Terminology of Overhead Catenary Parts and Assemblies

Green Line Overhead

This material has been compiled to assist Green Line personnel in the proper identification of overhead catenary parts and assemblies. Please use this terminology in reporting any problems or potential problems which you may encounter.

POWER DIVISION
Transmission and Distribution Area
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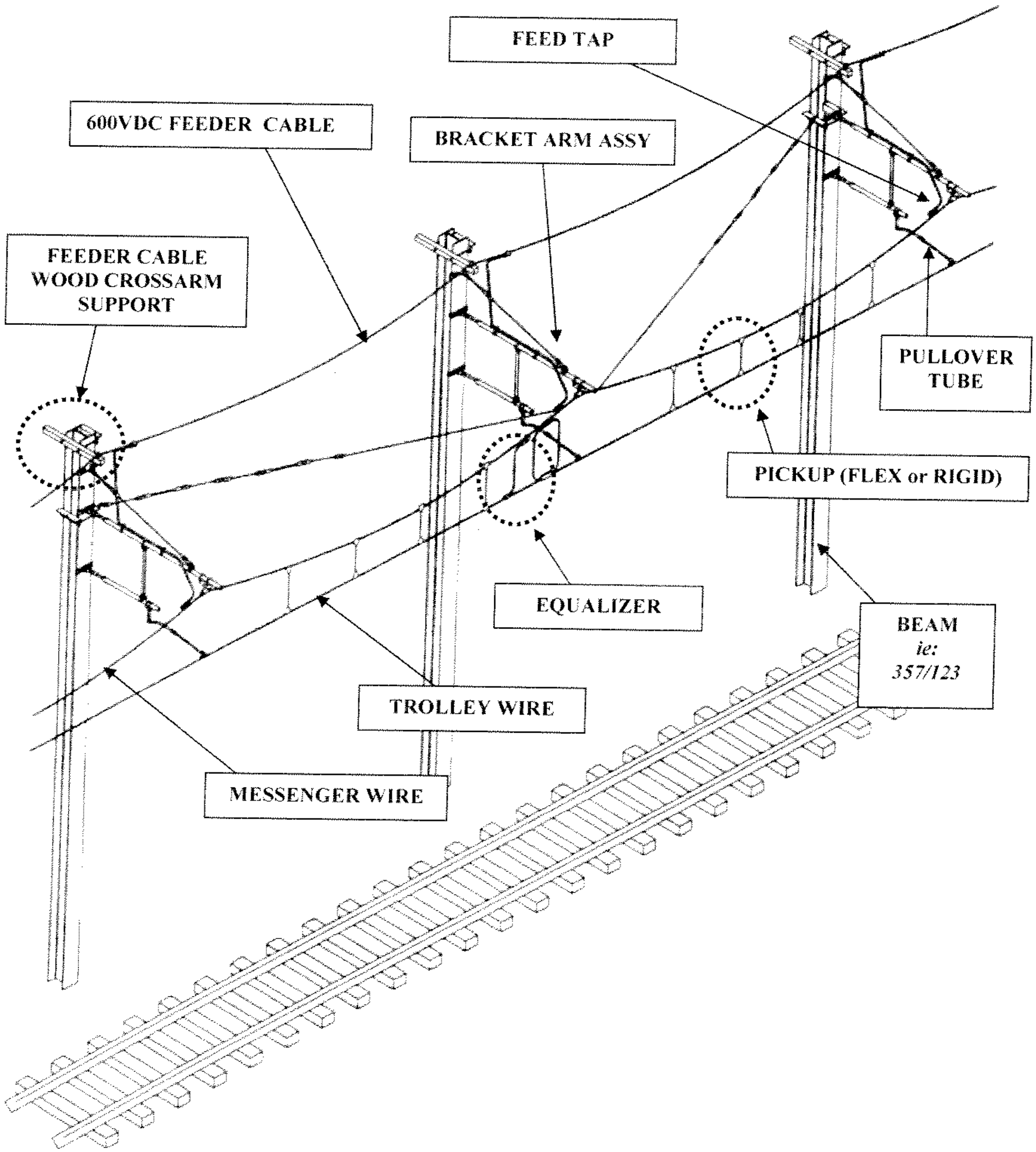
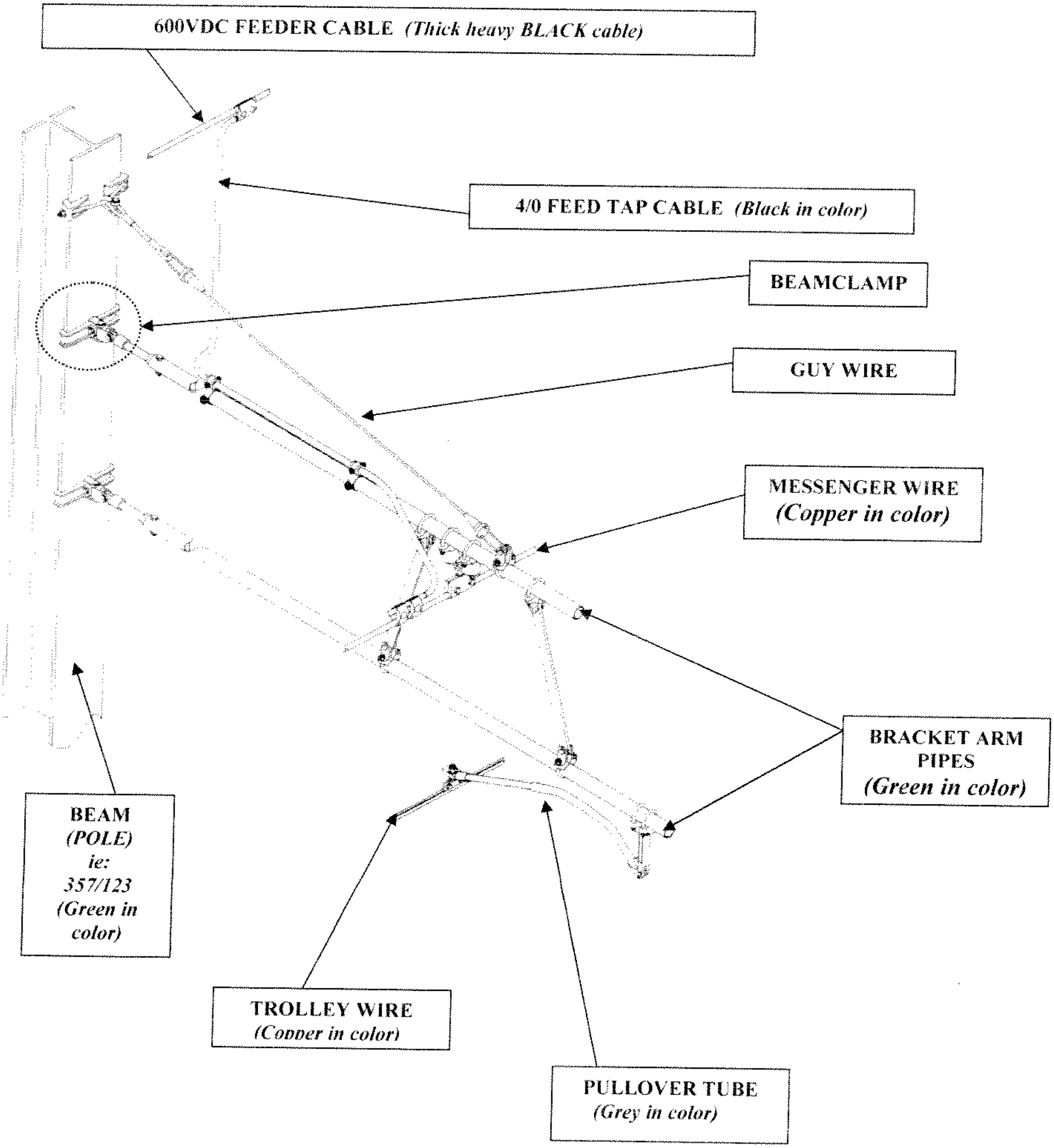
TYPICAL MAINLINE CATENARY ASSEMBLIES
(Highland Branch)

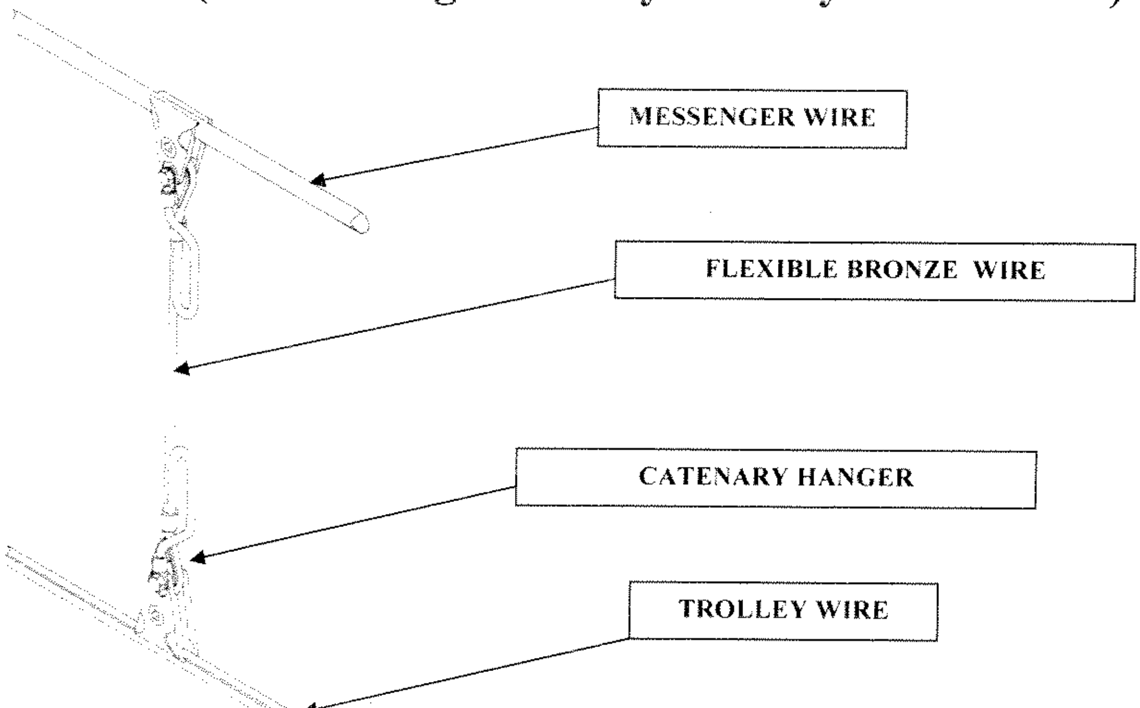


TYPICAL BRACKET ARM ASSEMBLY

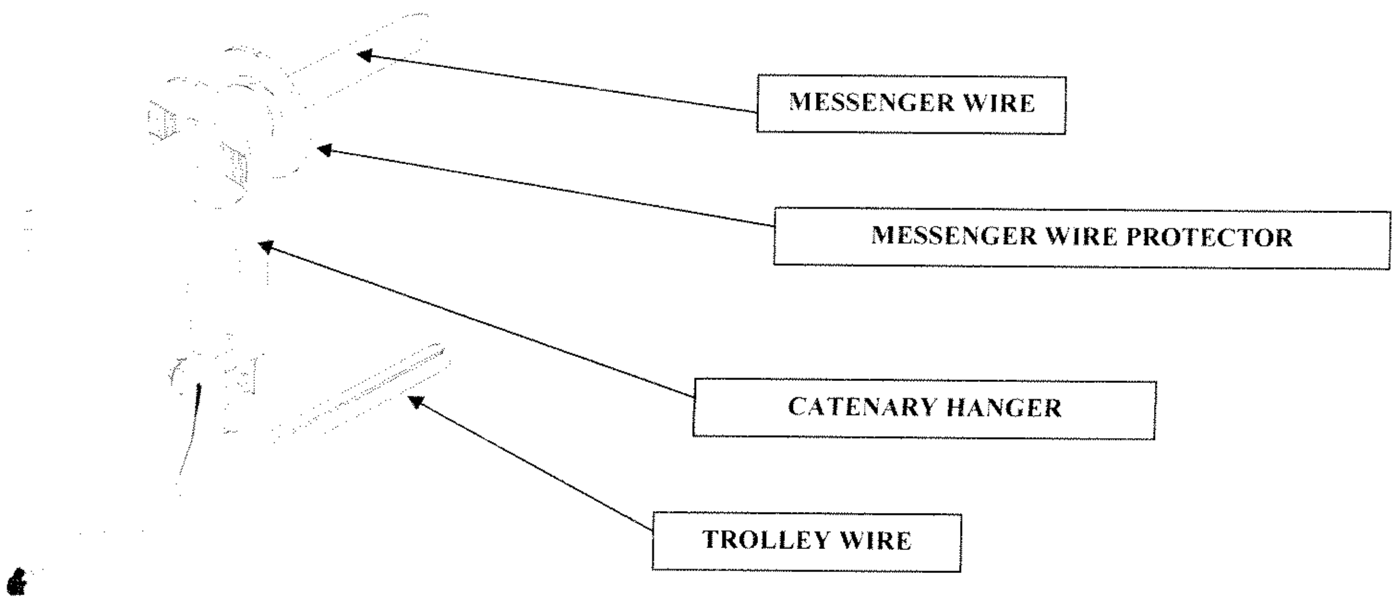


(FLEXIBLE and RIGID) PICKUP ASSEMBLIES

(for Messenger/Trolley Wire Systems ONLY)



CONDUCTIVE FLEXIBLE PICKUP ASSY.

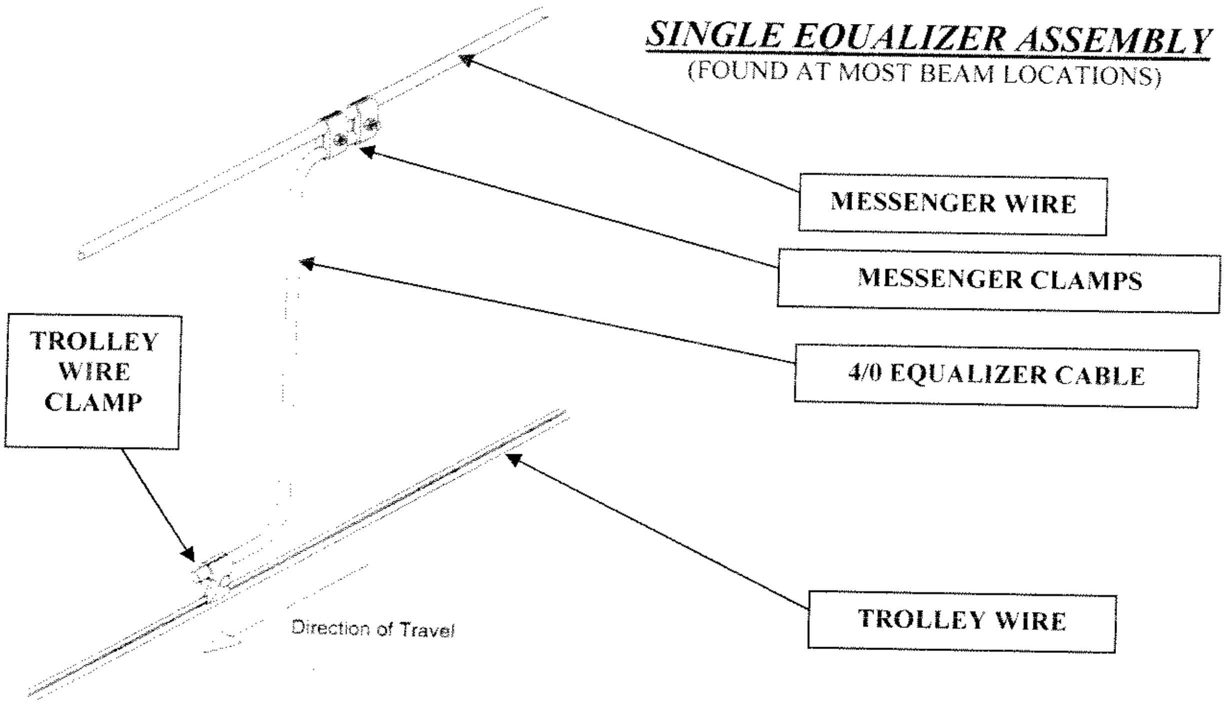


NON-CONDUCTIVE RIGID PICKUP ASSY.

SINGLE and CROSSOVER/OVERLAP EQUALIZER ASSEMBLIES

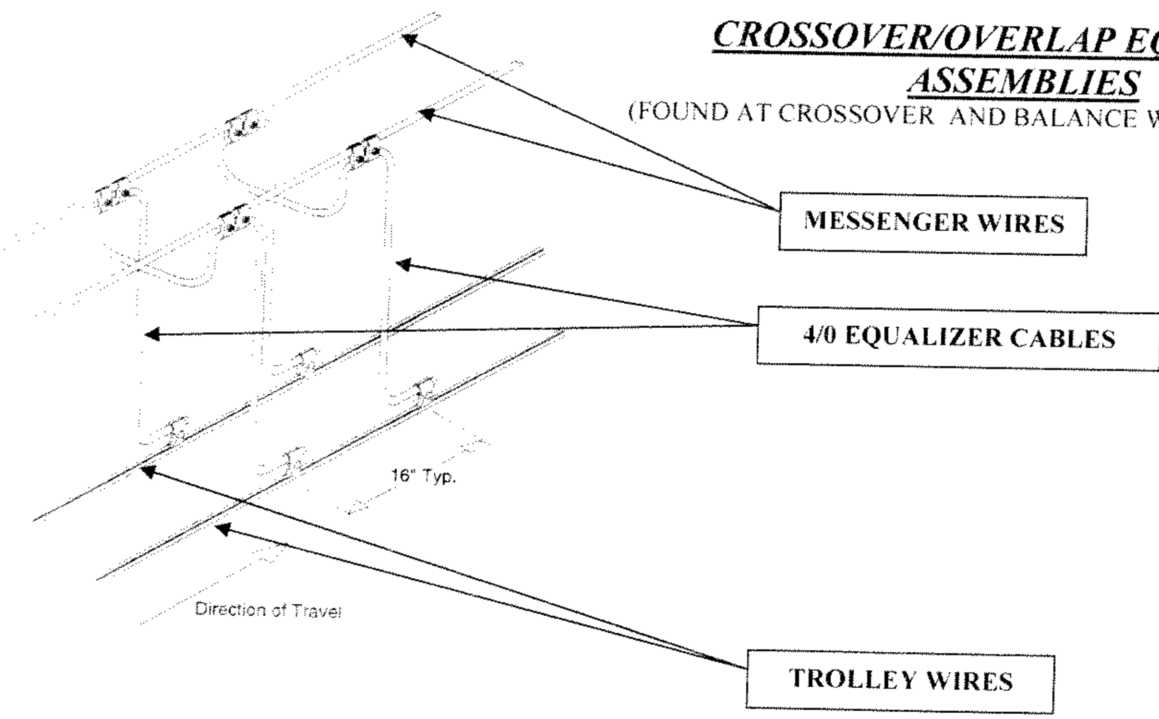
SINGLE EQUALIZER ASSEMBLY

(FOUND AT MOST BEAM LOCATIONS)



CROSSOVER/OVERLAP EQUALIZER ASSEMBLIES

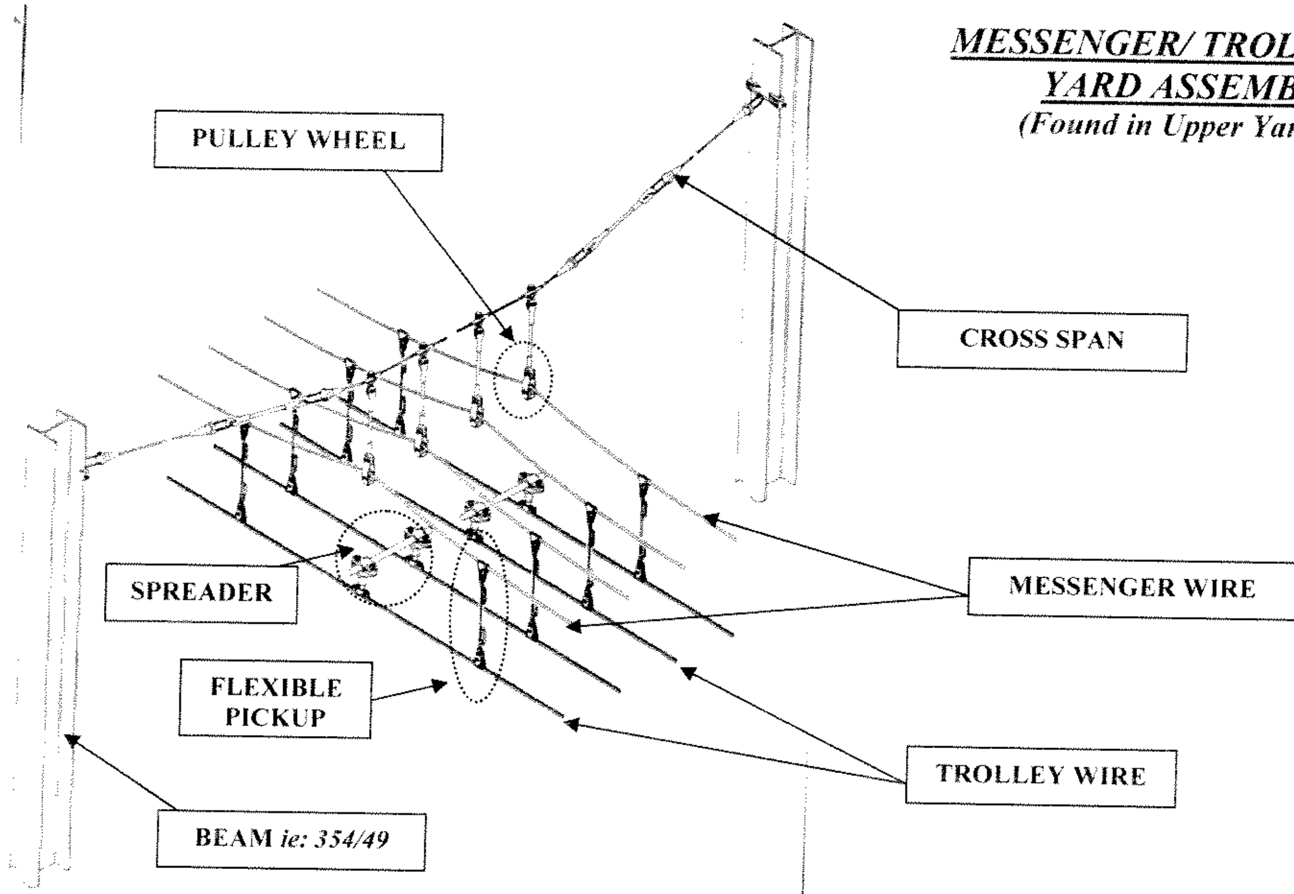
(FOUND AT CROSSOVER AND BALANCE WEIGHT LOCATIONS)



