized locations.

Drill, cut and shape the ladders to fit the various signal mounting conditions in the field.

All unused threaded openings shall be suitably plugged with pipe plugs.

In general, the installation of the signals come under the following types of mountings:

(1) Mounted On Terminal Compartments Or Cases. The signal unit and, if required, the steel pipe post shall be mounted on a cast-iron case or terminal compartment.

(2) Column Mounted. In general, signals shall be column mounted where columns are available. The signal shall be attached to the column by means of approved cast-steel column clamps. Where signals are mounted on columns in curtain or side wall construction, it will be necessary to chip out concrete about the column for the installation of the cast-steel column clamps. Refinish the wall disturbed by the installation of the signal.

(3) Wall Mounted. Signals shall be wall mounted, where columns are not suitably located. The signals shall be attached to the concrete wall by means of bolts and "slug-in" type anchors. Wall mounted repeater signals shall be supported by angle brackets, the angle of which shall be adjustable and suitable for the proper radius of the curve on which the repeater signal is located. Filler blocks shall be installed between the signal head and the wall, as required, to provide sufficient space for the full opening of the case door. Where signals are wall mounted it may be necessary to recess them into the concrete wall to provide sufficient train clearance.

(4) Pedestal Mounted. Signals shall be pedestal mounted where column or wall mounting is not practicable. Pedestals shall be attached by means of bolts and "Slug-in" type anchors. After installation, the bottoms of pedestals shall be grouted. In certain special locations the pedestal may require concrete bases for mounting. In such cases the surface under the base shall be roughened to insure bonding of the concrete base thereto; the pedestal anchor bolts shall be cast in the concrete base.

On type III track, signals mounted on pipe pedestals shall have the base of the pipe pedestal attached to steel supporting platform by means of bolts.

Furnish and install the steel supporting platforms (where required) complete, including all mounting and fastening materials, assemble and install the equipment and furnish and install all mounting and fastening

materials, assemble and install the equipment and furnish and install all mounting and fastening materials required for mounting the equipment to the supporting platform or structure including shaping and drilling the ladders as required. The lengths of poles furnished for signals will, in general, be greater than required and shall be cut to the proper lengths in the field so that the height of the signal head will conform to that shown on the drawings. Install pole steps on the poles where required.

(5) Signals Located Over Station Platforms. Signals located over station platforms shall be vertically or horizontally mounted. Vertical signals shall be installed only where it is impracticable to install horizontally mounted signals and in such cases they shall be mounted on pedestals. If the pedestal mounted signals are to be installed on concrete station platforms, they shall be attached to the concrete base by means of slug-in type anchors. Where aspects of vertical signals installed in the station may be obscured by passengers, a repeater signal shall be installed. Approved brackets both for support and storage of portable ladders for pedestal or horizontally mounted signals installed over station platforms shall be utilized. Means shall be provided for locking the portable ladder when not in use.

Outdoors, horizontally mounted signals shall be suspended from the framework of the canopy by means of suitable plates or brackets. In certain cases, signals shall be mounted on pedestals.

In the subway, horizontally mounted signals shall be clamped to the underside of a cross beam where the minimum permissible headroom is available, or if the headroom for cross-beam mounting is less than the permissible minimum then the signals shall be suspended from the ceiling by means of rigid steel conduit and malleable iron pipe flanges attached to the ceiling with bolts and "slug-in" type anchors. Union fittings shall be used to permit a horizontally mounted signal to be disengaged from the supporting conduits.

A minimum headroom of seven (7) feet six (6) inches shall be provided between horizontally mounted signals and station platforms. Where signals mounted over or on station platforms interfere with existing fixtures, signs, etc., relocate the lighting fixtures, signs, etc., complete

including wiring, conduit, etc.

(b) Number plates and signs shall each be fastened to the signal head or brackets, as applicable, by four (4) brass screws, with lead and brass washers under the screw heads and under the enameled plate. The lead washers shall be installed adjacent to the enamel. The arrangement for fastening the number plates and signs shall be such that they will not become loosened from vibration. Enamel number plates fastened to signals by means of brackets may be shipped separately and installed after the signals have been installed in the work.

Certain signals may require shields to be mounted adjacent to the signals in such manner as to prevent the aspect of a signal on one track from being visible on an adjacent track. Shims or special offset brackets, required to properly focus and align the signals both horizontally and vertically in order to obtain the proper sighting distances shall be utilized.

Iron grab handles, if required, to provide a hand or armhold shall be incorporated.

Where signals are located over a duct bench, and handrailing is required in the vicinity of the signal location, attach the ends of the handrail to the wall.

Chapter **4**

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Chapter 4

SIGNS, STARTING LIGHTS AND HOLDING LIGHTS

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Chapter 4

SIGNS, STARTING LIGHTS AND HOLDING LIGHTS

I - FURNISHING REFLECTORIZED SIGNS

(a) General Requirements. Signs shall be furnished as indicated by the drawings. All signs, dimensions, legends and backgrounds shall conform to the latest guidelines. Drawings shall be submitted for approval, showing the signs to be furnished and the details of their method of installation.

(b) Fabrication of Signs. All reflectORIZED signs shall be fabricated from wide angle flat top reflective sheeting, film, and transparent color. All processing shall be performed in accordance with the recommendations of the manufacturer.

All sheeting shall be vacuum applied to degreased and etched sixty-three thousandths (0.063) inch aluminum. Aluminum shall be punched or drilled and cut to size prior to application of sheeting. Signs shall be given two coats of clear finish.

All signs shall be furnished complete with all material, including bolts, bases, poles, pole steps, washers, supporting brackets, angles, straps and clamps for fastening signs to pedestals or structures as required. Back plates shall be furnished where two or more signs are fastened to the same bracket.

The arrangement for fastening signs designed for mounting on two (2) inch diameter pipe pedestals equipped with bases to be bolted to the structure, shall be such, that they shall not become loosened by vibration.

Signs shall be designed for mounting at a height above the base-of-rail in accordance with typical drawings.

II - INSTALLING SIGNS

(a) General Requirements. Signs shall be installed as indicated by the drawings. Where practicable, signs shall be installed so that they may be serviced from the walk level without the use of ladders or pole steps. They

shall be mounted at a height above the base-of-rail in accordance with the Guidelines.

(b) In general, signs shall be mounted by means of brackets attached to columns or slugged into the structure. Where this type of mounting is not practicable, the signs shall be mounted on two (2) inch diameter pipe pedestals. The installation of the pedestals shall be similar to that specified for pedestals for signal mounting. The arrangement for fastening signs shall be such that they shall not become loosened by vibration. All signs shall be installed complete with all required mounting and fastening material.

(c) Signs mounted on two (2) inch diameter pipe pedestals equipped with bases, shall on Type III track, be bolted to the structure. Two (2) of the four (4) bolts in the base shall be passed through a tie or stringer supporting the footwalk planks. The remaining bolts shall be passed through foot walk planks. Angle washers fabricated from 2" x 1-1-2" x 1/8" iron shall be used on the underside of the footwalk planks and stringers. If required to provide proper clearance, catwalk handrails shall be offset. The arrangement for fastening signs shall be such that they shall not become loosened by vibration.

III - FURNISHING TRAIN STARTING LIGHTS

New train starting lights shall be furnished and installed at locations as specified. The new train starting light unit shall consist of the fixture mounted on a 4" x 4" x 2" outlet box fastened to the ceiling.

A minimum headroom of seven (7) feet six (6) inches shall be provided under the lights to the station platform. The exact location of the new starting lights will be designated in the field.

The starting lights shall be controlled from a starting light control box on the Dispatcher's track indicator panel and if required from an auxiliary control panel desk as shown on the drawings.

IV - INSTALLING TRAIN STARTING LIGHTS

The installation of starting lights shall be such that they will not interfere with the motorman's view of the horizontal signals, and in addition, starting lights shall be readily visible to the Conductor. Any signs, lighting equipment, etc., that interfere with the viewing of the starting lights shall be relocated.

The starting light units furnished under this contract shall be installed complete with three (3) 36-watt, 130-volt, ceramic amber lamps and all necessary mounting and fastening materials.

Install all new wire, cable and conduit for the control of the starting lights as indicated on the drawings.

V - FURNISHING AND INSTALLING DISPATCHER'S STARTING CONTROL BOX

Starting lights, holding lights and "Next Train" signs shall be controlled from an approved starting light control box on the Dispatcher's desk and from the control panel.

Furnish the Dispatcher's starting light control box complete with approved switches and approved illuminated indicators. Where the circuits require a three (3) position switch on the Dispatcher's control box, such switch shall be toggle type micro-switch. The control box shall be factory assembled and internally wired to the extent practicable.

Install the starting light control box and all new wire, cable and conduit required.

VI - FURNISHING AND INSTALLING MAINTAINER'S WARNING LIGHTS

Furnish and install approved type light fixtures at locations as indicated on the drawings. The manner and method of mounting shall be as approved. Lamps shall be included with the fixtures and shall be yellow, 36 watt, 120 volt as are used in holding or standing lights.

Chapter **5**

100-100000

Chapter **5**

AUTOMATIC TRAIN STOPS

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Chapter 5

AUTOMATIC TRAIN STOPS

1 - FURNISHING AUTOMATIC TRAIN STOPS

(a) General Requirements. Automatic train stops shall be furnished for the various signal locations as shown on the drawings. Automatic stops shall be of the all-electric type.

The stop layout shall be arranged with the stop arm mounted near the right-hand rail looking in the direction of traffic, for right-hand tripping and conversely for left-hand tripping. All parts of the mechanism cases mounted between the rails and connections shall be at least one-half (1/2) inch below the plane of the tops of the rails.

Housing and covers for automatic train stop mechanisms shall be cast-iron.

(b) Layout Includes. The stop layouts shall include, as required for the particular location involved, stop mechanism complete, stop arm, bearings, connecting links, bearing strap, stop arm hold-down hook, spring mounting facilities and universal joint or other approved coupling for all electric type, and all other material required to make a complete installation in accordance with the typical drawings.

All stops shall be equipped with a full complement of terminals, tags and all other necessary material. All unused threaded outlets shall be suitably plugged or capped.

(c) Mechanisms, Stop Arms, Bearings, etc. Automatic stop mechanisms shall be designed to clear the stop arm in not more than two (2) seconds on eighty (80) per cent of normal voltage.

Automatic stops shall be so designed that absence of power or failure of any essential part of the mechanism or controlling circuits shall result in the stop arm assuming the "Stop" position.

The stop arm shall be of an approved type and shall be in accordance with typical drawings. Stop arms shall be furnished with adjusting fillers or screws as applicable, for adjusting the height of the stop arm. When in the "Stop" position, the top of the stop arm shall be adjustable between two and one-half (2-1/2) inches and two and three-fourths (2-3/4) inches above the plane of the tops of the rails. When in the clear position the arm shall be at least one-half (1/2) inch below the plane of the tops of the rails. Means shall be provided for adjusting the vertical and lateral positions of the stop arm to compensate for wear in track. The stop arm shall be so designed that the force of a blow on the stop arm will not be transmitted to the mechanism, or cause the stop arm to break.

The driving torque and return spring torque developed at the stop shaft shall be of an approved value. Lubrication of the bearings of the automatic stop shaft shall be by means of pressure grease fittings.

Stop mechanisms shall be provided with a removable cable entrance to permit changing out a stop mechanism without disconnecting wires from the circuit.

Each stop shall be equipped with means for fastening the stop arm in the clear position in case of failure of the mechanism or for any other reason. This device shall be sufficiently strong and positive in action to hold the stop arm clear under all conditions and shall be so designed that when not in use it will not interfere, under any conditions, with the normal operation of the stop arm, or come in contact with the rail or rail connections. The stop hold-down hook shall be so designed that when the stop is "hooked down" in the clear position, energizing the stop will not cause the hook to become disengaged from the stop arm. Bolts for the hook shall be so designed as to insure the proper functioning of the hook and to prevent premature failure due to wear, corrosion or vibration.

Stop layouts shall be so designed that they may be adjusted to track construction using tie plates of a different thickness without requiring the replacement of stop bearings or moving the stop mechanism.

In general, stop mechanisms will be mounted on the ties between the rails. At certain locations, where it is impracticable to install standard layouts, furnish special layouts to suit the conditions encountered. At certain locations the stop layout may require a connecting rod with a remote stop arm.

(d) The all-electric stop circuit breaker, its method of operation and type of contacts shall be as approved.

The motor and any coils or capacitors located in the stop mechanism cases shall be encapsulated to prevent the entrance of moisture.

The mechanical construction and the electrical parameters of capacitors and resistors mounted in the stop mechanism cases shall be as approved.

All-electric stop mechanism cases shall be equipped with spring mounting facilities. The stop shaft shall be equipped with a universal or other coupling. An approved bearing arrangement shall be installed in the bearing strap. Drawings showing the method of mounting the stop mechanism and the coupling and bearing arrangements shall be submitted for approval.

(e) Miscellaneous, All terminals in stop mechanisms shall be numbered with stencils, plastic markers or in another manner so as to correspond with the wiring diagrams.

At each automatic and approach signal location, provide an approved type insulated joint marker plate to identify track circuit limits for motormen. Insulated joint marker plates shall be installed on the top of the third rail protection board by means of brass screws.

II - INSTALLING AUTOMATIC TRAIN STOPS

(a) All new automatic stops at automatic and approach signals shall be installed in such position relative to the signal and insulated joint as will provide for automatic key-by. Automatic train stops shall be installed at locations approximately as indicated on the drawings. The exact locations will be designated in the field by the Engineer.

At certain points where the railroad is equipped with steel emergency and/or guard rails, the steel rail shall be cut and the ends beveled to clear the stop mechanism and shaft, etc., where required.

At such locations, where the steel emergency rails have been cut and these emergency rails are required to be a part of the negative rail system, install two (2) 500 MCM insulated jumper cables in order to provide a continuous negative return system.

Make adjustments, as required, to provide clearance for the stop arm bearing layout, and to maintain the required vertical distance between the stop arm and the top of rail.

Take all necessary precautions to insure that the stop layout does not come in contact with the rails or tie plates.

Where signals are located close to the point of a switch, and there is interference between the automatic stop layout and the switch plates, it may be required to modify the switch plates and/or provide special brackets or other facilities to install the automatic stop layout.

Build and use an approved template or gauge when setting the stops.

Install all required conduit, brackets, Cordura hose, riser boxes and foundations or couplings, mounting and fastening material and all other material required to make a complete stop layout. Install cable to the automatic stop in conduit.

If any stop location selected required a slot in the roadbed and/or toe bench for the installation of the stop layout, cut the slot and finish the sides and bottom of the slot.

Replace the ties and perform any other work necessary to accomodate the stop layout.

III- FURNISHING STOP RELEASE CONTRACTORS

(a) General Requirements. Stop release contactors for the automatic train stops shall be furnished for each interlocking home signal. The releasing device, when operated with the "Call-on" signal displayed, shall cause the stop arm to assume the clear position.

(b) Construction. The releasing device shall consist of a cast-iron box housing a circuit controller held in a normally open position by a combination of counterweight and retention spring, and be further equipped with an operating handle. The releasing device shall be of substantial construction and so designed that the normally open contacts shall be closed only upon manipulation of the operating handle, and the contacts will be positively restored to the normally open position after operation, this to preclude the necessity of any additional circuit check on the integrity of its operation. The design of the releasing device shall be such that it can be readily disconnected from the conduit line and easily removed for replacement. Unused conduit outlets shall be suitably plugged or capped.

IV - INSTALLING STOP RELEASE CONTRACTORS

Stop release contactors shall be located at each interlocking home signal. At outdoor home signals, the stop release contactor will be mounted on a bracket cantilevered off the home signal head. Where this is impracticable, the stop release contactor will be mounted on a pedestal. Where required, a conduit connection shall be provided between the stop release contactor and the signal for the accommodation of control wires. The release shall be mounted with the operating handle exposed to the full view of a motorman and located at a height and distance which can be reached by the motorman without leaving his cab. The release shall be located from two (2) to five (5) feet in approach to the signal. In the subway, when the distance between the stop release contactor and the side of the train exceeds twenty-four (24) inches, furnish and install an extension arm on the contactor, so that the motorman may release the stop without leaving his cab. These extension arms shall not be installed on contactors located over high benches or at other locations where they might cause injury to persons. The release shall be fastened to the subway structure by means of bolts and "slug-in"

type anchors where mounted on a flat wall or on special brackets or column clamps where column mounted. Where contactors are mounted on columns in side wall construction, it will be necessary to chip out concrete about the column for the installation of the column clamp. In certain cases where the stop release contactors are wall mounted, it will be necessary to cut out concrete so that the box may be set into the wall in order to prevent interference with the visibility of the signal head. Where home signals are mounted on station platforms, the stop release contactor shall be mounted in an approved manner.

Where a route request telephone is at a home signal, the stop release contactor, if practicable, shall be combined with the telephone box and mounted on the same support in an approved manner.

V - FURNISHING AND INSTALLING FIXED STOP ARMS

(a) Fixed stop arms shall be furnished and installed at locations approximately as indicated on the drawings. The exact location will be designated in the field by the Engineer. Fixed stop arms shall be arranged for mounting near the left-hand or right-hand rail to correspond with the location of automatic stop arms. The fixed stop arms shall be of the same size and arranged to occupy the same position as the automatic train stop arm when in the tripping position. The fixed stop shall be arranged so the top of the stop arm shall be adjustable between two and one-half (2-1/2) inches and two and three quarters (2-3/4) inches above the plane of the tops of the rails. Furnish the fixed stop arms complete with brackets, mounting and fastening materials.

VI - FURNISHING AND INSTALLING SNOW MELTERS FOR AUTOMATIC TRAIN STOPS

At locations as specified snow melters for automatic train stops consisting of heating units shall be furnished and installed on stop layouts in the outdoor portion of the railroad.

The purpose of these units is to keep the stop free and clear of snow and/or ice to the extent necessary to permit free and unobstructed operation under all weather conditions.

Furnish and install all material, cable, conduit, junction boxes, concrete foundations, etc., required to make complete automatic stop snow melter installations. The connections between the flexible leads of the stop heater and the control cable shall be housed in a junction box. Each heater shall be individually fused.

The heating element shall be so designed that when the individual heating element is connected across a 125 volt 60 Hz source, it will consume two hundred (200) watts continuously.

The manufacturer, after completing the assembly, shall form the tubing.

An Inspector shall have free access to the manufacturer's plant, or elsewhere, in order to inspect the material at any stage of production and for the final inspection and tests.

Chapter 6

In general, the control boxes shall be mounted on steel platforms. External shock mountings of an approved type shall be furnished for each switch snow melter control box.

Switch snow melter control boxes shall be painted.

X - INSTALLING SWITCH SNOW MELTER CONTROL BOXES

Sheet metal housings equipped for use as switch snow melter control boxes shall be installed where required. The maximum distance between the control boxes and the snow melters shall, in general, be fifty (50) feet.

Install the boxes and such materials as usually supplied by the manufacturer. Furnish and install all other necessary mounting and fastening materials including connecting conduit, conduit fittings, clamps, nipples and supporting brackets necessary to adapt the boxes for mounting at any location.

Switch snow melter control boxes shall be mounted by means of brackets attached to supporting steel and the supporting steel bolted to steel platforms.

The snow melter heater elements shall be energized from the contact rail. A negative rail connection shall be provided for each snow melter control box. The connection shall be by means of a rail clamp. The size of the wire for the connection between the contact rail fuse box and the control box depends upon the number of heaters controlled.

All electrical connections between control box and each heater element flexible lead shall be made with No. 6 A.W.G. cable. The connections between the flexible leads of the switch snow melter and the No. 6 A.W.G. wire from the snow melter control box shall be housed in a conduit or junction box.

XI - FURNISHING CONTACT-RAIL FUSE BOXES

Contact rail fuse boxes associated with contact rail indicator cases shall be equipped with fuse clips for

0-30 ampere, 600 volt spacing and with the required fuses. Contact rail fuse boxes, associated with control boxes for controlling snow melters for one (1) or two (2) switches, shall be equipped with fuse clips for 61-100 ampere, 600 volt spacing. If the control box controls the snow melters for three (3) or four (4) switches, the fuse clips shall have 101-200 ampere, 600 volt spacing.

Right angle brackets shall be furnished to fasten the contact rail fuse box to the contact rail protection board. Right angle brackets shall be provided with insulation on the surfaces of the brackets where the surfaces are to be exposed to the contact rail. Furnish the contact-rail clamps, tapered bronze pins, nipples, fuses, supporting brackets, etc.

XII - INSTALLING CONTACT-RAIL FUSE BOXES

Install contact-rail fuse boxes associated with contact rail indicator housings and with control boxes controlling snow melters.

Install the fuse boxes complete, including internal equipment with fuses, insulated supporting brackets, contact-rail clamp and other materials usually furnished by the manufacturer.

The contact-rail fuse boxes shall be fastened to the contact-rail protection board by means of right angle brackets. Install the contact-rail clamps, nipples, fuses, supporting brackets, etc. and the connection to the clamp shall be made by means of a solderless connector.

XIII - CONTACT-RAIL INDICATOR HOUSING

The contact rail indicator housing shall consist of a single vertical cast-iron instrument case equipped with all internal equipment required to provide contact rail indications. Each contact rail indicator housing shall be equipped with a suitable top and base.

The case shall be arranged for accommodation of shelf-mounted relays, resistors, fuses, terminal boards, and associated equipment required for contact rail power-off indications. All terminals in the 600 volt circuit

shall be equipped with insulating sleeves and caps. The resistance units, their mounting clips and terminal posts shall be provided with an insulating covering.

XIV - FURNISHING INSTRUMENT RACKS

Instrument racks shall be furnished for relay rooms, central instrument rooms, central instrument housings.

Relays shall not be mounted at a height of more than six (6) feet from the finished floor of the room. Finished floors of new enclosures will be of the random access type. The overall height of the rack shall not exceed seven (7) feet six (6) inches and will be dependent upon the height of the room or housing.

In general, the types and sizes of racks furnished shall be as required for the purpose for which they will be used. The width of rack frames and the depth of section used for side rails for rack frames to be installed in central instrument housings and relay rooms shall be of the manufacturers standard.

Rack frames furnished for installation in rooms utilizing a random access floor shall be of such width and depth of side rail section so as to accommodate all required interrack cables and wires within the channels of the side rails of the rack frame. Such cable and wire includes, but is not limited to, multi-conductor number 19 AWG flourocarbon insulated cables, 14 AWG neoprene insulated cables and wires and number 9 AWG neoprene insulated single or multi-conductor wire or cable. The rack shall be designed so that the cables within the channels of the side rails of the rack frames are not crowded and are easily accessible to maintenance personnel.

The arrangement of terminals, plug couplers, relays and other equipment on all instrument racks to be furnished shall be as follows:

- 1) Terminal boards, plug couplers and other terminating devices shall be mounted on the top of the instrument racks. Plug couplers will be used only for connections between instrument racks and the control panel. A.A.R. terminals and miniature terminals as hereinafter mentioned

will be used for connections between racks.

2) Relays and other equipment shall be mounted below terminal boards and plug couplers.

Except as otherwise mentioned herein for plug connected multi-conductor cables, terminal boards will be required on all racks to terminate wires leaving the individual rack. Except as otherwise mentioned, the spacing of terminals on all relay racks shall conform with the A.A.R. Signal Section standards. In general, wiring between pieces of equipment on the same rack will not be required to be terminated other than on the pieces of equipment. The arrangement of the terminal board shall, in general, be in accordance with the manufacturers standards, but may require changes in the location of the terminal boards and the method of terminating wires to meet the requirements of the signaling, the physical layout of signal equipment and the room or case housing such equipment.

If the method of terminating wires for rack mounted relays utilizes a terminal board located directly behind the relays, then all contacts on such relays shall be wired to the terminal board in a uniform manner. Connections between relays, wired in this manner, shall be made by way of the terminal boards. Wiring between such terminal boards and the receptacle portion of plug connectors, described elsewhere herein, shall be tagged at the terminal board only.

The instrument racks shall be fully equipped with the required numbers and types of relays, circuit modules, train identity equipment, transformers, resistors, rectifiers, fuse blocks, self-indicating fuses, terminal board with a full complement of insulated terminals, tags, identification of relays and all necessary equipment and accessories, all assembled and wired as far as possible and practicable. To prevent damage on shipping all relays required on racks shall be shipped separately.

Provide approximately ten (10) per cent, (eight (8) to twelve (12) per cent) spare space and sufficient spare terminals on each group of instrument racks.

Provide means whereby each individual relay rack can be individually grounded to a common ground bus. Means

of insulating the racks from each other and from any supports shall be provided.

In general, instrument racks furnished for new enclosures and housings shall be spring mounted. All material, including the insulating material described above, needed to assemble the several racks one to another to form complete units shall be furnished.

Provisions shall be made on the instrument racks for the installation of the maintenance test telephone equipment. Convenience outlets shall not be provided on the rack frames.

XV - FURNISHING TERMINAL RACKS

All incoming wires, including spare wires, in the relay rooms and central instrument rooms will be terminated on terminals on terminal racks.

XVI - FURNISHING FUSE AND MISCELLANEOUS RACKS

Terminal boards shall be provided at the top front and top rear of the fuse racks for terminating wires entering and leaving the rack.

Terminal boards, with terminals strapped together by copper buses, shall be provided on the lower front portion of the rack. A separate set of bussed terminals shall be provided for each secondary voltage tap of the track power transformer and signal lighting transformer.

Fuses shall be located on the center portion of the rack and the maximum number of fuses on a rack shall be two hundred and twenty-four (224). Where more than one (1) fuse rack is required in a particular enclosure, the number of fuses per rack shall be made as nearly equal as a logical grouping of circuits will permit.

Wiring between fuses and buses shall permit selecting any voltage tap of the associated transformer.

XVII - INSTALLING RACKS

Instrument, power, terminal, fuse and miscellaneous racks shall be installed in central instrument rooms and relay rooms.

Furnish the racks complete including all internal equipment all assembled and wired as far as practicable.

All required relays associated with these racks will be furnished separately for subsequent installation.

Install the racks including any other associated materials as usually supplied by the manufacturer and furnish and install all other material required to make a complete installation.

New racks, in general, will be of the self supporting type and will be designed for mounting on steel supporting braces installed on the concrete sub-floor below the random access floors.

New racks and steel supporting braces shall be installed so that each individual rack shall be insulated from each other and the random access floor. Steel supports for each self supporting rack shall be insulated from each other and from its respective rack frame.

Cable shall enter the racks from below the random access floor. Means shall be provided to suspend and hold cables in place and to provide slack. Each rack shall be individually grounded to a common ground bus. Each common ground bus shall be grounded at not less than two (2) separate points to structural steel.

XVIII - RACK IDENTIFICATION

Where racks are located in rooms, furnish and install an approved metal or plastic identification number plate on the front and rear of each rack and at each open aisle end of each row of racks, identifying the number of the racks in that row. The number plates shall be readily readable.

XIX - FURNISHING INSTRUMENT CASES AND HOUSING EQUIPMENT

A. GENERAL REQUIREMENTS

The equipment referred to in this section shall also apply, where applicable, when such equipment is located in enclosures. Instrument cases and housings shall be furnished complete with all terminal boards, a full complement of terminals, tags, fuses and fuse blocks, plug-in and shelf-mounted type relays, code transmitters, rectifiers, transformers, impedances etc., as required, cable supporting devices, and all other equipment and associated apparatus necessary to adapt the cases and housings to the purpose for which they are to be used. Instrument cases and housings shall be delivered complete with plugboards, terminal boards, and all other interior equipment securely held in place to prevent damage in shipment, except where equipment is required to be shipped separately.

Instrument cases and housings shall have terminal boards. Terminal boards shall have a full complement of terminals. Binding posts shall be of the A.A.R. Signal Section standard type, or of other approved design where larger or smaller terminal posts are required, and shall be so mounted on the board as to prevent turning.

In general, relays connected to the contact rail for contact rail indications shall be shelf mounted. Relays in instrument cases shall be on spring or otherwise flexibly supported shelves or racks or, if of the plug-in type, mounted on plug boards. Relays located in central instrument housings shall be of the plug-in type mounted on racks.

B. RELAYS

The types of relays to be used are as mentioned elsewhere.

C. TRACK CIRCUIT EQUIPMENT

C.1 GENERAL

Track circuits shall be 60 Hz matching transformer type. The design and operating characteristics of all track circuit equipment shall be such as to permit using the sizes

and lengths of wire for typical track circuits. The feed end of each track circuit shall be equipped with an individual track feed transformer and the relay end of each track circuit shall be equipped with a track relay matching transformer. Unless otherwise permitted, matching transformers shall not be equipped with taps for regulating the voltage.

Where the location of the track circuit equipment in a relay room, central instrument room or central instrument housing would exceed the maximum distances permitted between the connections to the rails and track equipment, said track circuit equipment shall be housed in an approved cast-iron vertical instrument case.

Matching transformers and track feed transformers shall be designed to provide positive and safe operation of the track relays; these transformers shall not be susceptible to D.C. saturation by propulsion current except as required to prevent deleterious effects of ripple. (Attention is directed to the higher starting current requirements of newer-type cars being operated.)

C.2 TRACK FEED TRANSFORMERS

Track feed transformers shall be of the constant potential type, capable of withstanding the maximum vibration encountered, and shall be air-cooled. The transformers shall be equipped with terminal boards of ebony asbestos, containing terminals for the primary and secondary leads and all taps required. The primary and secondary windings shall be tapped. The track secondary taps shall be arranged to provide for varying the voltage in 1 volt steps up to a maximum of 15 volts, with a primary excitation of 110 volts 60 Hz.

C.3 RESISTORS AND FUSES

Resistors and fuses shall be connected into the now track circuits and shall be of such design and capacity so that they will protect the

transformers and relays against the effect of the propulsion current in the rails and short circuit current between contact rail and signal rails, and also provide positive and safe operation of the track relays. Resistors, fuses, etc., shall be furnished wired into the housing. Fuses shall be mounted in a vertical plane and shall be easily accessible for replacement.

XX - RELAYS

(a) Relays for the controls and as otherwise mentioned, shall be of a design best suited for the type of installation and, in general, shall be of the plug-in type. All relays shall be packaged so as to prevent breakage and shall be shipped separately.

An encapsulated diode arc suppressor shall be furnished and installed for all relays where, arc suppression is required.

(b) In general, the relays to be used in the relay rooms, central instrument rooms and central instrument housings shall be of the plug-in type. Relays of each type shall be uniform in design and contact assembly and shall be interchangeable with relays of the same type used elsewhere.

(c) Relays for the control of signals and signal equipment shall be, in general, D.C. relays capable of operating on a 12-24 volt system. It may be necessary under certain circuit conditions that a D.C. relay be provided with a resistor and/or rectifier to make the relay slow-acting or to minimize arcing. Resistor leads shall be insulated. The D.C. relays shall be biased neutral plug-in relays unless otherwise mentioned herein. Certain D.C. relays shall be of the reed-type as described elsewhere herein.

