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# **LAPP**

## **HORIZONTAL VEE**

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### **COMPACT TRANSMISSION LINE DESIGN**

### **115kV - 500kV**

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## **CATALOG 606**

LAPP INSULATOR  
LEROY, N.Y. 14482



# LAPP

## HORIZONTAL VEE

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The Lapp Horizontal Vee (U.S.Pat.No. 3002043) is a unique insulator-hardware assembly specifically designed to help electric utilities meet today's stringent environmental requirements for new transmission line construction and for upgrading existing high voltage lines to higher voltages. The compact, armless assembly controls conductor position, supports the conductor on tension loaded suspension insulators, and restrains it in position with a strut insulator.

Mounted on wood, concrete or steel structures, Lapp Horizontal Vee construction provides lower visual impact than conventional overhead transmission designs for voltages 115 kV through 500 kV. The trim, narrow profile design requires less right-of-way for either single or double circuit construction and meets public demands for clean overhead transmission design with minimum environmental impact effects.

Lapp Horizontal Vee assemblies utilize standard insulator-hardware components in an assembly patterned after the controlled conductor position designs introduced by Lapp in 1961. Complete assemblies are now available by catalog number in a choice of strength ratings and electrical characteristics match-

ing conventional vertical or Vee-string suspension-hardware assemblies.

The Horizontal Vee design has been thoroughly tested in the Lapp Mechanical Test Laboratory with a series of full scale static and dynamic tests; including broken conductor, unbalanced ice-loading and wind-loading, to prove the stability of the design under unbalanced conductor forces. Full scale electrical tests on complete assemblies have verified the electrical integrity of the Horizontal Vee design. Horizontal Vee installations have already compiled an enviable record of performance in the field at 115 kV, 138 kV, 161 kV, 230 kV, 345 kV, and 500 kV on both single and double circuit construction.

The Horizontal Vee assemblies listed in this catalog meet the requirements for most 115 kV through 500 kV construction. The flexibility of the design, however, allows for modifications to fit special application requirements using similar basic components.

Customer designs for certain 500 kV applications have been made that provide the same space reduction and cost saving characteristics as the lower voltage assemblies. Applications will be reviewed and recommendations made on request.

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## SEE IT ALL IN THE MOVIES



You can see all of the design features and concepts, technical considerations, plus construction techniques and hot-line maintenance methods for yourself — on video. Lapp's video on Horizontal Vee transmission line designs is available for viewing through the Lapp sales office in your area.

# HORIZONTAL VEE APPLICATIONS

## DESIGN CONSIDERATIONS

The Horizontal Vee assembly is completely articulated. It is free to rotate about the axis between the attachment point of the suspension string to the structure and the attachment point of the rigid insulator, or strut, to the structure. Should unbalanced longitudinal loads occur, for any reason, the insulator will tend to rotate about this axis. Since the strut is a tension or compression insulator only, the points of attachment to the structure are designed to provide freedom of movement, preventing both bending and torsional loading of the strut. Refer to Figure 1 below.

The axis of rotation is inclined at an angle from vertical at the hinge angle so that, when the assembly rotates, the line end rises. This provides a self-restoring force which is particularly helpful during construction and conductor stringing operations. In service, the conductor weight and tension stabilize the assembly in its normal position.

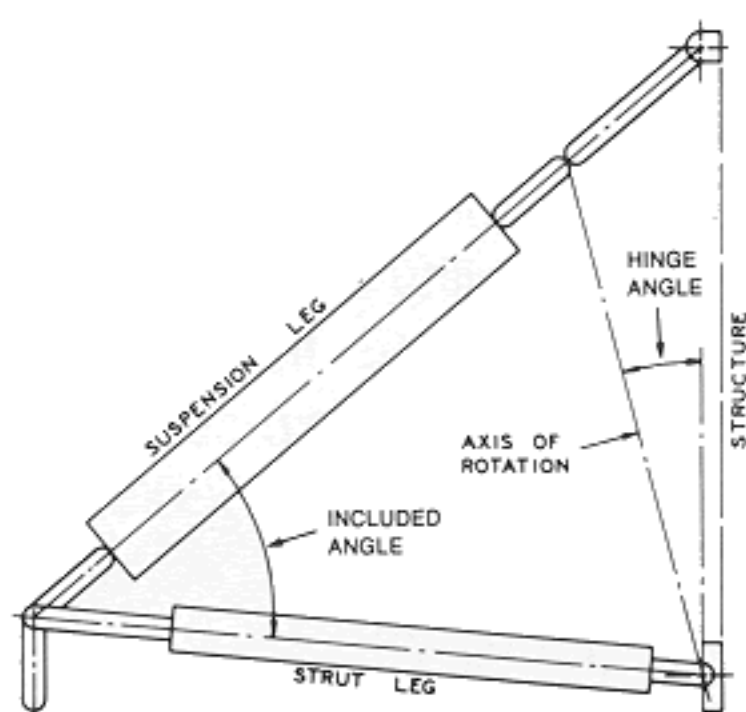


FIGURE 1

The line load is applied to the Horizontal Vee assembly at the point where the axes of the suspension string and the strut intersect. This prevents bending forces on the strut, particularly under unbalanced loading, either static or dynamic. Only tension loads can be transmitted to the suspension insulators, but alternately, both tension and compression loads can be applied to the strut insulators.

Rotational freedom is provided between the conductor and the insulator assembly by standard suspension fittings. If the conductor breaks, the Horizontal Vee assembly adjacent to the break will swing in line with the conductor, and act as a dead-end assembly.

All of the standard Horizontal Vee assemblies listed in this catalog have a 45° included angle. Experience has shown 45° to be an efficient angle for loading the insulator legs while, at the same time, minimizing the distance between the conductor and the structure. Assemblies with other angles can be provided.

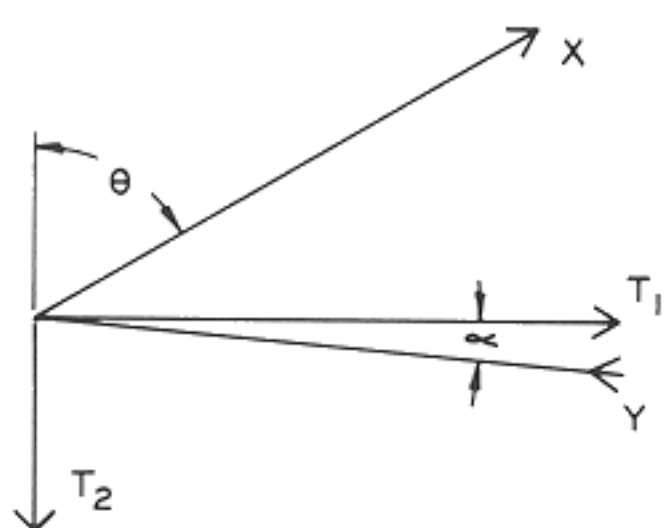


FIGURE 2

Figure 2 is a load diagram showing the division of externally applied loads into the two insulator legs. The relationship between these loads is expressed in the following formulae:

$$\begin{aligned} T_1 &= Y \cos \alpha - X \sin \theta \\ T_2 &= X \cos \theta + Y \sin \alpha \end{aligned}$$

where

$$\begin{aligned} T_2 &= \text{Vertical load, downward, lbs.} \\ T_1 &= \text{Horizontal load toward structure, lbs.} \\ X &= \text{Suspension insulator load, lbs.} \\ Y &= \text{Strut insulator load, lbs.} \\ \theta &= \text{Angle of suspension string to vertical} \\ \alpha &= \text{Angle of strut insulator to horizontal} \end{aligned}$$

Angles  $\alpha$  and  $\theta$  are constant for all the assemblies shown in this bulletin ( $\alpha = 5^\circ$ ,  $\theta = 50^\circ$ ). The equations for insulator loads can, therefore, be simplified to the following:

$$\begin{aligned} X &= 1.409 T_2 - 0.123 T_1 \\ Y &= 1.083 T_2 + 0.909 T_1 \end{aligned}$$

As an example, the following calculation applies to NESC heavy loading on a No. 307318 345 kV Horizontal Vee tangent assembly to be used on 800 ft. spans (equal weight and wind spans) two 954 MCM 45/7 ACSR "Rail" conductors per phase.