YARD ASSEMBLIES

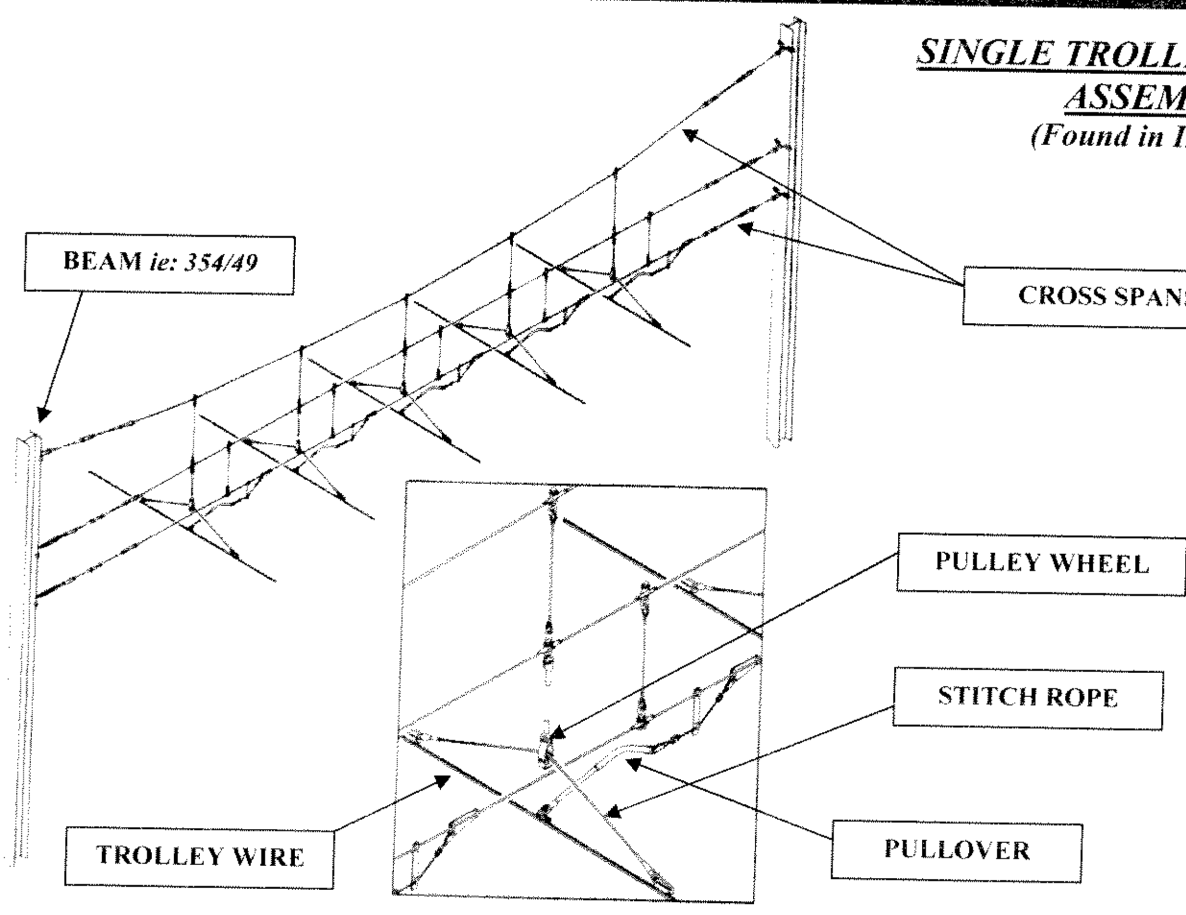
MESSENGER/ TROLLEY WIRE YARD ASSEMBLIES

(Found in Upper Yard Area)



SINGLE TROLLEY WIRE YARD ASSEMBLIES

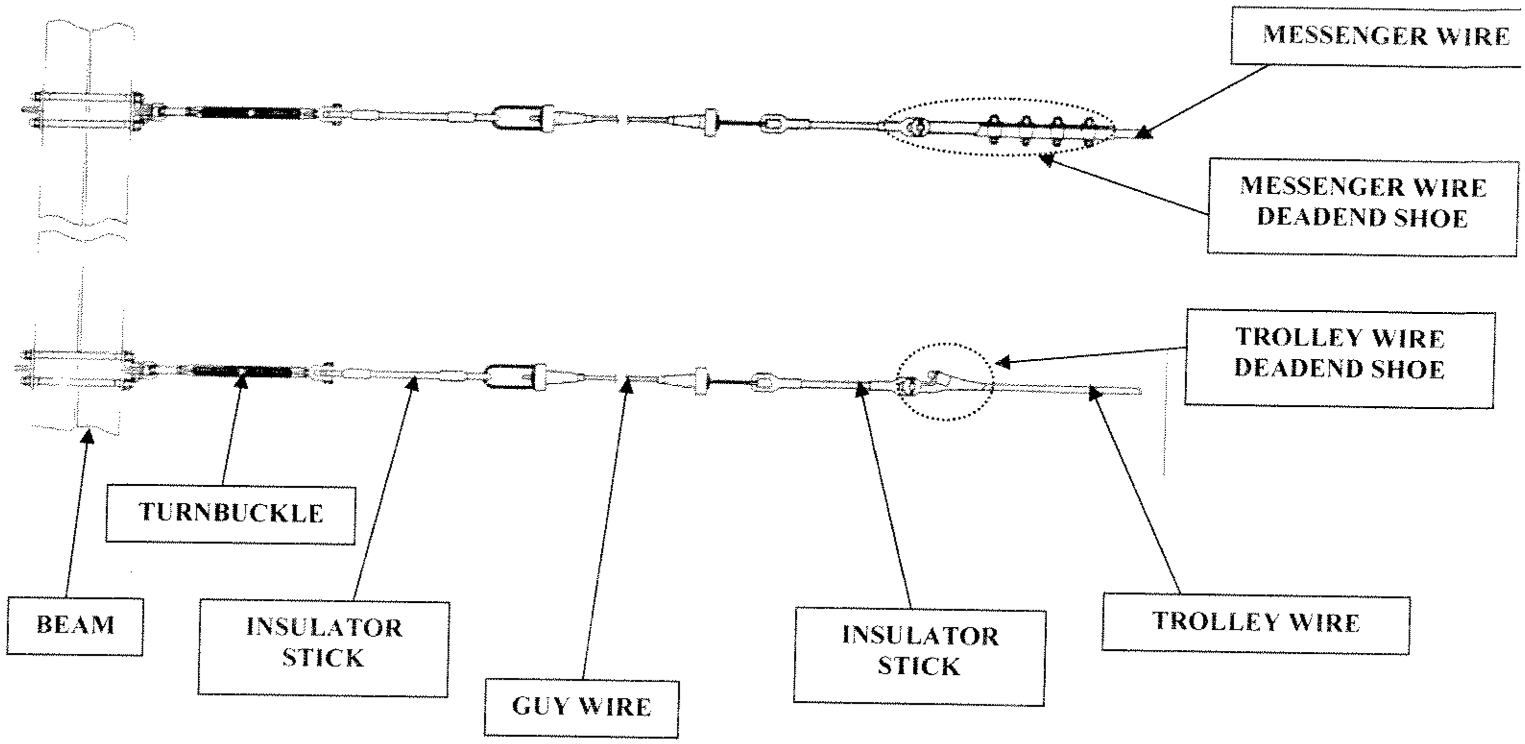
(Found in Inner Yard)



FIXED and SPRING TENSION DEADENDS (at CROSSOVERS)

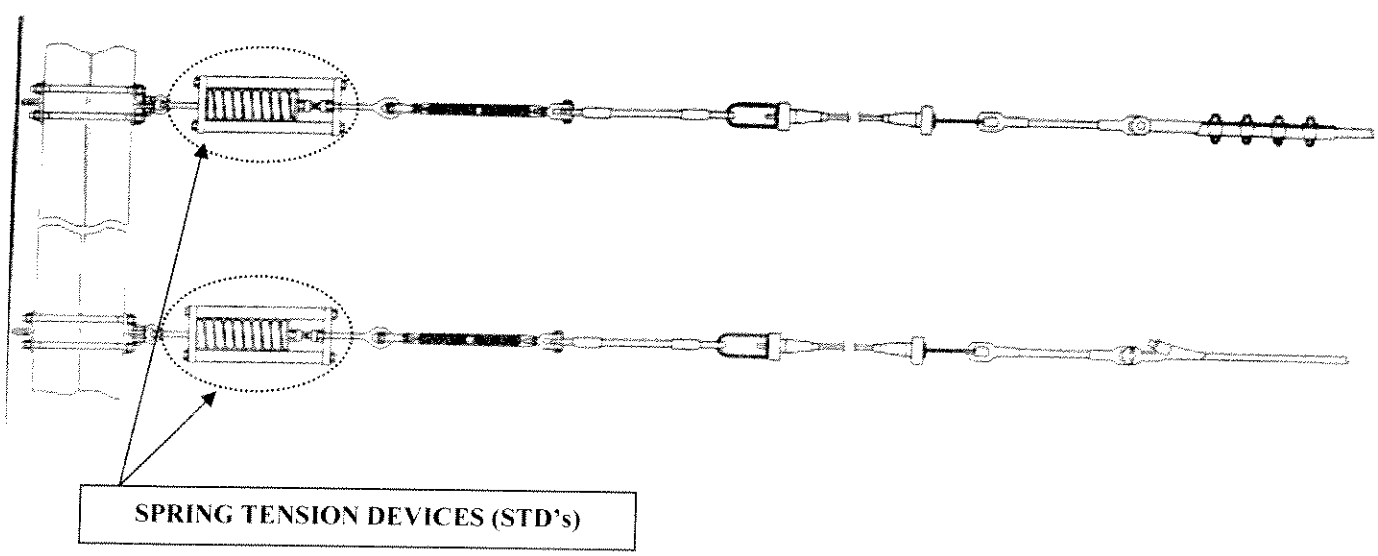
FIXED MESSENGER AND TROLLEY WIRE DEADEND ASSEMBLY

(FOUND AT ONE END OF CROSSOVER LOCATIONS)

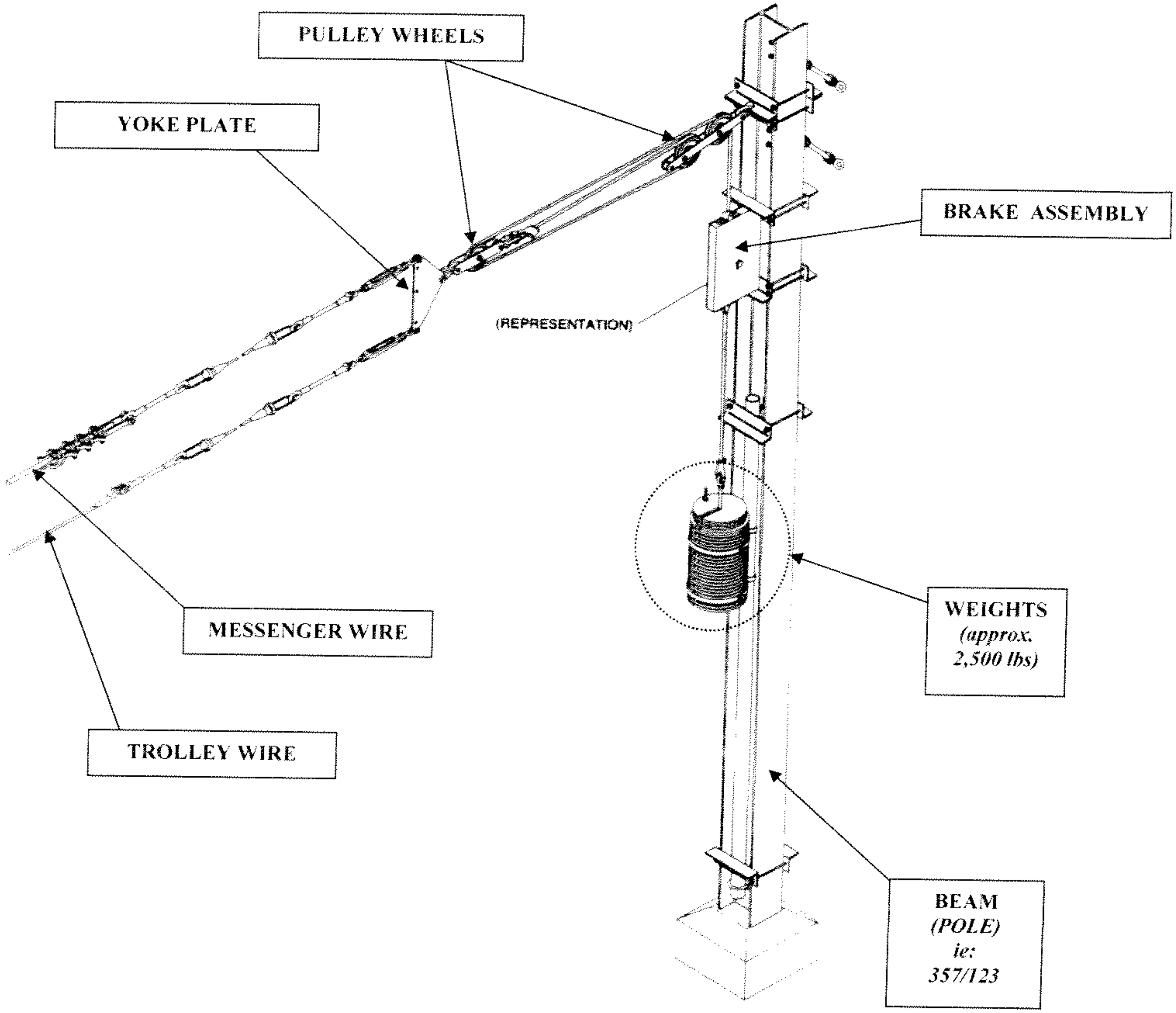


SPRING-TENSION MESSENGER AND TROLLEY WIRE DEADEND ASSEMBLY

(FOUND AT ONE END OF CROSSOVER LOCATIONS)



BALANCE WEIGHT ASSEMBLY
(Highland Branch)



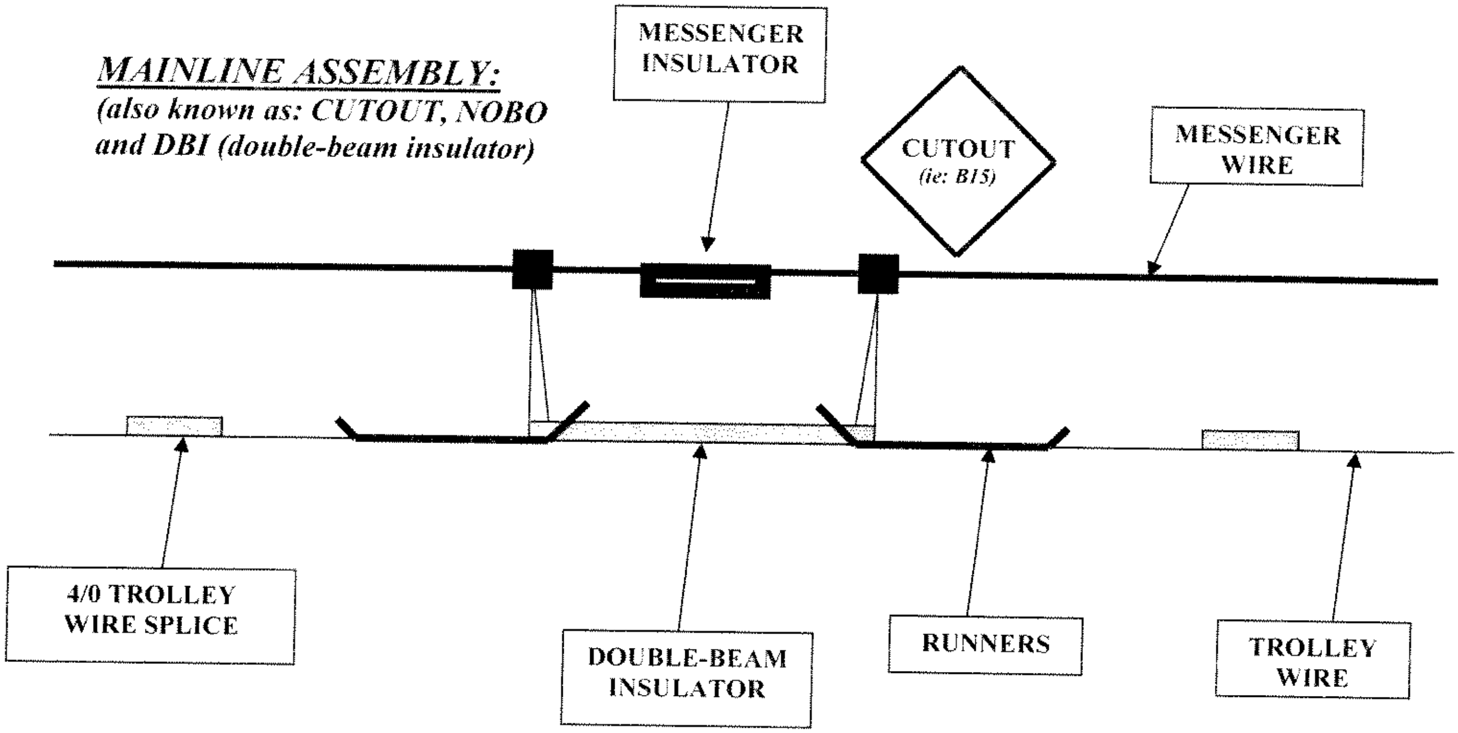
NOTE:

1. TENSION IN MESSENGER WIRE = 4000 POUNDS
2. TENSION IN TROLLEY WIRE = 3000 POUNDS

TROLLEY WIRE and MESSENGER WIRE INSULATOR ASSEMBLIES

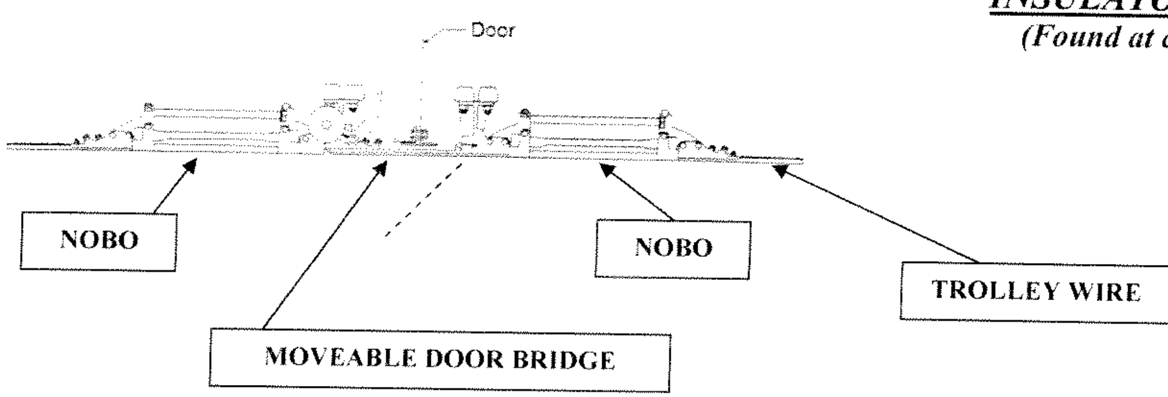
MAINLINE ASSEMBLY:

(also known as: CUTOUT, NOBO and DBI (double-beam insulator)



CARHOUSE TROLLEY WIRE INSULATOR ASSEMBLY

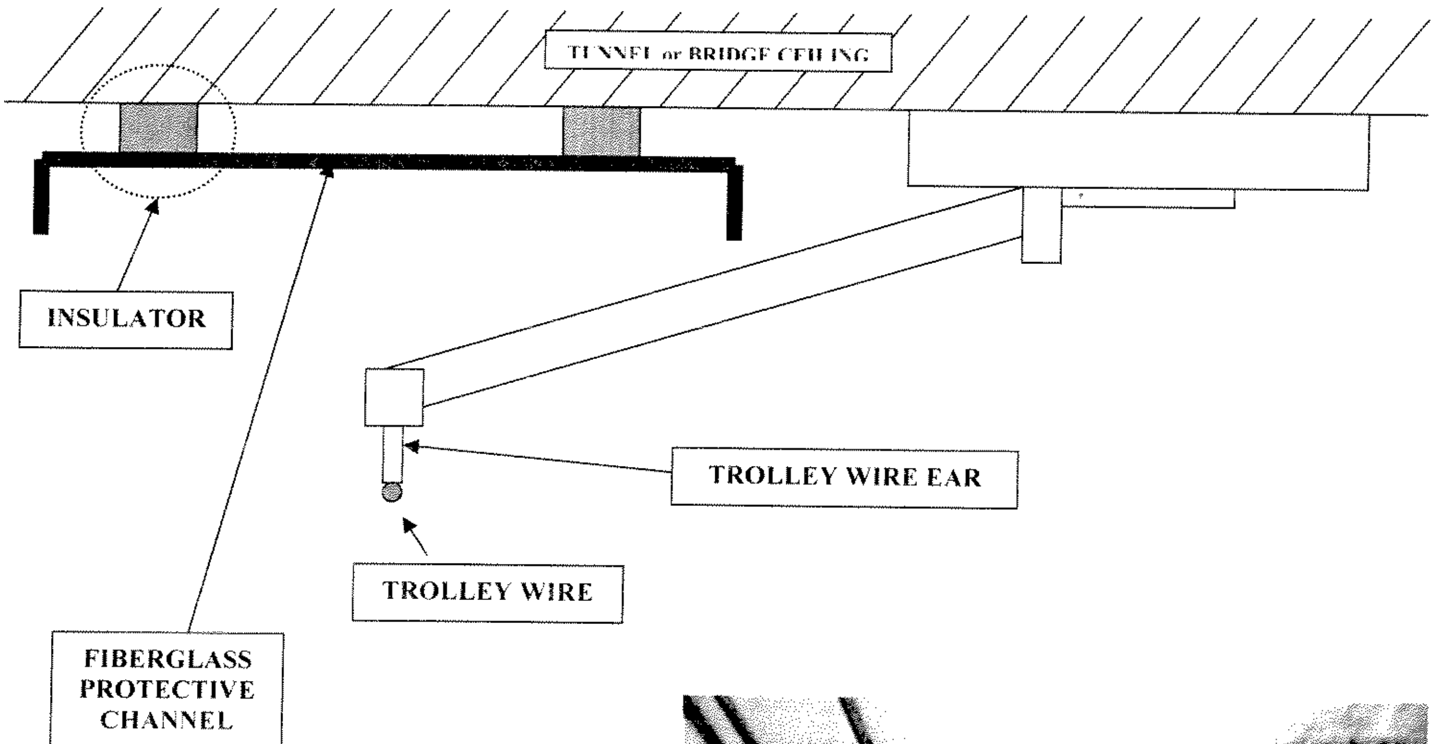
(Found at carhouse doors)