(d) Track relays shall have two (2) front and two (2) back contacts and shall be of the A.C. two (2)-element type best suited for the length of track circuits and character of track in which they are to be used. Track repeater relays shall be used for signal controls. Track relays shall be designed for 60 Hz. Each track

relay local element shall have its own individual fuse. Plug-in track relays shall not be equipped with a test contact.

(e) Time element relays shall be of the plug-in type. Plug-in time element relays shall be of the A.C. or D.C. type. Any D.C. type plug-in relay to be furnished shall be provided with an approved encapsulated diode type arc suppressor and shall be capable of operating on D.C. directly or by means of coded energy with one (1) code transmitter for a group of time relays. If the proposal is to furnish an A.C. plug-in time relay, it shall be capable of operating on 110 volt 60 Hz. energy and means shall be provided so that the relay will not be retained in its picked up position if the operating circuit is de-energized.

If time relays are operated on coded energy, the code energy wires shall not be longer than necessary to take care of the timing signals in any one (1) group or track. Separate code transmitters shall be used for each group of time control signals and for each track.

Time element relays shall be time-adjustable to meet the signal control conditions. Time relays shall be so designed that a voltage or mechanical variation in the relays will result in the least possible variation in the operating times. Front contacts of time element relays shall be closed only at the end of the adjusted time interval, and back contacts shall be closed upon the de-energization of the relay. Time element relays shall be provided with a special contact which, when closed, shall check the fully de-energized or normal position of the relay.

(f) Reed-type relays shall be incorporated in circuit modules. In general, circuit modules shall be of two types, a "Receive Module" containing reed-type relays, diodes, and capacitors and a "Diode Module" containing diodes. These modules, shall comprise the transmitting and receiving portions of a direct wire reed-type relay control and indication system.

At certain locations, furnish and install plug-in type reed-type relays, each with one (1) "Form A" contact. These relays shall be mounted on instrument or miscellaneous racks.

(g) Relays furnished to provide contact rail power-off indications shall be spring-mounted D.C. relays. These relays shall not be equipped with plug couplers, but shall be equipped with insulating terminal sleeves and caps for the control terminals.

(h) Each switch-operating mechanism shall be controlled by switch-operating and overload relays of the plug-in type mounted in the relay rooms. The relays shall be mounted on racks.

(i) Plugboards for plug-in relays other than the reed-type relays described above, shall be equipped with removable contacts. The wiring to each removable contact shall carry an approved tag indicating its destination, the relay contact number, and nomenclature of the circuit. Plug-in relays shall be mounted on a rack or frame. Each relay shall have individual mountings on the rack or frame.

The wiring between plugboards of the plug-in relays and the terminal boards shall only be that necessary to complete the individual relay requirements. All wires shall be of sufficient length to permit the relays or plugboards to move with freedom. All terminal boards shall be provided with a full complement of hardware and insulated nuts.

(j) Relays shall be uniform in size and contact arrangement and shall have a sufficient number of contacts for the number of circuits to be controlled thereby, with the exception of reed-type relays, plus at least one (1) spare independent front and one (1) spare independent back contact in each relay. Where relays are repeated by additional relays, only one (1) spare independent front and back contact need be provided for the group. Relays and plugboards shall be indexed to prevent insertion of wrong relay type. Relay plugboards in general, are to be furnished wired in the relay racks or cases. Relay covers shall not be capable of supporting combustion and shall be of glass.

(k) All relays supplied shall conform to Part 228 of AAR Specifications.

(l) Complete electrical and mechanical tests shall be made at the factory on all relays to be furnished.

The tests shall be designed to insure that all relays conform to the requirements described. The factory tested relays will be spot checked by a representative.

Except as otherwise mentioned herein, all new relays will also be given performance tests at the site of work in the presence of a representative of the manufacturer before the circuit breakdown test is made. The manufacturers representative shall be fully qualified to make adjustments and repairs, if required, to relays found to be defective.

In general, the performance tests shall be for pick-up, drop-away and for contact resistance, and may also include such other tests as may be necessary. In conjunction with the field tests, records of relay serial numbers and test values shall be made.

Any relay not meeting the relay specifications shall be replaced with one meeting such specifications.

Chapter 8

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Chapter 8

INTERLOCKINGS

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Chapter 8

INTERLOCKINGS

1 - FURNISHING EQUIPMENT FOR THE ALL RELAY INTERLOCKINGS

A. GENERAL REQUIREMENTS

The new interlocking control panel to be furnished shall be the panel type arrangement for route interlocking and shall be complete in all respects including line-of-light indications and pushbuttons necessary for the control and indication of signal apparatus.

The interlocking layout shall be engraved on the face of the control panel.

B. INDIVIDUAL UNITS

The pushbuttons and light indication units on the control panel shall be of the unit type. The term "unit type" shall be understood to mean that each of the above units may be completely and easily removed from the control panel without interfering with the operation of any other unit. Line-of-light units shall also be of the unit type.

The design of the electrical contacts, light bulbs, etc., in the above units shall be such that any circuit or light bulb may be disconnected or removed without disturbing or interfering with other such equipment on an adjacent unit.

C. PUSH BUTTONS

(1) All push buttons on the control panel shall be of the push-pull, turn right, turn left, center return type.

Although in certain applications only the push-pull or only the turn positions of the buttons are utilized, the same type of buttons shall be provided for all applications.

In order to facilitate quick replacement of the push button units, all contacts on each push button shall be connected to the plug portion of ready-disconnect polarized connector in order that all push button units shall be interchangeable, however, only the required wires shall be provided in the wiring tree and connected to the other side of the connector. The plug portion of the connector shall be an integral part of the push button assembly. Each push button contact assembly shall be protected by an approved dust-tight cover which shall be an integral part of the push button, completely enclosing the contact assembly. The material used in the fabrication of the covers shall be such that it will not support combustion.

Where applicable, the same push button shall serve as both an entrance and an exit push button. Signal indication lights shall not be an integral part of the push button but shall be separate spotlights located in the vicinity of the push button. Fleeting shall be established by pushing a button and turning it to the right or left position, as applicable, and releasing the button.

All push buttons shall be equipped with a full complement of contacts.

(2) The button to be used for initiating a route shall be used in the following manner.

To initiate a route when it is desired to set up the route for each train movement - push the button. To cancel - pull the button.

To complete a route to a specified point - push the button at the exit point of the route.

To initiate a route for continuous operation, known as fleeting, push the button and turn in the direction of the route selected. To cancel - pull the button. To cancel the fleeting feature without cancelling the route - turn the button to the position opposite that used to establish fleeting.

(3) Separate buttons, located in rows on the face of the panel, shall be used to provide call-on and route request indications for interlocking home signals. If the home signal is to have a route request telephone installed beside it, the indication lamp on the telephone equipment shall become illuminated when the button is pulled. Inscriptions indicating "Push for call-on" and "Pull for route request" shall be engraved on the face of the control panel.

(4) Auxiliary control of individual switches or crossovers shall be accomplished by means of separate buttons located on the face of the control panel. Turning the button to the left or right position shall control the operation of the associated switch or crossover to the normal or reverse position respectively, in accordance with the circuit requirements. Such auxiliary operation shall remove the control of the switch or crossover from the interlocking route controls and shall cause the illumination of the line-of-light units denoting the position of the switch or crossover. Pulling the button shall restore the control of the switch or crossover to the interlocking route controls.

(5) Where required for traffic control, a push button shall be provided on the control panel for each track so controlled. The right and left positions of the button shall be used for establishing direction of traffic.

(6) A three (3) position brightness switch shall be provided on the control panel to control the brightness of the light indications from "Off" to "Dim" to "Bright", except those light indications in alarm circuits. The controlling device shall have sufficient capacity to provide for future additions to the control panel.

(7) A push button shall be provided for the acknowledgment of the following indications: A.C. power-off, power-off D.C. signal power buses, blown fuse, power-off battery charging rectifier, smoke detector alarms, ground detector alarms and

contact rail power-off. Similar buttons shall be provided for maintainer's call and for telephone ringing.

The acknowledging button to cancel the audible alarm for the sections of contact rail may be the same button as that used to acknowledge the other indications or a separate button.

(8) Push button of the self-restoring type shall be provided on the control panel which, when operated, shall cause an indication light for each switch to be illuminated, indicating the position of all switches within the interlocking area associated with each push button.

(9) A control button with associated illuminated indication shall be provided on the control panel for the automatic interlocking facility, to enable the towerman to place such facility on automatic control.

(10) Push buttons shall be provided for the control of the train starting lights.

D. LIGHT INDICATIONS ON THE INTERLOCKING CONTROL PANEL

(1) All light indications on the control panel shall be by means of clear lamps and colored filters. The lamps for light indications shall be of low wattage type. Flashing light indications shall be flashed at a rate of approximately seventy-five (75) cycles per minute.

The track occupancy light indications on the control panel shall be of the line-of-light type, and shall be energized from a local source over contacts of a track repeater relay or from the track indicating relays.

There shall be not less than four (4) light units to a switch section as follows: One (1) for entrance, one (1) each for the switch points of a crossover or diamond, and one (1) for the exit unit. The exit light unit shall be located adjacent to the exit button for that route.

In addition to the above, there shall be sufficient light units to obtain the proper relation of switches and signals.

Each track occupancy indication light shall consist of a minimum of two (2) light units.

The line-of-light with two (2) colors of light, one white and one red, shall be furnished for each track circuit between the two (2) extreme interlocked signals of each interlocking for the tracks shown on the panel of the control panel. All other line-of-light indications outside the above limits need only have the red light indication.

For any portion of automatic signal territory shown on the control panel, which is not part of any approach locking control, provide track occupancy indications lights for each track as follows: one (1) indication light for the track within station limits, one (1) indication light for the track in approach to the station and one (1) indication light for each nine hundred (900) feet of track, or fraction thereof, between stations.

The section of tracks in approach to the station shall be that section between the entering end of the station and the first signal which cannot be cleared, either by normal control or "ST" control, with the station occupied.

Providing more than two (2) light units for one (1) track occupancy indication to indicate the presence of a train between stations in automatic signal territory will not be necessary. The number of track occupancy indication lights to indicate the presence of a train in these areas shall be reduced to the minimum required.

The circuits will be so designed that white flashes will not appear after a train has vacated a section due to route locking still being in effect.

(2) The signal indication lights on the panel shall be of the spotlight type. The signal indication light shall be located on the panel near the associated entrance button, and shall not be an integral part of the button.

A triangular shaped, green light indicator shall be provided on the control panel near the entrance button from which a route can be fled. The light shall be illuminated when fleeing is in effect.

(3) Spotlight indications shall be furnished near the associated acknowledging or operating button to indicate that the equipment has failed or operated for each of the following: A.C. power-off, power-off D.C. signal power buses, power-off battery charging rectifier, blown fuse, smoke detector alarm and ground detector train starting lights, "Next Train" signs, switch snow melters. Separate spotlights shall be provided to indicate on the control panel that one or more of the above functions, as applicable, has operated at the central instrument or relay rooms.

A bell shall be mounted at a convenient location on the interlocking control panel to call the attention of the operator to the fact that, with the exception of the train starting lights and "Next Train" sign, one or more of the above groups of indications have functioned. A suitable cutout shall be arranged for the bell.

(4) The traffic lever indications required on the control panel shall be in accordance with the manufacturer's latest standard practice and as modified by the circuit requirements.

(5) Lighting shall be provided for the inside of the control machine. The fixture shall be of an industrial type complete with shading device and switch. A duplex convenience outlet of the self-grounding type shall be installed in each section of the machine.

E. INTERLOCKING CONTROL PANEL CABINET

Interlocking control panel equipment shall be enclosed in a suitable ventilated metal cabinet. The cabinet shall have removable panels or hinged doors to provide free and ready access to all parts of the control machine. Sufficient doors or panels shall be provided so that each may be easily removed or replaced by one (1) man. The panels or hinged doors shall be arranged for locking with cabinet locks having a standard key change.

F. TELEPHONES

The interlocking control panel shall be designed to accommodate the telephone equipment. The face of the front panel shall be drilled to support the maintenance test telephone equipment, route request telephone equipment and facilities required for common battery telephone equipment at the control panel, including all jacks.

Telephone circuits shall be terminated on a terminal strip, with an adaptor of sufficient capacity, mounted in the control panel. It is understood that the terminal strip shall be used for communication circuits only. No power circuits are to be terminated on the strip.

The control panel shall also be equipped with 115-volt, 60 Hz. receptacles for energizing the loudspeaking telephones.

The panel shall be furnished with two cutouts to accept loudspeaking telephone equipment.

The locations of the above-mentioned equipment and facilities, on or in the control panel, shall be arranged for maximum operating efficiency during operation of the control panel; and for easy maintenance by Maintenance Forces.

G. METERS

Furnish and install on the control panel a voltmeter which is to indicate at all times the voltage of the storage batteries supplying the switch mechanisms; and a high reading ammeter and a low reading ammeter to indicate the current being delivered by the switch batteries when switches are in transit. The low reading ammeter is to

be connected into the circuit by means of a push button located under the low reading ammeter. The shunts of these ammeters are to be located on the rectifier racks in the relay room.

H. MISCELLANEOUS PROVISIONS

The control panel frame shall be equipped with terminal lugs for the purpose of grounding. Insulating plates, bushings and washers shall be provided for use between the footings and the floor.

A shelf with three (3) pull-out drawers for the use of the towerman shall be provided on the control machine. The panel cabinets shall be completely finished with an enamel or lacquer.

II - FURNISHING LINE-OF-LIGHT INDICATOR PANEL

Furnish an indicator panel, each housed in a cabinet and mounted on the wall, at each remote interlocking, for indications of switches, signals, and track occupancy. The light indications for track occupancy shall be of the line-of-light type and shall indicate, in addition to track occupancy switch position and switch in transit indications.

Line-of-light indications shall be limited to the minimum required. The signal call and clear indications, call-on signal indications, and illuminated indications for alarm circuits shall be of the spotlight type. Provisions for an audible indication for alarm circuits will not be required. Traffic direction symbols and associated illuminated indications shall be provided on the panel for each track signaled with traffic locking controls. A switch shall be provided on the panel that, with the exception of the illuminated indications for alarm circuits, will cut out all light indications on the panel.

III - FURNISHING TRACK OCCUPANCY INDICATOR PANEL

Furnish and install an illuminated track occupancy indicator panel of the spotlight type. A switch shall be provided on each panel that, with the exception of alarm indications, will cut out light indications on the panel.

In each central instrument room, the panel shall be housed in a wall-mounted cabinet. In central instrument housings, the panels shall be rack mounted.

IV - FURNISHING DISPATCHER'S TRACK INDICATOR PANEL

Furnish, for the dispatcher's office, an illuminated track indicator panel to indicate track occupancy. In addition to track occupancy indications, indications shall be provided on the panel to indicate the function of the automatic interlocking. The panel shall be adaptable for mounting on the wall or hung from the ceiling.

V- CONTACT RAIL POWER-OFF INDICATION PANEL

The contact rail power-off indication panel shall be designed as part of the interlocking control panel in the signal tower. The light indications shall be of the "line-of-light" type and shall indicate contact rail power-off indications. There shall be at least two (2) red line-of-light units for each section of contact rail for which indication is provided.

VI - FURNISHING SWITCH REPEATER LIGHT PANEL

Furnish a separate panel board containing lights for switch-in-transit indications in the signal tower relay room.

A light shall be furnished for each crossover or separate switch. The lamp assembly shall be of the spot-light type similar to those used on the control panel for alarm purposes.

The light indications shall be arranged in rows on the face of the panel and shall be identified by white plastic tag with black letters showing the corresponding switch or crossover number and the number of the relay rack upon which the switch control equipment is mounted. The tag shall be fastened with two (2) self-tapping screws.

VII - INSTALLING CONTROL PANEL

The interlocking control panel will be of the panel type arrangement for route interlocking and will be furnished complete with all devices and internal wiring including mounting and fastening materials required to mount the control panel to the sub-flooring of the tower.

The control panel shall be installed in the tower. Install the panel and such materials that are furnished and furnish and install all other required mounting and fastening materials including concrete. The panel shall be insulated from the sub-floor and the random access floor and shall be grounded to the structure. Care must be taken to allow proper fitting of the control panel cabinets and for leveling the entire unit. Cables shall enter the control panel from the bottom. The base of the control panel cabinets shall be even with the top of the random access floor and waterproofing material shall be placed between the top of the access floor and the panel.

VIII- INSTALLING INDICATOR PANELS

Indicator panels, for the various enclosures, will be furnished complete with all devices and internal wiring including mounting and fastening materials.

Panels for relay rooms and central instrument rooms will be designed for wall mounting. The dispatcher's panel will be adaptable for either wall mounting or hanging from the ceiling.

Cables shall enter the wall mounted panels via conduit extending from the bottom of the panels into the random access floor.

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Chapter 9

SIGNAL POWER SUPPLY AND DISTRIBUTION

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Chapter 9

SIGNAL POWER SUPPLY AND DISTRIBUTION

I- POWER SUPPLY EQUIPMENT

A. GENERAL REQUIREMENTS--A.C. SUPPLY

The energy for the signal system shall be obtained from 120 volt 60 Hz power services. Normal and reserve power shall be applied to A.C. buses through automatic transfer panels and the various loads shall be fed from these buses.

The 120 volt, 60 Hz power will be used, in general, as an energy source for the track circuits, signal lighting, light indications for interlocking control panel and indicator panels, the control of all-electric automatic stops, A.C. time relays, rectifiers and charging panels.

Compute the size of the signal power distribution system required to feed equipment being furnished and installed. Compute the complete power calculations and design the complete power layout of feeders, transformers, switches, fuses, buses, locations, and size of individual signal loads. For purposes of computation, it shall be assumed that at any given time one-third ($1/3$) of the automatic stop mechanisms shall be operating and two-thirds ($2/3$) of the automatic stop mechanisms shall be in the hold-clear position. Furnish and install the complete power system for the supply of power from the signal power sources to the signal system, including feeders, mains, buses, electric power transfer switches, disconnect switches rack mounted transformers, ground detector and power-off indicating equipment and associated auxiliary materials and equipment. The signal feeders shall be twin conductor rubber insulated neoprene sheathed cables. One of the two (2) wires of each twin conductor will be distinctly marked as a tracer, and such tracer wires shall be connected in the same manner at all locations.

The size of feeders shall be such as to carry the rated load with a voltage drop of not more than five (5)

per cent, except that no feeder shall be smaller than No. 6 A. W. G. The size of feeders shall be such as to carry a load equal to one hundred and twenty-five (125) per cent of the total load that will be imposed by the portion of the signal system to be fed.

Each feeder shall be of the same size wire from the source of supply to the furthest point of application. In computing the maximum voltage drop specified, the load current at any point shall be assumed to be delivered at 110 volts. Furthermore, the size of the feeders shall be sufficient to carry the emergency load imposed by the clearing of all apparatus obtaining current from the respective feeders within a period of thirty (30) seconds after they become energized.

B. GENERAL REQUIREMENTS--D.C. SUPPLY

D.C. power shall be used, in general, for the control of the signal system as follows: for the signal control relays, switch controls, switch repeater relays, stop repeater relays, vital networks, selection networks, direct wire reed relay systems and track repeater relays. D.C. energy required shall be provided by transformer-rectifiers, some of which shall be in combination with standby batteries. The primary energy for the transformer-rectifiers shall be taken from the 120 volt, 60 Hz A.C. signal buses and the D.C. voltage shall be suitable for the apparatus to be operated. Supply any filtering and/or voltage regulating components necessary for satisfactory operation of the equipment.

Reserve transformer-rectifier units shall be furnished for the D.C. power supply circuits. When suited to the power requirements of the various equipment furnished, one (1) reserve rectifier shall be furnished and installed on an instrument rack for connection into the circuit as a standby for any of several rectifiers.

Where required suitable switchboards arranged with selection switches for the connection of low voltage rectifiers and reserve rectifiers into the buses shall be installed on the racks. The switchboards shall be furnished with ammeters, voltmeters, switches, plugs, etc. Means shall be provided to check that the rectifiers are in continuous operation, and any interruption of the current supplied by the rectifiers shall be indicated on

the control panel.

Plug connectors in lieu of selection switches shall be provided for the connection of the spare low voltage rectifier into the buses.

Instructions for manipulation of switches required to place spare rectifiers in service shall be displayed in a conspicuous place on the power racks.

Wherever there is the installing of rectifiers in combination with batteries, furnish the necessary voltmeters, ammeters and switches. The rectifiers, ammeters, voltmeters, switches, etc., shall be mounted and wired on instrument racks.

Means shall be provided to check whether or not the rectifiers are in continuous operation and, should a rectifier become incapable of supplying the required energy, the fact shall be indicated on a control or indicator panel.

Furnish and install D.C. ground detectors for each D.C. bus or common.

C. CODED ENERGY

The coded energy for the operation of the D.C. time element relays and the flashing lights on the control panel shall be provided by a separate code transmitter. When coded energy is used to release locking of any type or to clear grade time home signals, an additional code transmitter shall be furnished to automatically provide reserve energy for the time element relay that releases the locking or clears the home signal.

For operation of ground detector equipment, coded energy shall be provided by use of a code transmitter. Provision shall be made to indicate the failure of the code transmitter.

The energy for the flashing lights on the indicator panels shall be taken from the same transformers that feed the lights of the indicator panels.

D. TRANSFORMERS-RECTIFIERS

The transformer-rectifiers shall be designed for use on 120 volts, 60 Hz. The transformer-rectifiers shall have suitable taps for voltage and adjustment to provide correct operation of the equipment supplied. Each transformer-rectifier, except transformer-rectifiers used with all electric switch operating batteries, shall be of sufficient capacity, whether associated with a standby battery or not, to carry one hundred and fifty (150) per cent of the full load applied without extreme variations in voltage between one hundred and fifty (150) per cent of full load and no load. In addition, transformer-rectifiers in battery charging service shall have sufficient capacity to recharge the battery within a period of forty-eight (48) hours with the load connected. Combinations of transformer-rectifiers of smaller capacity shall not be furnished to supply any of the above loads.

Transformer-rectifiers in battery charging applications shall be as recommended by the manufacturer of the batteries, and shall be of the battery eliminator type with manual start timer for equalizing charge, equalize pilot lamp and low D.C. voltage alarm relay.

Transformer-rectifiers shall be mounted and wired on the instrument racks.

E. GROUND DETECTORS

A.C. and D.C. ground detectors shall be furnished and installed. These ground detectors shall be so arranged as to detect and indicate, immediately, a ground on the 60 Hz signal lighting transformer-secondaries and a positive or negative ground on the D.C. tower buses and on each D.C. system connected to the common mains. The sensitivity of the ground detectors shall be such as to detect grounds of a relatively high resistance value.

Ground detector equipment shall, to the extent practicable, be mounted and wired on the instrument racks.

A.C. ground detectors shall be capable of being reset locally and, where required, of being reset from remote locations. D.C. ground detectors shall be capable of being reset locally.

The housings for ground detector equipment shall be so ventilated and other provisions shall be so made as to effectively safeguard all apparatus and wiring from the effects of overheating. The devices shall be sealed so as to prevent unauthorized manipulation of adjustments. Ground connections for each system shall be made by means of two (2) separate wires.

II - FURNISHING SIGNAL TRANSFORMERS

A. GENERAL REQUIREMENTS

Furnish all transformers and transformer oil required to feed the loads for the equipment being furnished and installed. The transformers shall be in accordance with the A.A.R. Signal Section specifications for single-phase transformers. Cocks, oil drain pipes and plugs shall be furnished and installed on all transformers larger than ten (10) KVA.

The primary and secondary taps shall be brought to a terminal board mounted inside of the transformer case, and a connection for each secondary tap and two (2) connections for the primary winding shall be brought out of the transformer case to suitable terminals on bushings.

B. TRACK POWER TRANSFORMER

The large track power transformer required to supply power to groups of track feed transformers shall be of the air-cooled type, or oil-cooled type, and shall have a normal primary voltage of 120 volts with taps for 125 volts and 115 volts at full capacity. Taps should be provided in the secondary for 125, 120, 110, 100, 90, 80 and 70 volts output with 120 volts on the primary. The size of the track power transformer shall conform to the general requirements for transformers where they apply.

C. SIGNAL LIGHTING TRANSFORMER

The large signal lighting transformer required to supply power to groups of signal lights shall be similar to the track power transformer. This transformer shall also feed the local element of the track relays, the electric stops and maintainer's call horns. The normal primary voltage shall be 120 volts with taps for 125 volts

and 115 volts at full capacity. The secondary shall supply power to individual signal lamp transformers. However, voltages in one volt steps from six volts to ten volts shall be supplied at the lamps. Therefore, secondary voltage taps shall be provided for 125, 120, 110, 100, 90, 80 and 70 volts output with 120 volts on the primary. The size of the signal lighting transformer shall conform to the general requirements for transformers where they apply.

D. SIGNAL POWER TRANSFORMERS (LINE)

The signal power line transformers required at the locations to energize the 110 volt signal mains shall be of the air cooled or oil cooled type and shall have a normal primary voltage rating of 120 volts and a normal secondary voltage rating of 110 volts. Taps shall be provided in the primary winding for 114/108 volts at full capacity and in the secondary winding for 115/110/105/100 volts with 120 volts on the primary. The signal power line transformer feeding a section of signal mains shall be capable of carrying the entire load of that particular section of mains plus twenty-five (25) per cent but in no case shall it be less than 2.5 K V A. In other respects, the transformer shall conform to the general requirements for transformers where they apply.

E. MISCELLANEOUS TRANSFORMERS

Transformers shall be furnished and installed for the lights on the indicator panels and for the A.C. indication system. The normal primary voltage shall be 120 volts with taps for 125 volts and 115 volts at full capacity.

The transformers for indicator panel lights shall have a nominal secondary voltage rating of 18 volts with 120 volts applied to the primary.

The transformers for the A.C. indication system shall have a nominal secondary voltage rating of 30 volts with 120 volts applied to the primary.

The transformers shall be capable of carrying the entire load called for at the locations, plus twenty-five (25) per cent. In other respects, the transformers shall conform to the general requirements for transformers where they apply.

Miscellaneous transformers shall be mounted and wired on the instrument racks.

F. TRANSFORMER OIL

If oil for the transformers is required, it shall be pure mineral oil, free from moisture, acid, alkali or sulphur compounds, and unaffected by temperatures reached under ordinary operating conditions. The oil shall have a dielectric strength of 22 KV or higher when tested between one (1) inch discs spaced one-tenth (0.1) of an inch apart. The transformer oil shall be delivered to the site of the work in the transformers, or separately from the transformers in sealed containers, in accordance with the recommendations of the manufacturer. The oil shall conform to standard specifications.

III - INSTALLING SIGNAL TRANSFORMERS

Install all signal transformers and transformer oil required in the work. The oil, if required, shall be shipped as hereinbefore mentioned.

Transformers shall be located in enclosures having random access floors.

Furnish and install these transformers including all miscellaneous mounting and fastening material, oil drain pipe and drain cock as required. As soon as the transformers are permanently installed, if the oil is required and is shipped separately, fill them with the oil to the prescribed level in order to prevent moisture absorption by the transformer windings.

Air cooled transformers, because of their higher operating temperatures, shall be located away from control or other equipment likely to be affected by heat, or where persons may come in contact with them.

IV - FURNISHING STORAGE BATTERIES AND ASSOCIATED EQUIPMENT

Furnish nickel cadmium batteries of the central-office type with battery chargers, ammeters, voltmeters, disconnect switches and ground testing equipment. In determining the ampere-hour capacity of the cells to be provided,

the manufacturer's rating for eight (8) hour service on one full charge shall be derated fifteen (15) per cent.

Storage batteries furnished for other purposes than the operation of all electric type switch machines shall be of sufficient capacity to carry one hundred fifty (150) per cent of the normal load of the circuit in which they are installed for eight (8) hours on one (1) full charge.

The storage batteries for the operation of all-electric switch machines shall be of sufficient capacity to operate the switches on eighty (80) per cent of normal voltage in not more than three (3) seconds from the closing of the energizing contacts on the switch control relays to the return of the indication and shall be of sufficient capacity to carry the entire load of the plant for a period of eight (8) hours on one (1) full charge.

The battery cells are to be arranged in trays which shall be mounted on steel racks. Batteries shall be mounted on battery racks having a single tier. An insulated cover shall be furnished to cover the battery cells. Battery filling apparatus for proper battery maintenance shall be furnished for each new room where batteries are required. This apparatus shall include plastic water tank, filler nozzle and hose, battery operated fill level detector (Portable) with shoulder strap, glass tube (with measured markings) to indicate electrolyte level.

Furnish all the above equipment complete including the mounting and fastening material for mounting and fastening the equipment. The batteries shall be fully charged complete with electrolyte properly diluted. Dry charged batteries will not be accepted.

In the relay room where the storage batteries for the operation of all-electric switch machines are located, furnish a voltmeter which is to indicate at all times the voltage of the batteries supplying the switch mechanisms; and a high reading ammeter and a low reading ammeter to indicate the current being delivered by the switch batteries when switches are in transit. The low reading ammeter is to be connected into the circuit by means of a push-button located under the low reading ammeter. The shunts of these ammeters are to be located on the rectifier racks in the relay room.

V - INSTALLING STORAGE BATTERIES AND ASSOCIATED EQUIPMENT

Install and connect the batteries in the racks and furnish and install all necessary mounting and fastening materials. Also install all necessary mounting and fastening materials to properly support the battery filler tank. An insulated cover shall be installed to cover the battery cells. A filling tank and associated apparatus for proper battery maintenance shall be installed for each battery layout.

In the relay room where the storage batteries for the operation of all-electric switch machines are located, install the necessary voltmeters, ammeters, push buttons, shunts, etc.

VI - FURNISHING AUTOMATIC TRANSFER PANELS

Furnish all automatic transfer panels including timers and relays required in the signal work, complete with housings. Cabinets for single location transfer panels shall have the same dimensions as those used for double locations.

The transfer panel shall be equipped with a green indication lamp which shall be illuminated when the normal source is connected to the load and with a red indication lamp which shall be illuminated when the reserve source is connected to the load.

Test pushbuttons for testing the transfer system and voltage sensitive supervisory relays shall be furnished on the panels.

Solid links shall be used in place of fuses.

Time delay relays and cutout relays which will delay the closing of the normal position of the transfer panel after restoration of the normal source of voltage when the reserve position of the transfer panel has been energized shall be furnished on the panels.

The nomenclature of the various instruments shall be attached to the transfer panels and shall be in the form of an engraved laminated phenolic plate. The designation "AUTOMATIC TRANSFER PANEL. SIGNAL", shall be stenciled on

the enclosure of the Automatic Transfer Panel.

Make any and all tests on the transfer panels and associated apparatus which is necessary and required to insure and check the proper functioning of the equipment. Such tests may be required to be made at the place of manufacture or in the field or both.