The transverse load from wind pressure on the iced subconductor is .7217 lb./ft., and the load  $T_1$  is:

$$\begin{aligned} T_1 &= .7217 \text{ lb./ft.} \times 2 \text{ (Conductor/Phase)} \times 800 \text{ ft.} \\ &= 1155 \text{ lbs.} \end{aligned}$$

The vertical load from the iced subconductor is 2.114 lb./ft. and the load  $T_2$  is:

$$\begin{aligned} T_2 &= 2.114 \text{ lb./ft.} \times 2 \text{ (Conductor/Phase)} \times 800 \text{ ft.} \\ &= 3382 \text{ lbs.} \end{aligned}$$

With transverse wind blowing toward structure, insulator loads are:

$$\begin{aligned} X &= 1.409 (3382) - 0.123 (1155) \\ &= 4623 \text{ lbs. (Tension load in suspension insulator string)} \\ Y &= 1.083 (3382) + 0.909 (1155) \\ &= 4713 \text{ lbs. (Compression load in strut)} \end{aligned}$$

With transverse loads blowing away from structure,

$$\begin{aligned} X &= 1.409 (3382) + 0.123 (1155) \\ &= 4907 \text{ lbs. (Tension load in suspension insulator string)} \\ Y &= 1.083 (3382) - 0.909 (1155) \\ &= 2613 \text{ lbs. (Compression load in strut)} \end{aligned}$$

These values are well within the maximum recommended working load ratings of the insulators.

The same procedure can be used to calculate loads for the extreme wind and/or ice loads which are assumed for the transmission line design.

The maximum conductor swing angle for each assembly is indicated on the catalog drawings. Adapters listed on page 9 are recommended for higher swing angles, such as may be required on heavy outside line angles (with resultant forces toward the structure), or high wind loading locations which may occur in hurricane areas.



Horizontal Vee assemblies are available in single or bundled conductor (horizontal or vertical) designs for all voltages. The bundled conductor yokes on page 9 are designed for use with any standard catalog Horizontal Vee assembly. Technical details of Horizontal Vee transmission line design are explained fully in the "The Better Way" video.

## NEW CONSTRUCTION

New construction with Horizontal Vee assemblies is accomplished with the same crews and equipment used for other types of overhead construction. Structures for Horizontal Vee construction are lighter in weight and installation is quicker than with conventional structures. Assembly of the Horizontal Vee to the single pole or structure on the ground cuts installation time still further and reduces overall costs.

## UPGRADING EXISTING LINES

A number of electric utilities have found the savings in this design even more pronounced when used for upgrading existing lines to higher voltages. The Horizontal Vee lends itself well to this construction because its controlled conductor position feature maintains phase-to-phase, phase-to-structure and conductor-to-ground clearances. This allows the utilization of the same structures, the same right-of-way, and often the same conductors. Scarcity of rights-of-way and increased construction costs have made upgrading of existing lines to higher voltages an attractive alternative to new construction.

An additional benefit results from upgrading with Horizontal Vee assemblies. The overturning moment of the structure is reduced because the load is transmitted through the strut to the structure at a lower point than with conventional construction.

## COST OF OWNING

As in any type of transmission line construction, cost of materials, rights-of-way, labor, etc. are of vital importance. Cost studies have been made comparing the Lapp Horizontal Vee design with conventional designs of the same voltage rating, constructed to similar specifications, in the same area of the country. Significant savings in material, labor and rights-of-way can accrue from the use of the Horizontal Vee design. Typical cost comparisons for 230 kV designs are shown on the back cover. Further information contained in a brochure entitled "Total Installed Cost Comparison of Various Transmission Lines", prepared by the consulting engineering firm of Gilbert/Commonwealth, details the savings that can be realized with Lapp Horizontal Vee construction. Copies of the brochure are available on request.

## CONSTRUCTION METHODS

Construction methods for erecting Lapp Horizontal Vee transmission lines differ very little from methods used in other types of high voltage overhead transmission. New construction on steel, concrete or wood poles begins with the mounting of the Horizontal Vee assemblies to the pole while it is still on the ground. Stringing blocks and ground lines can also be attached at this time to the clevis-ball fitting on the apex point of the strut-suspension assembly. The framed structure is then

lifted into position and set. Stringing, sagging and clipping-in the conductor proceeds as smoothly as on other types of construction. No special techniques are required, except that longitudinal stabilization may be needed on outside angle situations. Loads should not be applied during construction that subject the strut insulator to bending moments.

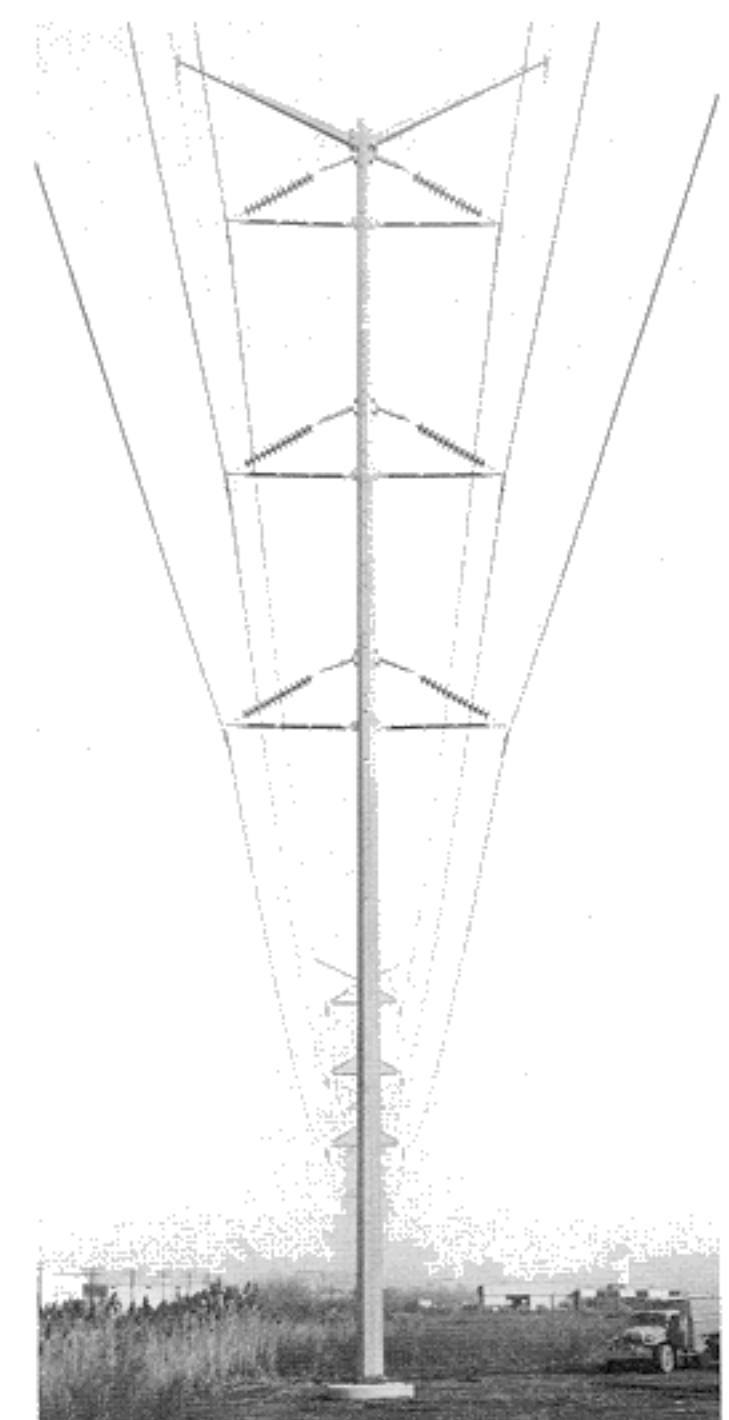
Upgrading lines to higher voltages with Horizontal Vee assemblies differs from job to job, depending on the voltage and the type of structure. Usually the structure conversion requires the removal of any crossarms, and their replacement with reinforcing members or stub arms. After mounting the Lapp Horizontal Vee assemblies to the structure, sagging and clipping-in the conductor follows standard construction practice.