NOTE: *Single **NOBOS** are used throughout the yard area and also at some crossovers*

ELASTIC ARM ASSEMBLIES

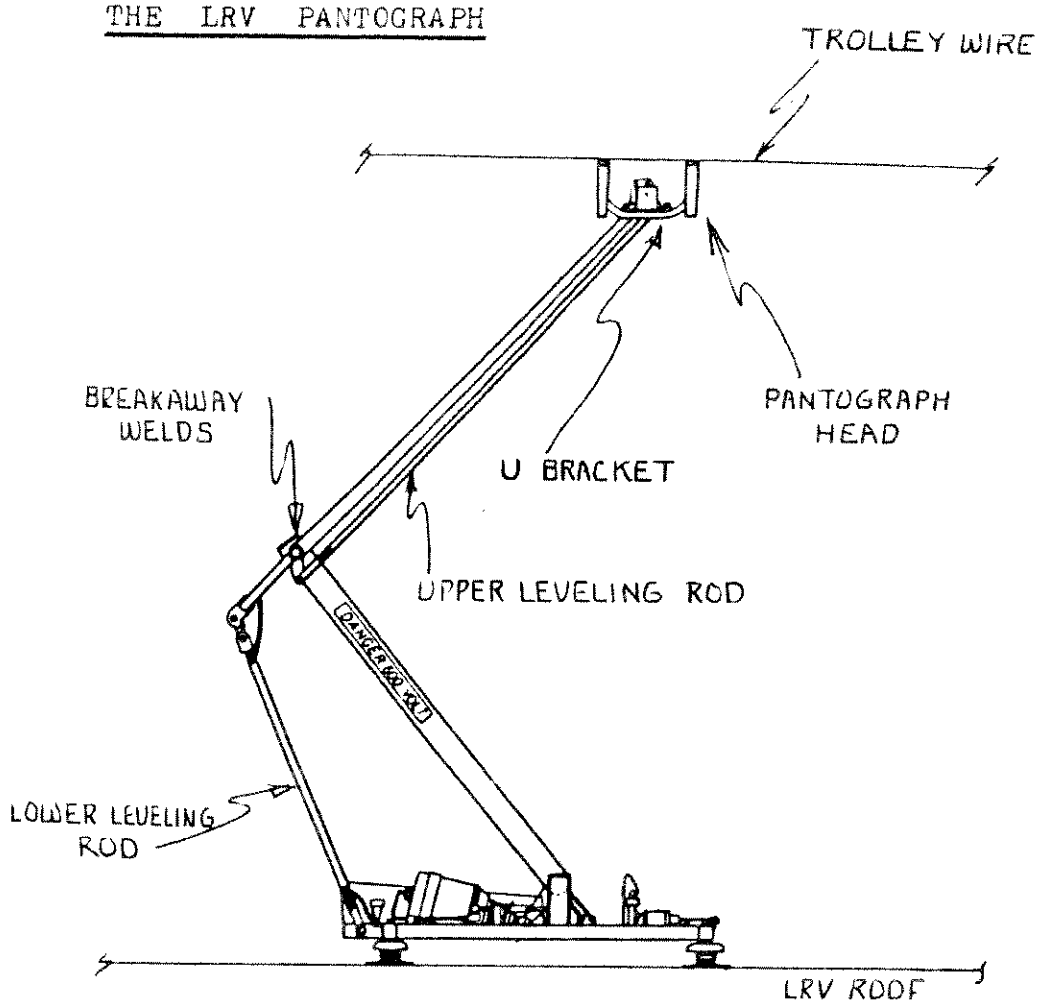
Elastic Arms:
(found in tunnels and under bridges)




ELASTIC ARM USED UNDER TEMPORARY WOOD SHIELD

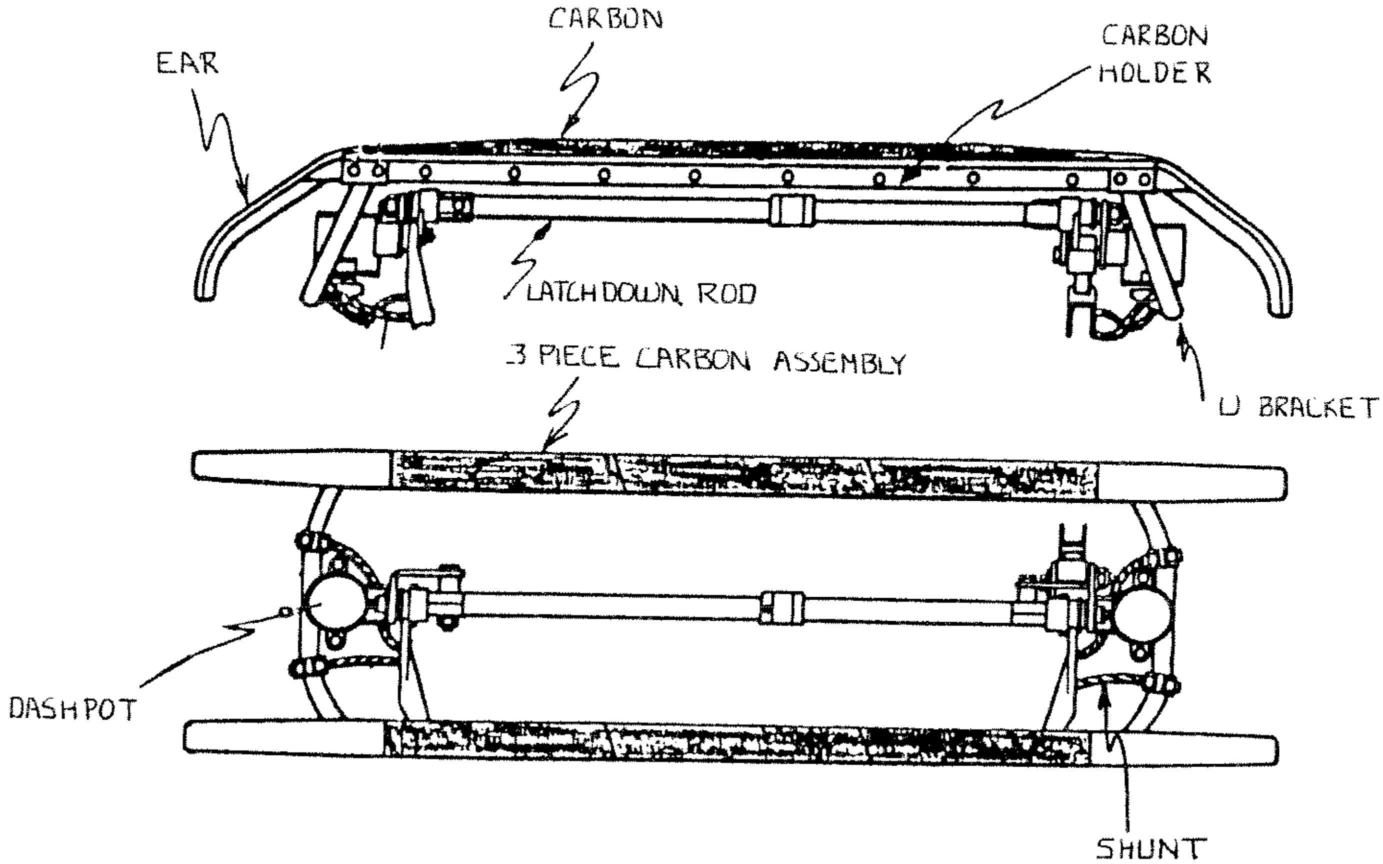
ELASTIC ARM and FIBERGLASS PROTECTIVE SHIELD ASSEMBLY

THE LRV PANTOGRAPH



The individual components shown above are usually the ones that become damaged during a mishap.

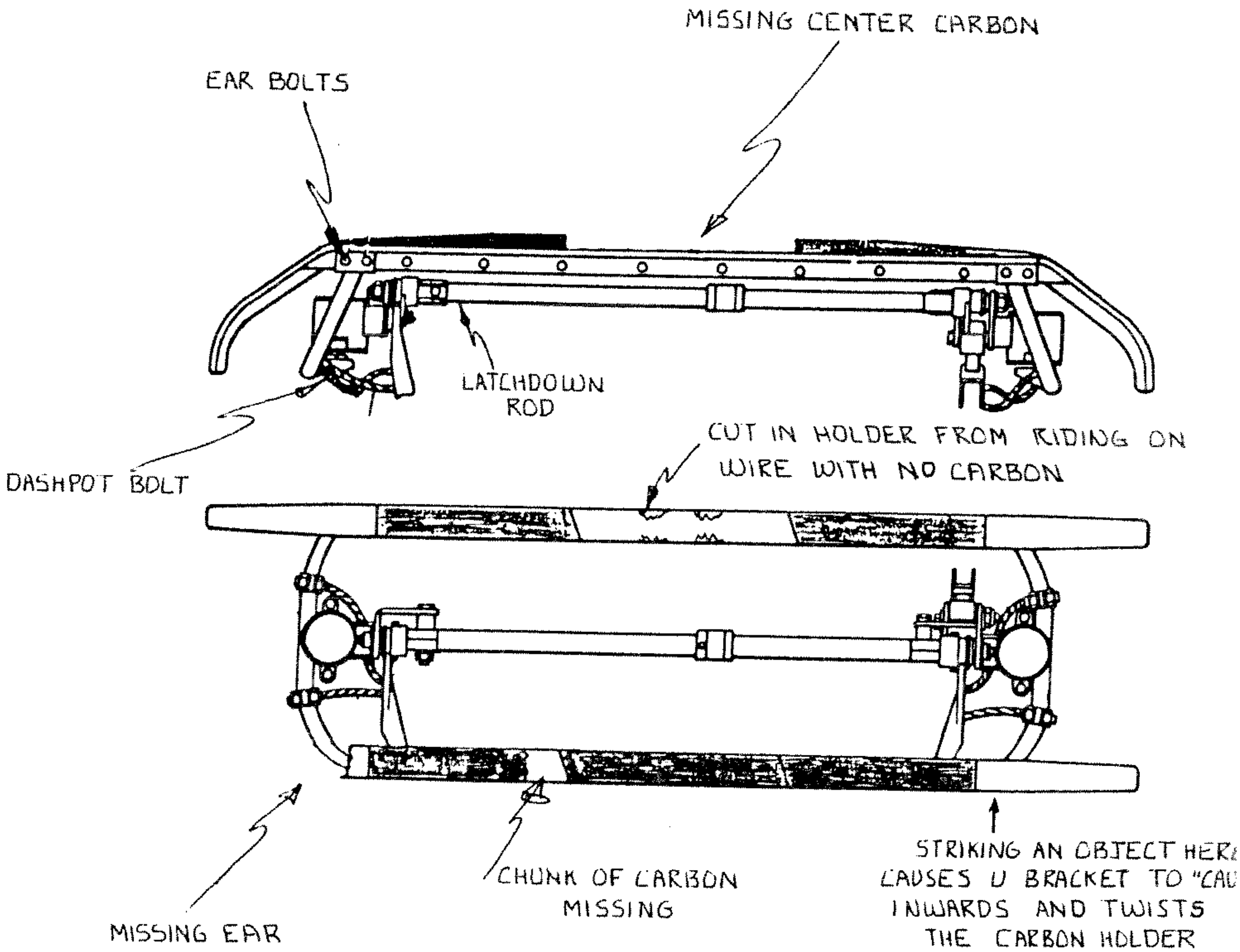
PANTOGRAPH CARBON HEAD



Each row of cabons contain three pieces: two identical end sections and one center section. Carbons are extremely brittle as they can be broken quite easily by striking them with a hammer.

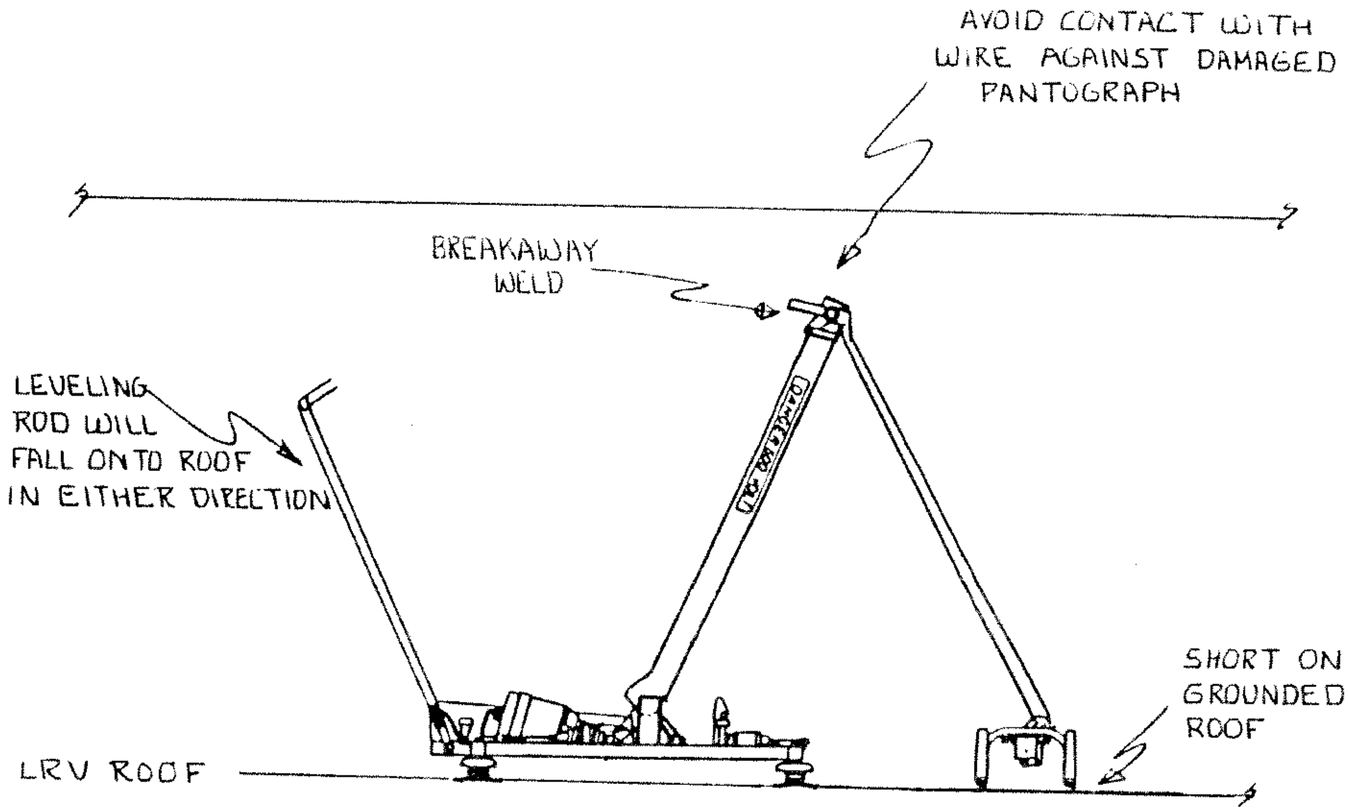
The four "ears" are of cast aluminum and also fracture easily. Their purpose is to guide the trolley wire onto the carbon area in areas where crossover wires merge with mainline wires. When a crossover wire becomes slack it is possible for the wire to become caught under the ear. When this happens several things can occur : the ear can break, the pantograph can break-away, or the wire can fracture. Sometimes, all three happen!

DAMAGED PANTOGRAPH COMPONENTS



When the overhead wire sustains damage such as a broken hanger or glider, the pantograph head can become damaged too. Entire sections of carbon can be knocked out of the holder, or chunks of carbon can be void. If the overhead problem is located at the extreme edge of the profile envelope, then the "ears" can be fractured. In these cases the pantograph should be lowered and the vehicle towed to the carhouse. Vehicles can usually be run under their own power if chips of carbon are observed to be missing. A missing dashpot bolt causes one side of the head to droop down allowing the wire to ride on the latchdown rod.

A BROKEN PANTOGRAPH

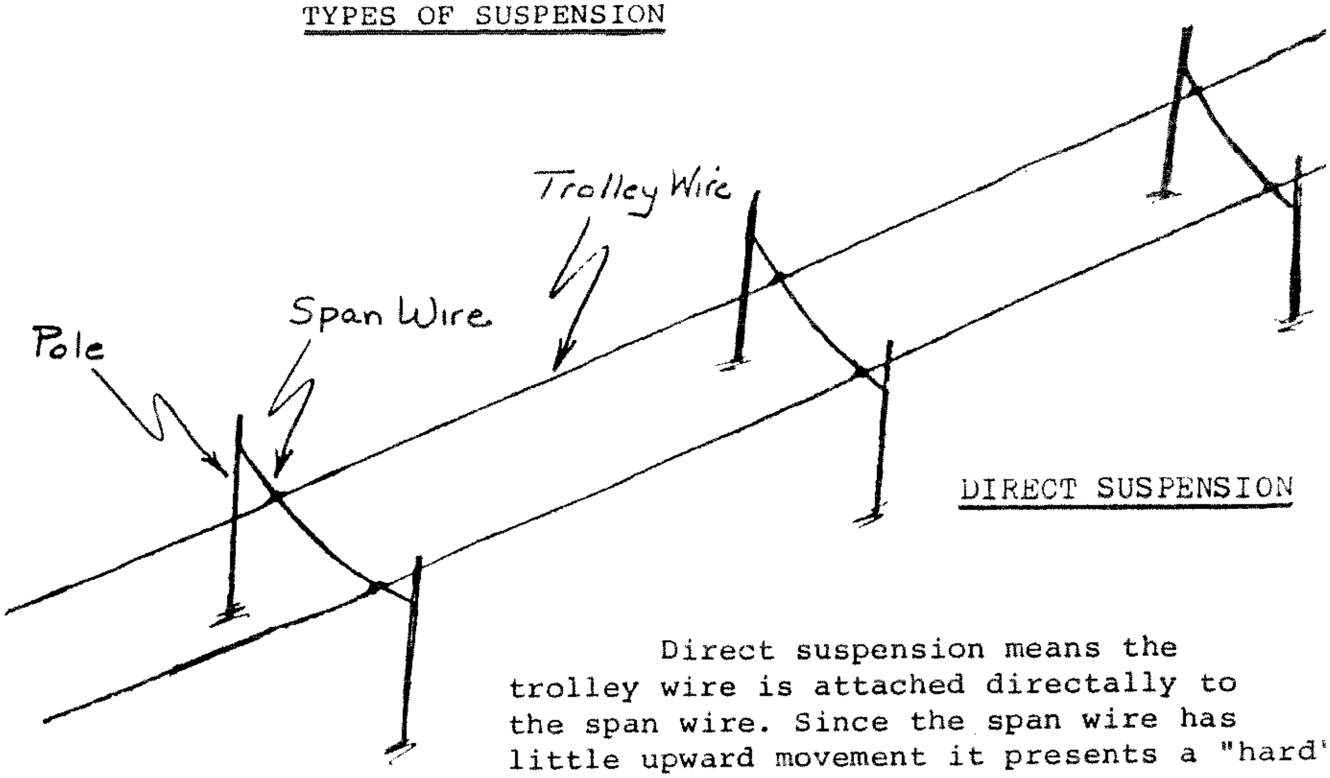


Often when a pantograph strikes an obstruction the specially fabricated "break-away welds" fracture; the pantograph then either lays flat on the roof, or in the position shown above.

The pantograph head usually contacts the grounded roof. If the 600 volt overhead touches any part of the pantograph, then a short circuit developes causing holes to be burnt in the roof and a lockout of the power section.

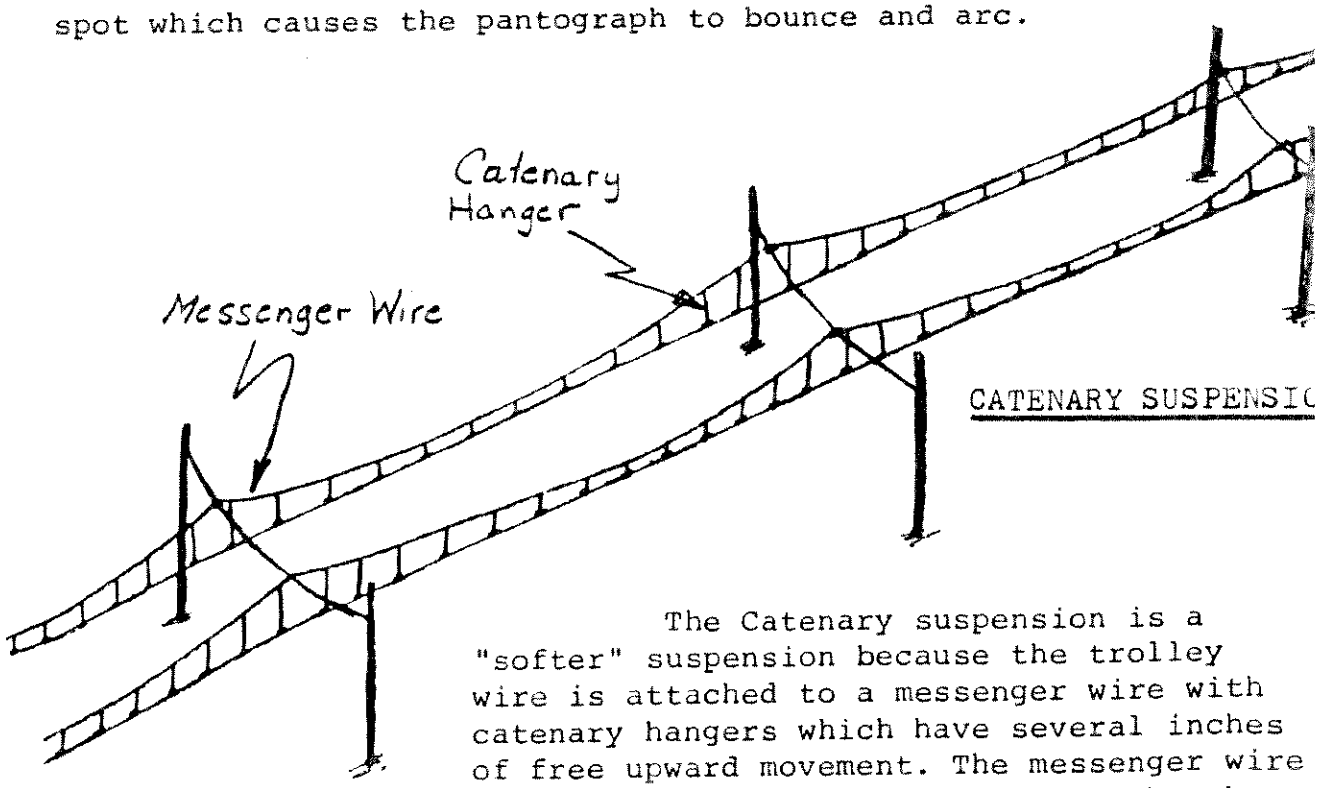
In order to move the car with the above type damage, power crews must tie down the pantograph so it will clear the overhead as the car is towed through the subway and low sections of overhead such as at bridges on the Highland Branch.