VII - INSTALLING AUTOMATIC TRANSFER PANELS

The automatic transfer panels shall be mounted on the concrete wall or on a steel framework.

The transfer panel shall be wired by forming the flexible single conductor wire jumpers into suitable bundles and applying spot taping, at four (4) inch intervals. Electrical plastic tape shall be used to form the wires in bundles. Terminations of wires shall be made by the use of bolts, washers and nuts. Terminals shall be pre-insulated with insulated grips. Solder connections will not be allowed. Sufficient slack shall be maintained in all wiring.

VIII - FURNISHING AND INSTALLING

MISCELLANEOUS SIGNAL POWER EQUIPMENT AND MATERIAL

Every effort shall be made to minimize the possibility of grounds or short circuits on the cables or buses energized from the Edison service prior to being isolated by a transformer. Such manner of protection shall include the use of insulated cables and the taping of exposed buses, after all connections have been made, with electrical tape.

In general, the power supply will be furnished to a fused disconnect switch in the signal power enclosures. In such cases, use this disconnect switch as a primary switch and make the electrical connections to it.

Furnish and install disconnect switches, and make the electrical connections to them as well as to the service switches. Fused knife switches shall be furnished and installed to isolate signal power transformers from the A.C. buses.

Furnish and install all mounting and fastening material and all miscellaneous material such as cable taps, insulating covers, cable lugs, copper tubing, copper grounding strip, etc., required in the electrical connection of the equipment.

Rubber mats shall be furnished and installed for new signal power locations in enclosures. The mats shall be three-sixteenths (3/16) of an inch thick and shall be located in front of all power equipment, including automatic transfer panels, transformers, disconnect switches, etc. Where practicable, protective matting shall be installed in a continuous length.

Chapter **10**

Of record

Chapter 10

SIGNAL RAIL BONDING AND CONNECTIONS

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Chapter 10

SIGNAL RAIL BONDING AND CONNECTIONS

I - FURNISHING TRACK CIRCUIT MATERIALS

A. GENERAL REQUIREMENTS

The insulated joints will be provided in place. Furnish all necessary bonds for signal rail joints, switch points, and frogs, and all material required for rail connections. Material for rail connections shall be deemed to include, as applicable for the types of track and rail encountered, solderless rail connectors, compressed terminals, riser boxes including foundations, angle connectors, ebony asbestos tops, conduit, condulets, wire, galvanized brackets, grommets and bushings, complete with fastening materials.

At each automatic and approach signal location, provide an approved type insulated joint marker plate to identify track circuit limits for motormen. Insulated joint marker plates shall be installed on the top of the third rail protection board by means of brass screws.

B. SIGNAL RAIL JOINT BONDS AND SWITCH BONDS

Bonds for signal rail joints, switch points, and frogs shall be stranded bonds, and shall consist of one (1) wire of seven (7) strands, with the center strand copper and the outside strands galvanized steel or all strands copper covered steel. Each strand shall be at least one hundred nine thousandths (.109) inch in diameter. The bonds shall be welded at both ends to galvanized steel pins.

C. SIGNAL RAIL CONNECTIONS

Signal rail connections and rail jumper connections shall be made by means of a solderless connector and tapered pin with elastic stop nut with nylon insert. Material used in rail connection pins shall be Silnic Bronze Alloy No. 647.

II - INSTALLING SIGNAL RAIL JOINT BONDS AND SWITCH BONDS

Install new signal rail joint bonds and switch and frog bonds as required. The bonds shall be so formed and placed as to withstand the wear, tear and vibration resulting from train operation.

Extreme care must be taken to insure that bonds shall be installed in accordance with the manufacturer's instructions. Pin type bonds shall be placed on the outside of the signal rail joint splice bar.

Signal rail joint bonds and switch bonds shall be formed by means of an approved tool specifically designed for this purpose. Holes for bonds shall be drilled into and perpendicular to the web of the rail by an approved rail drilling machine, using a three-eighths (3/8) inch drill. Care shall be used to see that the drills are properly sharpened at all times so that the holes shall not exceed three-eighths (3/8) inch diameter. The bond pin shall be driven into the rail with a three (3) pound hammer immediately after drilling. Where space does not permit the drilling of the hole into the web of the rail, for installation of switch bonds, the hole shall be drilled into the base of the rail.

Test for and clear all grounds on track circuits installed.

III - INSTALLING RAIL CONNECTIONS

Signal Rail Connections. Signal Rail connections for power frequency track circuit shall be made with single conductor insulated stranded copper wires, from the rails to the terminal housings, etc. Separate negative rail connections to track relays and transformers shall be provided approximately opposite the insulated joint; in no case shall they be located farther than fifteen (15) feet from the center line of the insulated joint. Jumper connections shall be made with No. 6 A. W. G. insulated stranded copper wire and shall be installed at rail transpositions, dead rail sections, track special work and elsewhere.

The solderless sleeve of the rail connector and the adapter shall be compressed with an approved sleeve compressing tool.

All necessary facilities and materials for the installation of rail connections, in addition to those mentioned below, shall be furnished.

Signal Rail connection installations are of the following general classifications:

(1) In Type I and III Track. Make the rail connection, including the installation of the PVC conduit, track lead wires, rail jumper wires, Cordura hose, bushing, grommet, and the rail terminal. The PVC conduit for the signal and negative rail connections shall be fastened to the ties by means of approved brackets. Where the track lead exits from an open end of the PVC conduit, a bushing shall be furnished and installed. Where the track lead exits from an intermediate point in the run of PVC conduit, a hole shall be furnished and installed to protect the wire. Conduit for rail jumpers shall not be drilled but shall have a bushing on each end.

Provide ten (10) inches of slack wire between the rail terminal and the grommet or bushing.

(2) In Type II Track. Make the rail connections including the installation of PVC conduit buried in concrete and install approved cast-iron riser boxes with ebony asbestos top and three-quarter (3/4) inch 90° angle connector and nipple. Provide eighteen (18) inches of slack wire in each riser box. Provide slots and cut concrete as required.

In general, one (1) junction box will be required for each two (2) rail connections. For transpositions and single connections to the rail, only one (1) riser box and connection is needed and no junction box is required.

(3) In Type VI Track. In general, track leads and rail jumpers shall be buried in trenches. Install approved riser boxes with ebony asbestos tops and three-quarter (3/4) inch 90° angle connector and nipple, and concrete foundations for the riser boxes. In lieu of a riser box and supporting concrete foundation for each track lead, a signal rail track lead and its associated negative rail track lead shall jointly enter one concrete foundation and riser box. The track lead for the rail

nearest the riser box shall exit from the 90° angle connector and shall be connected to the rail. The remaining track lead shall exit from the side of the riser box and shall continue to the opposite rail in PVC conduit fastened to the tie by means of brackets. A bushing shall be furnished and installed at each open end of the PVC conduit and at the side exit of the riser box. Install the track lead and rail jumper wires, make the rail connection including the installation of the rail terminal, and provide eighteen (18) inches of slack wire in each riser box.

Chapter **11**

11-10-50

Chapter 11

SIGNAL CABLE, WIRE AND MESSENGER WIRE

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Chapter 11

SIGNAL CABLE, WIRE AND MESSENGER WIRE

1 - FURNISHING SIGNAL WIRE AND CABLE

(a) The number of conductors in the cable to be used for multi-conductor signal cable, except track circuit leads, are as follows: 2, 3, 7, 10, 12, 14, 19, and 30. Where a two (2) conductor cable is required, supply either a flat twin or a round cable. Multi-conductor No. 9 A.W.G. cable is required for distributing track circuit energy.

(b) Synthetic rubber insulated multi-conductor cables shall have the following maximum number of working wires and minimum number of spare wires:

<u>NUMBER OF CONDUCTORS</u>		
Total	Working	Spare
7	5	2
10	8	2
12	10	2
14	12	2
19	15	4
30	24	6

Where more than one (1) cable is used between the same locations, the spare wires shall be distributed. No spares will be required in the multi-conductor No. 9 A.W.G. cables. The multi-conductor No. 9 A.W.G. cables shall contain one (1) red marker conductor in each layer.

Signal code type cable shall have the following maximum number of working pairs and minimum number of spare pairs:

<u>NUMBER OF PAIRS</u>		
Total	Working	Spare
6 pair	4 pair	2 pair
12	8	4

NUMBER OF PAIRS

Total	Working	Spare
18	13	5
25	20	5
50	40	10
75	65	10
100	85	15
150	125	25

II - CLASSIFICATION

The wire and cable shall be of the following classification:

- (A) Synthetic Rubber Insulated Wire and Cable
- (B) Synthetic Rubber Insulated Signal Wire and Cable
- (C) Kerite Insulated Signal Wire and Cable
- (D) Fluorocarbon Insulated Wire and Cable
- (E) Communications Wire and Cable

Reels shall be lagged with 2 x 3 or 2 x 4 inch lumber.

III - WIRE AND CABLE ORDER FORMS, SAMPLES AND TEST REPORTS

(a) Samples not less than twelve (12) inches in length and seven (7) copies of the notarized certified test reports of each type and size of wire and cable to be furnished shall be submitted for approval prior to delivery. All wire and cable is subject to inspection before delivery.

There shall be given one (1) week's written notice of the time and place of the factory tests.

(b) All orders for wire and cable are subject to approval, except that lengths on each coil or reel and total quantities are the sole responsibility of the furnisher of cable. The order for each item of wire and cable must state definitely under which specification it shall be furnished. Before any order for wire and cable is placed with the wire manufacturer or his agent, copies of each order shall be forwarded for approval. Orders

for wire and cable shall not be placed with the manufacturer or his agent until the approval has been received. All ordering descriptions for wire and cable shall be as shown in the following paragraphs.

(c) In general, all wire used for the control wiring of signal apparatus, except when wires carry 600 volt energy, shall be ordered as follows:

1. For the interior control wiring of field cases, central instrument housings and automatic transfer panels, and for automatic stop circuits, signal lighting circuits, switch operating circuits and all 110 volt circuits in relay rooms and central instrument rooms.

- a) Wire, signal, one (1) conductor No. 14 A.W.G., 19 strands, 2/64 inch insulation and 1/64 inch black neoprene sheath, 0-300 volt service.
- b) Or wire, signal, one (1) conductor No. 14 A.W.G., 19 strands, 2/64 inch insulation and flame and moisture resisting black nylon braid, 0-300 volt service.
- c) Wire shall have wax finish. No mica dust permitted.
- d) Maximum O.D. to be specified.

2. For rack to rack and internal wiring of relay racks located in relay and central instrument rooms (except for all 110 volt circuits, switch operating circuits, track circuits, automatic stop circuits, signal lighting circuits and signal power jumpers). For rack to control or indication panels and internal wiring of control and indicating panels.

Cable, signal, number of conductors, No. 20 A.W.G., 19 strands, color coded, Fluorocarbon insulated. Overall: marker tape, binder (barrier tape), and single layer black Polyvinyl chloride jacket sheath. 0-600 volt service.

3. For track circuit wiring in relay rooms and instrument housings. (Except where No. 14 A.W.G. wire 0-300 volt service is indicated.)

Wire, signal, one (1) conductor No. 9 A.W.G., 19 strands, 4/64 inch insulation and 3/64 inch black neoprene sheath, 601-1000 volt service.

4. For wiring between relay rooms for control of reed type relays.

Cable, signal code, number of pairs, No. 19 A.W.G., 7 strands. Polyethylene insulation of low density type on each conductor. Polyethylene inner jacket. Copper shield, helically applied. Polyvinyl chloride outer jacket.

The outer jacket of all completed cables shall be tested after cable has been immersed in water for at least six (6) hours. The outer jacket shall show an insulation resistance of at least one (1) Megohm-Mile at 15.6° C.

5. For maintainers test telephones.

Cable, communication, 6 pair, No. 19 A.W.G., solid, polyethylene insulated, polyvinyl chloride jacket.

(d) All other signal wire and cable, exclusive of those mentioned above, shall be ordered as follows:

1. SINGLE CONDUCTOR NEOPRENE SHEATHED:

Wire or cable, signal, one (1) conductor, A.W.G. or MCM size, number of strands*, insulation, black neoprene sheath with thickness for "Aerial, duct, and direct burial installation", 601-1000 volt service.

* The number of strands shall be as follows:

For sizes No. 14 to No. 00 A.W.G. inclusive:
19 strands.

For sizes No. 000 A.W.G. to 350 MCM inclusive:
37 strands.

For size 500 MCM: 61 strands.

For No. 14 A.W.G. the sheath thickness shall be 2/64 inch for "Conduit Installation".

2. MULTIPLE CONDUCTOR NEOPRENE SHEATHED:

Cable, signal, number of conductors (flat twin or round for two (2) conductors). A.W.G. or MCM size, number of strands,* insulated. Over-all: cable tape and black neoprene sheath, 601-1000 volt service. For all types of installation.

(e) 600 Volt Service. Wherever the wiring of cases, etc., include the 600 volt contact rail energy, use wire and cable as described in Paragraphs (d) (1) and (2).

(f) Where alternate specifications are given above, the over-all diameter of any item of wire or cable may vary depending on the specification under which the cable will be manufactured. Make the necessary allowances for such variations.

(g) The applications of the various wire types and sizes described above are furnished as a general guide. Certain wires such as power jumpers, light commons, etc., and wiring for special circuits, will require larger sizes and different types of wire than that described for the particular application. All such wires shall be of suitable size, insulation and makeup for the particular application involved.

IV - INSTALLING SIGNAL CABLE AND WIRE

(a) General. When installing cable or wires extreme care must be used to prevent any injury or damage to them. Avoid dragging cables across abrasive surfaces or obstructions in a manner which would tend to damage the cable covering. Cables shall be installed in such manner that danger of fire due to an accumulation of papers or rubbish around the cable shall be reduced to a minimum, and so that they will clear all conduits, structures, etc., and

* The number of strands shall be as follows:

For sizes No. 14 to No. 00 A.W.G. inclusive: 19 strands.
For sizes No. 000 A.W.G. to 350 MCM inclusive: 37 strands.
For size 500 MCM: 61 strands.

all equipment by at least three (3) inches. Multi conductor signal code type cable shall not be terminated on terminal racks. In enclosures code cable shall not be terminated in junction boxes, and shall run directly to the reed racks. The shield on signal code type cable shall be grounded. Provide all necessary means to insure that the cable shield cannot become grounded at any but the designated point.

When a portion of cable is removed from a reel, the open or cut end remaining on the reel shall be properly taped to prevent the entrance of moisture. This shall apply to all types of cable. All multiple conductor cables shall contain a marker tape located under the outer sheath. This marker tape shall have printed thereon a serial number which changes by one (1) each foot. The end of the tape is to be left exposed for ready reference.

At points where cables and wires enter instrument housings, junction boxes, etc., seal the openings around the bundles of cables or wires, with encapsulating resin.

(b) On New Messenger. Signal wire and cable shall be fastened to the messenger wire by means of cable straps. In the subway, it shall be done at a minimum distance of six (6) inches from existing radio antenna cables. The maximum distance between straps shall be fifteen (15) inches, but this distance shall be reduced to meet special conditions. At points where cables leave the messenger wire to enter terminal or instrument boxes, conduit, or any other equipment, the cables shall be served and shall be securely fastened and anchored to the messenger by extra wrappings of nylon filament rope to prevent cable from slipping or sagging. The radius of cable bends for synthetic rubber insulated cable shall be not less than ten (10) times the diameter of the cable. The radius of cable bends for signal code type cable shall be not less than fifteen (15) times the diameter of the cable. For flat twin conductor cable, the diameter over the major axis shall be used. The wire and cable shall be tied to new messenger in two (2) steps as follows:

(1) Temporary tying, which consists of tying the cable close to the messenger by means of temporary marline or rope ties, placed sufficiently close together to hold the cable to the messenger without undue sagging or slack.

(2) The permanent tying, which shall be done with approved cable straps and nylon ties.

(c) Installing Cable Straps. Any new cable straps required shall be of an approved type and shall be pulled up tightly around the cable bundle.

(d) In Ducts. Before cables are pulled into ducts, the ducts shall be cleaned and rodded. The cleaning of the ducts shall be done by the use of proper rodding tools. A wire brush of the same size as the duct shall then be pulled through the duct. Break away all projecting pieces which may cause injury to the cable before cables are pulled into the ducts. Clear or repair broken ducts. Cable ducts shall be sealed after cleaning and shall be kept sealed until the duct is to be used. After the cables are installed a final seal consisting of a mixture of asbestos and cement, or an approved sealing compound shall be used. The proportion of the mixture shall be such that it may readily be removed without damage to the cable or cables. Furnish and place approved duct shields beneath the cable at the end of ducts for the purpose of cushioning the cable and protecting its sheath. Install cables only in such ducts as are assigned to the cables.

(e) The method of pulling cable through ducts shall be subject to approval. Cable reels shall be set upon jacks in such position that the cable can be fed from them freely, without distortion or injury, into the ducts through an approved type of bell or shield. All cables to be placed in one (1) duct shall be installed simultaneously. Extreme care must be used in installing cables so as to avoid twisting, kinking, or in any way injuring the cable or its sheath. In pulling cable, an approved wire cable grip extending not less than eighteen (18) inches back from the end of the cable shall be used and the pulling force shall not exceed fifty (50) per cent of the weight per thousand (1000) feet of the cable to be pulled. The equipment used for pulling cable shall be equipped with a dynamometer which will indicate the pulling force in pounds. Glycerized liquid lubricant or other approved lubricant shall be applied to the cable when installing cables in ducts. After the cable has been installed, the portions within the manholes and pull chambers shall be coiled. The ends of the cable shall be sealed until such time as the complete installation (splicing or terminating), racking and protecting of the

cable in the manholes and pull chambers is effected.

(f) On Cable Bars, in Conduit and Wire Chases. Where wires and cables cross the trackway on cable bars, the wires and cables shall rest on approved wooden cleats, micarta strips or other material, fastened to the cable bar. The cable bundles shall be fastened to the wooden blocks or micarta strips by means of nylon ties.

Signal wire and cable shall be installed in conduit and wire chases in such manner as to avoid any injury to the wire and cable. Observe the installation instructions and precautions issued by the manufacturer of the wire and cable to be used. When a number of loose wires are to be run in chases or conduit between points, the required length of the wires to be run shall be measured allowing a reasonable amount of slack at both ends. The required number of wires shall then be cut and laid in, or pulled through the conduit and fittings as a group, not singly. Care must be taken to avoid unnecessary crossing of wires and cables in conduit, chases and fittings.

Where cable is to be pulled into conduit, cable pulling compounds shall be used.

All cable running under the platform overhang in the station area shall be installed in conduit.

(g) Cable Bars. Cable bars supporting cable shall be made of one-half (1/2) inch by two (2) inch hot dipped galvanized steel bars. The cable bars shall be equipped with wooden blocks made of maple boiled in paraffin or linseed oil. The wooden block shall be fastened to the cable bar by bolts equipped with lock washers. Where the depth of the arch is too shallow to permit the use of the bars described above and wooden blocks, install the cable on saddle type bars and, if necessary, Micarta strips or other approved material. The ends of the cable bars shall rest on the flanges of adjacent ceiling beams of the ceiling bay. The concrete about the flange of the beams shall be cut out for the installation of the cable bar and after the cable bar has been installed the cut out portion shall be cemented in, to securely fasten the cable bar in place. In portions of the subway it may be necessary to support saddle type cable bars from bolts slugged into the ceiling. Cable bars shall be placed sufficiently close together to prevent sagging of the cable below the edge of the roof

beams. Five (5) equally spaced cable bars shall be required for each track crossed where track centers are thirteen (13) feet six (6) inches or less. Where track centers are greater than thirteen (13) feet six (6) inches, the maximum spacing between cable bars shall be two (2) feet six (6) inches.

A maximum of three (3) cable bundles will be permitted on each cable crossing. Unless otherwise permitted, the weight of a cable bundle installed on a cable block shall not exceed ten (10) pounds per foot.

(h) Direct Burial in the Ground. New signal wire and cable, where installed directly in the ground, shall be laid in trenches so that the top of the cable is at least thirty (30) inches below the base of rail and the cables shall be surrounded by not less than three (3) inches of sand. Care shall be exercised that no cinders or large stones are either put in, or fall into the trench when it is refilled. The cable must be protected in the trench and elsewhere from projecting rocks, duct banks, pipes, etc. When the route of the cable crosses permanent obstructions in the ground and the thirty (30) inch depth cannot be maintained, install protective covering of conduit or split concrete duct. The cable shall be installed over or under the obstruction. All cable trenches shall be shored.

When the route of the cable trench crosses roadways, footwalks, etc., remove surfacing as required, including removal of concrete if required, and upon completion of the cable installation provide new surfacing of a type similar to that originally existing.

No single conductor wire, No. 9 A.W.G. or smaller, shall be installed directly in the ground.

Buried cable and wire shall be brought up to signal equipment mounted on concrete foundations via the chaseway to be provided in the concrete foundations. Where signal equipment is not mounted on concrete foundations, buried cable and wire shall be brought to the equipment via riser boxes mounted on concrete pedestals.

Where buried cables and wires rise vertically to enter a concrete foundation, concrete pedestal or conduit, and the horizontal run of cable exceeds one hundred (100)

feet, a coil in each cable and wire shall be left in the trench below the foundation or pedestal or in front of the conduit elbow, as applicable. The coils shall be arranged in such a manner that little difficulty will be encountered when additional slack is required for the equipment. The length of the cable and wire to be coiled in the trench shall be not less than five (5) feet for each coil.

In excavating the trench for the installation of cables, any abandoned cables, conduits, etc., which may be encountered, are to be cut off and removed where they traverse the trenches.

Where signal cables or track connections being installed are to be installed in the same trench as, or are required to intersect cables or wires carrying 600 or more volts, the signal cables shall be installed so that the distance between the signal cables and such high voltage cables shall not be less than twelve (12) inches, while maintaining the depth of not less than thirty (30) inches for the signal cables. The twelve (12) inches between the cables shall be filled with sand to a distance of two (2) feet for each cable from the point of intersection.

If cables cross under the tracks, the cable shall be installed in conduit or transite duct. Take precautions to provide proper support for the roadway during the installation of the conduit or duct.

At certain locations, existing cables may be buried beneath the tracks and along the right of way. Extreme care must be exercised when excavating for concrete foundations, cable installations, etc.

Partial installation of cable in trenches shall not be permitted. When cables to be installed in trenches are ready for installation, all cables shall be placed in the trench at the same time. If only some cables are ready, installation shall not begin until such time as all cables can be installed.

Sand protection, as mentioned herein, and backfilling, shall be carried out on the same day cables are placed in trench and no cables shall be left exposed. One (1) foot 2x2 inch blue tipped stakes shall be installed as temporary

cable trench markers as the backfilling proceeds and shall be removed after installation is completed.

(i) Through Walls. Bring cables and/or wires through walls in ferrules, in conduit, or in wire chase.

(j) Power Cable. Signal power cables carrying 120 volts or less shall be suspended on the same messenger as the control cables.

V - INSTALLING WIRE AND CABLE IN SIGNAL ENCLOSURES

(a) General. In general, fluorocarbon insulated multiconductor cables shall be used for wiring between racks, and between the control panel and racks in relay and central instrument rooms, however, install separate wires with a larger current carrying capacity where required for special circuit applications such as all 110 volt circuits, switch operating circuits, track circuits, automatic stop circuits, signal lighting circuits, and power jumpers, etc. Where racks are installed in central instrument housings, single conductor number 14 wires will be used for wiring between the racks.

Methods of installing wire and cable shall be as follows:

(b) Plug Connected Cables. Wiring between the control panel and racks and interrack wiring shall be multiple runs of 16 conductor fluorocarbon insulated plug connected cable. Not more than one (1) cable shall be terminated on each plug connector. Connections shall be made with a minimum number of cables.

Provide an emergency 16 conductor cable equipped with plug connectors at both ends for each new enclosure, which shall be of sufficient length to replace the longest plug-connected cable used within that enclosure. The length shall be such that replacement may be made by laying the emergency cable along the floor rather than in the chase. The emergency cable shall be coiled and mounted in a housing in each enclosure. Cables shall be wired to the plug connectors in a uniform manner so that an emergency cable may be substituted for a defective cable.

Each end of each wire shall be connected to corresponding contacts on the plug connectors. The wires shall be identified by means of a color combination and tagging of individual wires will not be required. Each end of each cable shall be identified with a cable tag and each receptacle shall be identified with a distinctive designation. Cables shall be racked and shall not cross the face of the adjacent panels.

Wiring between the relay plugboards and the receptacles shall be tagged at the plugboard end only.

Contact lugs on receptacles and plugs to which wires are attached shall be enclosed with insulating sleeving. The sleeving shall provide a snug fit so that it will not be loosened by vibration.

All fluorocarbon insulated cables shall be cut to final required length, and connected to the plug connectors prior to testing. The length of the cables shall be determined on the basis of room layouts and cable runs between the respective equipment requiring such cable. Sufficient slack shall be allowed in the cables to enable replacement of the plug connectors in the event of damage. The cable and plug connector assemblies shall be tested prior to installation of the cables and the manufacturer shall certify that the tests have been performed. Wires shall be soldered to plugs and receptacles using the resistance soldering method by personnel experienced in the assembly of plug connected cables, and all soldered connections shall be inspected, prior to assembly and testing to insure work of the highest quality. Flux residue shall be removed. All connections shall have a conductivity at least equal to that of the wire and care shall be exercised not to damage insulation of the wire.

(c) Wires and Cables Not Terminated on Plug Connectors. In certain applications such as rack to indicator panels, and between racks, fluorocarbon insulated cable shall be installed without plug connectors, and terminated on miniature terminal posts. Such cables may be installed using two or more smaller cables in lieu of one large cable, however, paralleling of conductors in fluorocarbon insulated cables to increase current carrying capacities will not be permitted. Spare conductors in non plug connected cables or terminals to be used solely for the purpose of terminating such spare conductors are not required.

Single conductor wire shall be used for certain applications, such as power jumpers, light commons, signal light circuits, stop and switch operating circuits, automatic transfer panels, track circuits, etc. Terminal boards will be provided on the racks for terminating such cables.

All wires entering or leaving the enclosures shall be terminated on terminal posts. Receptacles shall be provided on terminal racks for such wires as will continue to other racks in plug connected cables.

Wires and cables, other than plug connected cables, shall be tagged and terminated.

VI - INSTALLING MULTI-CONTACT CONNECTORS

Multi-contact connectors furnished will be a solder terminal connector with gold plated over copper contacts. Each plug and receptacle combination shall be equipped with seal which must be broken before the connector can be opened.

Receptacles will be mounted on panels attached to the racks in a manner such that both the front and rear of the receptacle are readily accessible. The plug portions with associated hardware will be furnished separately. Connect the plug portions of the multi contact connectors to the multiconductor cables. Supporting panels shall be punched to hold a full complement of receptacles, however, only the number of receptacles actually required shall be installed.

VII- CABLE STRAPS AND SPUN NYLON FILAMENT ROPE

(a) Spun nylon filament rope and cable straps shall conform to the following specifications. The nylon filament rope shall be made from pure nylon fibre. The nylon filament rope shall be three (3) ply and the strands shall have a left lay of approximately ninety-six (96) crowns per foot. The rope shall have a nominal diameter of one-eighth (1/8) of an inch. The size of the strands and the diameter of the finished rope shall show uniformity throughout the length of the product. The tensile strength of the finished product shall be not less than

four hundred (400) pounds and the number of feet per pound shall be not less than two hundred (200).

(b) Cable straps shall be a neoprene impregnated dacron strap with bronze hook. At outdoor installations, the bronze hook shall be provided with a neoprene impregnated, dacron pad for protection of the messenger.

VIII - CABLE RACKS AND INSULATORS

The cable racks shall be hot dip galvanized. Cable racks shall be installed at designated points and shall be securely bolted in place. All racks shall be drilled and formed before being given the protective coating. Each rack shall be equipped with suitable maple cleats or porcelain insulators. The cables shall be fastened to the porcelain insulators by means of nylon ties. Wooden cleats shall be of maple, boiled in paraffin or linseed oil, the cleat being completely made up before boiling. The hole in the cleat shall be of sufficient size to firmly clamp the cable, including listing where used, without distorting or injuring the cable. Cables that have been listed together must be clamped separately in the wooden cleats. Porcelain insulators shall be glazed.

IX - PROTECTING CABLE

(a) Cables where installed on messenger wire, etc., at a distance of eight (8) inches or less from the contact rail or any power cable (except signal power cable), equipment or apparatus shall be listed. The cable bundle and messenger shall be listed together wherever listing is required. The cables to be protected shall be covered with two (2) layers of approved asbestos listing, which shall be one and one-half (1-1/2) inches wide, and shall weigh not less than three and six-tenths (3-6/10) pounds per one hundred (100) feet. Protecting materials for cables shall be furnished and installed and shall be applied to the cables in the following manner.

(1) Cables to be listed, shall be wrapped with one (1) layer of listing with joints abutting.

It is permissible to apply the listing around a group of cables, providing that such cables are installed as a

group on a single messenger, on cleats or supports or enter enclosures as a group.

(2) A thorough coating of approved silicate of soda shall be applied to the entire length. Silicate of soda is not to be diluted, but must be used full strength.

(3) A second wrapping of listing shall be applied with joints abutting, but overlapping the joints of the first wrapping approximately one-half (1/2) of the width of the listing.

(4) Another coating of silicate of soda shall be applied to the entire length.

(5) The ends of the listing shall be securely fastened.

(6) The workmanship of racking and protecting the cables when completed shall present a neat and orderly appearance.

(b) Wherever signal cables are to be installed in pull chambers or other enclosures which contain power cables, other than signal power cables, list the signal cable in the manner described herein. In addition, list signal cables in a similar manner at any other point as may be required. Such signal cable shall be wrapped or covered for the full length within the enclosures plus three (3) inches inside the duct.

Where cables pass under ventilation gratings, the cables shall be protected with an approved fire-proof shield or by listing.

X - SPLICING AND POTHEADING CABLES

(a) All multiple conductor cables which are to be terminated in a piece of signal equipment shall have the outside neoprene covering of the cable carefully cut away. Two (2) layers of electrical plastic tape shall then be applied to the end of the neoprene covering of the multiple conductor cable.

(b) Where the outside covering of cable installed in wet places is to be removed, the cable shall be weather-

proofed at that point by means of a pothead. The tops of all potheads shall be at least four (4) inches above the bottom of the equipment which the cable enters. Potheads on cable shall be made up by carefully cutting the neoprene sheath and tape back to the desired point and by installing a neoprene end seal pothead. The space between the conductor or conductors and the pothead shall then be filled with "Encapsulating Resin". The top of the sealing compound shall be above the pothead and shall be shaped to shed water. Care shall be taken to see that the sealing compound flows freely between all conductors and the conductors shall be turned to permit the sealing compound to thoroughly seal between them.