## HOT LINE MAINTENANCE

The number of miles of Horizontal Vee construction has increased dramatically over the past several years, and improved construction techniques and methods for live line maintenance have kept pace with this growth. Engineers and line crews at several large utilities have simplified techniques for working Horizontal Vee configurations under energized conditions.

Tangent, inside angles and outside angles are worked hot using conventional hot line tools, with a two-man crew on the structure aided by a third crew member on the ground. Time required is comparable to hot line work on conventional transmission line designs at the same voltage under similar conditions. There is no need to rig ladders or climb out on crossarms to work Horizontal Vee assemblies. A 15-minute video detailing actual construction techniques and hot line maintenance methods is available for viewing from any Lapp field sales office.

*Horizontal wind forces on conductor are transferred to the pole through the strut member of the Horizontal Vee, reducing the overturning moment on the pole.*





# HORIZONTAL VEE ASSEMBLIES

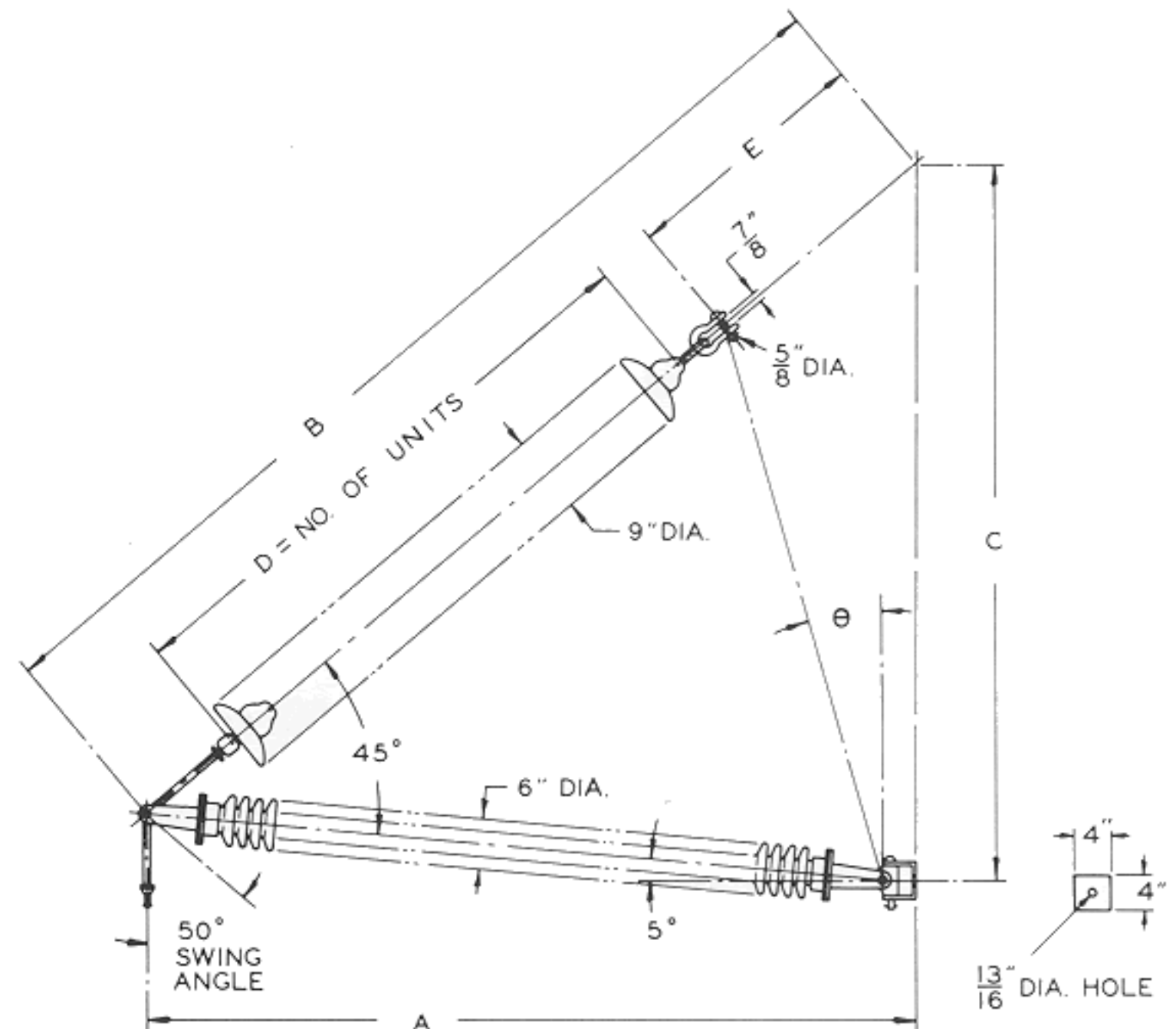
## 115 kV - 161 kV

The standard Horizontal Vee designs for 115 kV through 161 kV, listed in the table, will meet the requirements for most applications. All of these assemblies have a 45° included angle and are available for steel, concrete or wood pole mounting in six insulation levels determined by the number of suspension insulators required. The strut insulator matches the electrical characteristics of the number of suspensions in the assembly.

The basic assembly is cataloged without the top mounting bracket for use on structures where a short arm is supplied as part of the structure. This design is recommended for new construction on steel poles or lattice towers.