TYPES OF SUSPENSION



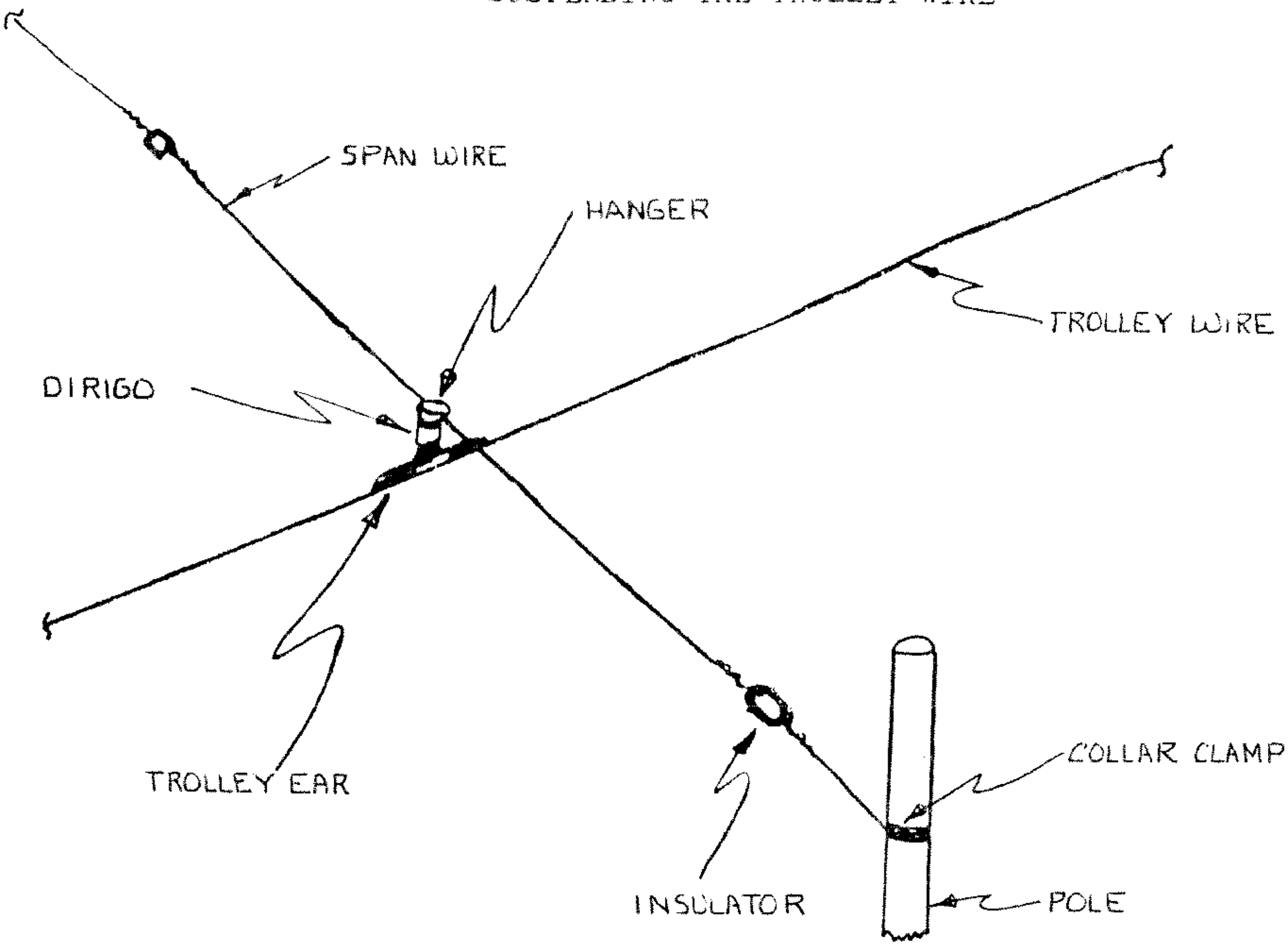
DIRECT SUSPENSION

Direct suspension means the trolley wire is attached directally to the span wire. Since the span wire has little upward movement it presents a "hard" spot which causes the pantograph to bounce and arc.

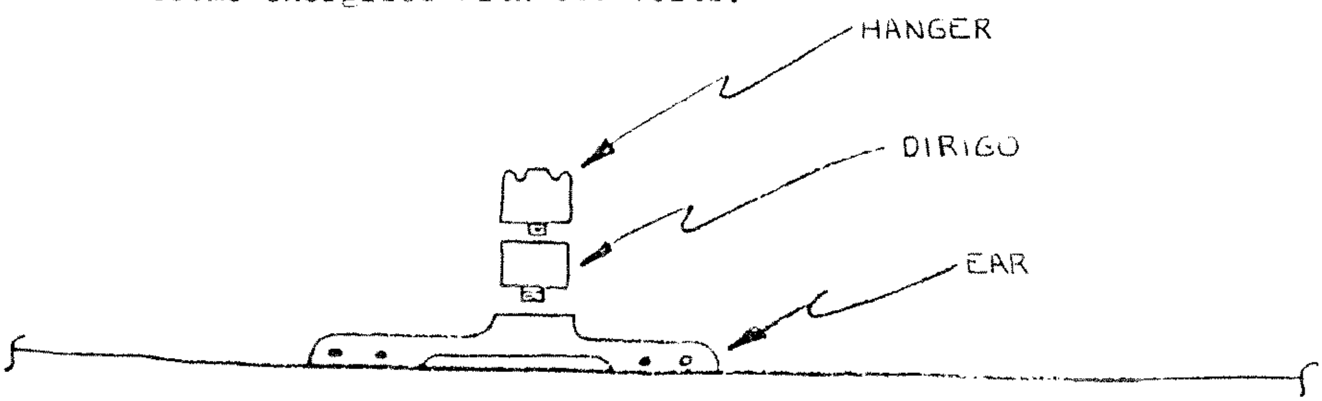


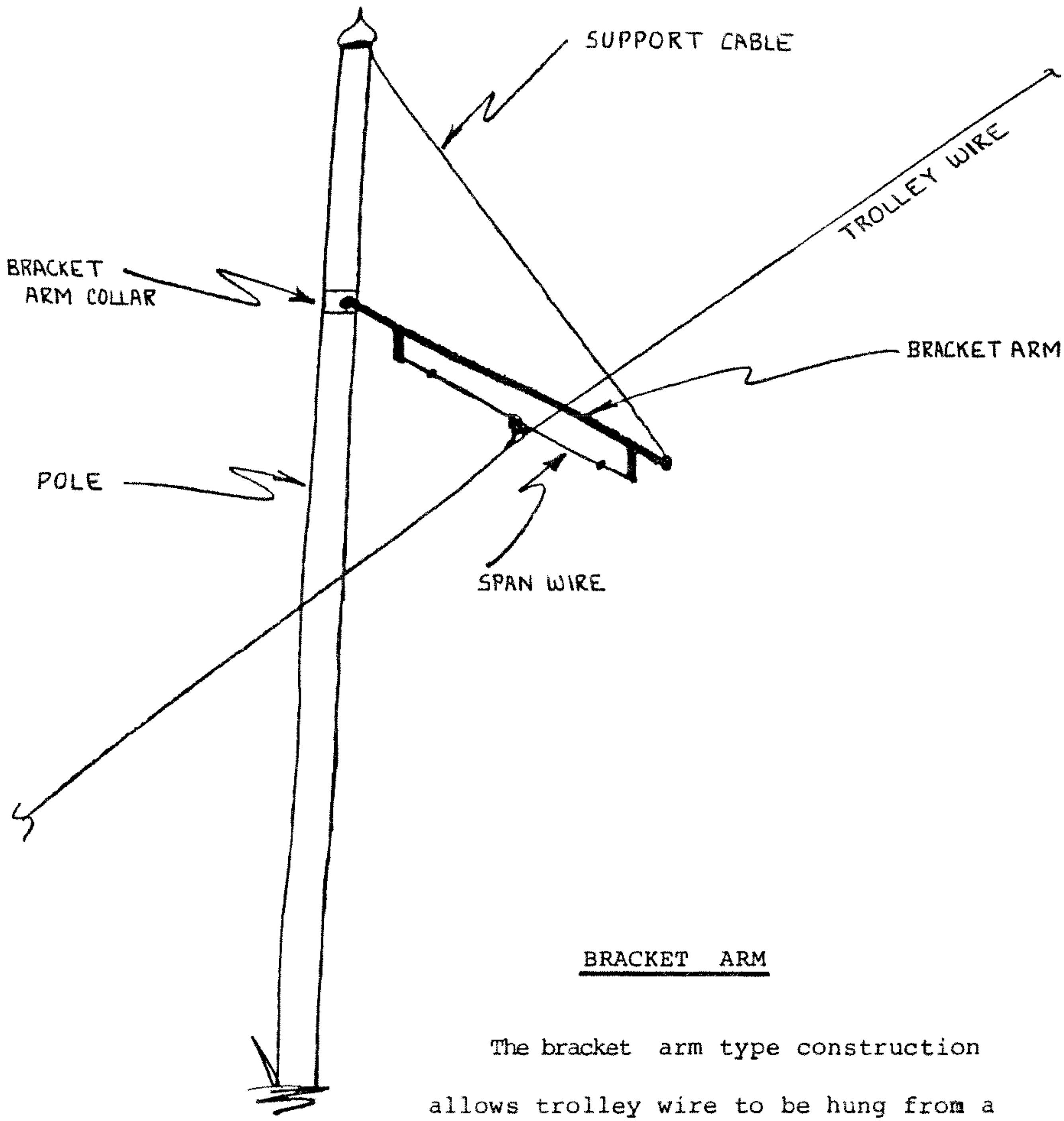
CATENARY SUSPENSIC

The Catenary suspension is a "softer" suspension because the trolley wire is attached to a messenger wire with catenary hangers which have several inches of free upward movement. The messenger wire is in turn attached to the span wire. This built in shock absorber type of trolley wire suspension eliminates the hard spots and allows pantographs to run at high speed with no bouncing or arcing. East Boston RTL has employed this type of suspension since 1952; the Green Line is currently being retrofitted.



The hanging of the trolley wire from a span wire requires a trolley ear which grips the trolley wire, a dirigo that insulates the trolley wire from the span wire and also acts to drop the trolley wire downwards below the span wire, and a hanger which grips the span wire and prevents lateral movement. Sometimes two and even three dirigos are screwed together to give extra spacing between the trolley wire and the span wire. The insulator provides electrical insulation between the span wire and the pole should the span accidently become energized with 600 volts.

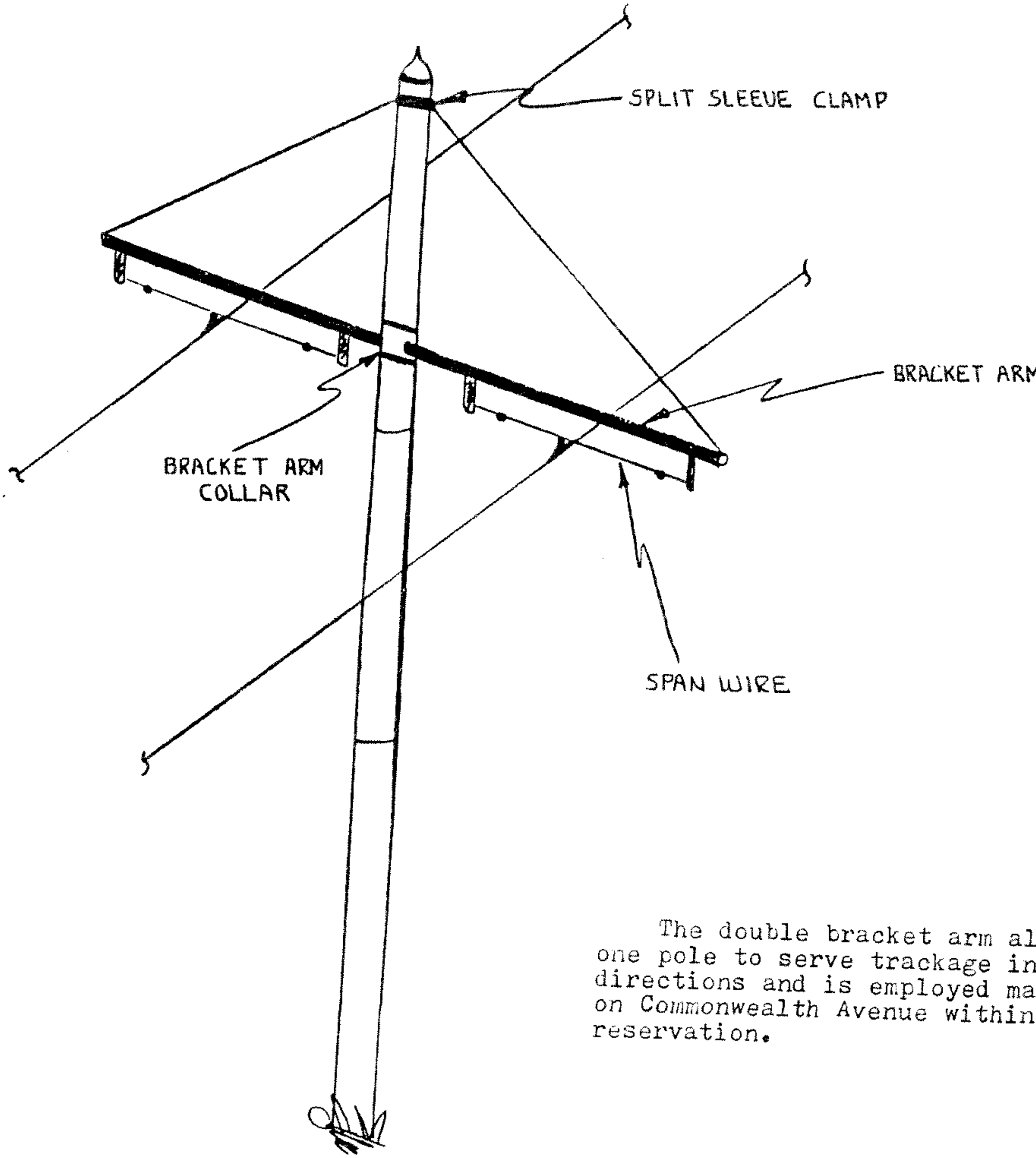




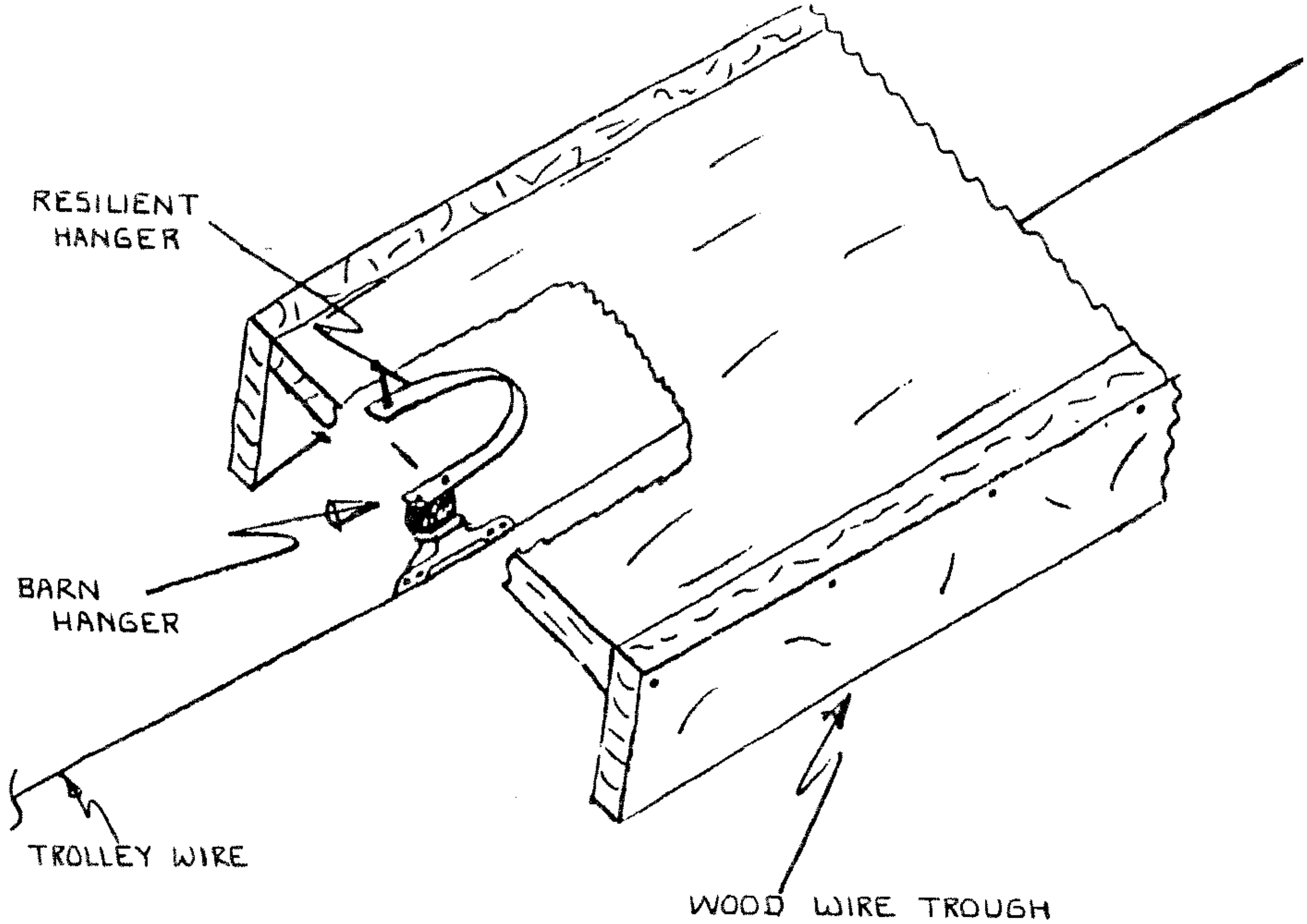
BRACKET ARM

The bracket arm type construction allows trolley wire to be hung from a single pole. Often two bracket arms are employed, one over each rail for inbound and outbound service. The bracket arm contains a short span wire which holds the trolley wire. This allows slight upward movement as the pantograph passes.

DOUBLE BRACKET ARM



The double bracket arm allows one pole to serve trackage in both directions and is employed mainly on Commonwealth Avenue within the reservation.

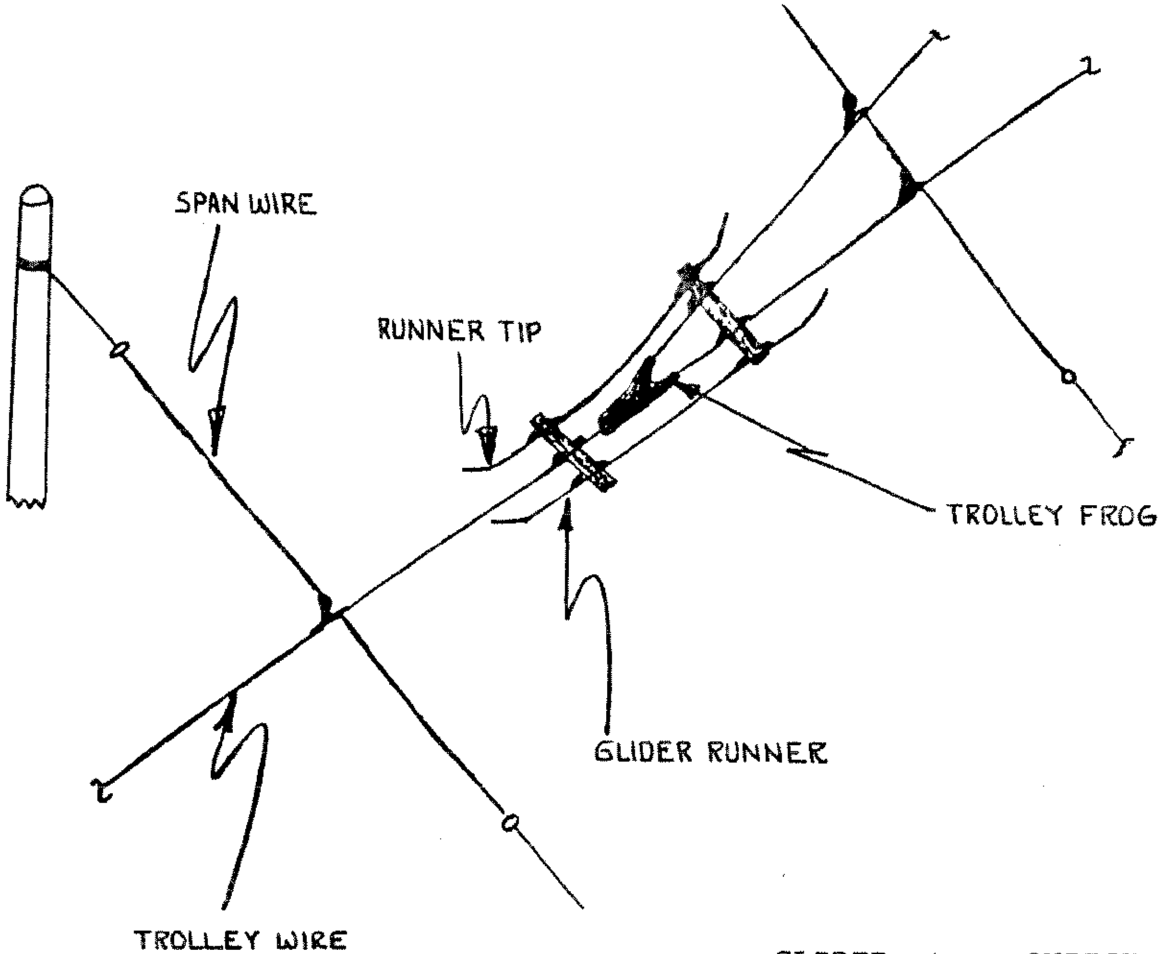


THE WIRE TROUGH

When a trolley pole would dewire, the wooden wire trough would catch the pole giving it a smooth place to contact until the car stopped. If the trough was not present the pole would hit steel beams and span wires, often shorting the power section to ground and damaging the pole.