(c) All wire and cable lengths shall be continuous and without splices between the points of connection unless otherwise directed.

If splices are made, it is of the greatest importance to secure perfect continuity at the points of connection of each conductor and cable. All splices shall be made in accordance with the best modern practice. All splices and connections shall have a conductivity and insulation resistance at least equal to that of the cable.

XI - FURNISHING AND INSTALLING MESSENGER WIRE

(a) General. Install all material and equipment required for the messenger wire system, complete, including messenger wire, messenger clamps, dead-ends, anchors, insulators, dead-end brackets, angle iron supporting brackets, clamps and all miscellaneous mounting and fastening material.

Messenger wire shall be made of seven (7) strands of No. 8 A.W.G. bare copper-plated steel wire. Copper shall be applied to each of the steel strands by the molten welding process, and the copper-covered strands shall be free of all surface imperfections. The overall diameter of the messenger wire shall be three-eighths (3/8) inch and the finished copper-covered steel messenger wire shall have a breaking strength of not less than eleven thousand (11,000) pounds. Messenger clamps shall be six (6) inch, three (3) bolt type, and/or a curved suspension clamp three (3) bolt type.

In general, the following weight of cable per foot of messenger shall be used as a guide for determining the approximate distribution of cable on the new messenger wire, except as hereinafter modified.

Where messenger supporting brackets are spaced at twenty (20) foot intervals, individual messenger loading shall be under six (6) pounds per foot.

Where messenger supporting brackets are spaced at ten (10) foot intervals, individual messenger loading shall be between six (6) pounds and ten (10) pounds per foot.

Where messenger supporting brackets are spaced at seven and one-half (7-1/2) foot intervals, individual messenger loading shall be between, over ten (10) pounds and up to and including fourteen (14) pounds per foot.

Cable bundle supported by a single messenger shall not exceed a diameter of six (6) inches.

Wherever cables to be installed on messenger make a bundle exceeding six (6) inches in diameter, provide additional messenger. Where multiple messenger runs are required, a division of the cable on each messenger shall be made.

(b) Messenger Installation on the Steel Elevated Structure. Messenger wire shall be securely fastened to steel elevated structure by means of clamps and angle iron supporting brackets. The supporting brackets shall, in general, be installed at intervals of twenty (20) feet depending upon local conditions and weight of cable supported.

No messenger shall be installed under the track girders of the elevated structure.

Install insulators to support the cables where they may come in contact with the steel or other surfaces which may abrade the cable.

(c) Messenger Installation on the Concrete Wall. On the concrete wall the messenger wire shall be supported on galvanized supporting brackets attached to the concrete or, to concrete-covered steel structural members depending on

the type of construction encountered. The messenger shall be installed so that the cables being supported shall be at an approved height.

Wherever messenger is used on the concrete wall, the weight of cable per foot of messenger shall be as mentioned above.

(d) Extreme care shall be used to prevent injury to the copper covering of the messenger wire by kinking, nicking or other rough usage.

The messenger wire shall not be spliced but shall run continuously from dead-end to dead-end without a break. The messenger wire shall be anchored. Serving at the anchors of the dead-ends shall be made. All dead-end messenger serves shall be painted with red lead. Dead-ends of a type that grip the messenger in such a manner that it may strip away or damage the copper covering will not be acceptable. Messenger wire shall be dead-ended not less than five (5) feet past the last point from which cable leaves the messenger.

Messenger wire installed at a distance of eight (8) inches or less from the contact rail or any power cable (except signal power cable) shall be covered with two (2) layers of approved listing.

The cable bundle and messenger shall be listed together wherever listing is required.

When messenger being installed changes its direction by more than fifteen (15) degrees, the messenger run shall not be continuous but shall be terminated on a bracket by means of dead-ends. At points of offset of less than fifteen (15) degrees a curved suspension clamp shall be used.

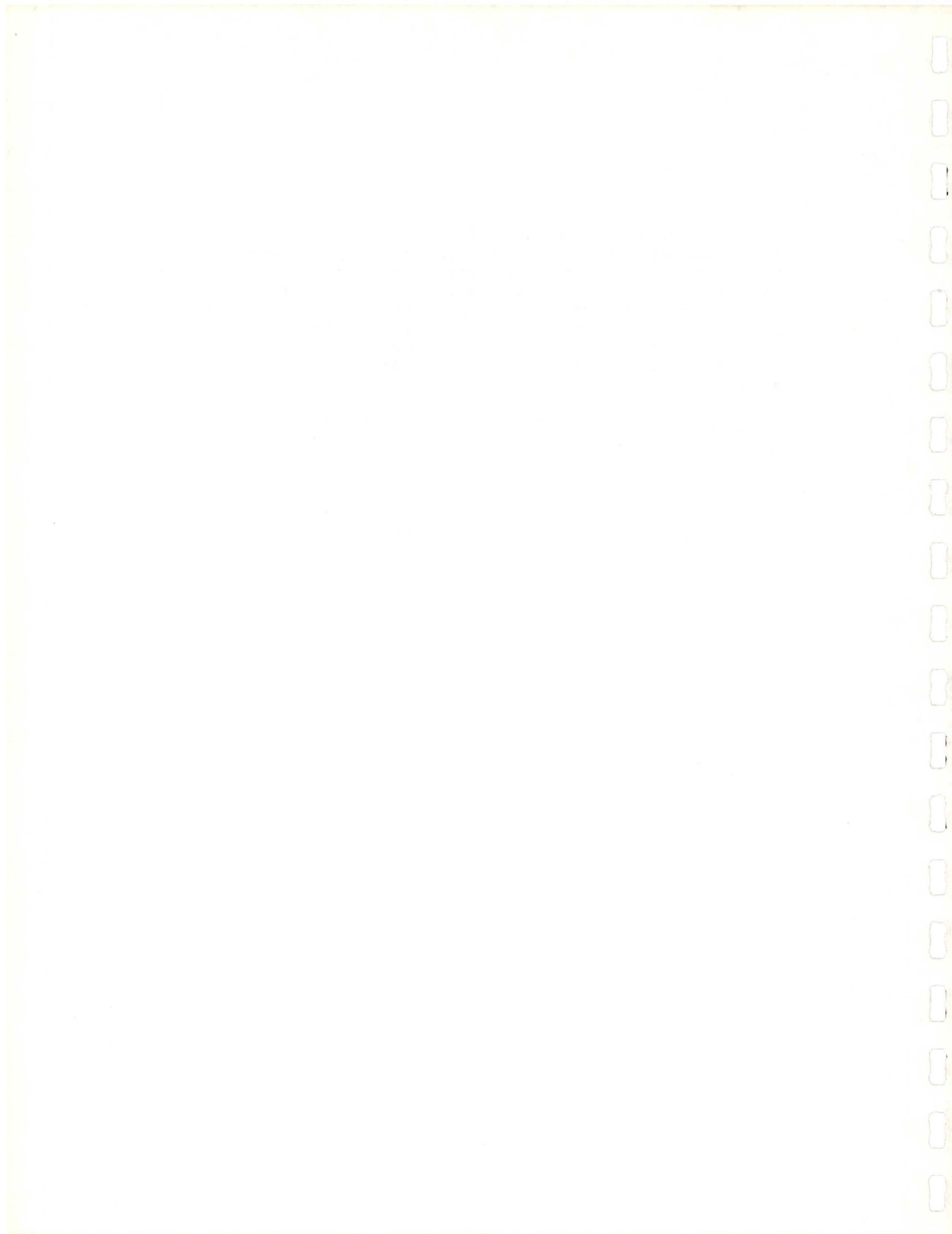
All messenger supporting brackets, and all other iron-work for the messenger system, including cast steel column clamps, shall be galvanized.

Messenger wire shall be drawn in place without injury to its supports or fastenings, and the tension therein shall not exceed twenty-five (25) per cent of the strength of the messenger wire at sixty (60) degrees F. This tension shall be measured by means of a dynamometer. Messenger

wire not longer than one thousand (1,000) feet between dead-ends may be installed using one (1) dynamometer placed in series with the messenger at the point of application of the pulling tension. Messenger wire not longer than three thousand (3000) feet between dead-ends may be installed using two (2) dynamometers, with a shunt dynamometer to measure the tension in the last span of the run in addition to the series dynamometer at the point of applying the tension.

In all other respects, the recommendations of the manufacturer of the messenger wire shall be followed in the installation as to sag, loading and tension, adjusted to sixty (60) degrees F. ambient temperature.

Particular attention must be given to the spacing of the clamps so as to maintain the wire well outside of the car clearance line, and to insure that the cable shall hang clear of all obstructions at all points.



Chapter **12**

St. Louis

Chapter **12**

SIGNAL CONDUIT AND WIRE CHASES

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Chapter 12

SIGNAL CONDUIT AND WIRE CHASES

I - FURNISHING CONDUIT

A. RIGID CONDUIT

Rigid Conduit shall be used for wire and cable installed within enclosures, on station platforms and under platform over-hangs, between the messenger and signal equipment, and at other locations. The types of rigid conduit to be furnished for the various applications shall, in general, be as follows:

(1) Steel conduit shall be furnished where conduit is to support or suspend signal equipment and if required at certain locations to provide access between buried cable and messenger, or wayside equipment. Steel conduit shall be made of the best grade standard weight steel pipe protected inside and outside by a coat of hot dip galvanizing.

(2) Thick wall polyvinyl chloride conduit. High Impact, Type II, Schedule 80, hereinafter referred to as PVC conduit shall, in general, be furnished wherever conduit is to be installed in the trackway and from the edge of the toe bench to a housing or junction box located on the same side of the track as the toe bench.

(3) For Conduit Risers. Steel conduit risers for instrument case, junction boxes and other equipment shall be furnished for installation between the housings and the messenger. Where PVC conduit installed in the trackway continues to the messenger, steel conduit shall be furnished for installation between the messenger and a point approximately one (1) feet above the toe or duct bench. Where steel conduit connects to PVC conduit, cast or malleable iron fittings or PVC fittings may be used.

(4) Miscellaneous Runs. Steel conduit shall be furnished as an alternative to cable bars where cables are to cross subway tracks and the number of cables does not warrant installing cable bars, or the ceiling of the subway will not permit the installation of cable bars.

B. FLEXIBLE CONDUIT

Flexible conduit shall be interlocking spiral strip steel of the best quality. The steel strips used in the construction of flexible conduit shall be thoroughly annealed and fully coated with metallic zinc, and shall have PVC covering.

Construction of the spiral strip shall be such as to permit bending of the conduit to a radius of four (4) times its internal diameter without spreading the strips to such extent that they will open on the outside of the bend, without compressing them to such extent that rough edges will result on the inside of the bend and without distorting or reducing the internal diameter of the flexible conduit at the bend. The interior and exterior of the flexible conduit shall be smooth, free from burrs, sharp edges or other defects which may injure the wires.

Flexible metallic conduit shall be installed for connections to switch heaters.

C. CORDURA HOSE CONDUIT.

A hose shall be furnished for installation in Type I track whenever the conduit buried in the concrete toe bench is to be connected with the PVC conduit connected to the equipment on the roadbed.

Where required for conduit layouts, the hose to be furnished shall be Braided Cordura Rayon, Vari-purpose hose, internal tube Hycar neoprene cover. Stainless steel clamps shall be used for clamping the hose.

D. CONDUIT FITTINGS

All fittings for rigid steel conduit shall be of cast or malleable iron, and shall be protected by hot dip galvanizing. The use of split fittings or fittings which are

attached to the rigid steel conduit with a clamping action will not be permitted. Fittings shall be furnished complete with gaskets, and blank or nipple covers, or composition outlet covers as required held in place with screws. All junction, pull and outlet boxes shall be watertight and of ample size to permit pulling of cables without injury to the cable. The length of the openings in fittings used as pull boxes shall be at least ten (10) times the diameter of the conduit entering the box.

Furnish all conduit fittings including all required condulets, condulet unions, conduit junction boxes, pull boxes, ells, tees, bushings, water-tight hubs, insulating bushings, grommets, lock nuts, chase nipples, flanges, squeeze fittings, eather heads and conduit bells, etc.

II - INSTALLING CONDUIT

Conduit shall be straight and neatly arranged on the structure and shall be securely supported at intervals not to exceed eight (8) feet, except where conduit is installed above the tracks where the supports shall be made at intervals not to exceed three (3) feet. Where a conduit crosses over a track, the conduit shall be supported by a minimum of three (3) supporting bolts and clamps. The bolts shall be attached in the concrete, except in exposed iron ring type construction where holes shall be drilled in the iron rings. Conduit shall be so installed as to prevent the collection of water between outlets. Conduit shall be of sufficient size to leave at least one-third ($1/3$) of the wire space free after the full number of wires required for the installation are in place. If a size of conduit is specified which does not allow for this one-third ($1/3$) free space, a largersize conduit shall be installed. Two (2) or more conduits may be used in place of one (1) run where the number of wires is greater than can be accommodated in one (1) run of conduit. All steel conduit shall be equipped with threaded fittings.

All bends and offsets on conduit must be made on a forming tool to prevent the conduit or coating from being damaged in the bending. PVC conduit bends made in the field shall be made in accordance with the manufacturer's recommended procedure. Care shall be taken not to over-heat the conduit during the bending process. Bends made by the manufacturer at the factory will be permitted.

Conduit shall be left clean, with inside surfaces smooth and free from obstructions liable to injure the wire or cable. Where conduits join any threaded couplings or fittings, the ends shall be reamed. Steel threads shall be painted with red lead to make them watertight. PVC conduit shall be connected to fittings with compound.

Conduit from the edge of the toe bench to an adjacent wall, column or housing shall be buried in slots cut in the toe bench.

Where a high or low bench exists, the conduit shall be installed in chaseways cut in the vertical side of the bench. The portion of the conduit on the top of the bench shall be buried in slots cut in the bench. While the slot is being cut, care shall be taken not to break any duct located below the surface of the bench.

Install conduit as soon as slots are cut and fill the slot with concrete as soon as the conduit has been installed.

Conduit crossing the drainage trough in Type II track shall be buried in slots cut in the concrete and covered with concrete.

All cables or wires installed under subway station platform overhangs shall be installed in steel conduit.

Conduit crossing the ceiling arch in tunnel and tube type subway construction, except in exposed iron ring type construction, shall be buried in the concrete of the arch if the ceiling arch is less than thirteen (13) feet above the base of rail.

Cable outlets for conduits rising from beneath the messenger shall consist of weatherheads for one (1) inch conduit and conduit bells for all other sizes. Where steel conduits cross the ceiling of the subway to meet the messenger, conduit bushings shall serve as cable outlets.

All exposed rigid conduit shall be rigidly supported by straps and/or other supports. All straps and supporting brackets shall be means of separable members so constructed as to retain their grip by means of clamping action. The general design of such clamping members

shall be such that no members shall be less than three-eighths (3/8) inch thick, and no bolt shall have a diameter less than three-eighths (3/8) inch.

All attachments shall be of such design and so installed as to permit easy access to all exposed surfaces of both attachment and structure.

All straps and metal supports shall be galvanized.

Where installed in the roadway in Type I and Type II track, PVC conduit shall be installed at least one (1) inch below the surface of concrete where in concrete, and at least one (1) inch below the base of rails where in ballast. Where installed in the roadbed in Type III and VI track, PVC conduit shall be installed at least one (1) inch below the base of rails.

Ballast removed for the installation of conduit shall be replaced.

Where PVC conduit located in the trackway is to be connected to conduit attached to the structure, install lengths of Cordura hose in the conduit run at various points in order to provide for minimum transmission of stress in the conduit run. Furnish and install all required fittings for the installation of the Cordura hose.

Wherever PVC conduit is to cross more than one track, the PVC conduit shall not be installed in one continuous run.

Where a conduit run contains a total of two (2) right angle bends or equivalent or exceeds seventy-five (75) feet between outlets, additional outlets for pulling the cable shall be provided.

Where conduit enters boxes, a water-tight hub shall be installed. In long straight runs of conduit, where it is necessary to pull cable at intermediate points, the fittings installed for that purpose shall be of such length and other dimensions to allow the pulling of cables in and out of the fittings without the necessity of any sharp bending or injury to cables.

In stone ballast track where PVC conduit to equipment located in the trackway is to be connected by Cordura

Hose to conduit buried in concrete, the buried conduit shall end with a coupling. The coupling shall be buried in concrete and shall be flush with the vertical side of the concrete. A short metallic nipple shall be used to connect the Cordura Hose with the coupling. The coupling shall be PVC with a female thread at one end for the metallic nipple and an unthreaded opening at the other end. The buried PVC shall be inserted into the coupling and sealed with an adhesive.

Conduit shall not be installed in such a manner that it creates a tripping hazard or interferes with the safety of the maintenance forces.

The method of making conduit connections to the various types of equipment is made by threading the conduit into the equipment or by using Cordura Hose.

Steel Conduit shall be painted.

III - FURNISHING WIRE CHASES

The wire chases shall be made of one-eighth (1/8) inch thick aluminum. The aluminum shall be bent to form three (3) sides of the chase in one (1) piece. The fourth side shall consist of removable covers.

Construct each wire chase with sufficient capacity to leave fifty (50) per cent of the cross sectional area as free air space after the full number of wires are in place.

The chase may be constructed in sections and shall be joined by a two (2) inch lap or butt joint.

Conduits may also be used as chaseways between the chase and other associated signal tower, relay room or central instrument room equipment. Conduit entering chaseways shall be equipped with insulating bushings.

Where applicable, the design of the chase shall be such that any wire from any rack, panel, etc., shall reach its destination without passing through any other rack or piece of equipment.

In lieu of the forty-five (45) degree corner for horizontal and vertical turns, provide a rounded corner with a minimum radius of six (6) inches. Covers for the horizontal chases shall have the ends turned down about three-quarters (3/4) of an inch to act as stiffeners. On wide chases, an additional steel angle shall be fastened or welded to the cover for reinforcement. Sufficient space must be available after installation when covers are removed to permit cables or wires to be installed or inspected. Care shall be taken to insure that no metal of any description shall protrude to the inside of the wire chases.

Vertical chases shall have covers with a lap joint on the upper end to provide a rest for the adjacent cover until fastened.

The chases shall be disassembled before shipping and shall be reassembled at the site of the work. Certain wire chases, due to conditions requiring that the wires be installed prior to the installation of the wire chases, shall be designed so as to permit assembly of the chase around the wires.

Where necessary, suitable openings and covers shall be provided to permit future expansion of the chase.

IV - INSTALLING WIRE CHASES

Wire chases shall be installed and painted.

The sections of chase shall be installed in continuous runs without gaps. Barriers of fibre glass batting shall be installed at five (5) foot intervals.

The angles for supporting the wire chase when installed in the signal towers, relay rooms and central instrument rooms shall not be galvanized but shall be painted.

Perform any concrete work required in connection with the installation of the chases. The chases shall be installed so that they do not come in contact with concrete.

Chapter **13**

Chapter 13

Chapter **13**

TERMINATING AND TAGGING OF SIGNAL WIRE AND CABLE

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1910

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DEPARTMENT OF CHEMISTRY

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Chapter 13

TERMINATING AND TAGGING OF SIGNAL WIRE AND CABLE

1 - TERMINATING WIRES OF THE SIGNAL SYSTEM

(a) Terminate all wires and cables in all of the equipment furnished and installed.

In general, all wires shall be terminated on terminal posts, however, certain cables as mentioned elsewhere herein, will be terminated on plug connectors. All spares in code type cable shall be terminated.

(b) Terminals and Terminal Boards. All terminals used for terminating No. 14 A.W.G. or larger wire shall be the standard binding post of the Signal Section of the Association of American Railroads and all terminals used for terminating wire smaller than No. 14 A.W.G. shall be a miniature binding post with individual insulating sleeves or the standard binding post mentioned above.

Each binding post shall be equipped with a full complement of brass washers and nuts; the top nut on each post shall be an insulated nut. Washers shall be chamfered on both outside edges and there shall be a washer on each side of each wire connected to the binding posts. All binding posts, nuts, washers, and connectors shall be plated.

All terminal strips or boards shall be provided with a full complement of terminals.

All terminal boards and their terminals shall be designed so that lugs can be used for terminating wires.

Certain of the terminals, in order to adequately provide for signal power line connections, shall be electrically connected by means of metal plates. All special plates furnished for terminating the larger size of incoming wires shall be furnished completely drilled with all edges chamfered and with lugs and bolts to accommodate the sizes of wires.

(c) All new signal wires to be terminated on binding posts shall be fitted with terminal lugs. The terminal lugs shall be of the solderless crimp-on type.

The lugs shall be attached to the ends of the conductor in such manner that the flexibility of the conductor will not be destroyed and the possibility of breakage at the terminal be reduced to a minimum. Lugs shall be attached to the conductor with a tool recommended by the lug manufacturer. The tool shall be equipped with a device to insure proper indentation of the lug.

(d) Where cable and wires are to be terminated in the equipment, the end of the wire or cable shall be pulled into the case or other equipment housing and potheaded.

The wires of the cable shall then be closely and neatly grouped together and taped at a maximum of four (4) inch intervals, using three (3) complete turns of approved tape. The turns of tape shall be wrapped directly over each other. The tape used shall be electrical plastic tape. In general, the group of wires shall be looped around in the equipment housings to allow for sufficient slack and then spread out and terminated. Form and support the wires so as to remove the weight of the wires from the terminals. Care shall be taken to assure that the internal wiring between terminal boards and relays does not become damaged or crowded out of shape during this work. Some equipment is provided with handholes to facilitate pulling and connecting wire and cable. Whenever a handhole cover is removed, it shall be replaced in such manner as to make an absolutely watertight seal.

The method of connecting wires to the terminal boards shall be such that each wire will be terminated without crossing the front of the terminal board.

Signal code type cables shall be so terminated that the length of the individual conductors exposed outside of the cable sheath or insulation is held to a minimum. In order to accomplish this, terminate the wires of each cable as close together as possible.

Wiring shall be done in a neat and workmanlike manner and shall have a finished appearance.

(e) The cable entering switch circuit controller boxes shall have the outer cover of the cable cut back to within one (1) inch of the entrance and shall be potheaded. The wires shall then be taped and run to the far side of the box from the entrance, looped back, spread out and terminated.

(f) Where wires or cables run from a wire chase to tower instrument or terminal cases or instrument or terminal racks, each wire shall have at least one (1) foot of slack. Individual wires between chase and rack shall be taped together as a group. The groups of wires shall be supported.

(g) The wires terminating in the control panels shall all have at least two (2) feet of slack, the slack to be left in the wire chase before the wire enters the control panels. The wires shall be taped together in convenient sized trees and brought up from the wire chase, and where wires enter through slots in the floor they shall be secured to floor cleats. Where the sealing compound in the floor is disturbed, it shall be replaced.

(h) If A.C. mains are tapped for power leads, the taps shall be made by means of a type of solderless connector. The insulation shall be cut from the mains and leads and the bare conductors shall be scraped clean. When the solderless connector has been installed in place, it shall be completely covered with several layers of rubber tape which in turn shall be covered with several layers of electrical plastic tape.

II - TAGGING OF CABLES AND WIRES OF THE SIGNAL SYSTEM

(a) For plug connected cables and signal code type cable, both ends of each cable and each cable wire and all single wires in the signal system shall be permanently identified with a tag. Tags shall be installed on all wires and cables that are installed.

Tags shall be installed so that they may be read with a minimum of disturbance to the tags. Each conductor of the cable shall be rung out and identified before applying the tag.

Each pair of wires in signal code type cable shall be identified by means of a tag. Each individual wire of each pair in signal code type cable shall be identified with respect to each other by means of an approved color code.

When fluorocarbon insulated conductors, which are not terminated on plug connectors, are installed and, as a result of the cable sizes used, spare conductors are installed, the spare conductors shall not be terminated but shall be tagged, protected and secured. One tag will be sufficient for each group of spare conductors in each cable. The spare conductors shall be of sufficient length to reach all terminals on the particular rack involved.

In general, tags shall be at least twenty-thousandths (0.020) of an inch thick. The four (4) corners of the tag shall be rounded to a one-eighth (1/8) inch radius. In new enclosures and housings, the base material of the tags shall be yellow vinylite. The nomenclature shall be printed on the base material in black, and protected with a five-thousandths (0.005) of an inch clear over-laminate. Lettering shall be one-eighth (1/8) of an inch high, with three-thirty seconds (3/32) of an inch spacing between lines.

Tags shall be applied directly to the wires by means of the hole in the tags at points adjacent to the terminals or binding posts, wherever possible.

Furnish, mark, and install all temporary tags which are required to properly tag all temporary wires and cables used in the work. All temporary tags are to be removed upon completion of work.

(b) On instrument racks, in housings, and in field cases, the wires terminating at plugboard contacts shall be identified by means of approved sleeve tags. In new enclosures and housings, the sleeve tags shall have black printing on yellow background. Each tag shall be numbered to correspond with the number on the relay contact, the wire destination, and the nomenclature of the circuit.

(c) All single wires or wires of cables to be terminated and connected shall be tagged at or immediately adjacent to all terminals or binding posts. Tags equipped

with a hole shall be slipped on over the wire before the terminal is applied to the end of the wire, or attached to the wire by means of nylon cord. The tags shall be so placed that they can be read easily and will not move away from the terminal. Tags shall be so placed as not to drift on the wire, or interfere with movement or inspection of the equipment.

(d) Tags to designate the cable shall be as described above, and shall be attached to the cable with approved pre-tied nylon cord loops. The tags shall be installed on the cable sheath near the pothead. Prior to the installation of this tag on the cable and at the time the cable has been installed, a temporary tag of linen shall be securely tied to the cable.

(e) If required in pull chambers or manholes, certain cables shall be tagged with lead or brass tags, bearing the cable identification, number, size of cable, in one-quarter (1/4) inch letters, and/or numbers. Tags shall be of sufficient size to contain the required information without crowding and shall be attached to the cables by means of No. 14 A.W.G. stainless steel wire.

(f) On the inside of the new control panels, all pushbuttons, switches and lights shall be identified.

Chapter **14**

Almond

Chapter 14

COMMUNICATIONS

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Chapter 14

COMMUNICATIONS

I - GENERAL

A. BRIEF DESCRIPTION OF WORK

(a) This portion of the Guidelines covers the work to be done in connection with

(1) the furnishing of telephone communications equipment and

(2) the installation, testing and placing in operation of said equipment. The telephone equipment shall consist of local magneto telephones, route request telephones, telephone at Train Order Signal, loudspeaking telephones and equipment, and various types of common battery telephone equipment rented from the Telephone Company.

(b) In addition to the abovementioned telephone equipment, also furnish and install terminal boxes, clocks, fire protection equipment, public address equipment, smoke detection equipment, and emergency alarm equipment.

(c) Hereinafter, all work will, in general, be referred to as communications work.

(d) In addition to the above, furnish and install communications cables into new enclosures.

(e) Furnish and install new equipment in the Signal Towers, Dispatcher's Office, relay rooms, central instrument rooms, maintenance enclosures and at central instrument housing locations.

(f) Furnish and install new cable and conduit into the Signal Towers, Dispatcher's office, relay rooms, maintenance enclosures, central instrument rooms and at the central instrument housing locations. Furnish and install terminating equipment for the new cables and furnish and install all twisted-pair wire for local distribution within enclosures and for cross-connecting at new terminal boxes.

(g) Furnish all labor, plant, tools, installation supplies and equipment, power layout, etc., necessary for the purpose of installing communications equipment.

B. COMMUNICATIONS EQUIPMENT IN MAINTENANCE ENCLOSURES

(a) Where a maintenance room is constructed in the vicinity of a tower or relay room, furnish and install twisted-pair telephone wire, in conduit, into the enclosure. Obtain a hang-up telephone for each such enclosure, mount the telephones within the enclosures and connect them into the twisted-pair wires.

(b) In addition to the telephones, each maintenance enclosure shall be equipped with a 15-pound CO₂ fire extinguisher and a 5 pound Type ABC fire extinguisher, complete with mounting facilities. Telephone equipment shall be placed in service and the fire extinguishers installed before the signal equipment is placed in service.

C. POWER FOR COMMUNICATIONS EQUIPMENT

(a) Power for the common battery telephone equipment will be delivered at the terminal frames in the satellite stations serving the area in which the telephones are located.

(b) Electrical energy for the magneto telephone shall be provided by local batteries (dry-cells).

(c) Receptacles providing 120-volt, 60 Hz, single phase electrical energy necessary for the operation of the loudspeaking telephones shall be furnished and installed. Also furnish and install the dry cells necessary for the operation of units.

(d) Electrical energy for synchronizing clocks shall be available at terminal boxes. Electrical energy for winding the clocks shall be provided by dry cells.

(e) Electrical energy for the smoke-detection equipment shall be supplied from the 120-volt, 60 Hz, A.C. signal supply.

D. TYPES OF RENTED TELEPHONE EQUIPMENT

(a) The types of rented telephone equipment are as follows:

(1) Western Electric Type 554CR-3 Wall Mounting Telephone Sets.

(2) Western Electric Type 526 Telephone Set. For outdoor use, with dial and with a "push-to-dial and talk" switch in the handset.

(3) Western Electric Type 500-K7 Hand Telephone Cradle Sets.

(b) The above rented telephone equipment shall be installed in accordance with the standards of the Telephone Company.

E. TELEPHONES AT TRAIN ORDER SIGNALS

(a) Telephones, consisting of an outside telephone set with dial and as described below, shall be located adjacent to train order signals. Obtain the telephones as described above and install the telephones in the vicinity of each train order signal by mounting them on the subway wall or on a column, or if required on a pedestal. The mounting height shall be such as to make the telephone readily available to a motorman in his cab. Telephones mounted on columns or pedestals shall have a ladder furnished and installed in a permanent manner so that the instruments can be maintained.

(b) Where there is to be an emergency alarm installation, over a high duct bench, in the immediate vicinity of a train order signal, install the emergency telephone so it may be used by the motorman, as hereinbefore described.

(c) The doors of instrument housing for outside telephones shall each be equipped with an approved spring latch; they shall not be equipped to automatically lock. The words "PULL OUT" shall be stenciled on the outside of each door directly over the door handle. The extension number and the ring for the instrument shall be stenciled on both the inside and outside of the housing door. All letters and numbers shall be of the block type, they shall be three-quarters (3/4) of an inch in height, and they shall be stenciled with black paint.

(d) The cases containing new telephones will be painted gray. The outside of these cases shall be sprayed with at least two (2) coats of quick-drying yellow lacquer, before installation.

F. BEST QUALITY OF MATERIALS

Material supplied shall be of the best quality and suitable for use in the communications systems of the Railroad. Where no requirements are herein specified for the equipment and materials, they shall conform to the latest specifications and requirements of the Telephone Company, the Institute of Electrical and Electronic Engineers, the Electronic Industries Association, the Standard Specifications of the American Society for Testing and Materials, the American Standards Association, and to the regulations of the National Board of Fire Underwriters as they apply.