The addition of suffix "A" or "C" to the catalog number indicates that a top mounting bracket is required and denotes the type of structure being used. A suitable top mounting bracket will be supplied. These assemblies are furnished complete, with the exception of the conductor clamps, which must be ordered separately. The Horizontal Vee assemblies accommodate all standard aluminum suspension clamps with a NEMA 52-5 socket and are suitable for single or bundled conductors. Clamps can be ordered by using a separate catalog number as shown on page 9.

Insulators are light gray, Lapp No. 70 glaze. Hardware is ferrous, hot-dip galvanized.



BASIC ASSEMBLIES									
Catalog Number	Hinge Angle	Dimensions in Inches					Strength Ratings Lbs.		Aprx. Net Weight/Assy. Lbs.
		A	B	C	D	E	Suspensions	Struts	
307306	22°	61½	80⅝	57	6	26⅞	15K	15K	155
307307	22°	67½	88⅞	62⅜	7	28⅝	15K	15K	170
307308	21°	72½	94⅞	66⅜	8	29⅞	15K	15K	190
307309	20°	77½	101⅞	71⅜	9	30⅞	15K	15K	200
307310	20°	83½	108⅞	77	10	32⅞	15K	15K	215
307311	20°	89⅝	116⅞	82⅜	11	34⅞	15K	15K	235
STEEL POLE OR CONCRETE POLE MOUNTING									
307306A	26°	61½	75⅜	53¼	6	—	15K	15K	210
307307A	21°	67½	84⅞	60⅞	7	—	15K	15K	225
307308A	20°	72½	90⅞	64¼	8	—	15K	15K	245
307309A	19°	77½	96⅞	68⅞	9	—	15K	15K	255
307310A	18°	83½	104⅜	73⅜	10	—	15K	15K	270
307311A	16°	89⅝	112½	79⅞	11	—	15K	15K	290
WOOD POLE MOUNTING									
307306-C	26°	61½	80¼	61¼	6	—	15K	15K	195
307307-C	22°	67½	88⅞	66⅝	7	—	15K	15K	210
307308-C	21°	72½	94⅞	71¼	8	—	15K	15K	230
307309-C	19°	77½	100⅜	75⅞	9	—	15K	15K	240
307310-C	18°	83½	108⅞	81⅞	10	—	15K	15K	255
307311-C	16°	89⅝	116⅝	87¼	11	—	15K	15K	270



# HORIZONTAL VEE ASSEMBLIES

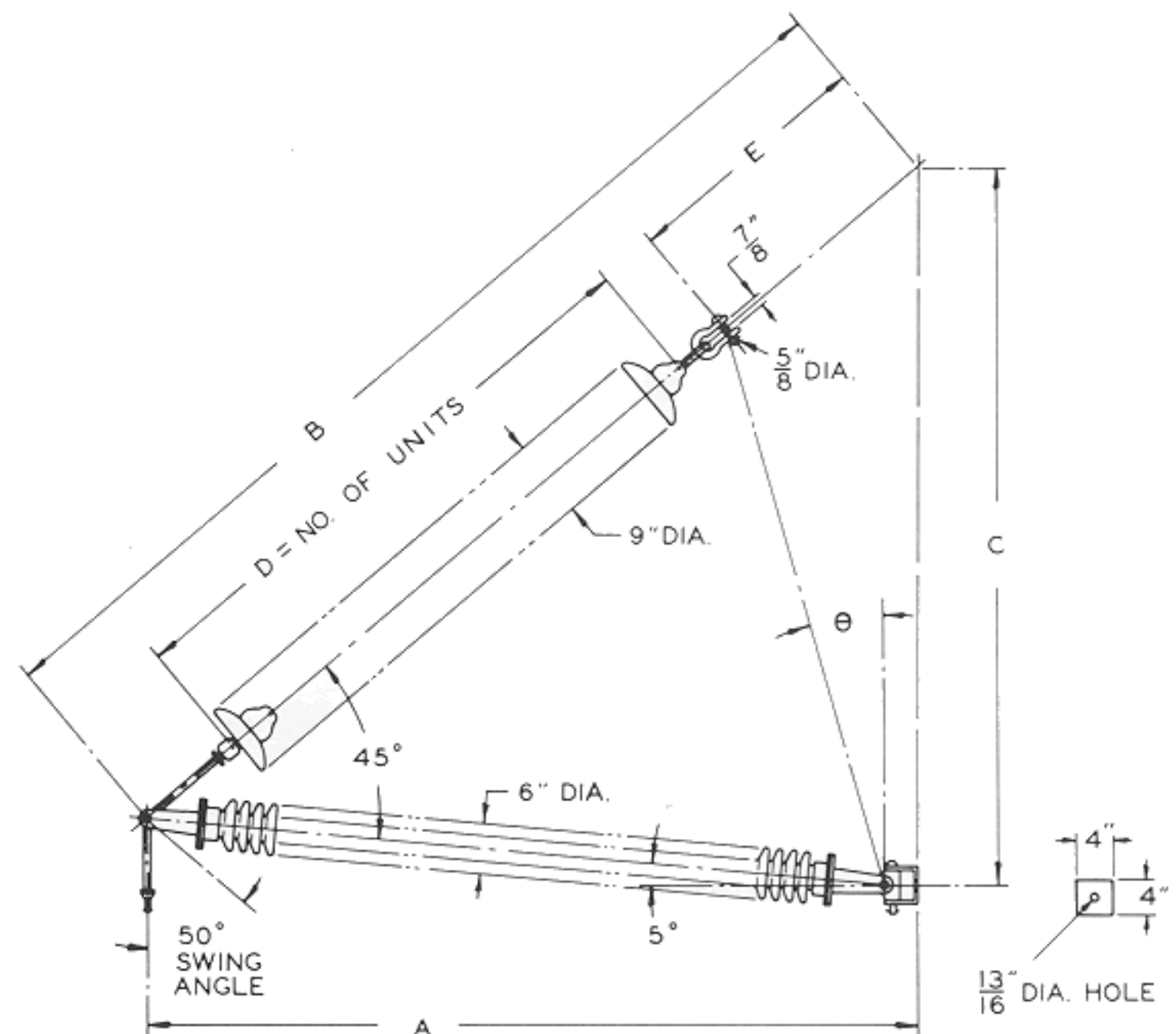
## 115 kV - 161 kV

The standard Horizontal Vee designs for 115 kV through 161 kV, listed in the table, will meet the requirements for most applications. All of these assemblies have a 45° included angle and are available for steel, concrete or wood pole mounting in six insulation levels determined by the number of suspension insulators required. The strut insulator matches the electrical characteristics of the number of suspensions in the assembly.

The basic assembly is cataloged without the top mounting bracket for use on structures where a short arm is supplied as part of the structure. This design is recommended for new construction on steel poles or lattice towers.