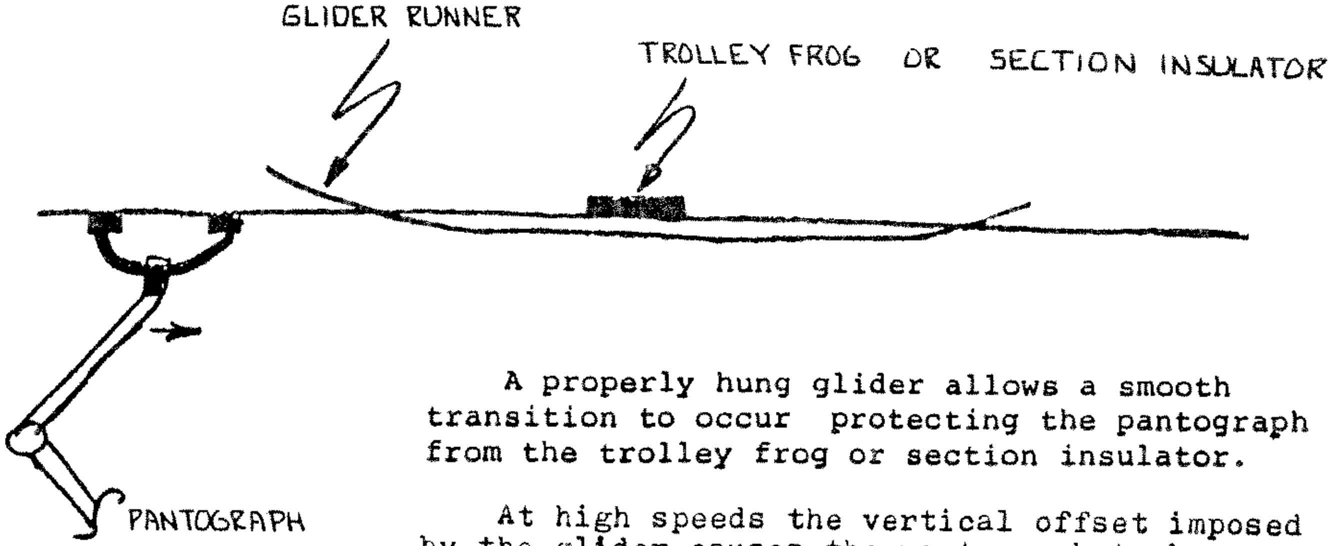
Pantograph opperation does not require troughing. In its place a flat board is all that is required to prevent the unit from contacting beams and other structures.

Fiberglass will probably replace wood in this application in the near future, as it requires less maintenance. Wire troughs and protective planks are currently employed in the subway and under bridges on the Highland Branch Line.



GLIDER at a SWITCH

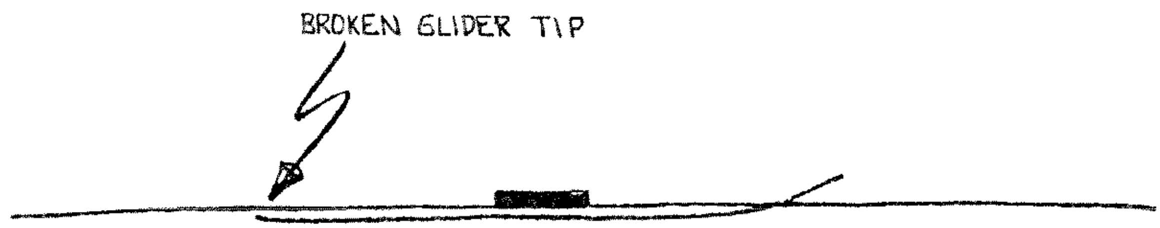
When a car with a trolley pole made a turnout at a track switch, the pole followed the car by passing through the trolley frog. Sometimes the pole would take the wrong direction and cause service delays. With the pantograph the need for the frog is eliminated, since the pantograph "glides" through from one wire to the other. However, since we have had to run a dual pole-pantograph operation the pantograph had to be protected from hitting the sharp edges of the cast metal frog. The glider runner (sled) was developed to lower the pantograph slightly and pass just underneath the frog. In order to insure a smooth transition into the frog the tip of the runner is bent up slightly.

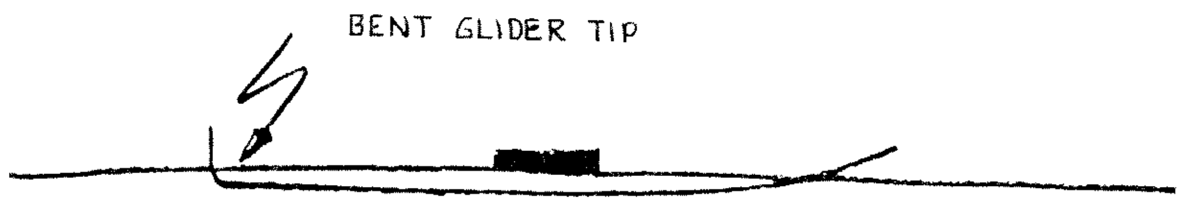


A properly hung glider allows a smooth transition to occur protecting the pantograph from the trolley frog or section insulator.

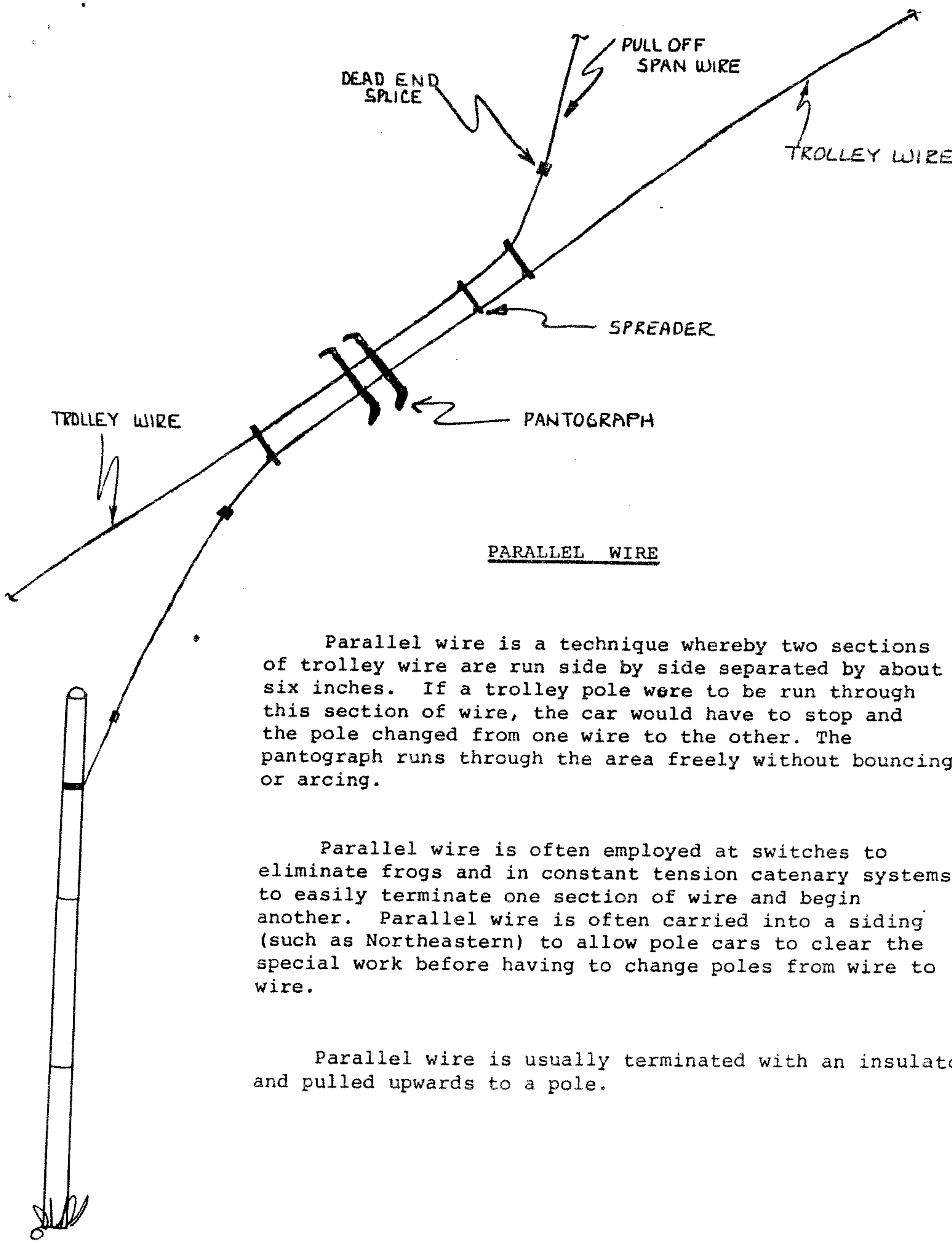
At high speeds the vertical offset imposed by the glider causes the pantograph to bounce and arc, which in turn causes accelerated wire wear.

THE GLIDER





When a glider tip breaks or becomes bent straight upright, pantograph carbons become damaged as they strike the blunt edge.



PARALLEL WIRE

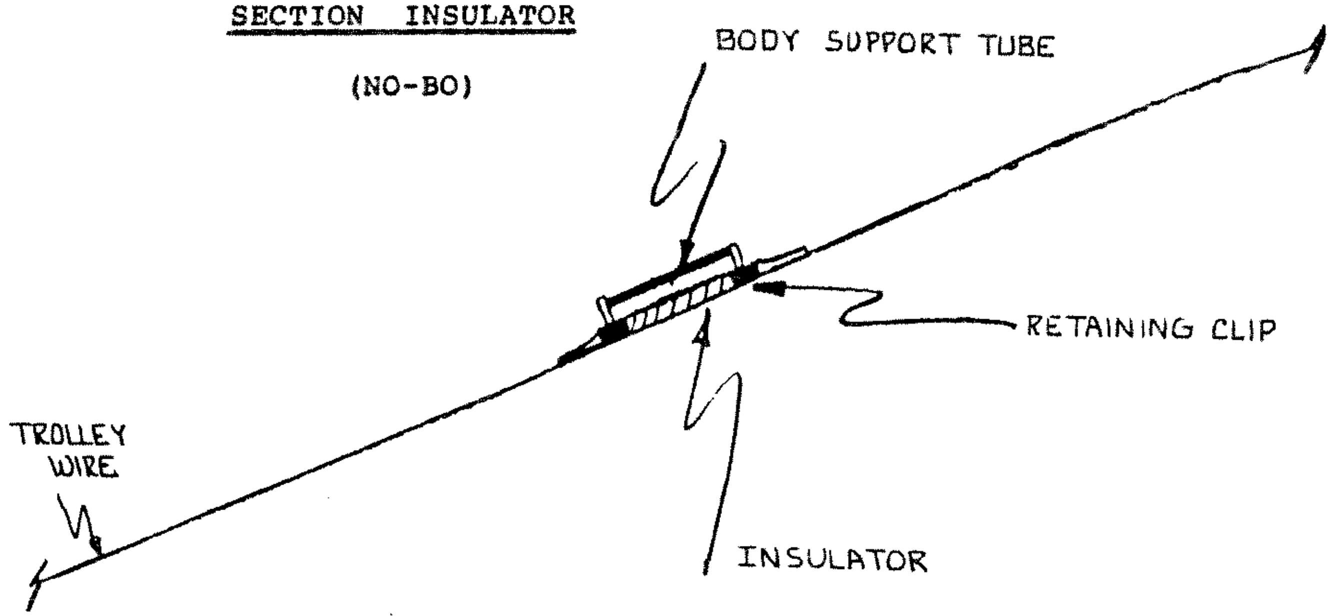
Parallel wire is a technique whereby two sections of trolley wire are run side by side separated by about six inches. If a trolley pole were to be run through this section of wire, the car would have to stop and the pole changed from one wire to the other. The pantograph runs through the area freely without bouncing or arcing.

Parallel wire is often employed at switches to eliminate frogs and in constant tension catenary systems to easily terminate one section of wire and begin another. Parallel wire is often carried into a siding (such as Northeastern) to allow pole cars to clear the special work before having to change poles from wire to wire.

Parallel wire is usually terminated with an insulator and pulled upwards to a pole.

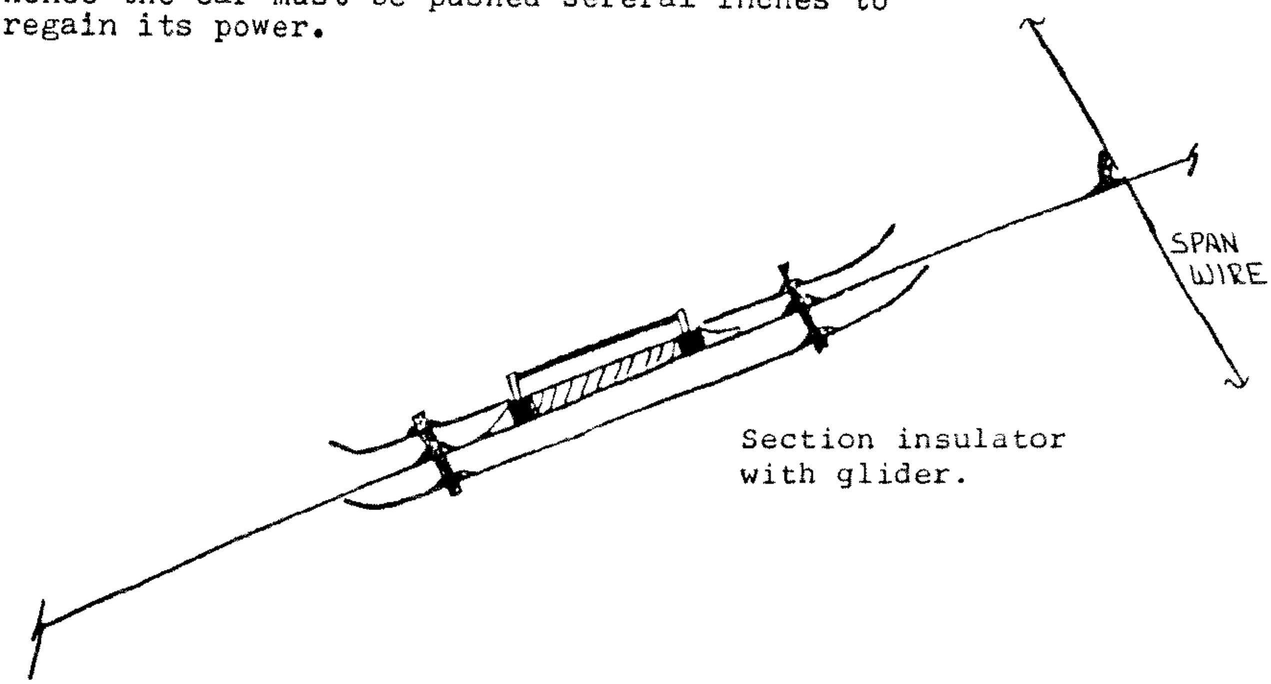
SECTION INSULATOR

(NO-BO)



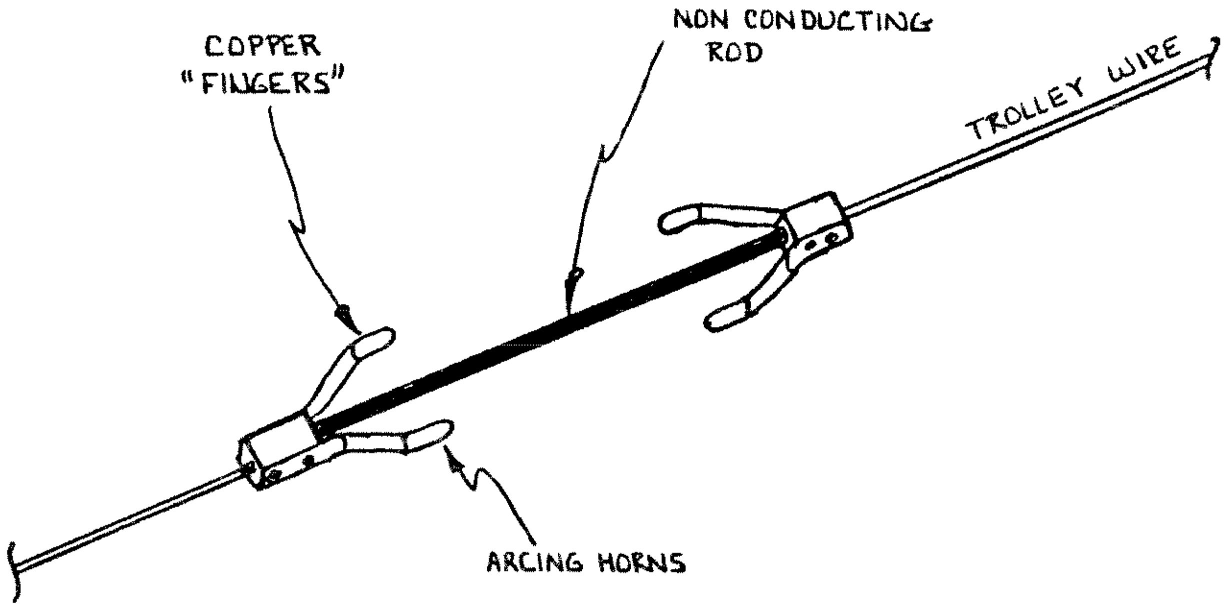
The section insulator is an electrical insulator that isolates two power sections. A pole or pantograph can pass through freely. In order for pantographs to pass through at high speed, a glider is usually installed. Newer designs that pass pantographs without gliders are beginning to appear. The newer units eliminate pantograph bounce and require less maintenance.

If a pantograph stops in the middle of the section insulator, it cannot collect power from either section, and hence the car must be pushed sereral inches to regain its power.



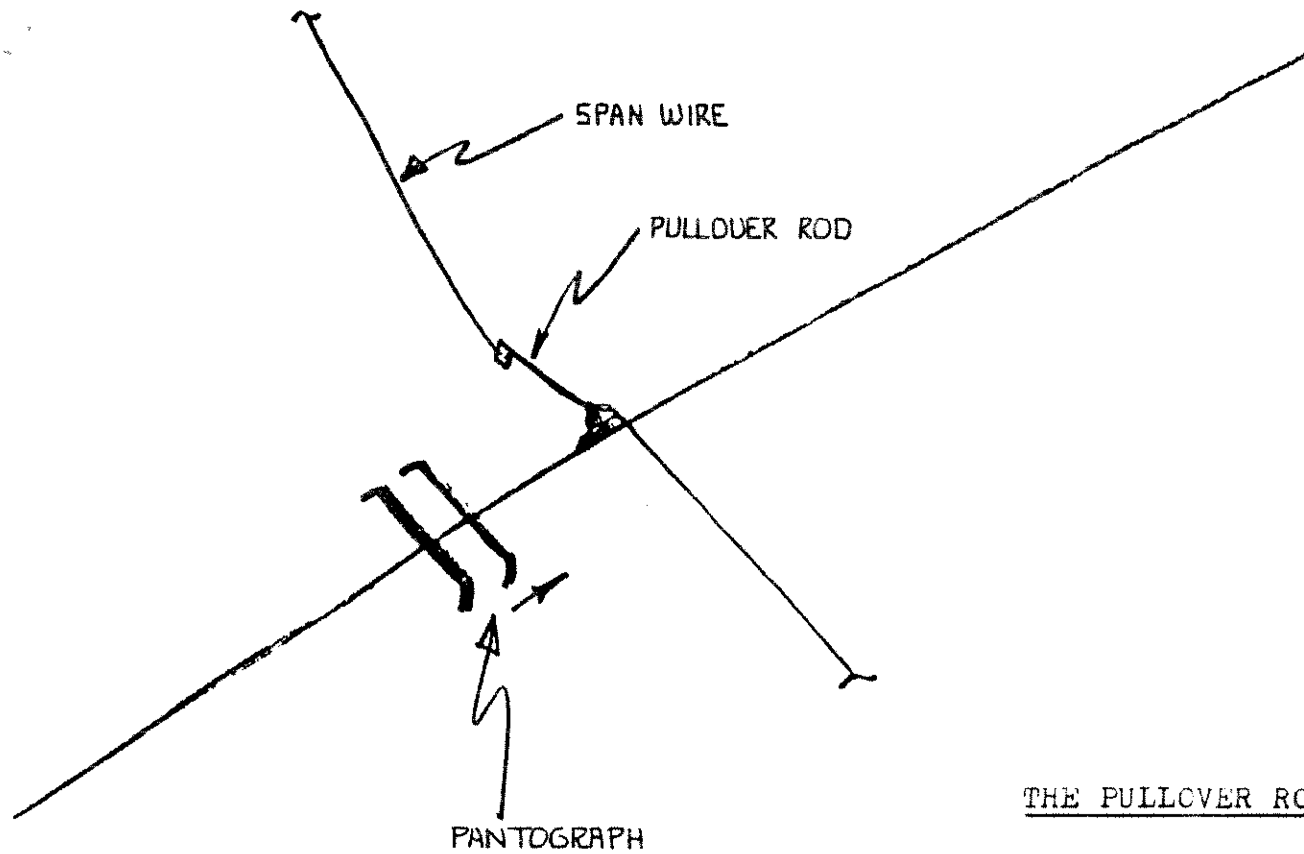
Section insulator with glider.