II - CONDUIT

A. FURNISHING AND INSTALLING CONDUIT

(a) Furnish and install all conduit necessary for the communications installation. Requirements for the conduit, fittings, straps and supports shall be as called for in the Signals Conduit Section. In general, PVC conduit shall be used for communications work.

(b) In general, communications cable and wire shall not be listed. When installed in manholes or other enclosures in which power cables are present, the communication cables shall be racked as far away from the power cables as possible. Where a conduit, containing a communications cable, abruptly changes direction, omit the conduit fitting or pull box. Where such fittings or box is omitted, the gap between the conduits shall be the minimum required for efficient handling of the cable. The ends of the conduits shall be fitted with bushings to prevent injury to the cable sheath. If the exposed cable may be subject to injury by abrasion or fire, the cable shall be protected throughout its exposed length by listing. Where the gap between the conduit ends exceeds two (2) feet, or where any droop in the cable would constitute a hazard, the cable shall be supported by a cleat.

III - MAGNETO TELEPHONE EQUIPMENT

A. FURNISHING AND INSTALLING MAGNETO TELEPHONES

Indoor Type-Desk or Wall Mounted.

(a) The telephone instrument shall be of the magneto, local-battery type. It shall contain an ALNICO permanent-magnet generator with polarized ringer and a moistureproof condenser of proper type, capacity and voltage rating, mounted within the instrument itself. The telephone instrument case shall be removable by disengaging ringer crank and a single screw, exposing all terminals and wiring to view and easy access. The telephone instrument shall be designed for conversion to either desk or wall mounting without any physical modification whatsoever and it shall be electrically designed for either common-battery or dial conversion by means of screw-terminal changes only; no unsoldering of connections shall be required for conversion to any conventional type of telephone system operation. Transmitter and receiver handle shall be equipped with a push-to-talk switch, and shall be suspended in the case by using a cup hanger. The cup hanger shall be shimmed to prevent contact between the instrument case and the push-to-talk switch. The handle shall be equipped with transmitter and receiver units. It shall be equipped with a moisture-proof three-wire coil cord.

(b) The transmission and reception of the telephone shall be such as to provide a good commercial grade of transmission between any two telephones connected together through a 31-decibel, type "H" transmission pad.

(c) Furnish and install, at the various locations a wall mounted magneto-telephone. Also furnish and install a battery box complete with three standard No. 6 dry cells at the location of the indoor magneto-telephone and connect these cells into the magneto circuit. The box shall be mounted where it shall be readily accessible for maintenance.

(d) The magneto-telephone equipment shall be mounted complete with all necessary supports, fastening, bushings, locknuts, etc. It shall have metal property tags permanently attached thereto.

IV - LOUD SPEAKING TELEPHONE EQUIPMENT

A. FURNISHING AND INSTALLING LOUD SPEAKING TELEPHONE EQUIPMENT

(a) The loudspeaking telephone equipment, to be furnished and installed shall be connected to the loudspeaking telephone systems of the Railroad and shall, consist of the following units:

- (1) Telephone Line Amplifiers.
- (2) Subscribers Sets.
- (3) Desk Stands, complete with Transmitter, Push-to-talk Switch and Five Conductor Cord.
- (4) Battery Boxes, each complete with three standard No. 6 Dry Cells.

(b) The loudspeaker sets shall be adjustable to operate at voltages ranging from 105 to 125 volts on 60 Hz alternating current.

(c) Make such changes, adjustments or additions to the loudspeaking telephone equipment in order to procure satisfactory reception and transmission and in order to have it applied to each particular location.

(d) The equipment shall be connected to ground.

V - ROUTE REQUEST TELEPHONE EQUIPMENT

A. FURNISHING AND INSTALLING ROUTE REQUEST TELEPHONE SYSTEM

(a) Furnish and install a route request telephone system at the various interlockings.

(b) Each route request telephone shall have a 6-pair, code-type cable terminated on its terminal strip and installed on the messenger runs carrying the signal cables. These cables shall be brought into the relay room controlling the interlocking. The talking circuits from each route request telephone shall be connected together at the relay room and shall be connected into a code-type cable.

(c) This cable shall be installed on the signal messenger wire and shall terminate at the control panel. Each talking circuit along the right-of-way from the route request telephones shall be connected into this cable. The system at the interlocking shall be comprised of the material described below.

(d) At the Interlocking, a route request telephone shall be furnished and installed at the home signal at facing point switches. The route request telephone shall consist of an aluminum instrument case accommodation a sound-powered telephone hung on a hook switch, a telephone type relay for controlling an indication light, a step-down transformer, a push-button to enable the towerman to call the control panel, and a terminal strip. The instrument case shall have a bull's-eye type of indication lamp mounted to display a white light on the face of its door. The case shall be supported from either a pedestal, cantilevered from a home signal, or column or wall at the stop-release contractor of the home signal.

(e) In the Tower, furnish and install on the control panel a single indication light and an audible signal for the entire group of route request telephones from the Interlocking; a cancellation button adjacent to the indication light; and a telephone jack, also marked in yellow, on the face of the control panel for the route request telephone system. The new buttons to be furnished and installed on the control panel to initiate a "call-on" indication when pushed shall also have a set of pull contracts to enable the towerman to transmit a signal to each home signal location provided with a telephone set.

(f) The number of sound-powered telephones required under other provisions, shall be in addition to those required for the route request telephone system.

(g) The instrument case enclosing the route request telephone and associated equipment shall be a type suitable for outdoor use, constructed of sheet aluminum or cast aluminum, and provided with a single cast aluminum door properly gasketed. A case constructed of sheet aluminum must have all seams welded. The case shall have screened ventilator openings and a weather hood. All screening shall be constructed of aluminum and shall be spot welded or attached by flat-head rivets which do not project through the case. The case shall be provided

with a threaded hub connection for 3/4-inch conduit on the top. All equipment shall be mounted with aluminum machine screws. All necessary supports for wires and cords shall be supplied with each case. All hardware subject to abrasion shall be of non-corrosive rust proof material; all other hardware shall be chemically treated to effectively resist such weather and moisture conditions as are prevalent on Rapid Transit Systems. The cast aluminum door shall be equipped with a gasket. The gasket shall be made from a single strip of 1/16-inch organic material, and shall be fastened to the door with organic adhesive. The fastening of the gasket to the door shall be performed in strict accordance with the manufacturer's recommendations and specifications. The door shall be hinged on the right side by means of a full-length, continuous hinge. It shall be capable of opening to the right through an angle of 200 degrees. The door shall be provided with a brass knob or handle for opening and with two magnetic catches at upper and lower left hand corners for stripping and holding the door closed. The instrument case shall not be painted.

(h) The instrument case shall be equipped with the following equipment, which shall be mounted and wired.

- (1) Hook switch, with spring switching arrangements.
- (2) Sound-powered telephone equipped with a ten (10) inch, moistureproof retractile cord.
- (3) Socket with a bayonet base clear bulb and a glass lens.
- (4) A momentary contact push switch, single-pole, single-throw, rated at 3 amperes at 125 volts.
- (5) A filament Transformer.
- (6) Two wire-wound potentiometers, 250 ohms at 2 watts.
- (7) A relay.
- (8) A connecting block.

(i) Wiring of the equipment in the instrument case shall, along with other wiring and component parts, make up a complete route request telephone system.

VI - MAINTENANCE TEST TELEPHONE EQUIPMENT

A. MAINTENANCE TEST TELEPHONE SYSTEM

A.1 GENERAL. Furnish and install certain equipment necessary to provide for a maintenance test telephone system which will extend between the control tower, the relay rooms, the various central instrument rooms and between designated locations in the field.

A.2 TELEPHONE EQUIPMENT. The following equipment shall be furnished and installed at each of the interlockings:

(1). Sound Powered Telephones. Each sound powered telephone shall be equipped with a ten (10) foot two (2) conductor cord. Each cord shall terminate on a plug. In addition to the plug, the cords shall terminate on all nylon insulated alligator clips terminated on separate leads about eight (8) inches long originating from the cord just above the plug. While the clips are in use, the plug termination shall be protected from grounds and shorts by a loose fitting cylindrical neoprene jacket.

A sound powered telephone equipped with a long lead shall be furnished for the control panel in the tower and for each relay room and central instrument room.

(2). Projection Type Horns. The horns shall be furnished complete with weather proof back boxes. The horns shall be energized from the 115 volt 60 Hz signal lighting transformers. Each circuit shall be separately fused. In general, horns shall be mounted on or adjacent to equipment or rooms that the horns are being fed from. Furnish and install all necessary counting and fastening materials required for the installation of the horns on the various types of equipment or structure.

(3). Jacks. A sufficient number of jacks shall be installed in order to provide convenient operation at the racks, in the relay room.

All telephones and telephone jacks furnished and installed for the maintenance test telephone system in the tower, etc., shall be designated by a red marking. Jacks will not be required at cast-iron junction boxes.

(4) Weatherproof push-buttons. Jacks and push-buttons shall be installed at designated locations on the control panel and on racks in central instrument rooms and relay rooms. A single jack and weatherproof push-button shall be installed in each central instrument house and each vertical instrument case. The weatherproof push-buttons and the jacks shall be mounted on vertical instrument cases and central instrument housing in such a manner that they may be used without opening the doors with exception of central instrument housing exposed to the public. At such locations the jack and push-button shall be mounted inside the housing. A single weatherproof push-button shall be installed in each junction box and terminal compartment in which the talking circuit will terminate. The maintenance test telephone system shall terminate on the last pair of terminals on the lower right-hand side of each terminal compartment, junction box and vertical instrument case.

(5) Push-Buttons on the control panel to operate the maintainers call horns shall be similar to other control panel push-buttons.

(6) Four (4) pole double throw switches shall be for switching from local to distant communications. The position on the switches shall be marked to indicate the mode.

(7) Handset mounting hooks shall be installed at relay racks in relay rooms, or central instrument rooms and housings.

(8) Hook switches and hand-set mounting hooks shall be installed on racks in relay and central instrument rooms, so as to make for convenient operation of the maintainers test telephone system. A hook switch shall also be mounted on the control panel.

A.3 SYSTEM OPERATION AND WIRING. In general, talk circuits shall terminate on jacks and hook switches. Ring circuits shall terminate on push-buttons in the various types of equipment.

Wire and cable for the maintenance test telephone system shall extend from the tower, to relay rooms, central instrument rooms and to such terminal compartments, junction boxes, and interlocking signal cases within the control of the relay room. The cable shall be terminated on the last pair of terminals on the lower right-hand side of each junction box or case on jacks at designated locations in the relay rooms.

In the automatic territories, the circuit shall again extend from each central instrument room or central instrument housing to the junction boxes or cases at each signal and cut-section location and shall be terminated as hereinbefore described.

At each relay room, central instrument room or housing, the circuit shall terminate on a jack or jacks, or on a four (4) pole double throw switch to transfer the talking and ringing circuits from local to remote control.

The first pair of the 6-pair cable shall be used for the talking circuit and the second pair shall be used for the ringing circuit. The ringing circuits from the relay room shall terminate at push-buttons in the relay room and in the junction boxes or cases. The terminations shall be made in moisture-proof push-buttons mounted in each junction box or case in which the talking circuit is available. These push-buttons shall operate a relay in the relay rooms associated with the junction box or case. Operation of the relay shall apply energy to a buzzer or buzzers in the relay room and to horns.

Power for operating the ringing relays shall be obtained from rectifiers in the relay room, or central

instrument rooms or housing. A.C. power for the operation of the buzzers or horns shall be 60 Hz energy. The horns shall receive energy from the signal lighting transformers and each circuit shall be properly fused.

Non-vital, buzzers, associated transformers and transformer rectifiers necessary for proper operation of the maintainers test telephone system shall be mounted on instrument racks. Push-buttons for the portion of the maintenance test telephone system mounted on the control panel shall be similar to other control panel push-buttons.

The maintenance test telephone equipment mentioned herein shall be installed and connected to the extent practicable in or on the housing and racks. All wiring for the maintenance test telephone system shall be No. 19 A.W.G.

VII - TALK-BACK PAGING EQUIPMENT

A. GENERAL

Install a talk-back paging system between the Signal Tower and designated locations throughout the Yard. The equipment shall consist of a master station equipped with annunciators, talk-back paging speakers and weatherproof push buttons throughout the Yard; and a 25 watt paging amplifier. The master station and amplifier shall be located in the Signal Tower. Connections between the equipment shall be made using 6-pair cable.

B. MASTER STATION

The master station shall have facilities for connecting into talk-back paging speaker locations and shall be equipped with annunciators. The annunciators shall be of the diffused light type and are combined with a tone signal to announce incoming calls. Operation of the station selector key to answer a call turns off the light.

The unit is equipped with two volume controls; one regulates the listening volume and the other regulates the outgoing volume. The audio output is 9 watts into a matched load of 45 ohms. A voice of ten bar sound pressure impinged on the speaker microphone will produce 9 watts of power.

The unit shall operate off a 110-125 volt, 60 cycle supply. It is equipped with an 8 foot, rubber-covered, 3 conductor cord. Furnish and install a 3 prong, duplex receptacle adjacent to the master station. The receptacle shall be fed from the flood lighting panel. The power drain shall not exceed 35 watts.

The master station shall be so wired that one switch can be used as an all-call switch. This switch, when operated, parallels all stations connected to it. Paging on all speakers shall be done through a 25-watt booster amplifier. The booster amplifier shall be connected into the master station in a manner to permit paging through the same speakers used for intercommunication.

C. PAGING AMPLIFIER

Install a paging amplifier to be operated through the master station in the all-call position. The input to the amplifier shall be either 50 or 500 ohms. The output shall be 25 watts with not over 5% total harmonic distortion at 400 cycles. Output impedances shall be 2,4,8,250 and 500 ohms. The 250 ohm tap may be used for a 70 volts line.

The output of the amplifier shall be regulated to within 2.2 db when load is varied from matched load to open circuit. It shall have a frequency response of ± 2 db from 30 to 15,000 cycles. A plate voltage relay controlled from the master station shall apply plate voltage to the tubes only during periods of speech.

The unit shall have one gain control, base-cut tone control, on-off switch and pilot light. It shall operate from 117 volt, 60 cycle energy obtained from the duplex receptacle. Power consumption shall not exceed 110 watts.

D. TALK-BACK LOUDEDPEAKERS

The talk-back loudspeakers to be furnished and installed shall be a weatherproof reflex horn with hermetically sealed driver unit. It shall have waterproof construction and a corrosion proof gun metal finish. The power handling capacity shall be 15 watts with a voice coil impedance of 45 ohms. The horn shall be 8-1/2 inches in diameter and have a 90° dispersion and be equipped with a mounting bracket.

E. WEATHERPROOF PUSH BUTTONS

At each location of a talk-back loudspeaker furnish and install conduit from underground to a 6"x6"x4" cast-iron pullbox mounted 4-1/2 feet from the ground. The pullbox shall be equipped with a terminal block, on which the 6-pair cable shall be terminated. The first pair in each cable shall be connected by twisted-pair wire to the paging speaker which shall be mounted approximately 15 feet above the ground. The twisted-pair wire shall be installed in conduit from the pullbox to the paging speaker and shall leave the conduit through an approved type weatherhead.

The cover of the pullbox shall be drilled to receive a heavy-duty push button. The push button shall be covered by a 1/16 inch thick cover. The cover shall be fastened to the pullbox cover with organic adhesive, and with a 3/8" wide by 1/16" thick brass ring which, in turn, shall be fastened to the pullbox cover with four roundhead brass machine screws.

The second pair in each cable shall be connected to the terminals of each push button and shall operate the annunciators at the master station.

The pullbox cover shall be equipped with a gasket to complete the weatherproofing.

VIII - SMOKE DETECTORS

A. FURNISHING AND INSTALLING SMOKE DETECTORS

(a) Furnish and install smoke-detecting equipment in the relay room and central instrument rooms. No smoke-detecting equipment will be required at the central instrument housings. The equipment shall consist of one or more detector heads mounted on the ceiling of the central instrument rooms; one or more detector heads mounted on the ceiling of the relay room; a fire indicating cabinet mounted in each relay room and central instrument room and an approved ten (10) inch gong so mounted outside the rooms as to be heard outside the relay room, central instrument room or dispatcher's office and along the right-of-way. In the vicinity of each gong, furnish and install an approved sign which indicates the purpose of the gong.

(b) Indications from the smoke-detector equipment at the central instrument rooms and relay rooms shall be displayed on the third rail indication panel at the control tower.

(c) The detector heads shall detect the presence of visible smoke and invisible products of combustion by the ionization chamber principle. They shall be mounted on four (4) inch conduit pullboxes and connected into the fire indicating cabinet by two No. 14 A.W.G. wires, run in conduit.

(d) The fire indicating cabinet shall be provided with contacts for fire alarm gongs and trouble signals and shall contain supervisory and power relays, constant voltage transformer, and other components to supervise the system in accordance with the Underwriters' Laboratories, Inc., requirements.

(e) In operation, no valving or timing mechanisms shall be necessary and there shall be no moving parts in the system. Each detector head shall be capable of having its sensitivity changed without removing it from its base. The heads shall be capable of being removed from their bases for sensitivity checks if it is desired to do so.

(f) The smoke-detecting system equipment shall be listed by the Underwriters' Laboratories, Inc. The manufacturer shall recommend the number and location of heads to completely and adequately protect the enclosures.

(g) Power for the equipment shall be 120 volt, 60 Hz.

(h) Furnish maintenance manuals covering the system installed.

IX - EMERGENCY ALARMS

A. EMERGENCY ALARM CIRCUITS

All emergency alarm boxes, within the limits of the respective contact rail sections controlled from each substation or zone control room, shall be connected in series in one circuit. The emergency alarm circuits shall be carried only in rubber or polyethylene insulated wire

or cable. For the purpose of reducing line resistance where the circuit is run in cable and to reduce interruption of service due to wire failures, two pairs of wires in multiple shall be used for each emergency alarm circuit.

B. FURNISHING EMERGENCY ALARM BOX

(a) The emergency alarm box shall be either a single or multiple type.

(b) The emergency alarm box shall also be of the positive noninterfering type, so arranged that the simultaneous operation of any number of boxes on the same circuit will not result in the transmission of an incomplete or confused signal from the box which is first pulled and therefore automatically selected to control the line.

(c) The mechanism, when operated, shall transmit a definite code signal over its circuit, repeating the signal four (4) times with one complete operation of the starting lever. The starting lever shall be so arranged that after the box movement has been set into operation, no manipulation of the starting lever can in any manner whatsoever interfere with the transmission. Should two (2) or more boxes in one circuit break the circuit at the same instant, the no-interference devices shall positively operate to insure the full and correct transmission of the signal of the one box automatically selected to transmit its signal.

(d) The signaling mechanism of the box shall be operated by means of a spring sector pull, and the pull or starting lever shall be arranged to wind the mechanism for four (4) complete rounds on one complete operation of the lever, but should the lever be released by the operator before the full number of rounds is wound, the mechanism shall transmit whatever rounds may be wound at the time the starting lever is released. The pull, or starting lever of the box shall be arranged to disengage itself automatically from the mechanism when the box is operated, and not again be in a position to engage same until the mechanism has completed its signal.

(e) When the signaling mechanism is at rest, the noninterference magnets and the signaling contacts shall be protected by an efficient shunt protector, which shall

be mechanically forced open when the starting lever is operated for the purpose of sending an alarm. After the transmission of an alarm, the protective shunt shall be automatically closed.

(f) The mechanisms shall be provided with multiple signaling contact springs of phosphor bronze, faced with heavy contacts of pure silver, and shall be self-cleaning. The noninterference magnets shall be wound to a resistance of approximately fifteen (15) ohms with the best quality enameled copper magnet wire, and the spools shall be constructed of porcelain or bakelite. The magnets shall be free from residual magnetism, and the windings thereof shall be so insulated and constructed as not to be susceptible to moisture absorption and corrosion. The mechanism shall be of the highest grade material and workmanship throughout. The wheel work, plates, frames, lever, signal keys, pulls and magnet armature holders shall be of Excelsior bronze composition, and the shafting of high grade steel. All steel parts of the mechanism shall be constructed of stainless steel except the main driving springs, clicks and escapement pallet which shall be protected against corrosion.

(g) The mechanism must be capable of withstanding an alternating r.m.s potential of 1000 volts between the equipment in the electrical circuit and the case, for a period of three (3) minutes without breakdown or injurious effect.

(h) The train movement of the mechanism shall be regulated to a constant speed of 1/2 second between consecutive strokes of the signal number; the time interval between the digits or sections of signal number shall be 1-1/4 seconds; and 3-1/4 seconds shall intervene between the rounds of all signals, all at seventy (70) degrees Fahrenheit.

(i) The time duration of any round of complete signal shall not differ by more than ten (10) per cent from the time specified in Paragraph (h) for each round.

(j) After the box mechanism has been regulated as prescribed in Paragraph (h) above, it shall be capable of being properly operated after an exposure of not less than twelve (12) hours at zero (0) degrees Fahrenheit. This test shall be repeated at one hundred and twenty (120)

degrees Fahrenheit. The mechanism shall operate satisfactorily at and between each of these temperatures and shall meet the requirements of Paragraphs (h) and (i).

(k) The mechanism shall fulfill all the requirements given above, when operated at any direct current value between 65 and 300 milliampers, inclusive. The noninterfering coils shall withstand the maximum current continuously applied for a period of one (1) hour without excessive heating.

(l) The outside housing of the emergency alarm box shall enclose an inner compartment containing the alarm mechanisms, plug switches and microswitches. The housing and its doors shall be constructed of the best quality of cast-iron and they shall be finished inside and out with red enamel. The door of the housing shall be of such design that it can be readily opened and fastened by means of a hand operated latch. The door shall be equipped with a number plate mounted in position on the inside. This plate shall be stamped with the signal code number of the box, and the numerals so made shall be painted to appear black under a protective coating of clear lacquer. On the outside of the door there shall be mounted an enameled plate bearing the words, "OPEN DOOR PULL LEVER" and "EMERGENCY ALARM". These letters shall be white on a red background, and the plate shall be of one-sixteenth (1/16) inch cast-iron. The plate shall be securely fastened to the door in a manner which will prevent chipping or cracking of the enamel around the points of fastening and eventual corrosion of the plate. The outside housing of the single unit emergency alarm box shall be drilled and tapped, top and bottom, for one-half (1/2) inch conduit; one of the conduit openings in the box shall be provided with a pipe plug.

(m) The interior equipment comprising the alarm mechanism, the plug switch and the microswitch, shall be arranged in relative positions inside of the emergency alarm box. The alarm mechanism and the plug switch shall be contained in an individual housing or compartment. This housing shall be constructed of the best quality of cast-iron and the cover shall be of No. 14 U.S. gauge (5/64") sheet brass or equal; both the housing and the cover shall be finished inside and out with red enamel. The inner face of the cover shall be properly gasketed so that when fastened in place, it shall positively exclude

moisture and dirt from the inside of the case. On the underside of each plug switch housing, a lava bushing with five holes shall be provided for the admission of line wires. No name plate will be required for the plug switch housing for the single unit emergency alarm box.

C. INSTALLING EMERGENCY ALARM BOX

(a) The emergency alarm boxes are approximately six hundred (600) feet apart. It will be desirable, however, to have the emergency telephone located directly below a tunnel lighting fixture. If the box, is not located under a lighting fixture, it shall be installed under the nearest lighting fixture.

(b) Installing the emergency alarm box shall include furnishing and installing all supporting posts, framework, bars, brackets, clamps, fittings, condulets, and fastenings; furnishing and installing pullboxes and all conduit interconnecting the various units at the telephone and emergency alarm locations; furnishing, installing and connecting all twisted pair wire; tagging; testing; doing all necessary drilling and patching; painting; stenciling; and all incidental work, material and labor necessary to install the emergency alarm box.

X - CLOCKS

A. GENERAL.

The clock to be furnished and installed shall be of the self-winding type.

B. FURNISHING AND INSTALLING CLOCKS

(a) The self-winding type clock shall be capable of continuous operation independent of any outside connection, and be designed for hourly synchronization by a master clock. The clock shall have a 300-beat marine type escapement and shall be equipped with an auxiliary synchronizing relay. This relay shall be connected in series with the synchronizing circuit from which the clocks receive a synchronizing electric impulse once an hour.

(b) The clock shall have solid, highly polished, cut-steel pinions, and shall have gears accurately cut

from best quality hard rolled sheet brass. The motive power of the clock shall be derived from a main spring enclosed in a spring barrel and coiled around an arbor in such a way as to avoid friction between coils. The spring shall uncoil one turn each hour and in so doing shall close an electric contact allowing current to be supplied to the motor which rewinds the spring. The winding motor shall be of the oscillating type so designed that it will wind the spring to the same degree each hour, the motor contacts being so arranged that the spring cannot be overwound. To insure against failure to start, the motor shall be so designed that there will be no dead point.

(c) Energy for the winding motor shall be supplied by dry cells, and of sufficient capacity to supply energy to both the motor and the synchronizing equipment for a period of not less than one year. The dry cells shall be suitably mounted in the clock case. The clock case shall be of such size as to accommodate, without crowding, the clock mechanism and batteries. The dial shall be 15 inches in diameter.

(d) The clock shall be securely mounted in a plumb position. Furnish the wiring for the clock.

(e) After a self-winding clock has been installed and before it is connected to the synchronizing circuit, it shall be manually regulated to run within ten (10) seconds in twenty-four (24) hours. This regulation shall be checked for a period of three (3) consecutive days.

XI - TERMINAL BOXES

A. FURNISHING TERMINAL BOXES AND CONNECTING BLOCKS

(a) General. Furnish and install terminal boxes complete with adaptors and terminal blocks. Also furnish and install connecting blocks with cover. The boxes and blocks shall be mounted in the relay rooms and central instrument rooms.

(b) The terminal boxes and connecting blocks to be furnished and installed shall be completely equipped for terminating and cross-connecting main, local and branch

communication cables. The locations of terminal boxes and connecting blocks may be changed where necessary. The terminal boxes and connecting blocks shall be of specified sizes. The terminal posts shall have locknuts and washers and the posts shall be spun over to prevent the loss of locknuts.

B. INSTALLING TERMINAL BOXES

(a) Certain pairs of terminal posts, carrying special circuits at terminal boxes, shall be provided with "Binding Post Insulators." These clips shall be colored.

(b) At each pair of wires in the terminal boxes, special circuits shall be tagged with an approved tag, on which such nomenclature, as may be deemed necessary, shall be stamped.

(c) All communications cable installed inside of the new terminal boxes shall be tagged with an approved tag on which the cable number and size of the cable shall be imprinted in three sixteenths (3/16) inch letters and/or numbers. Where a cable is split over two strips, two tags shall be provided.

(d) In general, tags shall be at least twenty-thousandths (0.020) of an inch thick. The four (4) corners of the tag shall be rounded to a one-eighth (1/8) inch radius. The base material shall be white vinylite. The nomenclature shall be printed on the base material in black, and protected with a five thousandths (0.005) of an inch clear overlamine. Lettering shall be one-eighth (1/8) of an inch high, with three-thirty seconds (3/32) of an inch spacing between lines.

XII - COMMUNICATIONS WIRE AND CABLE

A. GENERAL

(a) The Contractor shall furnish, install, connect, terminate and splice communications wire and cable (including cross-connecting wire). Terminating a cable shall mean the connecting of the individual wires of the cable to binding posts at equipment such as terminal boxes.

(b) In general, when new cable pairs are installed, 20% spare pairs are to be provided.

(c) Samples of all units and materials proposed for use in the communications cable installation, such as cable racks, supporting brackets, cleats, cable bonding straps, listing etc., shall be submitted for approval before proceeding with any of the work.

(d) No communications cable shall be pulled, cut spliced or connected, and no cable work shall be performed unless a duly authorized representative is present.

(e) Proper precautions shall be taken and extreme care must be exercised in handling and installing cables and wires to avoid any injury to the wires, cables, or their sheaths.

(f) All wire and cable shall be continuous and without splices between points of connection.

(g) All wires and cables shall be so installed in ducts, conduits and manholes, and on the structure, and so racked, as to facilitate any future work which may require repair, clearing or cleaning of ducts, and the installing and racking of any future cables. Cable which is required to be protected (listed) shall have the listing installed.

B. FURNISHING COMMUNICATIONS WIRE AND CABLE

(a) General. Wire and cable, as specified herein, shall be installed.

(b) All orders for wire and cable are subjected to approval. The order for each item of wire and cable must state definitely under which specification it shall be furnished.

C. CLASSIFICATION

The wire and cable shall be of the following classification:

Communication Wire and Cable
Synthetic Rubber Insulated Wire and Cable

D. WIRE AND CABLE SAMPLES AND TEST REPORTS

In general, wire and cable will be inspected at the factory, prior to shipment. In lieu thereof, samples not less than twelve (12) inches in length and five (5) copies of the notarized certified test reports of each type and size of wire and cable to be furnished shall be submitted for the approval prior to delivery.

E. COMMUNICATION WIRE AND CABLE

(a) Single-and multiple paired, polyethylene insulated polyvinyl chloride jacketed, communication cable shall be ordered as described in the following paragraphs.

Cable, telephone, No. 19 or No. 16 A.W.G. solid. Polyethylene insulation of low density type on each conductor. Polyethylene inner jacket. Copper shield, helically applied Polyvinyl outer jacket.

The outer jacket of all completed cable shall be tested after cable has been immersed in water for at least six (6) hours. The outer jacket shall show an insulation resistance of at least one (1) Megohm-Mile at 15.6° C.

- (1) 2-pair, No. 19 A.W.G. Solid.
- (2) 2-pair, No. 16 A.W.G. solid.
- (3) 6-pair, No. 19 A.W.G. solid.
- (4) 100-pair, No. 19 A.W.G. solid.
- (5) Wire, twisted-pair, No. 19 A.W.G., solid. Polyvinyl chloride outside. All weather insulation.
One conductor black, other red, for cross-connecting.
- (6) Wire, twisted-pair, No. 19 A.W.G., solid. Polyvinyl chloride outside. All weather insulation.
One conductor black, other brown, for wiring to equipment.
- (7) Wire, twisted-pair, No. 16 A.W.G., solid. Polyvinyl chloride outside. All weather insulation.
One conductor black, other red, for maintenance test ringing circuit.
- (8) Wire, twisted-pair, No. 16 A.W.G. solid. Polyvinyl chloride outside. All weather insulation.

One conductor black, other brown, for maintenance test talking circuit.

F. INSTALLING COMMUNICATIONS CABLE AND WIRE

All provisions concerning the installation of signal cable and wire shall govern the installation of communications cable and wire. Communications cable and wire shall also be governed by the provisions regarding listing.

G. PROTECTING CABLES IN MANHOLES AND ENCLOSURES

Where necessary, pump the water out of manholes or other enclosures before installing any cables and keep the manholes, ducts or other enclosures clear of water during the installation of cables. Provide all the necessary power and pumping equipment.