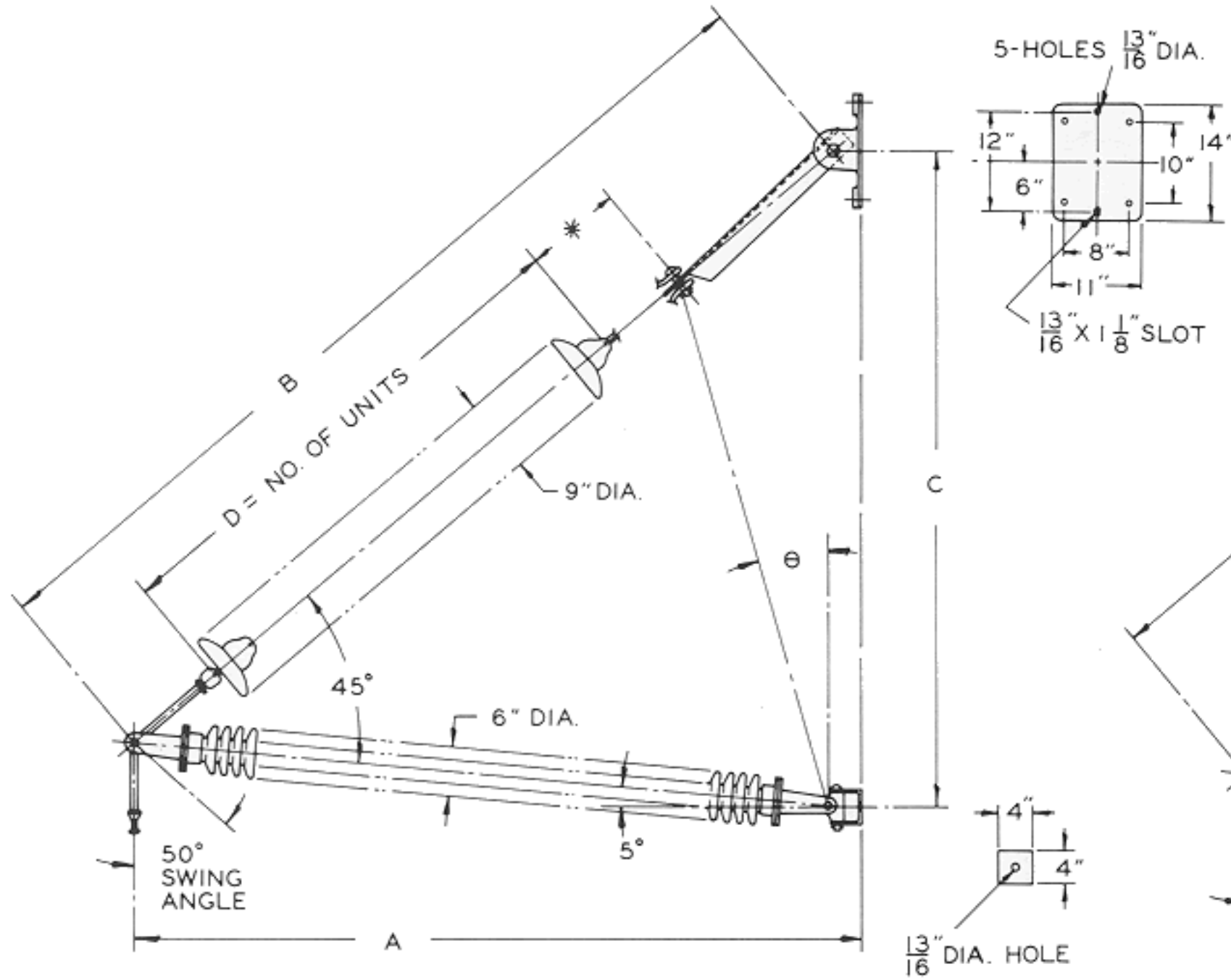
The addition of suffix "A" or "C" to the catalog number indicates that a top mounting bracket is required and denotes the type of structure being used. A suitable top mounting bracket will be supplied. These assemblies are furnished complete, with the exception of the conductor clamps, which must be ordered separately. The Horizontal Vee assemblies accommodate all standard aluminum suspension clamps with a NEMA 52-5 socket and are suitable for single or bundled conductors. Clamps can be ordered by using a separate catalog number as shown on page 9.

Insulators are light gray, Lapp No. 70 glaze. Hardware is ferrous, hot-dip galvanized.