KUPLER SECTION INSULATOR



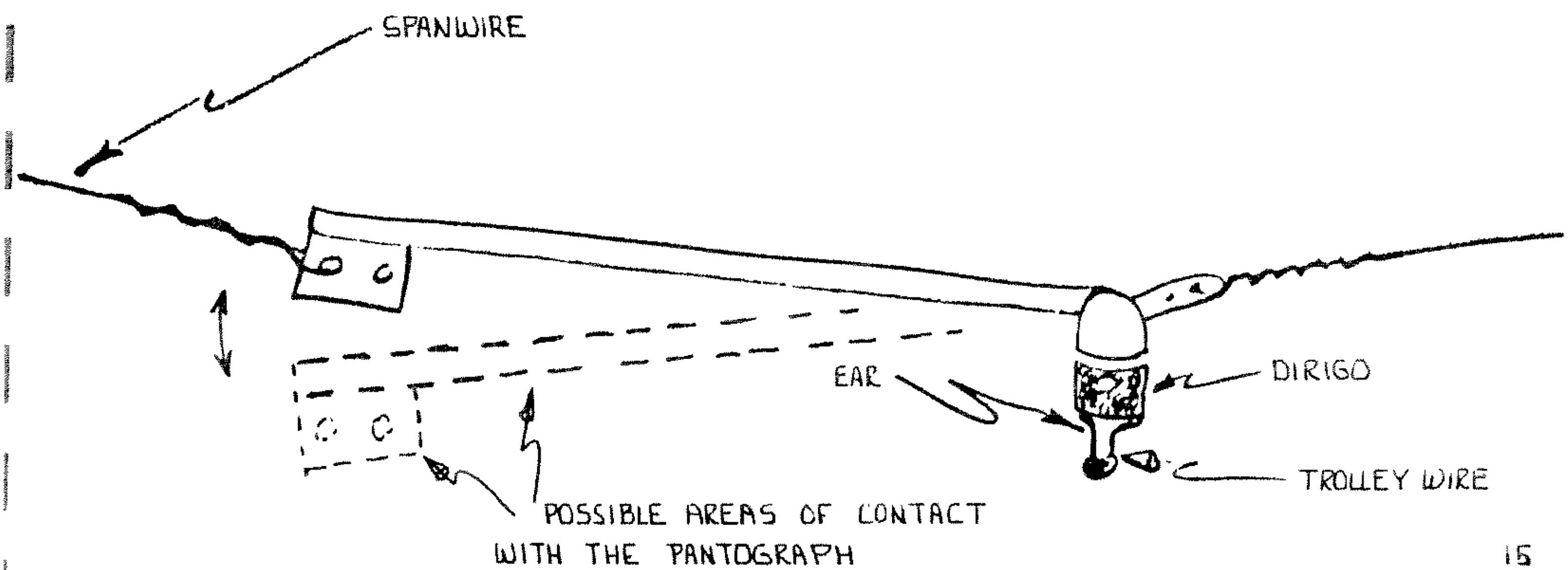
The "Kupler phase break" is a new style section insulator that is pantograph compatable but contains no gliders. The copper fingers shaped in the form of a "V" break the arc as the power becomes interrupted when leaving the section. The pantograph then rides on the non conducting rod which is level with the trolley wire, and hence produces no bounce.

The copper fingers are referred to as arcing horns.

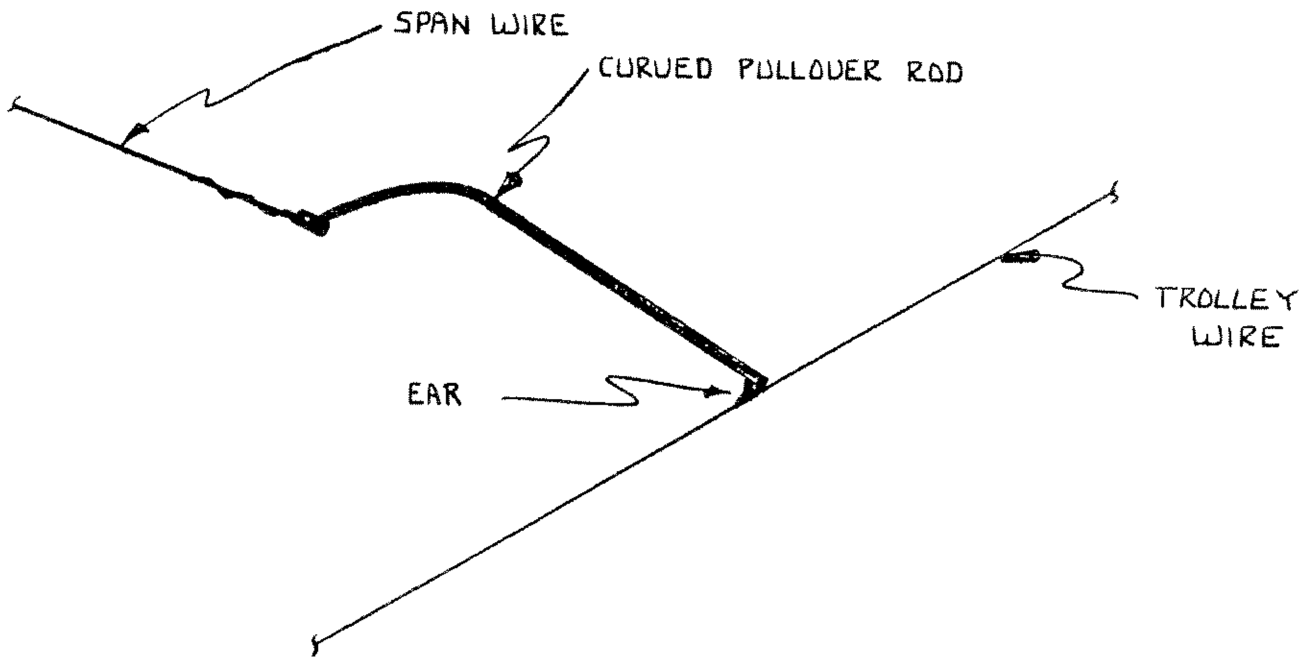


THE PULLOVER ROD

The pullover rod, often referred to as the "hockey stick", was developed when the LRVs first arrived to allow the existing wire to serve a dual function: pole and pantograph. The intent is to allow a pantograph to clear the span wire on curves when the pantograph tilts due to the superelevation of the track and the speed of the car. Its use has been unsuccessful due to the end of the rod saging downwards striking oncoming pantographs. Often the rod will vibrate up and down, being set in motion by a car traveling in the opposite direction. Other times the lead car will cause the pullover rod to vibrate, and the trailer car's pantograph will strike the end of the rod. New techniques have been developed.



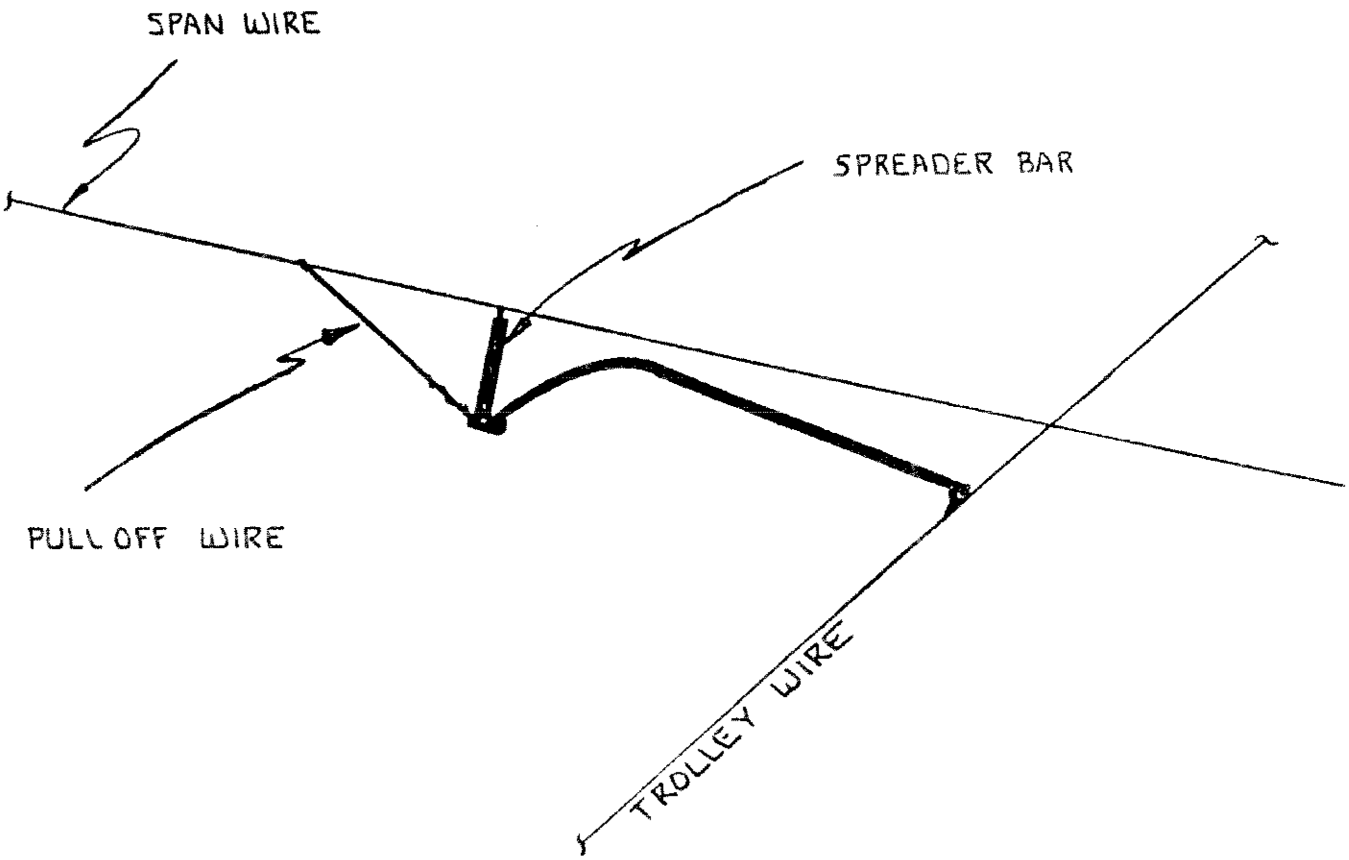
THE CURVED PULLOVER ROD



The curved pullover rod was developed to eliminate the many shortcomings of the "hockey stick" pullover rod. The curved upward profile of this design allows room for the pantograph to clear during the extremes of temperature (ie wire sag) and carbody roll.

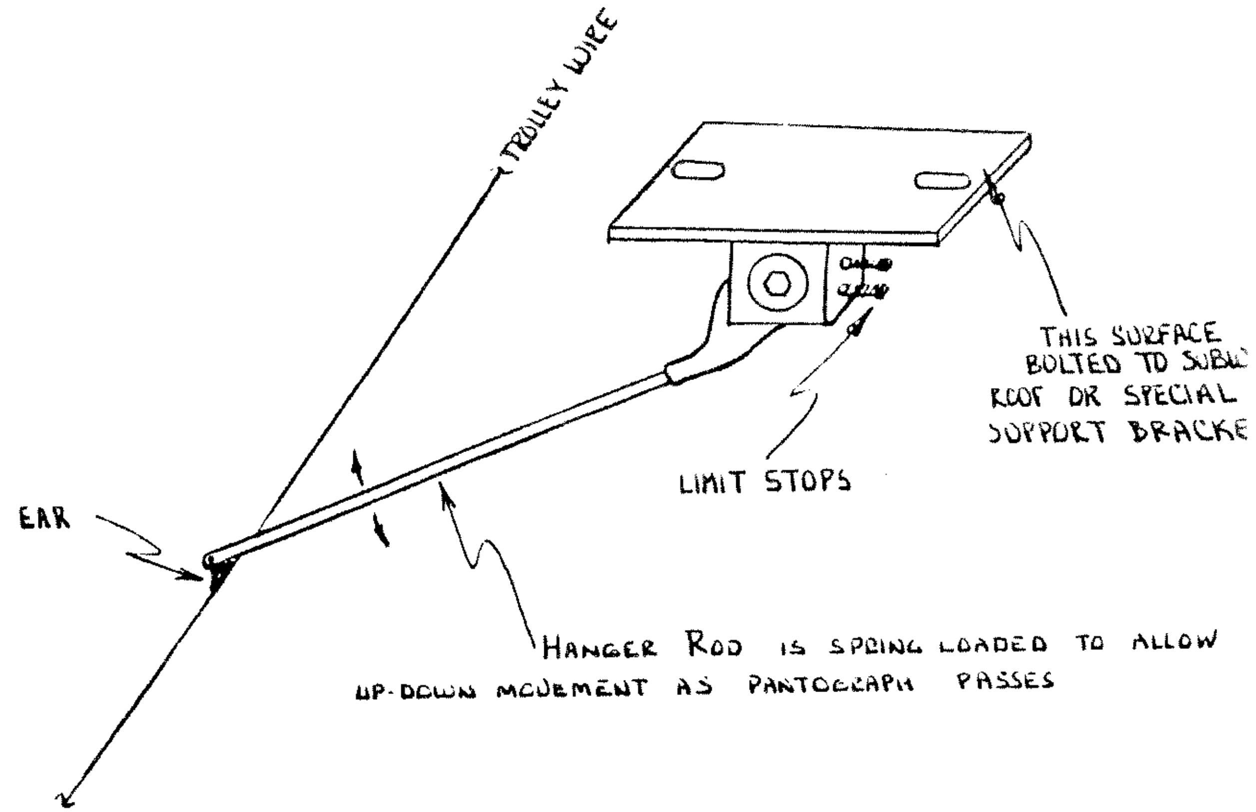
The curved pullover rod is replacing the "hockey stick" pullover rod in critical areas and as time allows.

THE CURVED PULLOVER ROD with VERTICAL SPREADER



In some areas where pullover rods are suspended from span wires, the wire pull is so great that the pullover rod would rise upward into the span providing no clearance for the pantograph. A vertical spreader is placed between the support span and the pulloff wire to maintain adequate clearance.

ELASTIC ARM

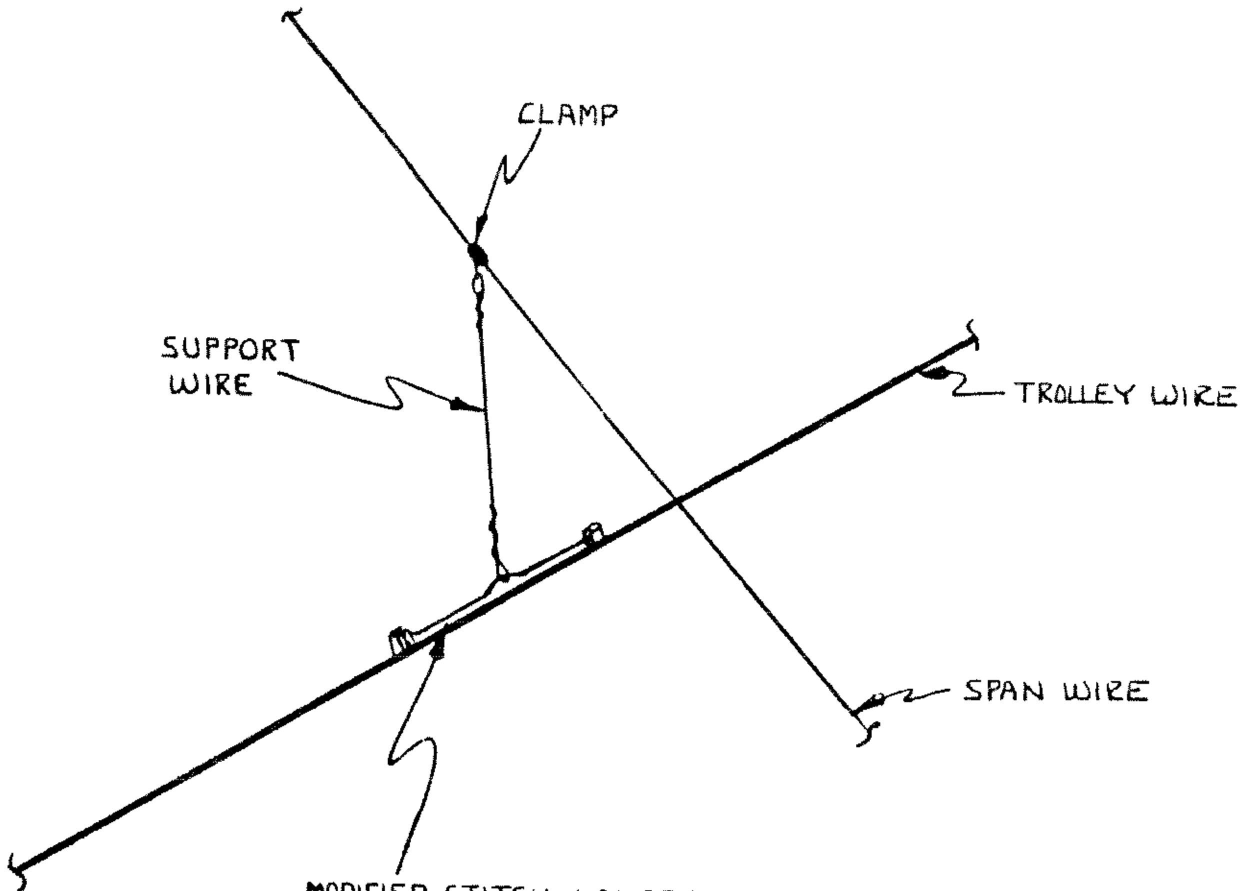


The elastic arm replaces the barn hanger in the subway and other areas where there is not sufficient height available to employ constant tensioning catenary techniques.

The fiberglass hanger rod is spring loaded and moves up and down. The weight of the wire loads the spring so that when a pantograph passes by, which pushes the wire upwards, the hanger rod is allowed to move slightly upwards, thereby eliminating "hard" spots associated with direct fixation techniques such as barn hangers and span wires.

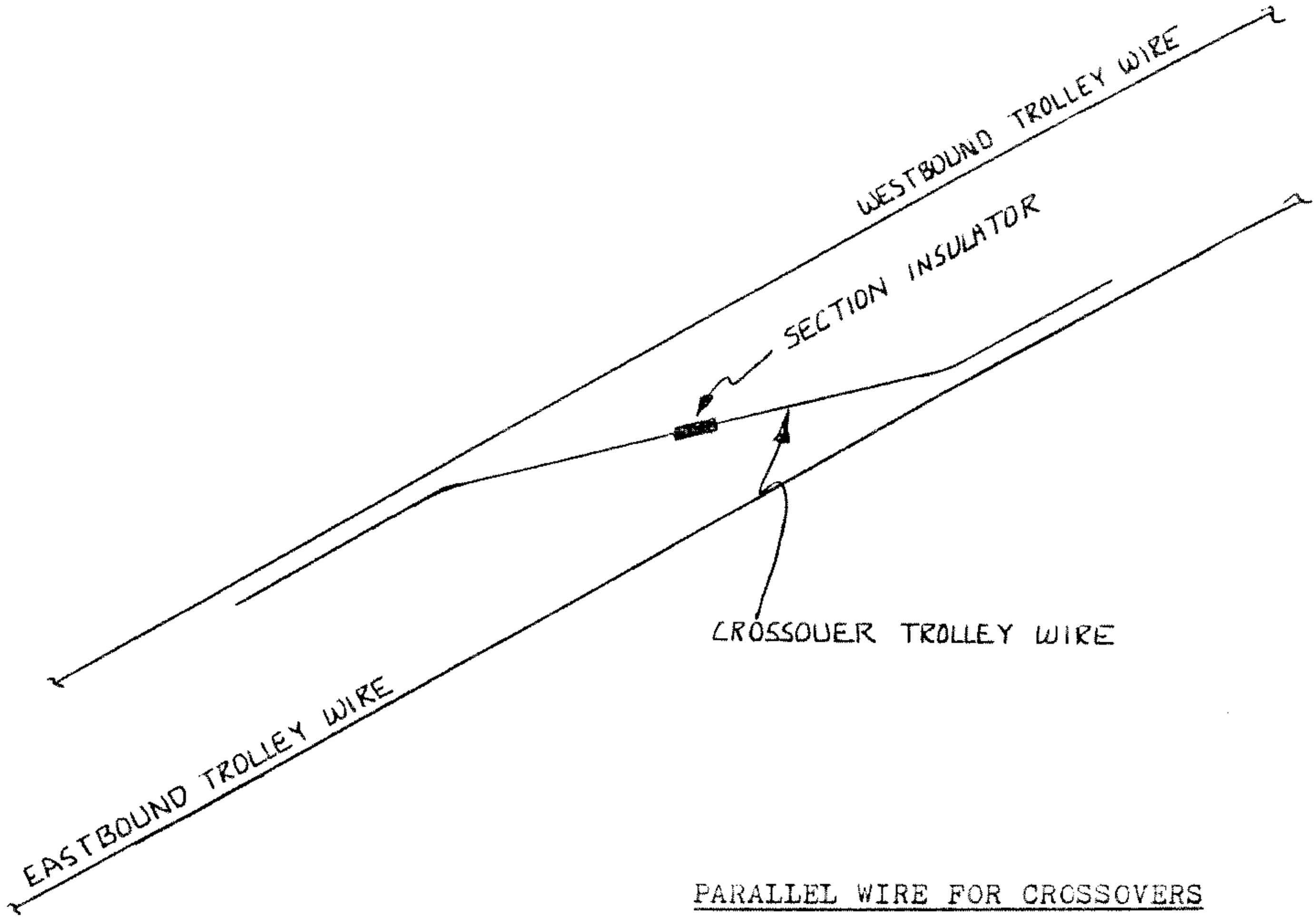
In those areas where the elastic arm has been installed in the subway, pantograph bounce and arcing have been eliminated.

The trolley wire is attached to the hanger rod by means of a conventional ear. The elastic arm is attached to the roof of the subway, either directilly or to an I beam. Dirigo insulators are employed to double insulate the unit.