H. CABLE RACKS, WOODEN CLEATS AND INSULATORS

(a) Where required for communications cable, furnish and install hot-dip galvanized, cadmium, or otherwise plated or protected, iron cable racks and hangers. Such racks and hangers shall be installed at points where cables are placed horizontally in manholes or other enclosures. Racks and hangers shall be installed by means of bolts securely fastened to the wall, using two (2) slugins or the equivalent per bolt. All racks and hangers shall be drilled and formed before being given the protective coating or coatings. Each rack or hanger shall be equipped with a suitable porcelain insulator on which the cable shall rest and to which the cable shall be tied. Porcelain insulators shall be glazed.

(b) Cables at terminal boxes and certain other locations, shall be supported by means of wood cleats. Where cables are installed vertically in manholes or other enclosures, they shall be securely supported by means of wood cleats mounted on galvanized iron supports securely fastened to the wall by means of bolts, using two (2) slugins, or equivalent per bolt. The racks and cleats shall be placed sufficiently close to prevent the cables from sagging. Wood cleats shall be of maple, boiled in paraffin or linseed oil for a period of six (6) hours, the cleat being completely made up before being boiled. The hole in the cleat shall be of sufficient

size to firmly clamp the cable, including listing, where used, without distorting or injuring the cable. Cables that have been listed together must be clamped separately in the wooden cleats.

(c) The racking of the cables shall be done in a neat and workmanlike manner. To avoid injury to the insulation and sheath, no cable shall be bent to a radius less than fifteen (15) times its outside diameter. The bending shall be done by rope, hands and feet, and shall be carried on slowly and without jerks. While bending the cable, a cable protector shall be used in the duct. Making sharp bends in any wire or cable, or bending such conductors over corners of structure, timber, or the ends of conduits will not be permitted. All workmanship in connection with the racking and protection of cables in manholes, or at other points shall result in a neat and orderly appearance of the completed work.

I. CABLE SHEATH ISOLATION

The metallic sheath of all cables shall be isolated at all points from contact with cable racks, steel rails, steel conduit, terminal boxes and structures. As far as possible, such cable sheath isolation shall be effected by means of insulated racks, bushings or supports.

J. BONDING STRAPS

Bonding straps shall be provided on all new shielded cables at terminal boxes and shall be connected together. Additional bonding straps shall be provided where necessary. The bonds shall be soldered to the metallic cable shields before protective wrapping is applied to the cable. Approximately three (3) inches of the strap shall extend through the asbestos listing.

K. TAGGING

All individual conductors and cables of all wiring installed shall be tagged in manholes and pull chambers and adjacent to the point of termination in each terminal box, etc. The tags shall be stamped with the cable identification number and size. Tags shall contain the required information without crowding.

L. SPLICING

(a) All cable lengths shall be continuous and without splices between the points of connections except as otherwise directed. If splices are made, it is of the greatest importance to secure perfect electrical continuity at the points of connection of each conductor and cable and consequently only the best and most highly skilled labor shall be employed. All splices shall be made in accordance with the best modern practice for the type and size of cables to be used. All splices and connections shall have a conductivity and insulation resistance at least equal to that of the cable.

(b) It shall be understood that all work necessary to prepare a cable for splicing such as racking, supporting, bending, shaping, preparing sleeves, etc., shall be done on the day previous to the actual splicing. On the day that the cable is opened to make the splice, the work shall proceed without interruption or delay, and the splice shall be completed, if possible, within the period of the normal working day. Employ only qualified telephone splicers to make splices on communications cables.

(c) If the splice cannot be completed within the period of the normal working day, the uncompleted splice shall be covered with a rubber bandage to prevent moisture or dirt from contaminating the open wires.

(d) Splicing the polyethylene insulated, polyvinyl-chloride jacketed cables shall be performed in the following manner:

1. The splicer shall remove, from the ends of both cables to be spliced, sufficient outer sheath, shield, inner sheath and wrapping to expose a length of twisted-pairs wires for splicing. If splicing kits cannot be obtained with unfilled polyethylene sleeves, the kits shall be ordered without sleeves and the sleeves ordered separately.
2. The splicer shall complete the splice in accordance with the instructions furnished with the splicing kit.

M. TERMINATING WIRES AT TERMINAL EQUIPMENT

Terminating of wires shall generally be done in the following manner: for solid wires, No. 19 AWG or smaller, the solid conductors shall be looped around the terminals and shall be securely clamped between brass washers by means of nuts provided on the terminal posts. Suitable slack shall be allowed in all wires adjacent to their terminals.

XIII - PUBLIC ADDRESS SYSTEM

A. FURNISHING PUBLIC ADDRESS SYSTEM

(a) Furnish a public address system on the platforms. The system shall consist of 50 watt solid-state audio amplifiers, sufficient loudspeakers to cover the station platforms without the sound level being objectionably loud in the immediate vicinity of any loudspeaker, and 2-pair telephone type cable between the loudspeakers and amplifiers and the microphone.

(b) All equipment furnished shall be operable without damage under any combination of the service conditions as follows:

1. Ambient temperature, -40°F to plus 130°F .
2. Ambient humidity, 0 to 95%.
3. Operating voltage, 105 to 130 volts A.C., 60 Hz.

B. FURNISHING MICROPHONE

(a) The microphone assembly shall consist of a dynamic noise cancelling microphone on a weighted desk stand housing a push-to-talk switch and a solid-state amplifier to provide a 52 dbm gain with a rated output level of -3 dbm into a 600 ohm load. The microphone shall be of the dynamic moving coil type. The microphone shall have a frequency response from 35 to 10,000 Hz. At 30 Hz, it shall not have a loss greater than 6 db or greater than 8 db at 10,000 Hz. The microphone impedance shall be 30/50 or 150/250 ohms and shall be balanced with respect to ground. The output level of the microphone, without the amplifier, shall be at least -55 dbm/10dynes/ CM^2 (or the equivalent EIA microphone system rating of -149 dbm for an input acoustical pressure of 0.0002 dynes/ CM^2).

(b) The unit shall be capable of operating from a power supply of 1⁴ volts D.C. maximum to 3.5 volts D.C. minimum. Operation of the push-to-talk switch shall apply power to the transistorized amplifier. The power shall be obtained from the power supply for the audio amplifier.

(c) Furnish a certified test report by the manufacturer of the microphone. The report shall follow the form specified in EIA standard SE-105, Section SE-4-H. The test report shall be submitted for approval prior to purchase of the microphone.

C. FURNISHING 50 WATT AUDIO AMPLIFIERS

(a) The 50 watt audio amplifiers shall be designed for standard 19" rack mounting. The amplifiers shall be suitably housed in protective outer covers to preclude dust and dirt from entering into the amplifiers. The amplifiers shall be operated on 60 Hz power. The power consumption shall not exceed 110 watts at rated output.

(b) An A.C. switch and fuse shall be provided on the chassis for protection of the amplifiers. The fuse shall be of the 1/4 x 1-1/4 inch glass cartridge type, mounted in an indicating type holder. All control knobs shall be securely attached to their shafts by means of "Allen" screws.

(c) The design of the amplifiers shall be such that all components will be operating at least fifty (50) per cent under their rated values. The amplifiers shall be capable of continuous duty under all conditions encountered in operation in subway structures.

(d) The chassis and cabinet shall be isolated from the 120-volt A.C. line and their connection to earth ground shall not have any detrimental effect on the operation of the amplifier. Each chassis common shall be insulated from the chassis with only one optional ground strapping location.

(e) The amplifiers shall meet or exceed the following specifications:

- (1) Gain
77 db

- (2) Frequency response - 1.5 db
200 to 5,000 Hz referred to 1000 Hz level
- (3) Power output, rated
50 watts RMS
- (4) Total harmonic distortion at rated power
5% or less
- (5) Mixer inputs-Mixer inputs shall be balanced and isolated.
 - (a) Microphone
-3dbm, 600 ohms sensitivity
 - (b) Auxiliary No. 1
-3 dbm, 600 ohms sensitivity
 - (c) Auxiliary No. 2
-3 dbm, 600 ohms sensitivity
- (6) Input connectors shall be Cannon Type XLR-4-14 for the Microphone Input and XLR-3-14 for the Tape Recorder and Carrier Inputs.
- (7) Output impedance
100 ohm (70v)
- (8) Noise level
-70 db below rated output
- (9) A.C. power input
105/130 volt 60 Hz
- (10) External power supply
12v at 300 ma
- (11) Protective devices shall be provided so that a short in the output line will not injure the transistors.

(f) Auxiliary Power Supply. A two (2) blade receptacle shall be installed and wired as follows:

Small blade-plus 12 VDC @ 300 Ma less than 10 MV.
Rms. Ripple
Large blade-negative

The above receptacle shall be labeled and located on rear of amplifier chassis.

(g) Output Characteristic. The amplifier shall be capable of delivering rated output into a 70 volt line or other load as specified. The 70 volt output shall be so designed that its output shall vary not more than 2 db from no load to full load.

(h) Output Impedances: The power output transformer secondaries shall terminate on a terminal strip consisting of terminals with the following output impedance taps, labeled as follows:

Terminal No. 1-Common
Terminal No. 2-4 ohm
Terminal No. 3-8 ohm
Terminal No. 4-16 ohm
Terminal No. 5-100 ohm (70 volt)

The above output terminals shall be mounted on the rear of amplifier chassis.

(i) Transistors. Transistors used in the amplifier shall be rugged, high-voltage silicon type and shall be of a standard commercially available type and shall not be operated with any current, voltage or dissipation in excess of that recommended by the transistor manufacturer for continuous duty commercial service. All transistors must be protected against heat generated within the equipment in such manner that the temperature of the transistor never exceeds its rated operating temperature.

(j) Current Limiting. Protective devices shall be provided so that in the event of a short circuit (or abnormally low impedance) developing across the output, a limiting circuit shall be instantaneously and automatically activated. When this condition occurs, an overload lamp (red lens) shall glow to indicate this circuit malfunction.

(k) Audio Compression. The audio compression circuitry shall be such that a 30 db input variation will result in less than 10 db change in output. A compression threshold control shall be located and properly labeled on the rear or the chassis and shall be adjusted at the factory for optimum compression and normally need not be reset. The compression control shaft shall be held in a secure position by an approved shaft lock nut.

(l) Audio Level Indication. The amplifier circuits shall be designed with an "Audio Level" indication lamp so that a visual indication will be displayed whenever the amplifier is functioning with a signal input. The audio level indication shall "flicker" in accordance with the signal level. This "Audio Level" indicator shall be

a red lens and shall be properly labeled and shall be installed on the front panel of the amplifier.

(m) High-low Voltage Compensation. A two position slide switch labeled "High and Low" shall be located on the rear of the amplifier chassis. This switch shall be wired in a manner that the switch is in the "Low" position whenever line voltages in the range of 105 to 117 are anticipated. The "High" position of the switch shall be wired such that when in this position line voltages of 117 to 130 are anticipated.

(n) Vendor Manuals. Supply pertinent Vendor manuals. These manuals shall contain, as applicable, detailed alignment procedures, diagrams, voltage readings, resistance readings, theory of operation, oscilloscope waveforms, pictorial layouts showing location of parts, parts list and other such information as may be required for an average technician to service and maintain the equipment without specific audio equipment experience. Supply one (1) manual for every ten (10) pieces of equipment, but with a minimum of ten (10) manuals for each different type of equipment.

(o) Submit one amplifier, conforming to the above specifications for a performance test prior to installation in the field. Furnish a certified test report showing conformity to the above specifications as measured in accordance with the relevant paragraphs of EIA Standard SE101-A and SE104-A and listing the methods and equipment used in testing.

D. FURNISHING PAGING LOUDSPEAKERS

The paging loudspeakers shall be of the radial type with a dispersion of 360°. The driver unit shall be completely sealed to preclude the entrance of moisture or steel dust and shall be capable of handling of 30-watts of continuous power. The speaker shall have a frequency response of 300 to 14,000 Hz at a sound level of 112 db. Each speaker shall be equipped with a matching transformer, either as an integral part of the speaker or, if separate, enclosed in dust and moisture-proof enclosure. The transformers shall have sufficient taps to match the speaker to any line impedance normally encountered in speaker applications including a 70-volt line tap. The speakers shall be equipped with mounting bracket.

E. FURNISHING TERMINAL BOXES

(a) Furnish and install NEMA Panel Enclosures.

(b) The terminal boxes shall be constructed of No. 14 Gauge sheet steel and shall be spot-welded. The panels shall be constructed of No. 12 gauge sheet steel. The covers shall have butt hinges with cadmium plated, trigger action flush latch. All surfaces shall be phosphatized prior to painting. The interiors of the terminal boxes and the panels shall have a baked white enamel finish and the exteriors of the boxes shall be finished with a primer.

(c) The terminal boxes shall be furnished with a semi-dust-tight gasket kit.

(d) The terminal boxes shall be equipped with hasp.

(e) The terminal boxes to be furnished and installed shall be completely equipped for terminating and cross-connecting main, local and branch communication cables. The locations of terminal boxes may be changed where necessary. The terminal boxes shall be of required sizes. Each terminal box shall be equipped with connecting blocks and fanning strips. One terminal shall be provided for each conductor of every cable entering the terminal box and a sufficient number of spare terminals, shall be provided. The terminal posts shall have locknuts and washers and the posts shall be spun over to prevent the loss of locknuts.

(f) All openings where cables enter shall be closed up with a soft, easily removable insulating compound, or otherwise sealed.

(g) Also furnish a terminal box complete with adapters and terminal blocks. The box shall be mounted in the Dispatcher's Office.

(h) Furnishing terminal boxes shall be deemed to include backboards, connecting blocks, fanning strips, protection clips, tags, bridle rings, cross-connecting and cross-connecting wire, stenciling, brackets, bolts and nuts, providing cable seals, paint and painting, and all additional material and labor necessary for a complete installation of the terminal boxes.

F. FURNISHING BLUE LIGHTS

(a) Blue lights shall be furnished to designate emergency telephone and alarm locations.

(b) Furnish an incandescent lamp of the proper voltage and wattage as required, for each location.

XIV - FIRE PROTECTION EQUIPMENT

A. FURNISHING AND INSTALLING FIRE EXTINGUISHERS

General. Furnish and install 15-pound and 20-pound carbon-dioxide (CO₂) fire extinguishers and 5-pound Type ABC dry chemical fire extinguishers. Fifteen (15) pound CO₂ extinguishers and 5-pound Type ABC extinguishers shall be placed in all new maintenance quarters. A 20-pound extinguisher shall be placed in each new relay room and central instrument room and at the central instrument housing location. At central instrument housings, the extinguishers shall be mounted on the outside of the housing or in the immediate vicinity of the housing. Also furnish and install all supporting hooks and marine type supporting brackets for mounting the extinguishers. Also provide any supporting bars and fastenings which may be necessary at certain locations in order to properly install these hooks and marine type brackets.

B. PORTABLE CO₂ EXTINGUISHER (15-POUND)

The 15-pound CO₂ fire extinguisher shall be the squeeze-grip or Disc Seal Type. The extinguisher shall be of the portable type with squeeze-grip, pressure-seat valve and insulated fan-shaped discharge horn, and shall have a rated discharge capacity of fifteen (15) pounds. The 15-pound CO₂ extinguisher and all its assembled parts shall be approved by the Underwriters' Laboratories and a label reading "Underwriters' Laboratories, Inc. Inspected Carbon Dioxide Extinguisher-Classification B-1, C-1" shall form a part of the name plate.

C. PORTABLE CO₂ EXTINGUISHER (20-POUND)

The 20-pound CO₂ fire extinguishers shall be the squeeze-grip or Disc Seal Type. The extinguisher shall be of the portable type with squeeze-grip, pressure-seat

valve and insulated fan-shaped discharge horn and shall have a rated discharge capacity of twenty (20) pounds. The 20-pound CO₂ extinguisher and all its assembled parts shall be approved by the Underwriters' Laboratories and a label reading "Underwriters' Laboratories, Inc. Inspected Carbon Dioxide Extinguisher-Classification B-1, C-1" shall form a part of the name plate.

D. TYPE ABC EXTINGUISHERS

New extinguishers shall be of the stored pressure type using a dry chemical extinguishing agent. The extinguishers shall be using 5 pounds of extinguishing agent. The extinguishers shall be of the portable type with squeeze-grip valve. The extinguishers shall be furnished with a mounting bracket. The type ABC extinguisher shall be approved by the Underwriters' Laboratories and a label reading "Underwriters' Laboratories, Inc. Inspected Dry Chemical Extinguisher-Classification A-1,12-BC" shall form a part of the name plate.

E. TAGS

Each extinguisher shall be provided with a tag and approved type card holder. Provision shall be made on the tag for inserting the following information:

Date of reweighing
Result of reweighing
Signature of persons who performed reweighing

F. LEAKAGE

Extinguishers shall be so designed and constructed that the maximum leakage in any one year shall not exceed five (5) per cent of the original gas content.

G. FINISH

All unfinished metal surfaces of extinguishers shall be painted with enamel. All exposed gas valve surfaces shall be chrome or nickel plated.

H. NAME PLATE

In addition to the Underwriters' Laboratories label appearing on each extinguisher, a manufacturer's name

plate shall be provided and shall be embossed or etched to bear the manufacturer's name and full directions for the proper operation of the extinguisher.

I. IDENTIFICATION

Each extinguisher shall have the identification information stamped into the crown of the cylinder in one-quarter (1/4) inch letters and numbers:

PROP
TRAN SYSTM
SER NO

The serial numbers shall be consecutively stamped clearly and legibly.

J. SUPPORTS

(a) Supporting brackets for the CO₂ extinguishers shall be of the Marine type and shall be constructed of malleable iron and equipped with spring steel grips so designed as to prevent any lateral motion when the extinguisher is mounted in a vertical position.

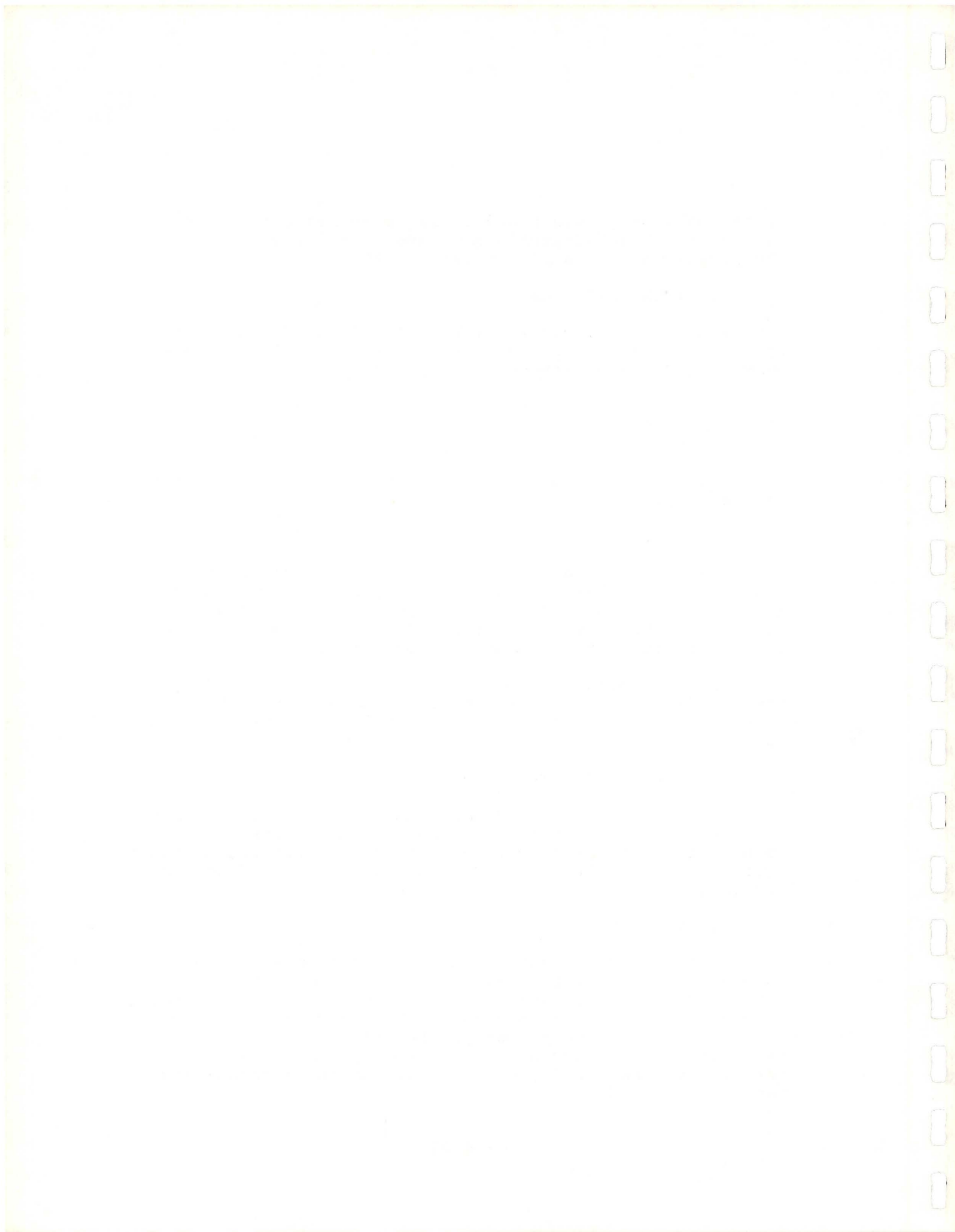
(b) All hooks and brackets shall be galvanized by the hot dip process. The protected surface shall be given a suitable primer coat, and shall be suitably treated to receive a final coat of black enamel.

K. PLACING IN SERVICE

Before the signal equipment in any signal tower, relay room, central instrument room or central instrument housing location is placed in service, all communications equipment for the particular location shall be placed in service.

L. TESTING

Make such tests during the installation and upon completion thereof, to demonstrate that the work, as furnished and installed, complies with the system requirements. If any of the work fails under test to meet the requirements or to function properly, the defects shall be rectified by readjusting, or by removing and replacing the faulty work, until, under test, the requirements are met.



Chapter **15**

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Chapter 15

TWO WAY RADIO SYSTEM

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Chapter 15

TWO WAY RADIO SYSTEM

I - DESCRIPTION OF WORK

A. BRIEF DESCRIPTION OF THE WORK

This portion of the Guidelines covers the work to be done in connection with the (1) furnishing of all the radio equipment and accessory items, inclusive of antenna cable along the subway right-of-way, for a complete two-way radio communication system between (a) motormen on trains and the Trainmaster's Central Control Headquarters and (b) patrolmen and the Police Radio Control Center; and (2) installing the required equipment and accessories as hereinafter described, throughout the Railroad. It is to be understood that "installing" of equipment and accessories shall include the testing and placing in operation thereof.

The major items of radio equipment and accessories required include single frequency FM transmitter-receivers and accessories for base stations; hand-carried portable FM transmitter-receivers and accessories; all equipment required for radio coverage of the subway; station platforms, mezzanines and passageways; equipment racks, cable, wire, hardware and other items; carrier frequency receivers, transmitters and repeaters and accessories; Local Dispatcher's Remote Control Units and accessories; and other miscellaneous items.

The base station equipment shall be located in enclosures. The final determination of the number of base stations and their locations will depend upon the results of radio frequency field strength surveys conducted within the base stations' limits.

The base stations shall be remotely controlled via carrier frequency equipment over telephone cable pairs. Survey the facilities to determine the transmission characteristics of the cable pairs to be used. This engineering field survey shall include attenuation, frequency response, noise measurements (total and per 3 KHz bandwidth) and cross talk noise in the frequency spectrum

of the carrier system. In making these tests, the line facilities shall be as near the same conditions as planned for the final installation as possible. Prepare graphs, charts and data, of the control scheme showing location of channel frequency and location of carrier repeaters and carrier terminal equipment.

Each of the remote base stations in the subway shall transmit to and receive from the mobile-portable, train-carried transmitter-receivers and the hand-carried Police transmitter-receivers, via a single antenna line cable. The antenna line cable will be installed, in the subway along the railroad right-of-way, station platforms, alcoves and mezzanines.

The work shall be performed in accordance and in compliance with the necessary radio service permits or licenses issued by the Federal Communications Commission.

B. STANDARDS FOR EQUIPMENT AND MATERIALS

All base station equipment and portable units must meet or exceed the applicable sections of the F.C.C., E.I.A., and Association of American Railroad specifications.

C. SPECIFICATIONS FOR MATERIALS

Materials supplied shall be the best of their respective kinds suitable for use in a communications system, under the condition prevailing in this work. Where no requirements are herein specified for the equipment and materials, they shall conform to the latest specifications of the Telephone Company, the Institute of Electrical and Electronic Engineers, the Electronic Industries Association, the Standard Specifications of the American Society for Testing and Materials, the American Standards Association, and to the regulations of the National Board of Fire Underwriters, as they apply.

II - CABLE AND WIRE INSTALLATION

A. GENERAL

(a) With the exception of the twin-lead antenna cable hereinafter referred to, all provisions concerning

the furnishing and installing of signal cable and wire and communication cable and wire shall govern the Two-Way-Radio System cable and wire.

(b) Furnish and install the antenna cable, in the subway on mezzanines and through passageways of subway stations.

(c) The type of antenna cable to be furnished and installed shall have an approved tensile strength and shall be capable of withstanding the severe vibration encountered in the subway. The antenna cable shall be manufactured of a material which, as far as practicable, shall not sustain combustion. The antenna cable shall be of a low R F loss type and shall have a propagation characteristic suitable for the type of transmission and reception hereinbefore mentioned. The antenna cable shall be immune to brittleness due to aging.

(d) Tests shall consist of a tensile strength test, resistivity of conductors, dielectric test, capacitance per foot test, characteristic impedance, attenuation tests at highest operating frequency before and after installation, flame test and accelerated aging test to determine any appreciable deterioration in the cable.

(e) The antenna cable lengths shall be continuous and without splices between points of connection.

(f) The type of connection for splicing the antenna cable and the method of making of "T" splices shall be in accordance with the best modern practice.

(g) Teflon insulated wire shall be used on all equipment specially built and designed for this work. Where equipment furnished is the manufacturer's standard product line of transmitters and/or receivers, the wire need not be teflon insulated.

B. TWIN-LEAD ANTENNA CABLE

(a) The Antenna cable to cover the subway, passageways and mezzanines and for connections into the main antenna system from base stations shall be Plastic Wire. The antenna cable shall consist of a dual conductor low loss, balanced transmission line. The dielectric material must meet or exceed the UL-83 Specification on Flame

Retardance. Each conductor shall be solid, bare copper wire. The cable attenuation at 161 MHz shall be not more than 0.7 db per one hundred (100) feet before installation and not more than 0.9 db per one hundred (100) feet after installation. Both measurements, in addition, are to be made at 158.88 MHz.

(b) Lengths of antenna cable shall be joined by means of approved solderless connectors which shall then be soldered and the resulting joint shall be covered by two (2) pieces of insulating sleeving, heat shrinkable type.

(c) Where T connections are required, they shall be of weatherproof construction.

(d) When transforming from a balanced transmission line to an unbalanced 52 ohm coaxial line, a balun or r.f. transformer shall be used. All electrical connections shall be weatherproof. The VSWR presented by the balun or r.f. transformer shall not exceed 1.2 when connected to a transmission line at least 1500 feet long or on shorter lines, if terminated.

(e) Where two or more balanced lines or coaxial lines are fed from a single base station, a suitable power splitter or quarter-wave matching transformers shall be used to present 50 ohms impedance to the base station. The VSWR as presented to the base station shall not exceed 1.5 for any combination feeding coaxial lines and balanced lines or 1.2 for any combination feeding balanced lines only.

(f) The balanced transmission line antennas shall be suspended by means of cable hangers. Neither the antenna cable nor the plastic cable hangers shall be painted.

(g) Install an approved type of bulkhead conduit when the radio equipment is located inside an enclosed area in a relay room.

(h) Provide special devices for joining or isolating separate sections of balanced transmission line or coaxial cable.

C. ANTENNA CABLE LOCATION AND RADIATION PATTERN
TEST THROUGHOUT THE SUBWAY

It is required that the location of the antenna cable in the subway shall be such that a signal received from a 1.4 watt portable transmitter unit operating within 20 feet of the cable will provide an input level of 6 db. above 20 db. quieting as measured at the input terminals of the receiver in the appropriate base station. The receiver in the base station shall have a useable sensitivity of 0.5 uv.

This specification must be met over 95% of the area in the subway through which a hand carried portable unit may move throughout the limits, and in no event shall the unit have to move more than 10 feet to have the ability to transmit this quality signal to the appropriate base station.

The test should take into account the losses due to cavity filter, power splitters, baluns, etc.

D. COAXIAL TRANSMISSION LINE

Coaxial transmission line where required, shall be Heliax foam dielectric.

The coaxial cable shall be mounted to walls, ceiling, or suspended by cable straps.

E. CAVITY FILTERS

Furnish and install high Q resonant cavity filters to prevent mutual interference between the Train-to-Way-side Radio System and Police Communication Systems. The cavity filters shall meet the following requirements:

(a) Each cavity filter shall consist of an outer cylinder of copper with an adjustable concentric center conductor of copper, tuning the frequency range from 148 to 174 MHz.

(b) Each cavity filter shall be temperature compensated to maintain its tuned frequency within ± 20 KHz over gradual temperature change between -30° C. to $+60^{\circ}$ C.

(c) Each cavity filter shall be provided with a mounting bracket which will allow mounting in any position.

(d) Each cavity filter shall be provided with a dust cover, through which the tuning rod pass, to prevent collection of dust inside the cavity or on contact fingers of the center conductor.

(e) Each cavity filter shall be furnished with means for adjusting insertion loss to meet the system requirements.

(f) The loaded Q at 160 MHz corresponding to the three sets of coupling shall not be less than 600, 1,200 and 3,000, respectively.

III - BASE STATION EQUIPMENT

A. GENERAL

The base stations shall include equipment for both train radio communication and police radio communication. Separate equipment shall be provided for the two systems, but both systems shall feed into the same antenna cable.

Each of the base stations shall be provided with remote control for train radio communication from the Trainmaster's Central Control Room over telephone cable pairs. The telephone carrier equipment required for remote control of the base stations shall be provided. The Trainmaster's control consoles shall be equipped with selective call features to energize the base stations as grouped, or to energize all the base stations within the area of his control.

The base station transmitter-receivers for train radio communications shall operate on a particular frequency or frequencies as authorized by the FCC.

In addition to the Trainmaster's control consoles, there shall be various Local Dispatcher's Remote Control Units which can remotely control base stations within a local area for train radio communication.

Furthermore, each base station shall be provided

with remote control for police radio communication from the Transit Police Radio Control Center Office over telephone cable pairs. The police control consoles will be similar in operation to the Trainmaster's control consoles. All consoles are described more fully elsewhere.