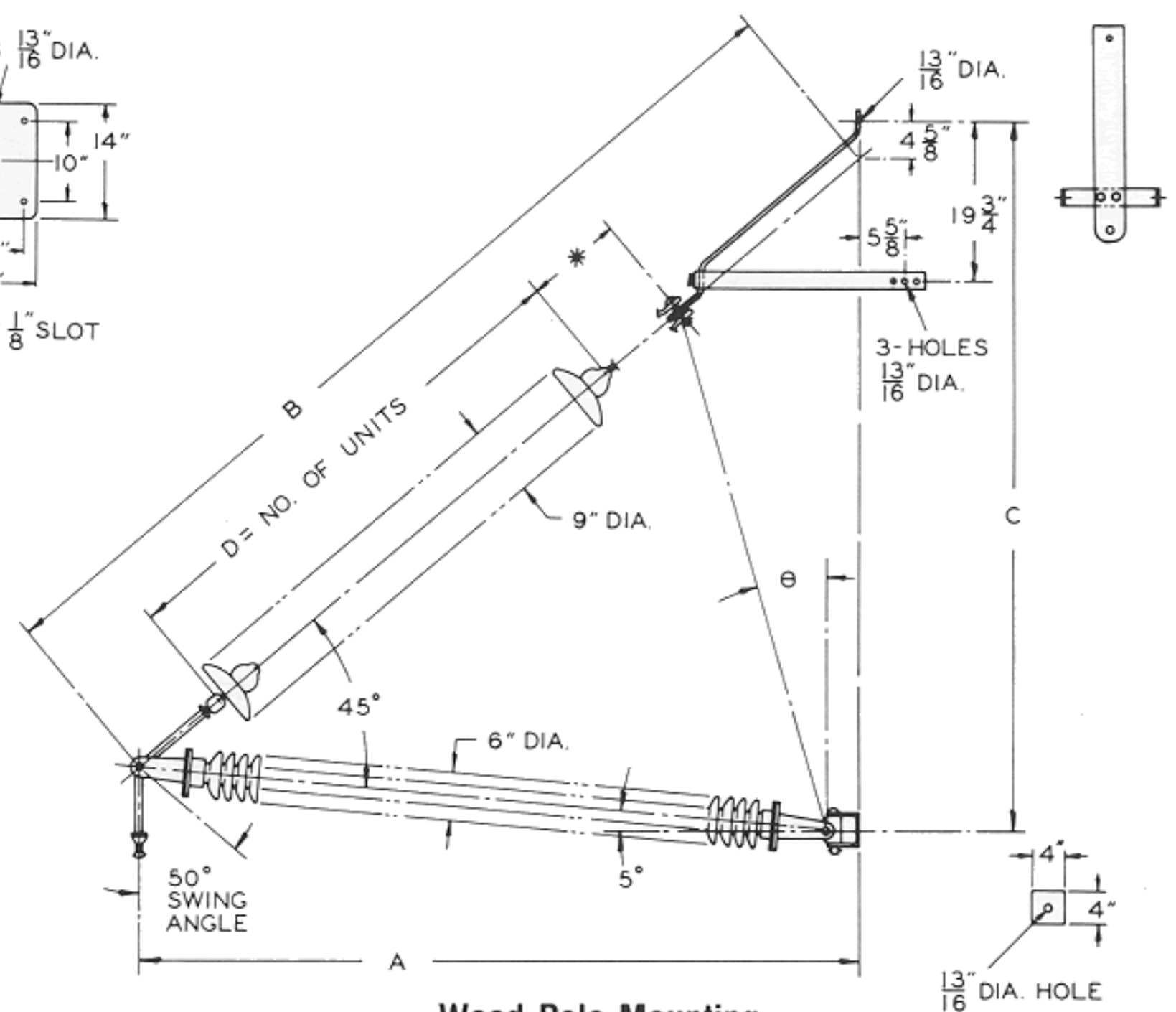


BASIC ASSEMBLIES									
Catalog Number	Hinge Angle	Dimensions in Inches					Strength Ratings Lbs.		Aprx. Net Weight/Assy. Lbs.
		A	B	C	D	E	Suspensions	Struts	
307306	22°	61½	80⅝	57	6	26⅞	15K	15K	155
307307	22°	67½	88⅞	62⅜	7	28⅝	15K	15K	170
307308	21°	72½	94⅞	66⅜	8	29⅞	15K	15K	190
307309	20°	77½	101⅞	71⅜	9	30⅞	15K	15K	200
307310	20°	83½	108⅞	77	10	32⅞	15K	15K	215
307311	20°	89⅝	116⅞	82⅜	11	34⅞	15K	15K	235
STEEL POLE OR CONCRETE POLE MOUNTING									
307306A	26°	61½	75⅜	53¼	6	—	15K	15K	210
307307A	21°	67½	84⅞	60⅞	7	—	15K	15K	225
307308A	20°	72½	90⅞	64¼	8	—	15K	15K	245
307309A	19°	77½	96⅞	68⅞	9	—	15K	15K	255
307310A	18°	83½	104⅜	73⅝	10	—	15K	15K	270
307311A	16°	89⅝	112½	79⅞	11	—	15K	15K	290
WOOD POLE MOUNTING									
307306-C	26°	61½	80¼	61¼	6	—	15K	15K	195
307307-C	22°	67½	88⅞	66⅝	7	—	15K	15K	210
307308-C	21°	72½	94⅞	71¼	8	—	15K	15K	230
307309-C	19°	77½	100⅜	75⅞	9	—	15K	15K	240
307310-C	18°	83½	108⅞	81⅞	10	—	15K	15K	255
307311-C	16°	89⅝	116⅝	87¼	11	—	15K	15K	270

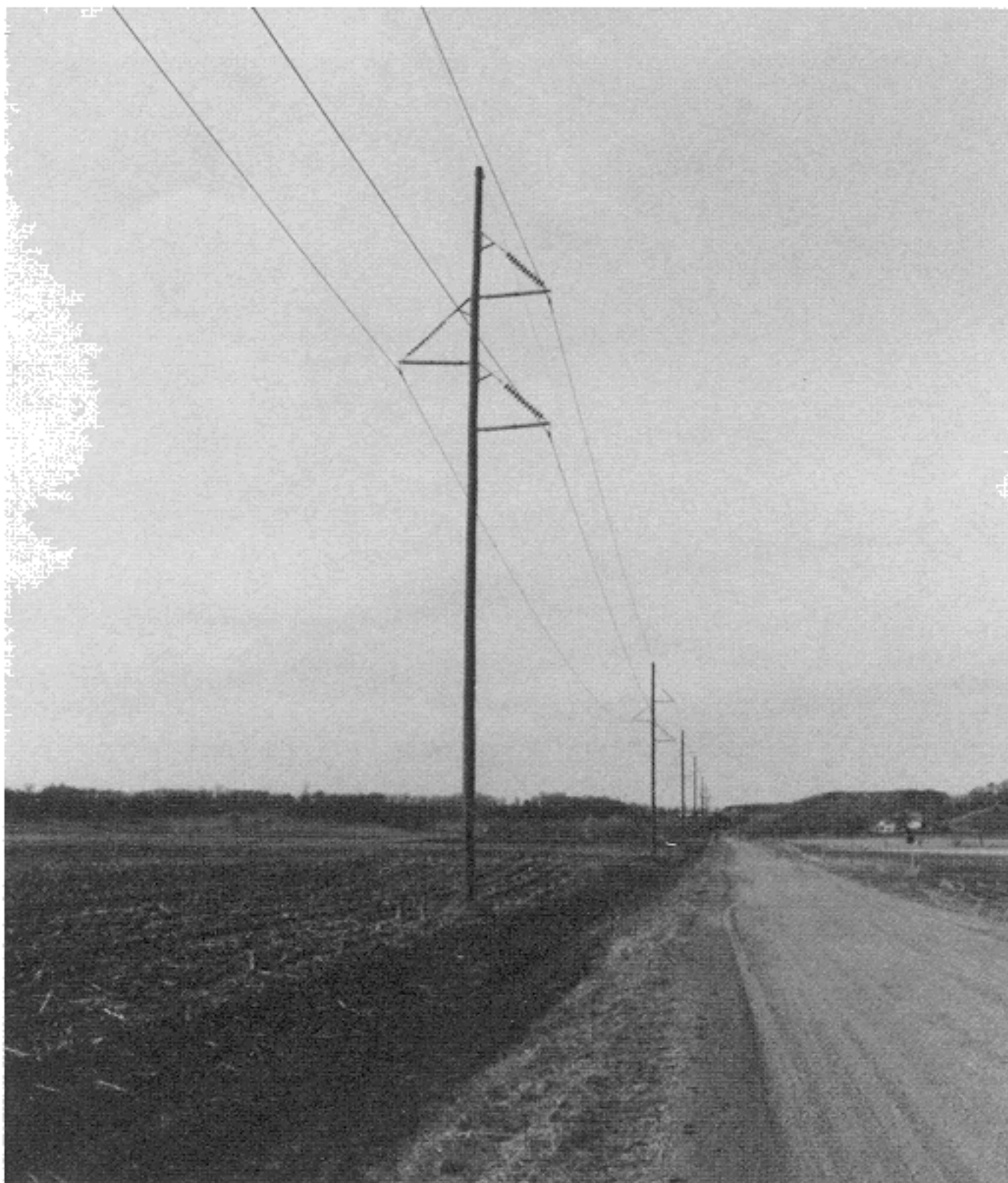




**Steel or Concrete Pole Mounting**



**Wood Pole Mounting**



161 kV Horizontal Vee construction with 425 foot spans on 90 foot Class 2 wood poles proved economical and maintenance-free for this rural line along a highway right-of-way.



Overinsulated 138 kV Horizontal Vee line through a seacoast city illustrates the versatility of the design. The Horizontal Vee assemblies were mounted in a delta configuration on wood poles with tie-bands to prolong the life of the treated poles.

\*Linkage made up of standard fittings to hold overall length.