THE MODIFIED STITCH

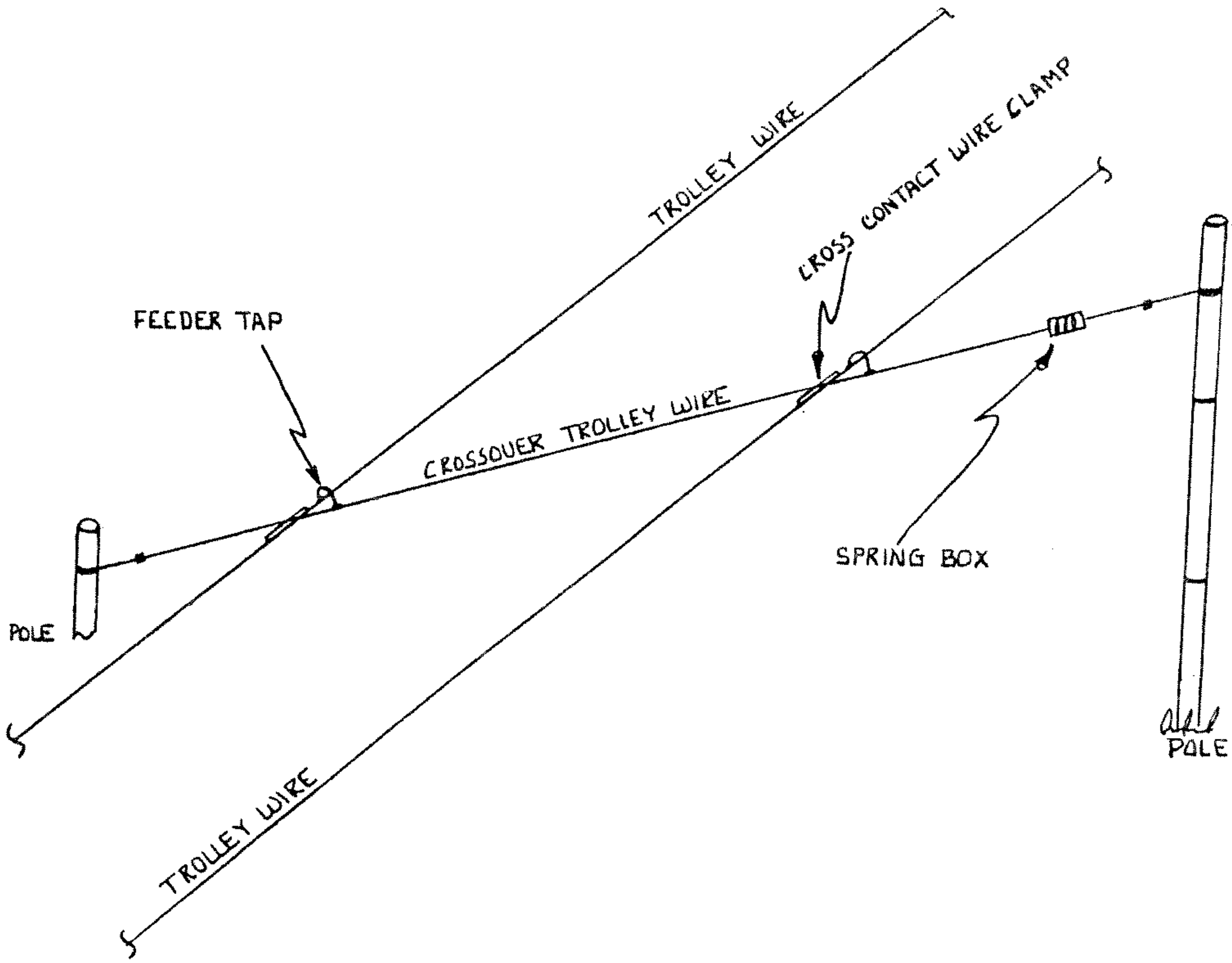
The Modified stitch is used in various applications to suspend the trolley wire where a catenary system is not employed. The hanger is suspended by a support wire which is a very small diameter cable that has good flexibility, allowing the trolley wire upward movement as the pantograph passes by. The trolley wire is staggered in opposite directions at spans.



PARALLEL WIRE FOR CROSSOVERS

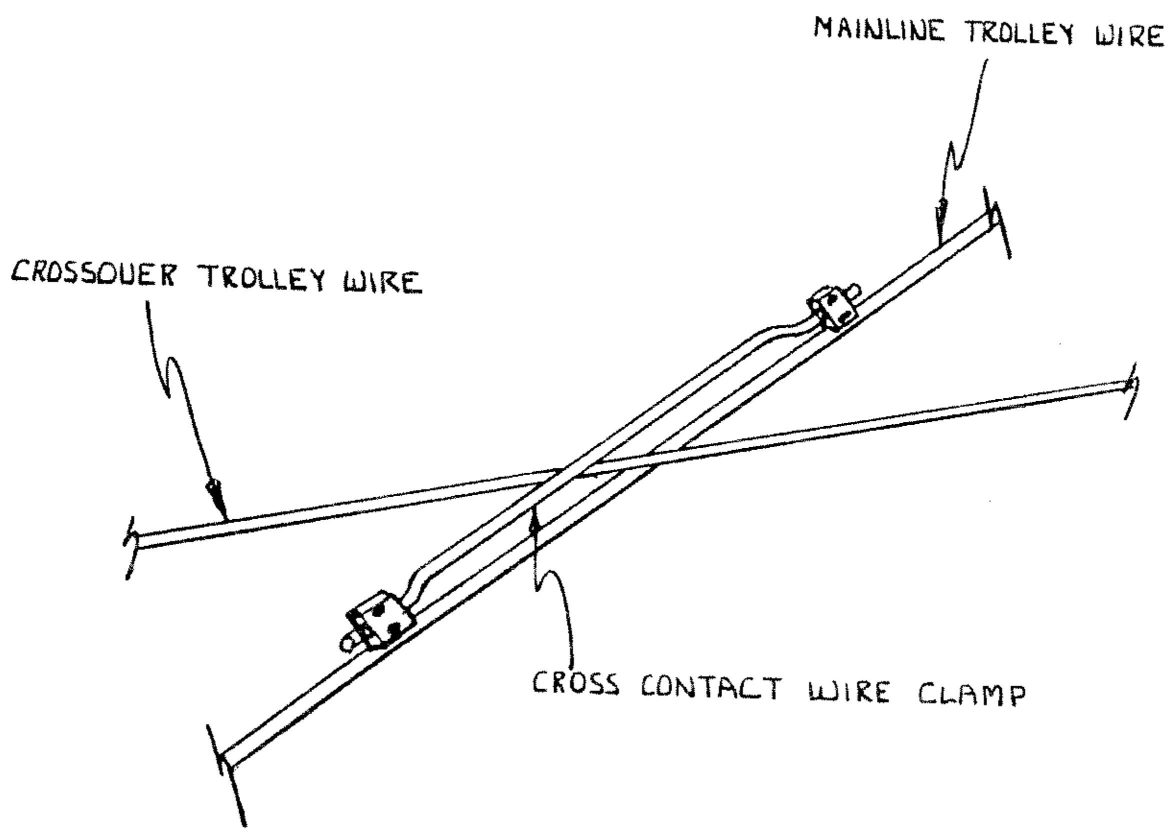
Parallel wire techniques are often employed at crossovers to eliminate frogs and gliders. If the crossover separates two power sections, then a section insulator must be employed as shown. Trolley poles can run on the straight sections of wire without stopping, but the pole must be changed twice if a crossover move is attempted. Parallel wire for crossovers is slowly giving way to cross contact wire techniques, which are easier to construct and maintain.

CROSS CONTACT CROSSOVER WIRE



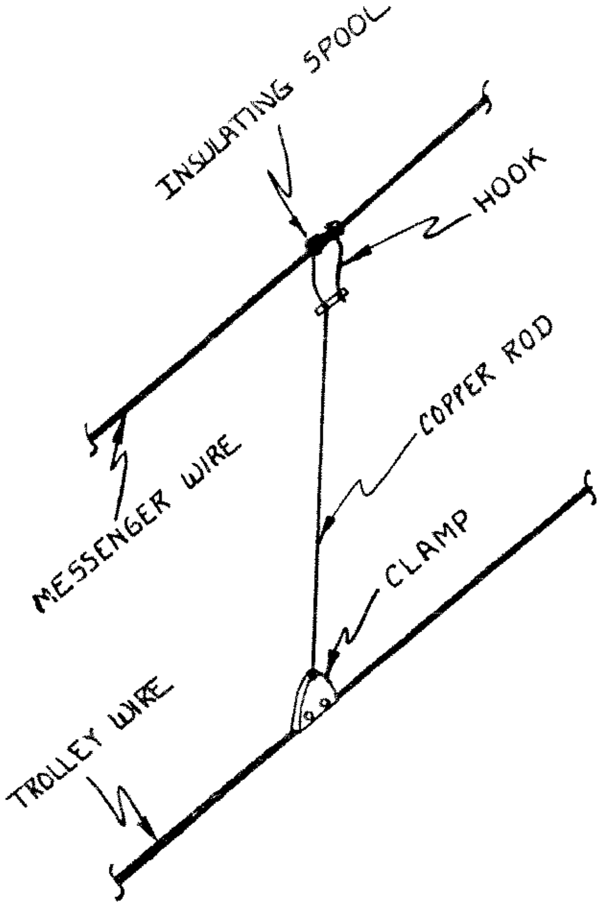
The cross contact wire employs a straight section of trolley wire held level with respect to the main line trolley wire by a cross contact wire clamp. A spring box is often employed to maintain a constant tension on the crossover wire. If either wire sags, it is possible for the pantograph to become caught in th "V" where the wires cross. A short feeder tap provides power to the crossover.

CROSS CONTACT WIRE CLAMP

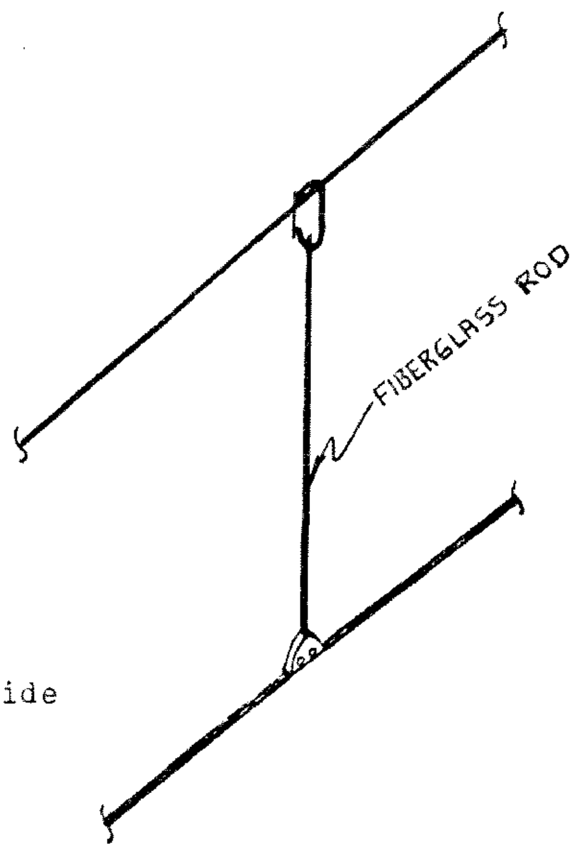


The cross contact wire clamp is employed where two trolley wires must cross, and eliminates the conventional frog and associated gliders. The design allows movement of both wires and permits constant tensioning techniques to be employed on one or both wires.

CATENARY HANGERS



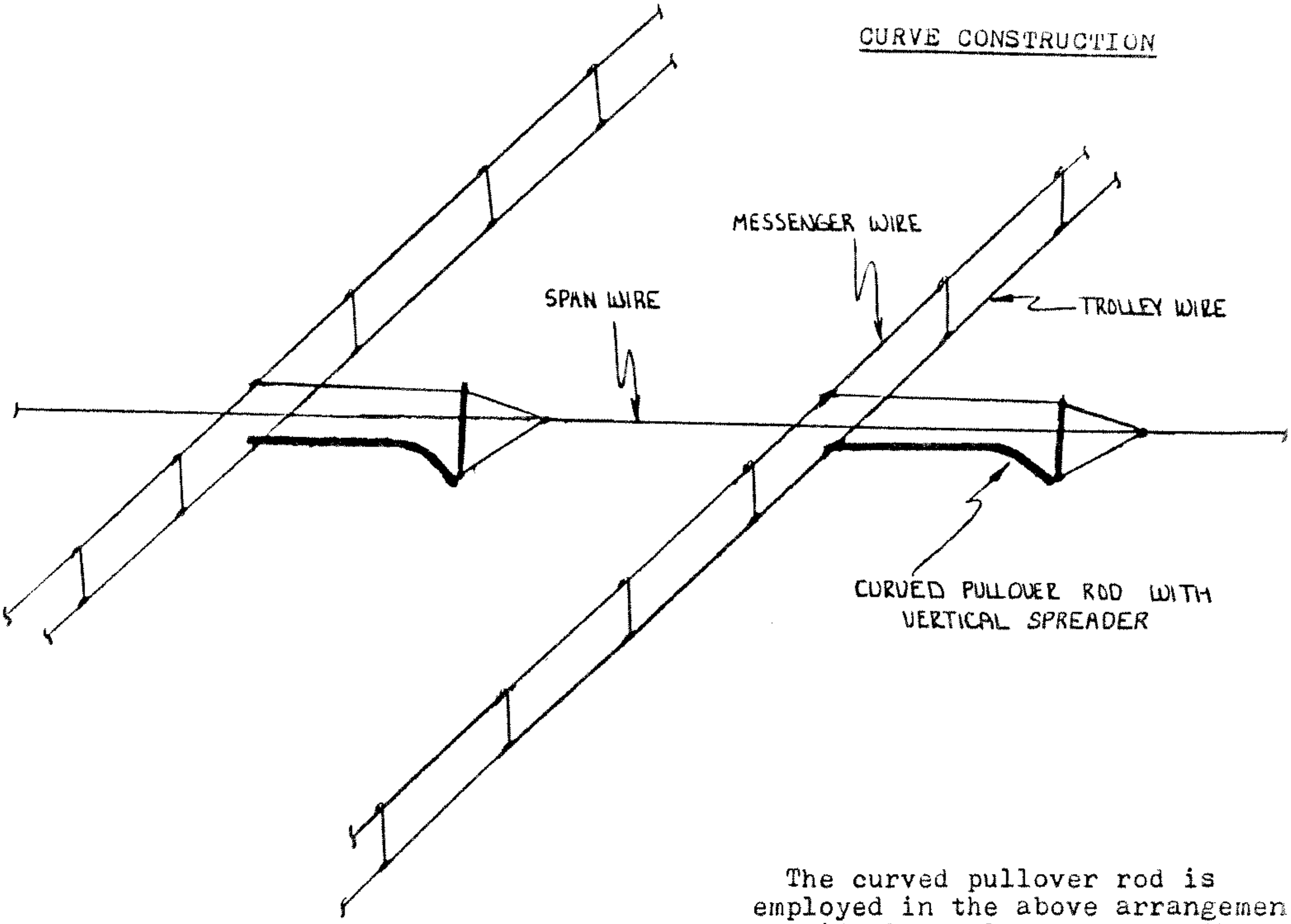
Catenary hangers are employ to suspend the trolley wire from the messenger wire. They are employed in various length to allow the trolley wire to be hung straight when the messenger wire sags from its own weight and that of the trolley wire.



The hook at the top of the hanger allows free upward movement of the trolley wire to occur when a pantograph passes through, thereby eliminating hard spots and associated pantograph bounce.

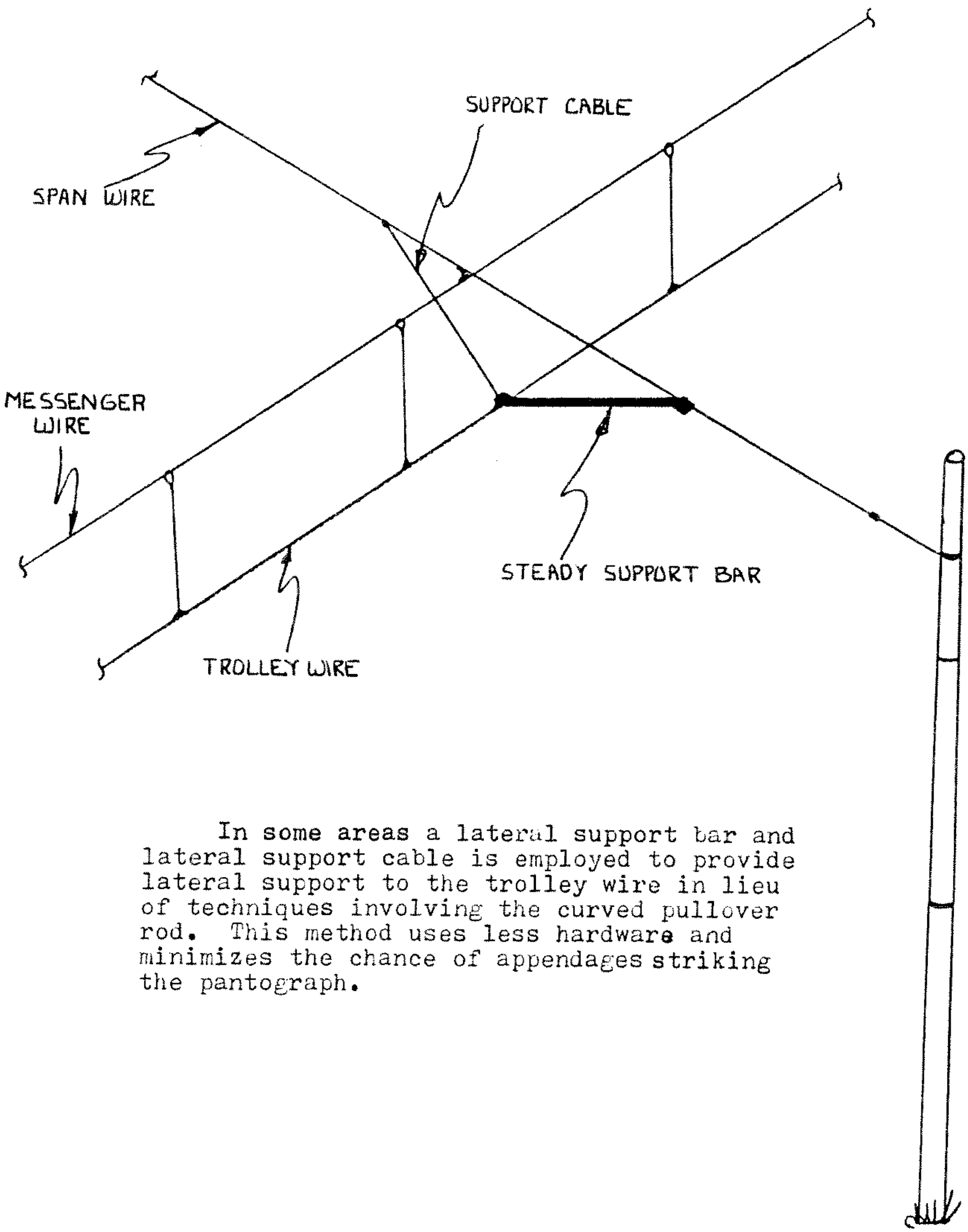
The catenary hanger provides no lateral support. In curves it is necessary to employ hardware to provide this lateral support and to "form" the curve that conforms to track geometry.

CURVE CONSTRUCTION



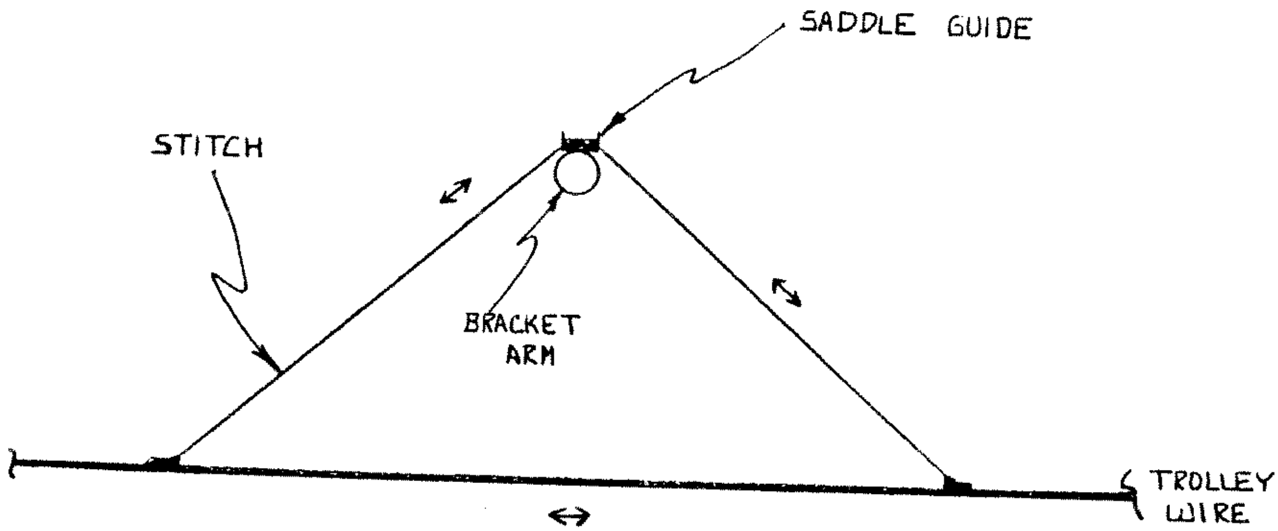
The curved pullover rod is employed in the above arrangemen to provide lateral support to the catenary system by locking together the messenger and trolley wire and attaching it to the span wire. This technique still allows vertical movement to exist when a pantograph passes by. This configuration works well on curves and is employed at various intervals on straight sections to provide the needed lateral stability.

STEADY SPAN



In some areas a lateral support bar and lateral support cable is employed to provide lateral support to the trolley wire in lieu of techniques involving the curved pullover rod. This method uses less hardware and minimizes the chance of appendages striking the pantograph.