The Police Radio Communication System shall operate on frequency or frequencies as authorized by the F.C.C.

The base station equipment shall be rack mounted in closed cabinets, and located in enclosures, or in separate approved housings located on station platforms.

Excluding the carrier equipment required in the Main Equipment Room, carrier terminal equipment for a base station shall be housed in the equipment cabinet at the base station location. No audio lines from or to the base station location shall be used except for Local Dispatcher's Remote Control Units.

The location of the base station antenna cable layout in the subway shall be such that signal received from a 1.4 watt portable transmitter unit operating from the accessory speaker-microphone worn in its normal manner of usage, with the whip antenna fully collapsed, shall provide an input level 6 db over 20 db quieting, as measured at the receiver input terminals of the appropriate base stations.

The aforementioned quality of signal shall be received from the 1.4 watt portable from at least 95% of the subway station area for each and every subway station throughout the railroad limits. The subway station area shall be deemed to include station platforms, mezzanines, passageways, control (change Booth) areas, stairways and escalators etc., which are part of the Transit System property, but not including enclosed rooms and not including those stairways and escalators which are between the street and the control (change booth) areas unless otherwise required. To account for columns, obstructions, etc., in the subway station area, the portable unit may be moved a distance of no more than 10 feet and if the aforementioned quality of signal is then received at the base station, that area shall be considered to be satisfactory.

Based on survey data, utilize the best method of obtaining the desired coverage where it is not attained by

the subway antenna cable layout. Bridge the antenna cable in the subway by "Tees" or other means, and provide antenna cable and/or baluns and antennas, for the subway station areas.

Install outdoor antennas at portals as required to provide communications within the railroad limits. The antennas shall be made as directional as possible consistent with providing coverage of the desired area.

Install at various locations a 50 foot free standing antenna tower with antenna, concrete base for the tower, and all necessary connections and equipment. The purpose of this antenna is to provide radio coverage for outdoor portions of the railroad.

The desired coverage for the outdoor stations is the same as previously described for the subway stations. Survey the outdoor station areas to be covered by this antenna tower and/or portal antennas to be provided to determine whether the desired coverage will be attained.

In designing the portal antennas and outdoor antenna tower, make every effort to prevent interference with other base stations.

A propagation survey shall be made in order to assure that radio coverage for train and police radio equipment complies with the requirements as mentioned.

Cavity filters, or other equipment, shall be located as needed to prevent mutual interference between the Train-to-Wayside Radio System and the Police Communication System.

The signal overlap region between any two adjacent underground base stations shall be designed to occur at least 100 feet away from any station platform in the area between the base stations in the subway. The signal overlap region is defined as any area in which the received signal level from or to any two adjacent base stations does not exceed a 6 db difference. Trim the antenna cable in the subway between adjacent base stations to prevent undesirable overlap.

The signal level from any given base transmitter in the subway shall not open the squelch of any other base receiver.

B. BASE STATION (GENERAL)

The base station equipment shall be mounted in a closed cabinet. The cabinet shall be designed to accept standard 19" relay rack panels mounted vertically.

The vertical panels shall include:

1. R.F. Filter Panel. The filter shall be designed to prevent interference between the train and police frequencies and may be an electronic type.
2. Fuse Panel.
3. Control Panel.
4. Jack Field Panel. Four jacks are to be provided for each carrier line. One Jack hooks into the line northbound, one southbound; a third jack bridges the line southbound for audio intercom in the south direction and the fourth jack bridges the line northbound for audio intercom in the north direction.

The northbound and southbound bridging jacks will be connected to opposite sides of the carrier repeater amplifier at locations having repeaters and will be tied together at locations not using repeaters.

A separate jack shall allow the handset and speaker to be tied onto the line for audio intercom between adjacent base stations.

5. Carrier Equipment Panels. The carrier equipment at each base station shall consist of at least two carrier transmitters (one for police, one for train), two carrier receivers (one for police, one for train), and one carrier metering unit. The carrier panels shall also include all other equipment for proper carrier operation, such as hash filter, power supply, etc.

On the basis of a survey of the carrier telephone cable pairs, provide carrier repeaters at those base stations where they are required.

6. Train Radio Panel. This panel shall hold the train frequency F.M. transmitter-receiver which shall be mounted on the standard AAP base plate.

7. Police Radio Panel. Same as paragraph 6 above except police frequency instead of train frequency.

8. Other Panels. Provide any other equipment required, like interface accessory items, relays, switches and so on, in order to have a completely functioning base station. However, equipment outside the cabinet like "Tees", power splitters, baluns, battery chargers and batteries shall be mounted and shall be provided where required.

All major components like battery chargers, transmitter-receivers and the carrier equipment items shall have property tags attached. All controls, lights switches, relays and so on, appearing on the front of the panels shall be clearly labeled. All components behind the panel shall be clearly identified. Wiring between panels shall be tagged.

Solid-state components shall be used throughout for all base stations in the subway.

External heat radiators shall be employed as necessary, to maintain transistors within conservative operating temperatures.

The base station transmitter-receiver shall be designed and constructed as a rugged and highly reliable FM two-way radio set conforming mechanically to A.A.R. Communications Section Specification 12.10. The transmitter-receiver shall transmit and receive specific frequencies in either the VHF or UHF bands. The unit shall be of single unit type construction and shall consist of a receiver, a transmitter, and a power supply, and weigh no more than 38 pounds. Two separate units, identical except as to frequency, shall be provided at each base station, one unit for the train radio system and the other unit for the police radio system. Each unit shall be a single-frequency unit. Each unit shall include a base plate as described in the A.A.R. Specification.

In this application, the mounting rack shall be part of a vertical panel designed for installation in a standard 19" relay rack. The transmitter-receiver shall remain in a horizontal position and be held with only two clamp assemblies. Size of the rack with transmitter-receiver installed shall not exceed 19" width, 12" height, 15" depth behind the panel and 5" protruding from the front of the panel. That

portion of the transmitter-receiver protruding shall contain an AAR 23 pin connector, coaxial antenna connector, and handle. The mounting rack shall contain a cable harness with the transmitter-receiver connector tied to terminal strips located on the rear surface of the rack. The 23 pin connector is to provide all connections except the antenna.

The transmitter-receiver and power supply shall be included in a single unit, pull-out type assembly. Removal for servicing shall be accomplished by removing the pull-out unit type assembly without distributing the housing mounting or installation brackets.

The equipment frame or housing shall receive the transmitter-receiver power supply unit with a minimum of required clearance and shall completely enclose the unit. The housing shall be devoid of any louvers or other openings, thereby protecting the enclosed radio equipment from dirt, dust, moisture and splashing water. The front panel shall be fitted with a key lock to prevent access to the unit by other than properly authorized technical personnel.

The equipment parts shall be readily accessible, both top and bottom, by simple removal of the radio unit from the housing.

Metering of all essential circuits shall be accomplished without removing more than the top cover of the equipment housing. All metering points shall be properly decoupled and connected to two multi-pin metering sockets, one for the receiver circuits and one for the transmitter circuits. Tuning and alignment shall be readily accomplished with an external 0-50 microampers, 20,000 ohms per volt, meter and cable. The manufacturer shall provide a suitable test set for convenient testing and tuning of the equipment.

All tuning adjustments shall be readily accessible and located on the radio pull-out unit assembly proper. The equipment shall be designed so that the tube and transistor replacements, if necessary, shall be made without the necessity of making specific parameter adjustments.

The control circuits of the equipment shall operate as follows:

(1) An on-off switch shall provide on-off control of all DC input to the equipment.

(2) The remote control unit shall operate a transmit-receive solid state switch or approved relay, which when operated shall mute the receiver and place the transmitter on the air.

(3) The microphone "push-to-talk" switch shall also operate the "transmit-receive" solid state switch or approved relay.

(4) An antenna solid state switch shall, when operated, disconnect the antenna from the receiver RF input and connect it to the transmitter RF output.

(5) A switch shall be provided so the servicing technician may monitor the audio output of the receiver and the audio input to the transmitter over a local loudspeaker.

(6) A receiver operated relay, or squelch relay shall cause the appropriate "call" lamp to light at the control console.

The equipment shall have a switch or other control expressly intended for use by an authorized service technician in tuning the receiver to the exact frequency emitted by the transmitter. This switch shall turn on the transmitter, at the same time keeping the receiver in normal operation. It shall be of the "spring-return" type and shall be mounted within the locked housing, accessible only to authorized personnel.

The internal power supply shall be used to provide all necessary "high voltages" for the radio equipment. The power supply shall be of high quality semi-conductor design.

The Control Panel shall be a matching 19" rack panel for mounting either above or below the transmitter-receiver unit. A handset and loudspeaker are to be included with the control panel.

The Control Panel shall contain all circuits and accessories required for : (1) Monitoring the police or train radio systems, or (2) taking over control of

transmission of the local base station for the police or train radio systems, or (3) permitting two way voice intercommunication between (a), the local base station and the Police or Train Central Control Headquarters and (b) the local base station and local dispatcher's remote control unit on the same telephone carrier pair. (Note that under condition (3), radio communication to or from the local base station is interrupted on the system selected, that is, the train or police radio system.)

The handset shall be ruggedly constructed to withstand severe usage. It shall have a sturdy housing to shield and protect interior components. A push-to-talk switch shall be mounted on the microphone housing. The handset cable shall be of the self-retracting, tinsel cord type. Cable terminations shall be standard AAR 6 pin plug-and-socket connection for ready detachability.

The handset circuitry shall also permit the handset to function for intercommunication use between two adjacent base stations in conjunction with the Jack Field Panel, as previously described.

The loudspeaker supplied shall be of the permanent magnet, moving coil type and shall have a cone diameter of at least four and one-half (4-1/2) inches. Loudspeaker input impedance shall be 8 ohms to match receiver audio output impedance in accordance with AAR Specification 12.10. The loudspeaker shall be designed for good sound reproduction in the voice frequency range used for mobile communications.

The Control Panel shall also include a loudspeaker volume control and "OFF NORMAL" light. The light shall be replaceable from the front.

The equipment shall be capable of operating from an AAR standard 13.6 volt DC (10.9 volts minimum and 15.5 volts maximum) primary source and the internal connections shall be such that a negative ground can be accommodated. The equipment shall provide protection from application of wrong polarity voltages. If this happens, the equipment shall function when the error is corrected, without fuse replacement or other repairs. Power supply heat-sinks shall be mounted externally on the main equipment chassis. Power supply semi-conductors shall be protected from mechanical damage by a suitable cover and shall be readily

accessible for servicing.

The external power supply shall be common to both the train and police transmitter-receiver units and shall consist of a transformer-rectifier battery charger in combination with a stand-by battery. The transformer-rectifier shall be capable of carrying normal transmitter-receiver load while keeping the lead-acid cells at full charge. The transformer-rectifier shall operate from the 110-volt 60 Hz A.C. power source. The transformer-rectifier shall be of sufficient capacity to carry one hundred and fifty (150) percent of the load applied, without extreme variations in voltage between one hundred and fifty (150) per cent of full load and no load. The voltage regulation shall be within $\pm 1\%$ from no load to full load with the battery on or off the line. Charger ripple voltage shall be less than thirty (30) milli-volts. Each feed shall be properly fused. Soldered-in fuses are not acceptable.

The storage batteries shall be arranged in trays, which shall be mounted on steel racks of a suitable design and size. The battery capacity shall be such as to provide 24 hours of stand-by service with the transmitter-receivers operating on a 25 per cent transmit, 75 per cent receive cycle.

The lead-acid batteries shall be of the telephone central office type. The number of cells and size of cells shall be determined by the desired capacity. The elements of each battery shall be enclosed in a clear plastic case. Suitable filling and testing equipment, shall be provided with each battery installation.

A housing shall be provided. This housing shall contain the battery fuses and a "zero center" ammeter to monitor the battery current.

The battery charger shall have a continuously variable charging rate that is controlled manually. High charge shall be as high as possible without damage to the batteries. In addition to the previously mentioned requirements, the battery charger shall be capable of recharging the stand-by battery within 48 hours, after the battery has carried the full load for a period of 24 hours (e.g., in the event of a 24 hour A.C. power failure), while at the same time the charger is supplying

full load for the base station. The battery charger shall be of appropriate rating, with voltmeter, "zero left" ammeter and equalizing timer.

The equipment shall be operable, without damage, under any combination of service conditions, as follows:

- (a) Ambient temperature - 30°C to +60°C.
- (b) Ambient humidity 0 to 95%.
- (c) Duty cycle for transmitter-5 minutes on and 15 minutes off for a period of 7 hours. Duty cycle for receiver-continuous.

In accordance with EIA Standards RS-152A, Section 14, and RS-204, Section 18, the equipment shall be constructed so that it will remain operative after being vibrated in simple harmonic motion having an amplitude of 0.015" (total excursion of 0.034"), with the frequency varied uniformly from 10 to 30 cycles per second and with an amplitude of 0.0075" (total excursion of 0.015"), with the frequency varied uniformly from 30 to 60 cycles per second. The entire cycle of frequencies for each group, i.e., 10 to 30 cps and 30 to 60 cps, shall be accomplished in five minutes and repeated three (3) times. The above described motion shall be applied for a total period of 30 minutes in each of three directions, namely, the directions parallel to both axes of the base and perpendicular to the plane of the base.

Adequate protection shall be provided for all primary power input circuits. This protection shall be provided by standard "one-time" fuses, to assure fast and positive action.

The manufacturer shall offer a complete contract maintenance service available through a factory-approved local service shop. Such service shall include routine preventive maintenance designed to minimize breakdown, periodic checks on equipment performance as required by FCC Rules and Regulations, and prompt repair service in case of equipment breakdown.

The manufacturer of the radio equipment shall maintain Replacement Parts Department to furnish replacement parts and service for the radio equipment. An ample stock of individual components and equivalent unit replacements shall be carried for as long a period as demand warrants.

This period shall extend beyond the normal life expectancy of the equipment.

C. BASE TRANSMITTER SECTION

The basic transmitter stages shall be an RF oscillator, one or more multipliers and a final RF amplifier. The RF oscillator stage shall be crystal-controlled. The number of multiplier stages and total multiplication factor shall be in accordance with the best engineering practice, considering crystal oscillator stability and modulator capabilities. The final RF amplifier shall deliver at least 25 watts into the balancing unit feeding the antenna line in the subway portions. The final RF amplifier output for outdoor Base Stations shall be sufficient to provide adequate reception over 95% of the area to be covered by the Base Station.

The transmitter audio section shall consist of an audio amplifier, deviation limiter and modulator. Transmitter audio response shall be within +1, -3 db of the standard 6 db per octave pre-emphasis characteristic from 300 to 3000 Hz, in accordance with EIA Standards RS-152-A, Section 6. The modulator shall produce phase modulation (a frequency modulated signal) and transmitter emissions shall be designated as defined in FCC Rules and Regulations, Part 2, Subpart C.

The RF oscillator shall maintain the oscillator frequency stability within $\pm 0.0005\%$ over the temperature range of -30°C to $+60^{\circ}\text{C}$ ($+25^{\circ}\text{C}$ reference) as well as over a $\pm 20\%$ variation in primary supply voltage.

At any frequency spurious radiation shall not exceed applicable FCC and EIA standards.

The deviation limiter circuit shall be instantaneous in action and shall have performance characteristics so that a 20 db increase in audio signal input over that required for ± 3.3 KHz deviation shall not increase deviation to more than ± 5 KHz. The deviation limiter shall continue to function as specified with input power supply variations up to $\pm 10\%$. This circuit shall have a deviation limiter control to permit exact setting of the deviation limit. It shall be set at the factory before shipment. The frequency of 1000 Hz shall be used as a reference frequency in setting the deviation control.

The FM noise level, including residual noise due to the semi-conductor power supply, shall be in accordance with EIA standard RS-152-A, Section 7.

The modulator shall be capable of handling voice modulation over the 300-3000 Hz range. A post-limiter filter in the voice modulation circuit shall attenuate all frequencies above 3000 Hz, as required by FCC regulations.

Audio frequency harmonic distortion shall be less than 10% measured at 1000 Hz with ± 3.3 KHz deviation as measured per EIA Standard RS-152-A.

Base Station transmitters having transistorized final RF amplifier stages, shall include circuitry to protect these transistors against overloads due to any cause, including shorting or opening of the antenna load.

All tuning adjustments in the tuning procedure (except final amplifier tuning) shall utilize peak meter readings as the indication of proper adjustment. There shall be a high-low switch to protect transmitter tubes during the tuning procedure.

D. BASE RECEIVER SECTION

The receiver shall be of the double conversion super-heterodyne type, with two crystal-controlled local oscillators. The circuit shall use high quality, long life transistors and diodes throughout; no tubes shall be used.

The usable sensitivity shall be 0.5 microvolt or less, measured in accordance with American Standards Specification C-16.18.

The major selectivity determining elements shall precede the major gain determining elements to minimize the effects of interferences from other channels. When measured in accordance with EIA Standard RS-204, Section 7, selectivity shall be at least -80db.

When measured in accordance with EIA Standard RS-204, Section 9, intermodulation attenuation shall be at least 60 db at the usable sensitivity level.

When measured in accordance with FIA Standard RS-204, Section 6, modulation acceptance band width shall be 5KHz minimum.

The RF impedance at the antenna shall be a nominal 50 ohms, and matched through the balancing unit to the antenna line.

The receiver section shall have sufficient gain, distributed throughout the receiver stages, to provide uniform reception under varying environment conditions.

The tuneable circuitry shall be provided for reduction of off-channel interference. This circuitry shall be highly selective and shall permit the reduction of interference on either the high or low side of the incoming receiver RF carrier frequency. A variable internal adjustment, or other satisfactory means, shall be provided to control receiver RF selectivity, thereby providing increased RF interference rejection on either the high or low side of the desired carrier frequency.

The frequency of the first local oscillator stage shall be controlled to maintain the oscillator frequency within 0.0005% for any ambient temperature in the range from -30 C to +60 C (+25 C reference). The first local oscillator shall have a variable reactance for minor adjustments in oscillator frequency.

One of the I.F. stages shall incorporate a fixed tuned, sealed filter which shall be the major factor in determining the band width of the receiver. This filter shall require absolutely no maintenance nor have any adjustable components and shall be unconditionally guaranteed for a period extending beyond the normal life expectancy of the receiver. The filter shall be designed for ± 5 KHz modulation acceptance.

There shall be at least two (2) low frequency I.F. limiter stages, preceding the discriminator stage, to reduce amplitude modulated interference.

The squelch circuit shall be of the noise-compensated, adjustable sensitivity type with a continuously variable control on the control unit. The threshold squelch opening sensitivity and the tight squelch opening sensitivity shall be in accordance with the AAR Specification 12.10.

The audio stages of the receiver shall deliver an output of at least 4 watts in accordance with AAR standards as measured at the receiver output terminals. Audio distortion shall be less than 10% at rated putput. All noise and residual hum shall be at least 50 db below the rated audio output level.

The audio frequency response shall be within +1 db to -8 db of the 6 db per octave de-emphasis characteristic over the frequency range from 300-3000 Hz (reference frequency: 1000 Hz).

All metering points essential to tuning and testing the receiver shall be properly decoupled and connected to a common multi-pin metering socket for ease in servicing and maintenance. Metering shall be readily accomplished with a 0-50 micro-ampere, 20,000 ohms per volt meter and cable with plug to match the metering socket.

E. TELEPHONE CARRIER EQUIPMENT

A separate carrier channel shall be provided to remotely control each of the base stations. The carrier equipment shall be capable of operating over No. 19 AWG telephone cable pairs. Two telephone cable pairs shall be used for the train radio system, one pair for transmitting to trains and the other pair for receiving from trains. All base stations shall operate over one telephone pair for transmitting and the other pair for receiving unless sufficient carrier channels exist to accomodate the number of base stations required. In this case, additional telephone cable pairs shall be provided. The same means of operation shall be employed for the police radio system; that is, one telephone cable pair common to all base stations shall be used for transmitting and another pair shall be used for receiving.

All carrier equipment shall be of plug-in modular construction and completely transistorized.

The carrier transmitter shall be modulated directly from its audio input and demodulated directly at the carrier receiver without intermediate modulation. The audio output from the carrier receiver shall be at least -3db into a 600 ohm load, with a 1000 Hz test tone at -25 dbm carrier frequency input to the carrier receiver.

The over-all voice frequency response shall be +1 db to -2 db between 300 and 3000 Hz, with a maximum of 4% total harmonic distortion.

The carrier transmitter shall have an adjustable output level control and a minimum power output of +10 dbm at the maximum setting of the output level control. The transmitter carrier shall be capable of being keyed for push-to-talk operation.

The carrier receiver shall have a sensitivity of -25 dbm for rated audio output and shall have automatic gain control throughout a carrier input range of +10 dbm to -25 dbm. The receiver shall be equipped with a circuit to detect its own carrier frequency and energize a relay within 25 milliseconds. The relays shall be equipped with at least two (2) Form "C" contacts and shall be wired to the plug coupler of the unit.

Carrier repeaters shall be installed where the line losses approach 35 db or more; due consideration shall be given to placement of repeaters in accord with available terminal locations (i.e., in the base station equipment rooms) and the signal to noise ratio requirements, to insure highest quality telephone grade communication. The over-all system response including the line losses, repeaters, etc., shall be arranged so that the audio output from the carrier receiver shall, in all cases, be at least -3 dbm into a 600 ohm load with a 0 dbm 1000 Hz test tone applied to the input of the carrier transmitter.

The carrier units and carrier repeaters shall operate from the nominal 13.6-volt DC supply used for the base transmitter receivers located in the signal equipment relay rooms.

Provisions shall be made for carrier unit power regulation and filtering, to provide rated performance from the specified battery and to provide immunity to induced transient spike voltages.

The highest quality of telephone type transmission with minimum noise is required for the radio system application. Make all provisions necessary to ensure high quality transmission, including the insertion of cross-talk balancing coils and noise suppression coils as required in order to meet or exceed the maximum noise limitation

power of -60 dbm "back-to-back".

The total adjusted carrier power level shall not exceed 18 dbm on the common telephone control line at any time.

All units in the carrier system shall be designed for standard 19-inch rack mounting.

Adequate fusing of the primary circuits shall be provided.

All carrier modules, including carrier transmitters, receiver, metering, power supplies, repeaters, shall be designed with positive supply voltage grounded.

IV - TRAIN EQUIPMENT

A. TRAIN CARRIED PORTABLE TRANSMITTER-RECEIVERS

The equipment shall be FM-2-way radio equipment designed for heavy-duty railroad application in either the VHF or UHF bands.

The transmitter-receiver shall be equipped with a voltage regulator and a transient spike filter. Solid-state components shall be used throughout the receiver, power supply, and in the transmitter to minimize battery drain and maximize life expectancy of the radio equipment in keeping with good engineering practice.

The transmitter-receiver shall be mounted on the vertical wall of the motorman's cab.

Construction shall be such that each stage shall be accessible without the necessity of removing other stages. Sufficient test points shall be provided so that stage by stage performance can be evaluated.

The antenna shall be of the rigid railroad mobile type. The antenna, after being mounted on a car, shall maintain a VSWR of less than 2:1 over a frequency range of 4 MHz centered on the operating frequency of the Train-to-Wayside System. An approved weatherproof microphone with a press-to-talk button shall be supplied as part of the equipment. A foot-operated press-to-talk switch shall

also be used to provide transmitter control facilities. The microphone cable shall be of the self-retracting, rubber-covered, multi-conductor type and shall be detachable from the unit housing. A separate microphone hang-up device shall be provided for positive holding of the microphone enabling the motorman to transmit with both hands free. The hang-up device shall provide mechanical isolation to ensure minimum noise pick-up when the motorman depresses the foot switch in the cab. The speaker shall be weatherproof, have a minimum cone area of ten (10) square inches and an impedance which properly matches the output of the receiver and shall be an integral part of the radio unit.

Adjustable volume and squelch controls shall be provided and shall be mounted externally for ease of operation.

All interconnecting, radio frequency, control bonding, and power cables necessary to complete the radiophone transmitter and receiver shall be furnished as an integral part of the unit. These cables shall be insulated and weatherproof. Facilities shall be provided at the housing to secure all external cables to the housing despite shock and vibration.

Complete mounting hardware shall be provided.

The foot-operated press-to-talk switch and/or the microphone press-to-talk switch shall control a "transmit-receive" solid state switch or relay which, when activated, shall:

- (1) Provide the transmitter with operating voltages.
- (2) Switch the antenna from the receiver to the transmitter.
- (3) Mute the receiver.

The case shall be rugged construction throughout and shall be designed with no ventilation openings so as to protect the internally mounted equipment against the degrading effects of dust, foreign particles and splashing water. The unit shall incorporate a handle for carrying of the unit when removed. In addition, the unit shall include a spring return toggle switch to provide a properly attenuated audio signal into the train line public address system. The receiver loudspeaker shall remain operative when the toggle switch is depressed. The audio signal fed

into the train line public address system for the receiver shall be a fixed voltage of 0.9 to 1.0 volts r.m.s. fed into an impedance of ten (10) ohms.

The portable-mobile transmitter-receiver shall be equipped with a receptacle or receptacles containing all connections necessary for power supply, public address audio feed, push-to-talk foot switch and coaxial antenna. The mounting bracket shall be equipped with a plug connector or connectors which will mate with the above receptacle or receptacles. Upon inserting the transmitter-receiver into the mounting bracket, the transmitter-receiver shall be ready to operate, without the necessity of any external connection being made. The transmitter-receiver equipment shall be designed to operate in connection with the train equipment in such manner that neither shall cause any malfunction in the operation of the other.

The weight of the portable-mobile to be carried from one end of the train to the other shall not exceed fourteen (14) pounds.

The power supply shall employ solid-state circuitry for developing the operating voltages necessary for operation from the primary power source of the rapid transit car. The power supply shall contain no batteries.

The nominal supply voltage is 32 V.D.C., positive grounded, in subway cars and may vary from 24 volts up to 44 volts; accordingly a voltage regulator must be used in conjunction with the 32-volt power supply of the radio equipment. The regulator shall be an integral part of the transmitter-receiver and must have provision for the suppression of transient voltage spikes up to 1000 volts with a duration up to 2 milliseconds. Spike duration shall be measured from the 50% voltage point of the leading edge to the 50% voltage point of the trailing edge of the spike.

All miscellaneous and mechanical requirements shall conform to applicable sections of AAR Specification 12.10 unless otherwise mentioned herein. However, the AAR base plate is not required.

All tuneable circuit adjustments shall be readily accessible. With the housing removed, adjustment of the equipment shall be possible, without the necessity of any special patch cords or intercabling between the unit and the housing.

The train carried transmitter-receiver shall perform throughout the ambient temperature range and the vibration test.

All meeting points shall be properly decoupled and test points readily accessible with the cover removed. Tuning and alignment shall be readily accomplished with an external 0-50 microampere, 20,000 ohms per volt meter and cable.

B. TRANSMITTER SECTION OF TRAIN CARRIED TRANSMITTER-RECEIVER

The interstage coupling coils between each multiplier stage shall use reactance tuning and efficient shielding methods to obtain maximum harmonic suppression and minimum overall spurious radiation.

A variable reactance in the oscillator shall be provided for the purpose of adjusting the crystal circuit to the exact operating frequency.

The rated RF power output of the transmitter when operated at the minimum battery voltage shall be not less than 8 watts.

The transmitter radio frequency output circuits shall be designed to operate with a minimum voltage standing wave ratio into a nominal 50 ohm load. Adjustable coupling and a variable reactance shall be provided.

Full modulation of the transmitter is required using normal voice levels directed into the microphone.

All spurious and harmonic radiations shall be attenuated to meet applicable FCC requirements and EIA standards.

Crystal control and over-all design characteristics of the transmitter shall maintain frequency stability to within $\pm .0005\%$ from -30 degrees C to +60 degrees C ambient (+25 degrees C reference).

A deviation control, instantaneous in action, shall permit substantially 100% modulation of the transmitter under normal speech conditions and shall prevent deviation in excess of 100% under extremely loud talking conditions. The deviation control shall be variable to permit exact setting to any pre-determined limit from 0 to ± 5 kc.

The transmitter modulation shall be of the 16F3 classification. The modulator shall be capable of handling modulation frequencies from 300 cps to 3000 cps. To avoid obsolescence, a low pass filter shall be incorporated after the modulation limiter to attenuate all frequencies above 3000 cps as required by the Technical Standards paragraphs of the applicable Rule Parts of the FCC Rules and Regulations.

Audio frequency harmonic distortion shall be less than 10% at 1000 cycles with ± 3.3 kc deviation, as measured through a de-emphasis circuit of 6 db per octave.

FM noise level shall be as previously mentioned in the Base Transmitter Section.

C. RECEIVER SECTION OF TRAIN CARRIED TRANSMITTER-RECEIVER

A double superheterodyne type of receiver shall be used, with each frequency conversion crystal-controlled. All tuned circuits shall be completely independent of the transmitter section. For reliability, miniaturization and low power consumption, transistors only shall be employed in the receiver.

There shall be at least two (2) transistorized limiter stages preceeding the discriminator. Essentially, noise excitation alone shall saturate the second limiter at all times.

A variable reactance shall be provided in the local oscillator, for the purpose of adjusting the crystal circuit to the exact operating frequency.

The antenna input circuit shall utilize multiple tuned circuits of the variable reactance type.

A noise compensated squelch circuit shall be employed to reduce noise during standby periods. This circuit shall provide a noise compensated type adjustable sensitivity with continuously variable control. The squelch shall not respond to noise bursts. Sensitivity shall be such that the squelch will open at levels of 0.35 microvolts or less.

All tuneable circuit adjustments required shall be

available from one side of the chassis and readily accessible.

An I.F. Amplifier shall incorporate a fixed tuned filter which shall be the major factor in determining the band width of the receiver. This filter shall require absolutely no maintenance or have any adjustable component and shall be unconditionally guaranteed for a period extending beyond the normal life expectancy of the receiver.

The receiver modulation acceptance shall be ± 5 KHz minimum.

The RF input impedance at the antenna terminals shall be designed to operate from a 50 ohm source.

The audio stages of the receiver shall deliver an output of at least two (2) watts in accordance with A.A.R. Specification 12.10 for train carried units.

Audio distortion shall be less than 10% at rated output.

Audio frequency response shall be within +2 db to -8 db as per EIA RS-204 specification.

Intermodulation spurious responses shall be attenuated at least 60 db per A.A.R. Standard 12.10.

Selectivity characteristics shall be such that an RF signal ± 30 kc removed from the center frequency shall be attenuated at least 80 db per A.A.R. Standard 12.10.

The usable sensitivity shall be 0.35 microvolts or less measured by the EIA 12 db Sinad method.

All noise and residual hum shall be at least 40 db below the audio output level.

Crystal control and design characteristics shall maintain over-all frequency stability to within $\pm .002\%$ over the operational band, from -30°C to $+60^{\circ}\text{C}$ ambient ($+25^{\circ}\text{C}$ reference).