# HORIZONTAL VEE ASSEMBLIES

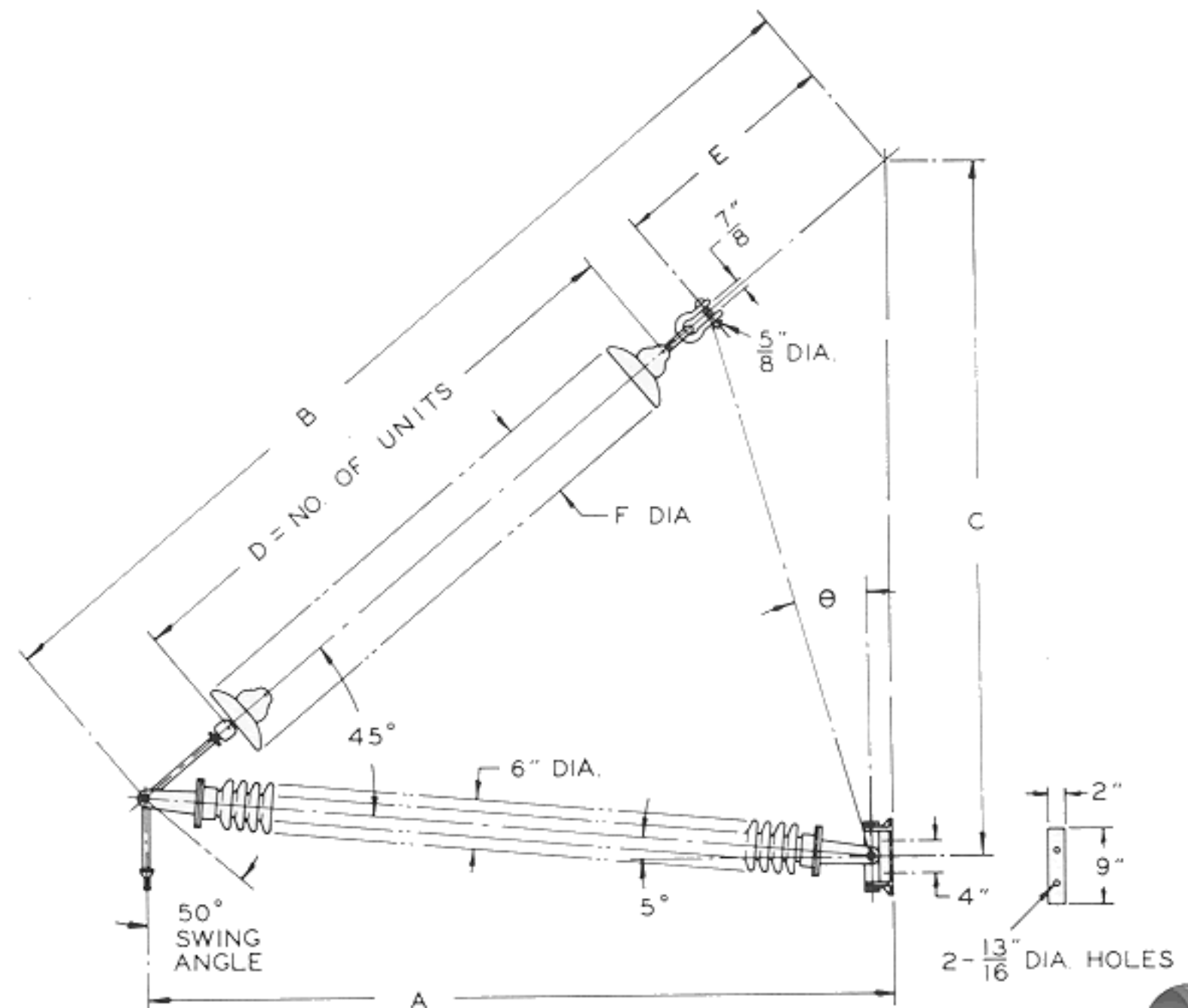
## 230 kV

The standard Horizontal Vee design listed in the table will meet the requirements for most applications at this voltage level. All of these assemblies have a 45° included angle and are available for steel, concrete or wood pole mounting in four insulation levels determined by the number of suspension insulators required. The strut insulator matches the electrical characteristics of the number of suspensions in the assembly.

The basic assembly is cataloged without the top mounting bracket for use on structures where a stub arm is supplied as part of the structure. This design is recommended for new construction on steel poles or lattice towers.

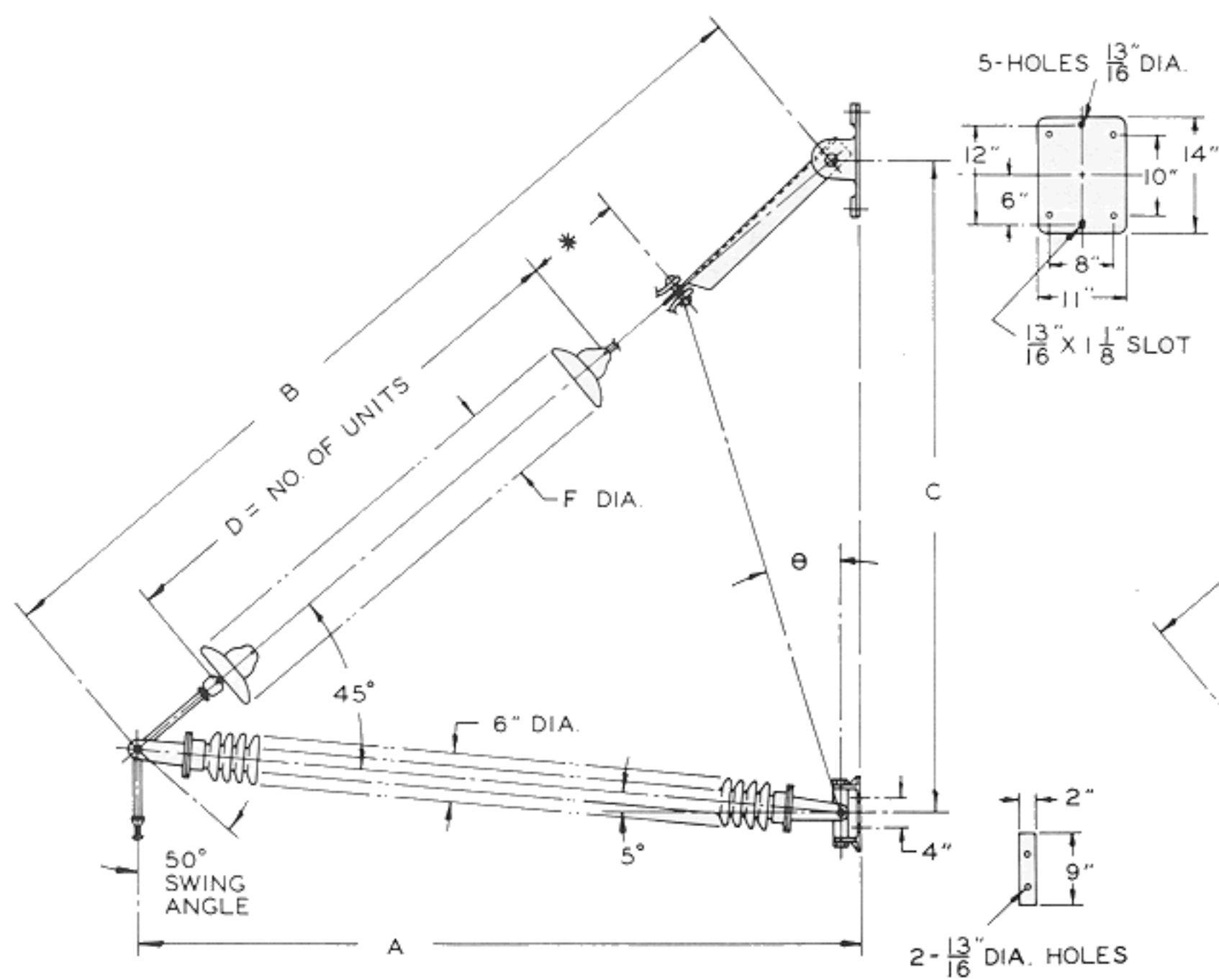
The addition of suffix "A" or "C" to the catalog number indicates that a top mounting bracket is required, and denotes the type of structure being used. A suitable top mounting bracket is supplied with the assembly. These assemblies are furnished complete, with the exception of the conductor clamps, which must be ordered separately. The Horizontal Vee assemblies accommodate all standard aluminum suspension clamps with a NEMA 52-5 socket and are suitable for single or bundled conductors. Clamps can be ordered by using a separate catalog number as shown on page 9.