THE STITCH

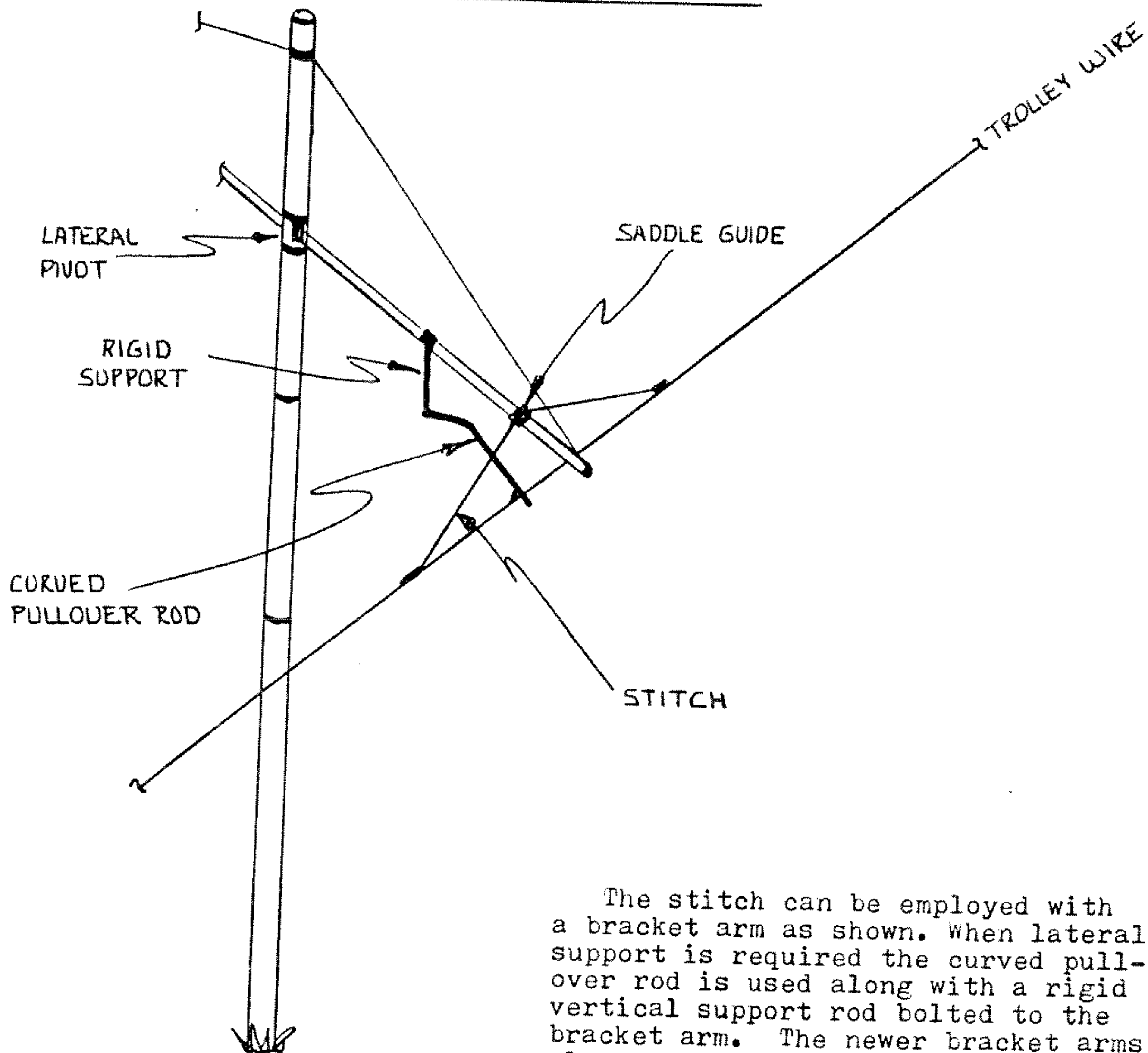


Certain areas, such as part of the Commonwealth Avenue Line, will not employ a messenger wire. Different techniques will be employed to provide constant tensioning for the trolley wire. In these areas the trolley wire will be designed to "slide" at each span wire or bracket arm and will be held to a constant tension by being pulled taught by a hydraulic spring cylinder.

The "stitch" is a section of Kevlar rope with an ear on each end which attaches to the trolley wire as depicted above. The middle of the stitch rides freely in the saddle guide, which is attached either to a bracket arm or span wire. The trolley wire is now allowed to expand and contract freely, as the stitch slides freely in its saddle.

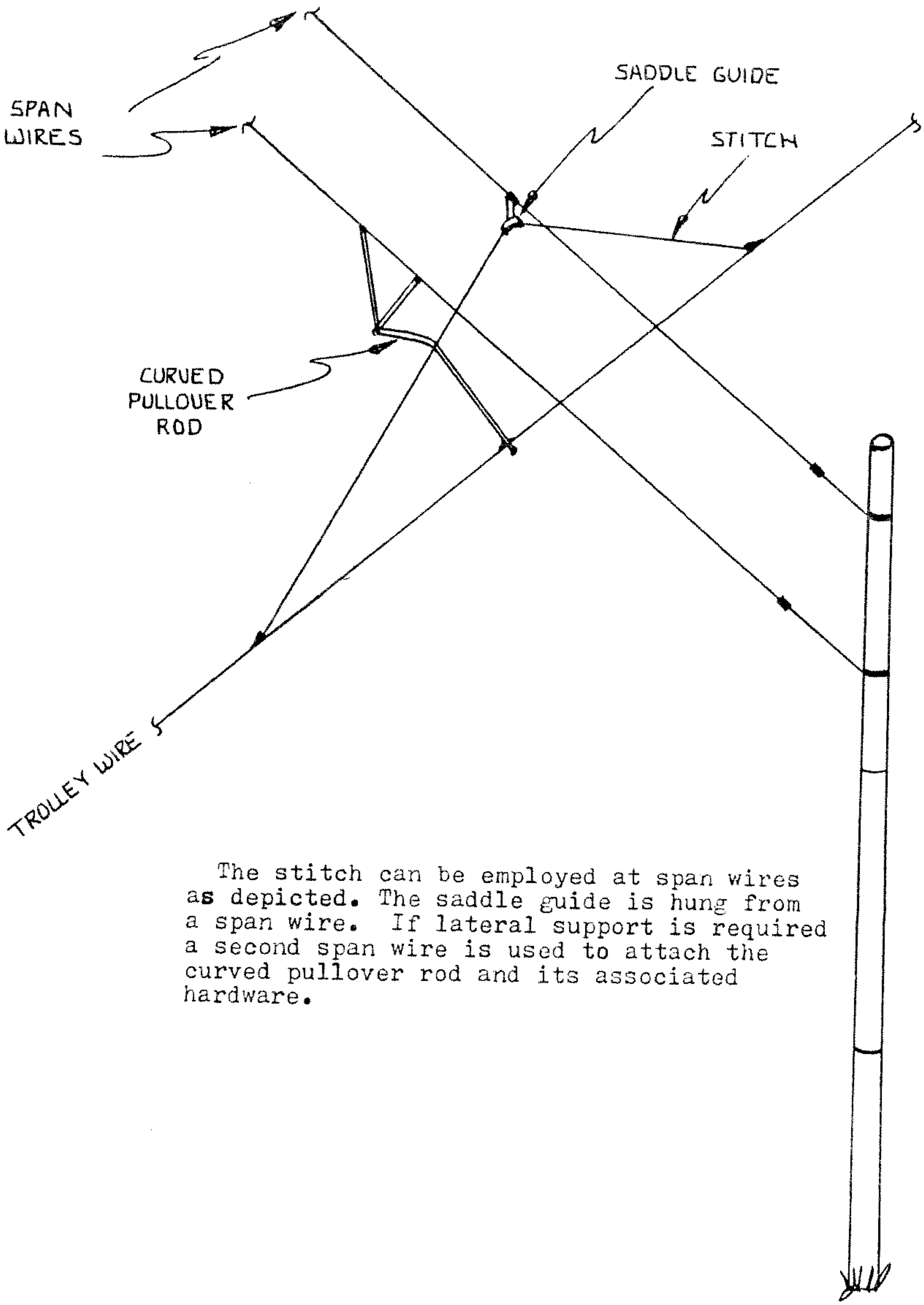
Kevlar is a brand of synthetic rope whose strength and flexibility is suited for this application.

BRACKET ARM STITCH



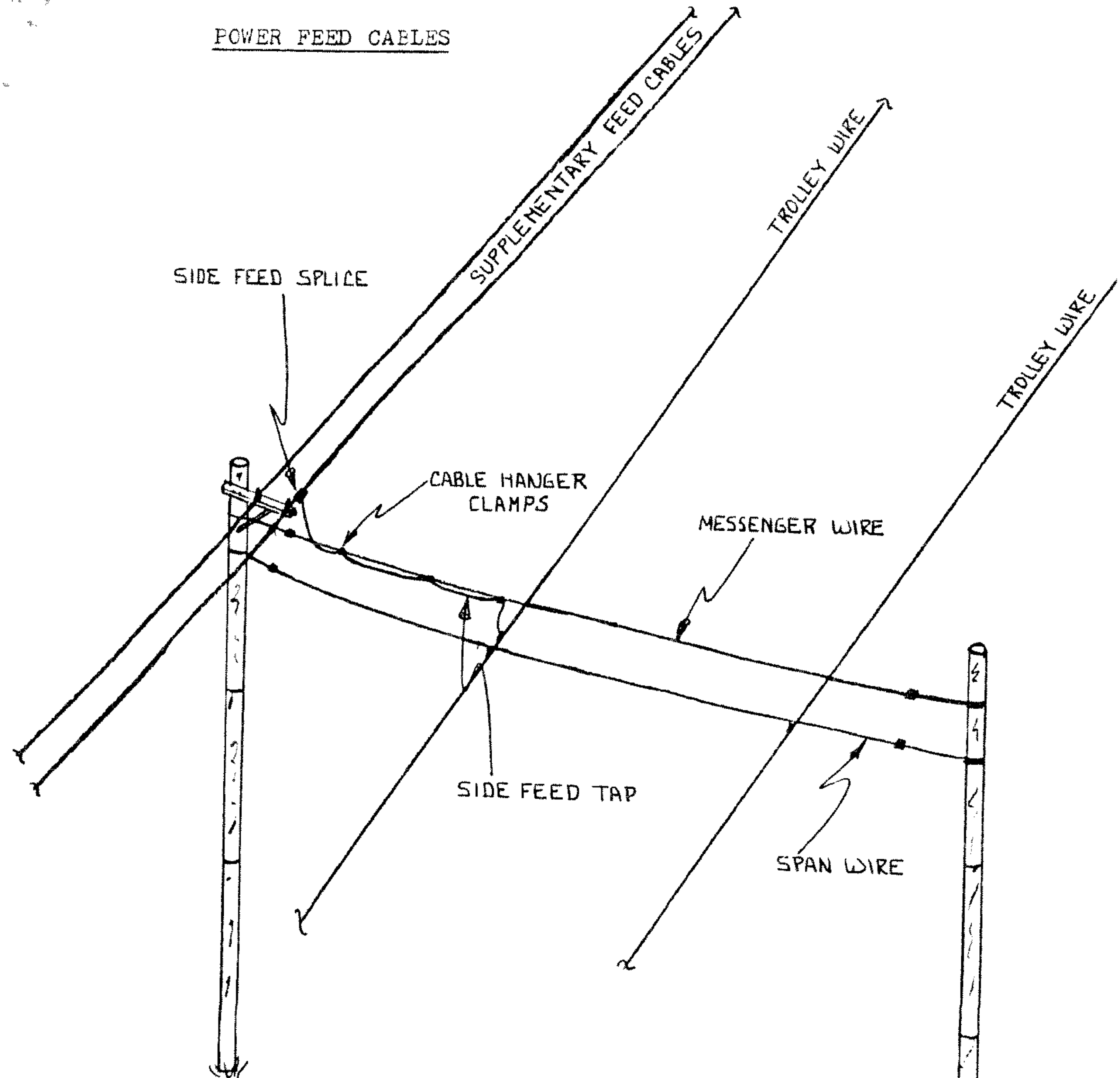
The stitch can be employed with a bracket arm as shown. When lateral support is required the curved pull-over rod is used along with a rigid vertical support rod bolted to the bracket arm. The newer bracket arms also contain a pivot pin to allow a small amount of movement.

SPAN WIRE STITCH



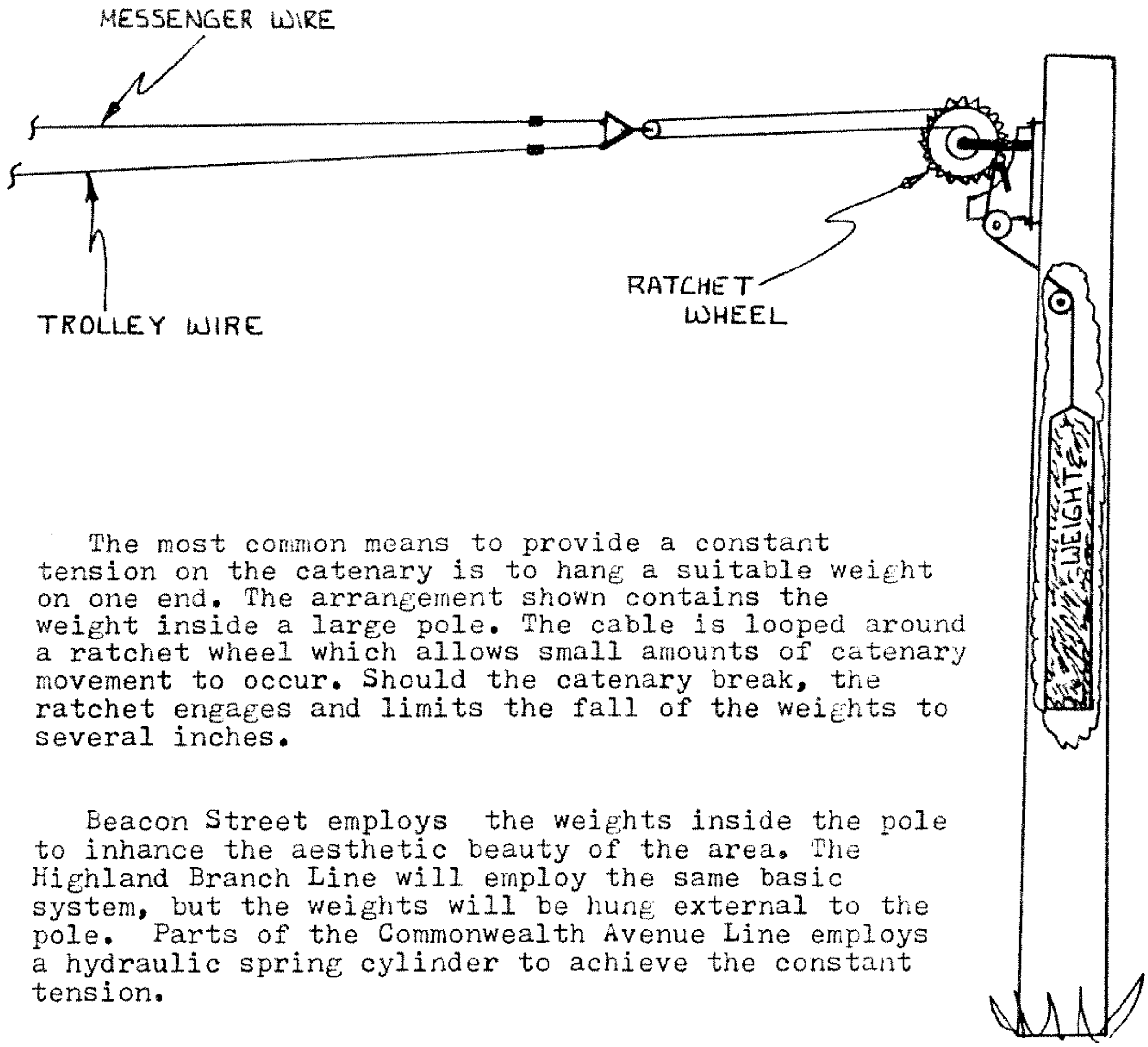
The stitch can be employed at span wires as depicted. The saddle guide is hung from a span wire. If lateral support is required a second span wire is used to attach the curved pullover rod and its associated hardware.

POWER FEED CABLES



Since the trolley wire has a small cross-sectional diameter, it cannot carry enough current to supply power to more than several LRVs. Supplementary feed cables supply bulk power from the substation to within 20' of the catenary. Side feed tap cables, normally 5/8" in diameter, bring the power from the supplementary feed cables to the trolley wire, at intervals of 100 to 500 feet. In some areas the supplementary feed cables may be buried underground, and vary in diameter from 1½ to 2 inches.

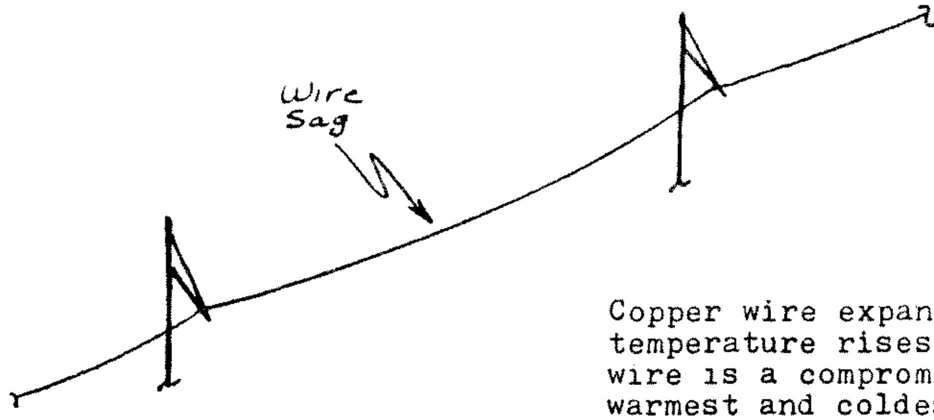
CONSTANT TENSION BY WEIGHTS



The most common means to provide a constant tension on the catenary is to hang a suitable weight on one end. The arrangement shown contains the weight inside a large pole. The cable is looped around a ratchet wheel which allows small amounts of catenary movement to occur. Should the catenary break, the ratchet engages and limits the fall of the weights to several inches.

Beacon Street employs the weights inside the pole to inhance the aesthetic beauty of the area. The Highland Branch Line will employ the same basic system, but the weights will be hung external to the pole. Parts of the Commonwealth Avenue Line employs a hydraulic spring cylinder to achieve the constant tension.

SAG IN TROLLEY WIRE



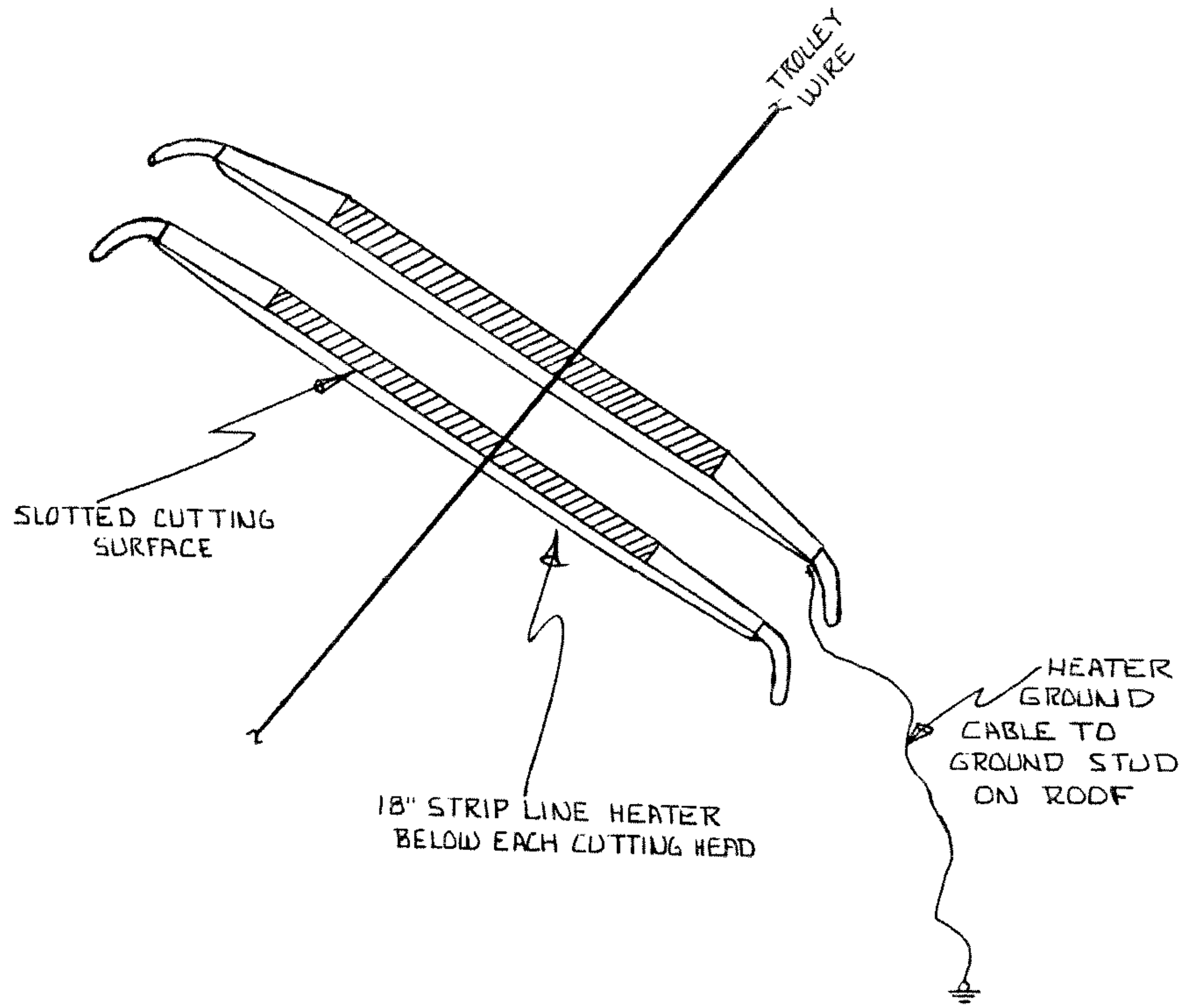
Copper wire expands as the ambient temperature rises. Tensioning the wire is a compromise between the warmest and coldest days. The following table is a generally accepted standard showing the amount of tension required for a given temperature and the resultant sag.

AMBIENT TEMPERATURE	2/0 SIZE WIRE		4/0 SIZE WIRE	
	Sag	tension	Sag	tension
0°F	3"	2020#	2 3/4"	3500#
30	3½	1730	3¼	2960
60	4¼	1420	4¼	2260
90	5½	1100	5¼	1830
120	7 3/4	760	7¼	1330

NOTE: The above table is for 100' spacing between span wires.

Constant tensioning techniques eliminates the excessive sag in the trolley wire as the temperature increases by hanging a fixed weight on one end of a run of wire. A run of wire is usually 2000 to 3000 feet in length. If a 3500 lb. weight is hung on a run of 4/0 trolley wire, then the sag will be 2 3/4 inches regardless of temperature, since the weight will move up and down, but still pull the wire with 3500 pounds of force.

PANTOGRAPH ICE CUTTER - HEATED



The pantograph with regular carbons installed works reasonably well to cut sleet from the overhead once the car is moving. If cars are being moved from the yard, however, it is often difficult to start the car moving due to the sleet on the pantograph as well as

In an effort to solve these problems the heated pantograph ice cutter was developed. The carbons have been replaced with hard copper strips with thin slots placed at 45° to the travel of the trolley wire. Beneath each cutting strip is located a strip line powered by the overhead, and is on even if the car is shut down. The purpose of the heaters is to prevent the ice cutter heads from freezing when the car is stationary, and to warm the wire 12" each side of the heads. When the car is moving the heater should prevent freeze-up of the heads. The moving car will shear the ice and sleet from the overhead.

The hard copper metal (131H) is identical to that used on the Blue Line pantograph shoes. The unit is installed on the LRV in about 15 minutes merely by changing the preassembled head.