D. MOTORMAN'S CAB EQUIPMENT

The equipment for the cabs shall include the following:

- (a) Low profile antennas, complete with cable, brackets, connectors, plugs, bolts and sealing material to make the installation watertight. The antenna must not interfere with normal operation of the train.
- (b) Heavy-duty, foot operated, press-to-talk switch.
- (c) Mounting brackets for transmitter-receiver.
- (d) Brackets, complete with nuts and bolts for mounting of microphone as required.
- (e) All other miscellaneous material required, including conduit, Greenfield cables, other wire and cables, clamps, etc., for a complete installation.

V - PORTABLE TRANSMITTER-RECEIVERS

A. PORTABLE TRANSMITTER-RECEIVERS (GENERAL)

Furnish transmitter-receivers complete with accessories. The portable transmitter-receiver shall be a subminiature, self-contained, two-way FM radio set. The transmitter and receiver sections shall have no common electronic circuitry, except for the power supply, and shall be completely solid state. Integrated circuits are to be used to the extent practicable under the current state of the art. Both transmitter and receiver shall be operated from the same power source. The unit shall be designed for operation on an authorized frequency or frequencies.

The switches and controls shall be so mounted that they cannot be accidentally operated.

The unit shall be single battery operated to ensure uniform battery depletion and shall include a rechargeable nickel cadmium battery. The battery shall be quickly and easily removed from the unit and shall produce sufficient output voltage for operation of both the transmitter and receiver sections of the unit. Battery life shall be at least 8 hours between charges at 10% transmit, 10% receive, 80% standby duty cycle. The useful life of the battery shall be guaranteed for at least five hundred (500) days after the battery has been placed in service.

The displaced volume of the radio battery housing shall not exceed thirty-one (31) cubic inches and the weight shall not exceed twenty-eight (28) ounces, including batteries but excluding cable and remote speaker microphones.

The unit shall be of modular construction. A test jig and instructions shall be provided to check the radio and modules so that the mean repair time for the portable shall not exceed 10 minutes.

The equipment shall operate independently of, as well as in conjunction with the prescribed accessories. The accessory equipment shall include a microphone-speaker, 2-1/4" wide, 2-7/8" long x 1-1/2" thick, or smaller, with flexible cord and plug-in connector. The microphone cord shall include an antenna as an integral part of its construction and the plug-in connector shall contain a suitable method of fastening such that it shall not become unplugged. The cord shall be designed so that normal flexing adjacent to the plug or microphone-speaker shall not cause failure of the cord for a period of at least two years. The microphone-speaker shall be equipped with an approved fastener capable of being fastened to a metal clip on the cross strap or hooked into the carrier's belt, adjacent to the carrying case, or onto coat lapel or elsewhere on his attire.

Weatherproof jacks shall be sealed inside of the jack mountings on the combination external antenna/speaker/microphone jack and any other jack furnished on the unit.

The carrying case to be furnished with each unit shall be of black leather and shall be carried on a matching crossstrap furnished as part of the accessory equipment. It shall have an opening for the push-to-talk switch.

Furnish a telescoping whip type antenna.

All tuneable circuit adjustments shall be readily accessible. Adjustment of the equipment shall be possible without the necessity of any special patch cords or inter-cabling between the unit and the housing.

The case shall be fiberglass filled nylon or similar shatter-proof material. It shall be sealed to protect the internally mounted equipment against the degrading

effects of dust, foreign particles, moisture and splashing water.

The unit (except for crystal as stated hereinafter) shall meet EIA Standard RS-316 for shock stability.

It is the intention to secure equipment of the latest design and incorporating the most recent advances in the state of the art. The detailed design requirements and specifications represent the state of the art existing at the time of preparation of these Guidelines.

In the event that further advances in the state of the art make it possible to secure the system performance required by means other than those mentioned herein, consider such equipment.

B. TRANSMITTER SECTION OF PORTABLE TRANSMITTER-RECEIVERS

Power shall be applied to the unit by turning the "receiver-volume" control or the squelch control "on". Immediately after application of power to the unit, it shall be ready to receive or transmit messages. Transmission shall be accomplished by depressing the "push-to-talk" switch on the unit or the push-to-talk microphone switch. The transmitter shall return to a condition of "standby" receive current drain when the "push-to-talk" switch is released.

The transmitter emission shall be designated split channel, 16F3, as defined in FCC Rules and Regulations, Part 2, Sub-part C.

The crystal oscillator shall control the transmitter frequency and maintain output frequency within $\pm 0.0005\%$ of the assigned center frequency over the temperature range from -30°C to $+55^{\circ}\text{C}$ ambient ($+25^{\circ}\text{C}$ reference). The oscillators shall have a control to permit minor adjustments in oscillator frequency.

The deviation limiter circuit shall be instantaneous in action and shall have a variable control to determine the point of 100% modulation. This circuit shall permit substantially 100% modulation of the transmitter under normal speech conditions and shall prevent deviation in excess of 100% under extremely loud talking conditions.

The deviation control shall be adjustable to permit exact setting from 0 to ± 5 KHz using a standard 1000 Hz audio reference frequency.

A low pass audio-filter shall be incorporated into the circuit after the deviation limiter.

Audio response shall be within +1, -3 db of the standard EIA 6 db per octave pre-emphasis characteristics between 300 and 3000 Hz (with an additional 6 db per octave roll-off from 2500 to 3000 Hz as permitted by EIA Standard RS-316, Section 3.5).

Audio distortion, measured at 2/3 rated system deviation with a 1000 Hz modulating signal, shall be less than 10%.

The FM noise level, measured at 2/3 rated system deviation with a 1000 Hz modulating signal shall be at least 35 db down.

The transmitter shall be designed to obtain maximum harmonic suppression and minimum over-all spurious radiation.

All spurious and harmonic radiations shall be attenuated in accordance with Part 93.104 of the F.C.C. Rules and Regulations.

The rated r-f power output of the transmitter as measured into a 50 ohm load shall be not less than 1.4 watts after 4 hours of operation, with a fully charged battery, on a duty cycle of 10% transmit, 10% receive, 80% standby.

The microphone element shall provide sufficient signal for 100% modulation of the transmitter at normal voice levels.

C. RECEIVER SECTION OF PORTABLE TRANSMITTER-RECEIVERS

The circuits shall be of the superheterodyne type using crystal controlled oscillators. All major selectivity elements shall be fixed tuned for permanence of adjustment. An adjustable sensitivity, noise-quieting squelch circuit shall be employed to silence the speaker

except when signals are being received.

The squelch sensitivity at threshold setting shall be 0.25 microvolt or less, measured at the external antenna terminals.

The usable sensitivity of the receiver chassis shall be 0.5 microvolts measured by the 20 db quieting method.

The r-f input impedance at the external antenna terminals shall be designed for a 50 ohm source.

The r-f circuit shall utilize at least two tuned circuits of the variable reactance type.

The operating frequency shall be maintained within $\pm .001\%$ of the assigned center frequency over the operational band, from -30°C to $+55^{\circ}\text{C}$ ambient ($+25^{\circ}\text{C}$ reference).

All tuneable circuits shall be readily accessible for aligning the receiver.

Selectivity characteristics shall be such that the response shall be at least 80 db down at adjacent channels for 20 db quieting.

All spurious and image response shall be attenuated at least 60 db per A.A.R. Standard 12.13.

The modulation acceptance shall be ± 5 KHz minimum.

Audio output of the receiver shall be at least five hundred (500) milliwatts into the loudspeaker at less than 10% distortion with the incoming carrier modulated at 70% system deviation by a 1000 Hz tone.

Audio frequency response shall be within +2 db to -10 db as per EIA Standard RS-316.

The loudspeaker shall be at least a nominal 1-3/4" diameter. The loudspeaker shall be provided with a weatherproof cone and a dust cover for maximum weather protection.

All receiver controls shall be mounted for easy access; control knobs shall be protected against accidental damage due to bumping, dropping or rough handling.

Receiver controls shall include at least a receiver volume control and a squelch control. The receiver volume control or the squelch control will be permitted to be combined with the radio set On/Off switch.

D. BATTERY CHARGER

Install battery charging equipment at various locations on the railroad.

The battery charger shall be of the multiple storage type, equipped for charging ten (10) or twelve (12) portable batteries, either in the portable or removed from the portable.

The charger shall incorporate an adjustment to provide a charging rate adaptable to battery usage. A charging rate of ten (10) ma. shall not damage a battery left in the unit for a period of two weeks or the charger shall be designed so that the charging current automatically becomes limited to a value which cannot damage the batteries.

The chargers shall be designed for wall mounting or rack mounting and shall be installed in approved wire mesh cabinets equipped with cylinder locks adequately protected against tampering.

Each location shall have a separate key change and two keys are to be provided for each location.

VI - CONTROL EQUIPMENT

A. CONTROL EQUIPMENT. (GENERAL)

The control equipment to be provided shall include equipment racks in the Equipment Room, Local Dispatcher's Remote Control Units and other items as hereinafter described. The central control consoles for the Police and Train Radio Systems will control the equipment mounted on the racks in the Equipment Room. Cable is to be installed from the consoles to a terminating rack in the Equipment Room. Install the wire and cable and plug connectors required from the terminating rack to the equipment racks which is necessary for the control of the base stations.

The consoles will not contain any active components such as transistors or relays, except transistorized microphone preamplifiers. All active components shall be standard 19 inch communications racks. All equipment on the racks shall be completely wired and tested before shipment from the factory. All the rack mounted equipment shall be solid state. The equipment shall be of modular plug-in construction wherever practicable. All wire and cable shall be tagged in accordance with herein-before mentioned methods for tagging.

Provisions shall be made to prevent interference and/or feedback between the outdoor portal antennas, antenna tower, and the outdoor T.A. base stations. Where this problem of interference or feedback cannot be solved by optimum design, provide rack equipment for cross muting as required.

All audio transmitted from the consoles must be equalized, i.e., equipment shall be employed to ensure uniform output levels with varying microphone input levels. Also means shall be employed in the receiver loudspeaker circuits to minimize blasting and to equalize the listening levels.

All equipment shall be operated from a D.C. power supply with stand-by battery to ensure reliable communications in the event of an A.C. power failure up to 8 hours in duration. Both a 12 Volt D.C. and a 24 Volt D.C. power supply will be required as specified hereinafter. The power supplies and batteries shall be common to both the police and train radio systems.

B. CENTRAL CONTROL ROOM DESK CONSOLES. (TRAIN RADIO SYSTEM)

There shall be consoles furnished and installed in the Rapid Transit Operations Command Center. The front panel of the console shall be formed of 3/16" aluminum. The console cabinet shall be furnished in a color or match the desks and chairs. The finish shall be a smooth baked-on enamel.

The desk consoles shall each be equipped with a capped connector for a boom type microphone, in addition to a speaker, speaker attenuator pad, telephone jack with associated volume control for external microphone and

headset, transmit bar switch, "Alert" switch, foot switch, busy line indicator lamps, and all the necessary pushbutton switches and lights for base station selection and muting.

The telephone jack receptacles in the desks shall be wired to the console in such manner as to permit switching the headset from the radio control circuits to telephone or intercommunication circuits.

Three (3) external microphones and headsets, complete, equipped with a plug shall be furnished for each console. The external microphone and headset shall mute the speaker only at the desk where they are in use.

The consoles shall be identical in operation as far as the radio portion is concerned, except that the supervisory consoles shall be capable of taking away control of radio transmission from the other consoles, as described hereinafter.

Each console shall have pushbuttons to select each zone of radio coverage. Any combination of zones shall be capable of being selected simultaneously. Each zone select pushbutton is to be mechanically linked to a switch. With the switch in the normal (off) position, pushing the select pushbutton is to operate the switch (on) and the select pushbutton lights, indicating that the zone has been selected. The pushbutton is to spring back to its original position after each push. In order to break the selection, the pushbutton is pushed again. The second push will return the select switch to its normal (off) position and the select pushbutton light is to go out. The pushbutton is to again return to its original position after being pushed.

When the same zone is selected at two or more consoles, the "In Use" light is to go on below that zone select button at each of the consoles where the zone has been selected.

At each console, the base stations and remote receivers which are in a given zone are to have the same color pushbuttons as the given zone select pushbutton. The base station and remote receiver pushbuttons at a console shall not operate electrically until the associated zone has been selected at that console.

The remote receiver pushbutton is to be single button labelled with the received location and word "CALL". The mechanical operation is to be identical to that of the zone select pushbutton; with associated switch in the normal position, one push on the button is to throw the switch to the operate position, the second push is to return the switch to the normal position. The button is to spring back to its original position after each push. With the remote receiver pushbutton switch in its normal position an incoming call from the receiver location is to be audible at the console and causes the "CALL" portion of the button is to remain lit, regardless of whether the switch is in the normal or operate position.

The base station pushbuttons are to consist of dual pushbuttons mounted side by side. Each of the dual buttons is to operate independently of the other; the mechanical operation of the buttons is to be identical to the zone select button. The lefthand base station button relates to the transmitting function, the righthand button to the receiving function. With the lefthand button pushed so that its associated switch is in the operate (on) position both the base station location and "BUSY" portions of the button are to light. The "BUSY" portion of the button will also light for that base station at any other console where the associated zone select button has been operated (on). The righthand base station button is to operate in a manner similar to that of the remote receiver pushbutton; with the associated switch in the operate (on) position, the "MUTE" portion of the button lights and any incoming calls from the base station location are to be muted at the console. With the associated switch in the normal (off) position, incoming calls are audible at the console. However, an incoming call is to light the "CALL" portion of the button regardless of the switch position.

Note that in most cases the base station pushbuttons mentioned above shall each actually control more than one base station.

The "ALL CALL" pushbuttons are to be mechanically identical in operation to the zone select buttons. Each "ALL CALL" button is to relate specifically to the zone select button above it. The "ALL CALL" button shall not operate electrically until the associated zone has been selected (on) at that console. When the "ALL CALL" button has been selected (switch operated "on"), the button

is to light and all base stations in the zone at that console shall be prepared for transmission. The "BUSY" portion of a base station buttons in the zone shall light at the console, regardless of the position of the base station switch. In addition, the "BUSY" portion of base station buttons in that zone is to light at any other console where the given zone select button has been operated (on). However, the receiving functions are not to be affected by the "ALL CALL" button; base stations and remote receivers must be able to be muted as desired even though the "ALL CALL" button has been selected (on).

The "TRANSMIT" bar switch and foot switch shall be wired in parallel and have the same function. Depressing either of these switches is to allow the console operator to transmit over any base stations selected by the pushbuttons. An "ON THE AIR" light shall be lit when the transmit bar switch or foot switch is depressed. The transmit bar switch and foot switch shall be spring loaded switches and must be kept depressed in order to transmit.

The "ALERT SIGNAL" button is to be mechanically similar to the "TRANSMIT" bar switch. The button is to be spring loaded and must be kept depressed in order to transmit. Depressing the button causes a 1000 Hertz note to be transmitted over every base station which has been selected at the console. The "ON THE AIR" light shall light when the button is depressed.

To summarize, the procedure involved at a console in placing a base station on the air is as follows:

1. Zone select button pushed on. Zone button lights.
- 2a. (Left-Hand) base station button in that zone pushed on (base station location and "BUSY" Portions of the base station button both light), or
- 2b. "ALL CALL" button for that zone pushed on, "ALL CALL" button lights and "BUSY" portions of all base station buttons in that zone light.
3. "ALERT SIGNAL" button kept depressed. A 1000

Hertz note is transmitted over all base stations selected either by the base station button or the "ALL CALL" button being pushed on. The "ON THE AIR" light remains lit as long as the button is kept depressed. This step may be omitted at the discretion of the console operator and he may instead proceed directly to 4 below.

4. "TRANSMIT" bar switch or foot switch kept depressed. The console operator can now talk into the microphone and his speech is transmitted over every base station selected. The "ON THE AIR" light remains lit as long as either switch is depressed. As long as the console operator is transmitting, as in either step 3 or 4, reception at the console is automatically cut out.

The supervisory desk consoles shall be capable of taking control of the transmitting function away from any of the non-supervisory desk consoles. When the supervisory console operator depresses the "ALERT" button, "TRANSMIT" button or foot switch, the rear console is to transmit over every base station he has selected in a zone or zones. Transmission from that zone or zones shall be automatically cut out at any non-supervisory console as long as the rear console is transmitting. At the same time, the "BY SVR" light shall light below that zone button or buttons at every other console where the zone or zones have been selected. Thus, the non-supervisory consoles are to be warned by the "BY SVR" light that they can not transmit from any base station in the associated zone as long as the supervisory console is transmitting.

However, neither supervisory console takes precedence over the other. The supervisory consoles shall operate on a "FIRST COME-FIRST SERVED" basis in relation to each other, that is the first supervisory console to transmit in a zone or zones shall prevent transmission at the other supervisory console in that zone or zones. The "BUSY" and "BY SVR" lights shall indicate at the other supervisory console as specified above. The "BY SVR" light shall not be lit at the supervisory console when that console has control of transmission.

The supervisory consoles shall also be capable of

monitoring the other consoles by plugging the headset into the telephone jack. However, the rear console must have the zone select button pushed on in order to monitor that zone.

C. LOCAL DISPATCHER'S REMOTE CONTROL UNIT. (TRAIN RADIO SYSTEM)

There shall be Local Disptacher's Remote Control Units.

The purpose of the Remote Control Unit is to allow the terminal dispatcher to contact trains in the vicinity of the terminal. Therefore, the Remote Control Unit shall provide means to remotely control a nearby base station.

The Remote Control Unit shall operate as follows:

(1) With the telephone type handset cradled, the unit shall monitor all calls received at the associated base station over the loudspeaker. The volume control shall adjust the audio level received but shall not permit complete muting of the speaker.

(2) With the handset removed from the cradle (handset transmit bar not depressed), all calls received at the base station shall be monitored over the handset ear piece and the loudspeaker shall be disconnected. The volume control shall adjust the audio level received but shall not permit complete muting of the ear piece.

(3) When the terminal dispatcher wishes to transmit, he shall depress the transmit bar switch and speak into the handset mouthpiece. This action shall key the transmitter on the disconnect the receiver at the associated base station. The "ON THE AIR" light (on the dispatcher's telephone type desk unit) shall light to indicate that the base station transmitter is turned on. A "modulation" lamp or meter shall be supplied to indicate audio output from the mouthpiece. At the same time, the audio output shall be transmitted, via the base station carrier transmitter, back to the Equipment Room so that the dispatcher's transmission is monitored by the Train Central Control consoles and recorded by the tape recorder.

(4) The Train Central Control consoles shall have the ability to take away control of transmission from the Remote Control unit. When the console operator (supervisory or non-supervisory) transmits over a base station, he shall automatically disconnect all Remote Control Units from that transmitter; all such transmission shall be monitored by the Remote Control Unit. A "Trainmaster" light or buzzer shall be supplied with each terminal dispatcher's Remote Control Unit to indicate that the console operator is transmitting over that base station. In addition, if the terminal dispatcher depresses his transmit bar switch while console operator is transmitting over the associated base station, the terminal dispatcher shall hear the console operator's transmission and shall be further warned by a buzzer, or other means, to release the transmit bar switch.

The terminal dispatcher's telephone type desk unit shall contain no active components except a microphone preamplifier, if required. All active components and accessory equipment required such as amplifiers, transformers, battery charger, battery, etc., shall be mounted in a suitable housing, designed for easy maintenance, in the dispatcher's office. The battery shall consist of nickel-cadmium rechargeable cells of sufficient capacity to provide 24 hours of uninterrupted service in the event of an A.C. power failure.

D. POLICE RADIO CONTROL CENTER DESK CONSOLES.
(POLICE RADIO SYSTEM)

The accessories provided for the police consoles shall be identical to those provided for the train consoles except that a boom type microphone is required for each console, the clock shall be a 24 hour clock, only one external microphone and headset is required for each console.

The operation of the radio portion of the consoles shall be identical to that described for the (Train Radio System) with supervisory consoles having the same transmission override and monitoring features.

E. POLICE RADIO CONTROL CENTER INCERCOMMUNICATION
SYSTEM

An intercommunication system shall be provided in

the Police Radio Control Center. This system shall interconnect master stations on the Captain's and Lieutenant's desk with staff stations.

The system shall be so designed that the Captain will be able to initiate a call both individually or simultaneously with the Lieutenant and the supervisors, and the Lieutenant will be able to initiate a call both individually or simultaneously with the supervisors.

One cable shall be installed between the Captain's master station and the terminal box of the Control Center. Another cable shall be installed between the Lieutenant's master station and said terminal box. These cables shall be interconnected in the terminal box to the staff stations.

A cable shall be installed between the terminal box and a staff station at the supervisory console. This cable shall be interconnected at the terminating box.

The master stations shall have two position switches. The stations shall be capable of operating on 110-125 volts, A.C. or D.C. These desk units shall be equipped with a six (6) foot thermoplastic covered cord. The voice coil impedance shall be 45 ohms.

The staff stations shall operate simultaneously. Only one pair of wires shall be required for the voice circuit and the terminals shall be of the screw type. The voice coil impedance shall be 45 ohms.

F. EQUIPMENT ROOM

All active components required for central control of the base stations for the Train and Police Radio Systems shall be mounted on racks in the Equipment Room previously mentioned.

A 24 volt and a 12 volt battery charger, both single phase, both with equalizing timers, and of appropriate capacity, shall also be included in the room. The 24 volt battery charger shall be floor mounted, but the 12 volt battery charger may be rack mounted.

The battery chargers shall operate in conjunction

with the 24 volt and 12 volt battery chargers to maintain the 24 volt and 12 volt stand-by batteries fully charged while at the same time supplying the full load current for the central control equipment. Furthermore, the battery chargers provided shall be capable of operating in conjunction with the chargers to recharge the aforesaid 24 volt and 12 volt batteries to full charge within 24 hours, after the batteries have carried the full load for a period of 8 hours (e.g., in the event of an 8 hour A.C. power failure), while at the same time the chargers are supplying full load current for the aforesaid central control equipment. The 12 volt system shall provide power for the central control carrier equipment. The 24 volt system shall provide power for the remaining central control equipment except for the equipment specified to be A.C. operated or otherwise specified.

The rack mounted equipment shall include all additional accessories required, such as Mixers Relays, Audio Preamplifiers, Audio Compression Amplifiers, Audio Power Amplifiers, Line Talk Amplifiers, etc., to provide a satisfactory system response.

The required carrier transmitters and receivers for central control of the base stations shall be mounted in the Equipment Room. The carrier equipment shall also include Carrier Meter and Test Modules, one for each carrier equipment panel, mentioned (Equipment Racks) hereinafter, to permit rapid checking of carrier units. Carrier equipment shall be identical to that previously mentioned. Note that the carrier equipment is designed with positive voltage supply grounded.

Teflon wire shall be used for all wiring in and between racks, and between interconnecting points on the same rack. Low level and audio circuit wiring shall be properly shielded. Plug connectors, shall be used for all terminal points. Wiring in conduit is not permitted on the racks; a removable metal chase or non-combustible plastic chase shall be used instead. Power loops shall be provided for D.C. power sources feeding the racks. Equipment on the rack shall be connected to the power terminals on that rack by means of separate indicating type fuses.

G. EQUIPMENT RACKS

Equipment racks shall be provided in the equipment room, to house the equipment controlled by the consoles. These racks shall be standard 19" communication racks with three coats of approved paint, having over-all dimensions of approximately 80-3/8" high x 21-1/8" wide x 26" deep (panel space 77" x 19"). From the terminating rack the installation shall proceed to a rack containing "Console" panels. From the "Console" rack(s) the installation shall proceed to the "Switching" rack or racks and thence to the "Base Station" rack or racks. The "Base Station" rack(s) shall contain equipment (mainly the carrier equipment) required for transmitting and receiving information to and from the base station field locations. All the carrier equipment for a given base station shall be grouped together as far as is practicable. Each base station rack shall contain at least one Carrier Meter and Test Module, and shall have provision made for quickly connecting the aforesaid module to check the carrier equipment on the rack. The carrier equipment shall operate from the 12 volt system.

The "Switching" rack (s) shall act as an interface between the "Console" and "Base Station" racks and shall contain all equipment required to permit consoles to transmit and/or receive from the appropriate base stations in accord with the pushbuttons and the limits of their control as shown on the console face plates in the radio control centers.

All equipment appearing on the front panels of the racks, including relays, shall be clearly labeled and identified. All major pieces of equipment shall be equipped with property tags. All components shall be identified.

H. RELAYS

Plug-in relays shall be used to control all push-button functions provided by the consoles. The relays shall be capable of rated performance from a nominal 24-volt D.C. power source. The relays shall be mounted individually on the equipment panels. Relay covers shall be transparent.

I. MIXERS

Mixers shall be provided. Maximum number of channels shall not exceed ten (10).

The units shall be completely transistorized, plug-in, and capable of rated performance when operating from a nominal 24-volt D.C. power supply. Each line input shall have a separate attenuator for adjusting its output level. The adjustment of any line shall not affect the level of any other line by more than 2 db. The sensitivity of the mixer shall be sufficient to accept a line signal level as low as -40 dbm. The output noise level of the individual channels shall be a maximum of -60 dbm with input shorted and the frequency response shall be essentially flat from 200 to 6000 Hz.

J. AUDIO PREAMPLIFIER

A plug-in audio preamplifier shall be provided for each zone. The preamplifier shall be a completely transistorized plug-in unit capable of rated performance when operating from a 24-volt D.C. power supply.

K. AUDIO COMPRESSION AMPLIFIER

A plug-in audio compressor amplifier shall be provided for each zone. The compressor shall be a completely transistorized plug-in unit capable of rated performance when operated from a 24 volt D.C. power supply.

L. AUDIO POWER AMPLIFIER

An audio plug-in power amplifier shall be provided for each zone. The power amplifier shall be a completely transistorized plug-in unit capable of rated performance from a 24 volt D.C. power supply.

M. LINE TALK AMPLIFIER

A plug-in talk amplifier will be provided for each zone. The characteristics and specifications for the line talk amplifier shall be identical with the audio preamplifier.

VII - CONDUIT

A. RIGID CONDUIT

Rigid conduit shall be used at such locations as signal towers, relay rooms, central control, base stations, etc.

(1) Rigid steel conduit shall be made of the best grade standard weight steel pipe, protected inside and outside by a coat of hot-dip galvanizing.

(2) Thick wall polyvinyl chloride conduit, High Impact Type 80, hereinafter referred to as PVC conduit, or approved equal, shall in general, be furnished and installed wherever antenna cable is required to be installed in conduit. PVC conduit may be used at other locations.

B. FLEXIBLE CONDUIT

Flexible conduit shall be interlocking spiral strip steel of the best quality. The steel strips used in the construction of flexible conduit shall be thoroughly annealed and fully coated with metallic zinc, and shall have an approved PVC covering. Construction of the spiral strip shall be such as to permit bending of the conduit to a radius of four (4) times its internal diameter without spreading the strips to such extent that they will open on the outside of the bend, without compressing them to such extent that rough surfaces will result on the inside of the bend and without in any other way distorting or reducing the internal diameter of the flexible conduit at the bend. The interior and exterior of the flexible conduit shall be smooth and free from burrs, sharp edges or other defects which may injure the wires.

C. RUBBER CONDUIT

Split rubber conduit shall be installed. The rubber conduit shall be held to the rigid conduit sleeves at both ends by means of approved type hose clamps. Where required, because of the length of the split rubber conduit, extra clamps shall be used to properly seal and hold the conduit in shape.

D. CONDUIT FITTINGS

All fittings shall be of the best quality. PVC fittings may be used with PVC conduit.

All fittings, for rigid steel conduit shall be of cast or malleable iron, threaded, and shall be protected by hot-dip galvanizing. The use of split fittings or fittings which are attached to the rigid steel conduit with a clamping action will not be permitted. Fittings shall be complete with gaskets and approved blank or nipple covers, or composition outlet covers as required, held in place with approved screws. All junction, pull and outlet boxes shall be watertight and of ample size to permit pulling of cables without injury to the cable. The length of the openings in fittings used as pull boxes shall be at least ten (10) times the diameter of the conduit entering the box.

Conduit fittings required will include condulets, condulet unions, conduit junction boxes, pull boxes, tees, pushings, water-tight hubs, insulating bushings, grommets, locknuts, chase nipples, flanges, weatherheads and conduit bells.

E. INSTALLING RIGID CONDUIT

Rigid conduit shall be installed straight and neatly arranged on the structure and shall be securely supported at intervals not to exceed eight (8) feet, except where conduit is installed above the tracks where the supports shall be made at intervals not to exceed three (3) feet. Where a conduit crosses over a track, the conduit shall be supported by a minimum of three (3) supporting bolts and clamps. Conduit shall be so installed as to prevent the collection of water between outlets. Conduit shall be of sufficient size to leave at least one-third (1/3) of the wire space free after the full number of wires required for the installation are in place. If a size of conduit is specified which does not allow for this one-third (1/3) free space, a larger size conduit shall be installed. Two (2) or more conduits may be used in place of one (1) run where the number of wires is greater than can be accommodated in one (1) run of conduit. All steel conduit shall be equipped with threaded fittings.

All bends and offsets on conduit must be made on a

forming tool to prevent the conduit or coating from being damaged in the bending. PVC conduit bends made in the field shall be made in accordance with the manufacturer's recommended procedure. Care shall be taken not to overheat the conduit during the bending process. Bends made by the manufacturer at the factory will be permitted. Conduit shall be left clean, with inside surfaces smooth and free from obstructions liable to injure the wire or cable. Where conduits join any threaded couplings or fittings, the ends shall be reamed. Steel threads shall be painted with red lead or an approved equal to make them watertight. PVC conduit shall be connected to fittings with a compound.

Where a conduit run contains a total of two (2) right angle bends or equivalent, or exceeds seventy-five (75) feet between outlets, additional outlets for pulling the cable shall be provided. Where conduit enters boxes, a water-tight hub shall be installed. In long straight runs of conduit, where it is necessary to pull cable at intermediate points, the fittings installed for that purpose shall be of such length and other dimensions as to allow the pulling of cables in and out of the fittings without the necessity of any sharp bending or injury to the cables.

All conduits shall be installed by the use of malleable conduit clamps, bolts and washers.

All exposed rigid conduit shall be rigidly supported by straps and/or other supports. All straps and supporting brackets shall be by means of separable members so constructed as to retain their grip by means of clamping action. The general design of such clamping members shall be such that; no member shall be less than three-eighths (3/8) inch thick, and the bolt shall have a diameter less than three-eighths (3/8) inch.

All attachments shall be of such design and so installed as to permit easy access to all exposed surfaces of both attachment and structure.

Attention is called to the method of making conduit connections to the various types of equipment. These connections are made by threading the conduit into equipment or by split rubber insulation known as "Condor".

All conduit shall be painted, except that PVC conduit used to enclose antenna cable shall not be painted.

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