Insulators are light gray, Lapp No. 70 glaze. Hardware is ferrous, hot-dip galvanized.

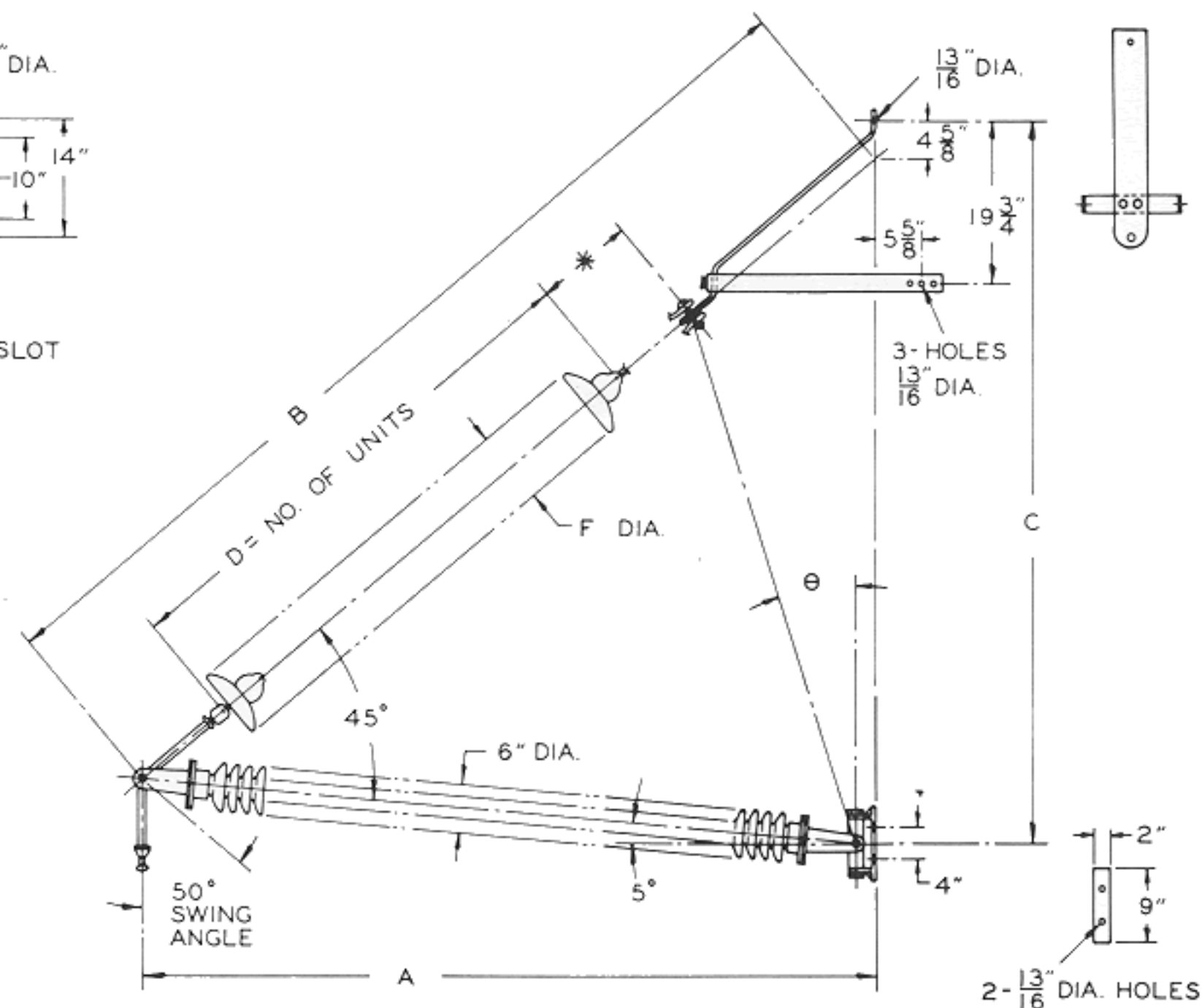


BASIC ASSEMBLIES										
Catalog Number	Hinge Angle	Dimensions in Inches						Strength Ratings Lbs.		Aprx. Net Weight/Assy. Lbs.
		A	B	C	D	E	F	Suspensions	Struts	
307312	22°	96 <sup>3</sup> / <sub>8</sub>	125 <sup>13</sup> / <sub>16</sub>	89 <sup>1</sup> / <sub>16</sub>	12	37 <sup>9</sup> / <sub>16</sub>	9	15K	15K	260
307313	21°	101 <sup>3</sup> / <sub>8</sub>	132 <sup>3</sup> / <sub>8</sub>	93 <sup>3</sup> / <sub>4</sub>	13	38 <sup>3</sup> / <sub>8</sub>	9	15K	15K	275
307314	22°	108 <sup>9</sup> / <sub>16</sub>	141 <sup>3</sup> / <sub>4</sub>	100 <sup>3</sup> / <sub>8</sub>	14	42	10	20K	25K	375
307315	20°	111 <sup>9</sup> / <sub>16</sub>	145 <sup>11</sup> / <sub>16</sub>	103 <sup>3</sup> / <sub>16</sub>	15	40 <sup>3</sup> / <sub>16</sub>	10	20K	25K	395
STEEL POLE OR CONCRETE POLE MOUNTING										
307312A	16°	96 <sup>3</sup> / <sub>8</sub>	121 <sup>9</sup> / <sub>16</sub>	86 <sup>3</sup> / <sub>8</sub>	12	—	9	15K	15K	315
307313A	15°	101 <sup>3</sup> / <sub>8</sub>	128 <sup>3</sup> / <sub>8</sub>	91	13	—	9	15K	15K	330
307314A	14°	108 <sup>9</sup> / <sub>16</sub>	137	97 <sup>3</sup> / <sub>8</sub>	14	—	10	20K	25K	430
307315A	13°	111 <sup>9</sup> / <sub>16</sub>	141 <sup>3</sup> / <sub>4</sub>	100 <sup>5</sup> / <sub>16</sub>	15	—	10	20K	25K	450
WOOD POLE MOUNTING										
307312C	16°	96 <sup>3</sup> / <sub>8</sub>	126	93 <sup>13</sup> / <sub>16</sub>	12	—	9	15K	15K	295
307313C	15°	101 <sup>3</sup> / <sub>8</sub>	132 <sup>9</sup> / <sub>16</sub>	98 <sup>1</sup> / <sub>2</sub>	13	—	9	15K	15K	310
307314C	14°	108 <sup>9</sup> / <sub>16</sub>	141 <sup>7</sup> / <sub>16</sub>	104 <sup>13</sup> / <sub>16</sub>	14	—	10	20K	25K	415
307315C	13°	111 <sup>9</sup> / <sub>16</sub>	145 <sup>11</sup> / <sub>16</sub>	107 <sup>13</sup> / <sub>16</sub>	15	—	10	20K	25K	435

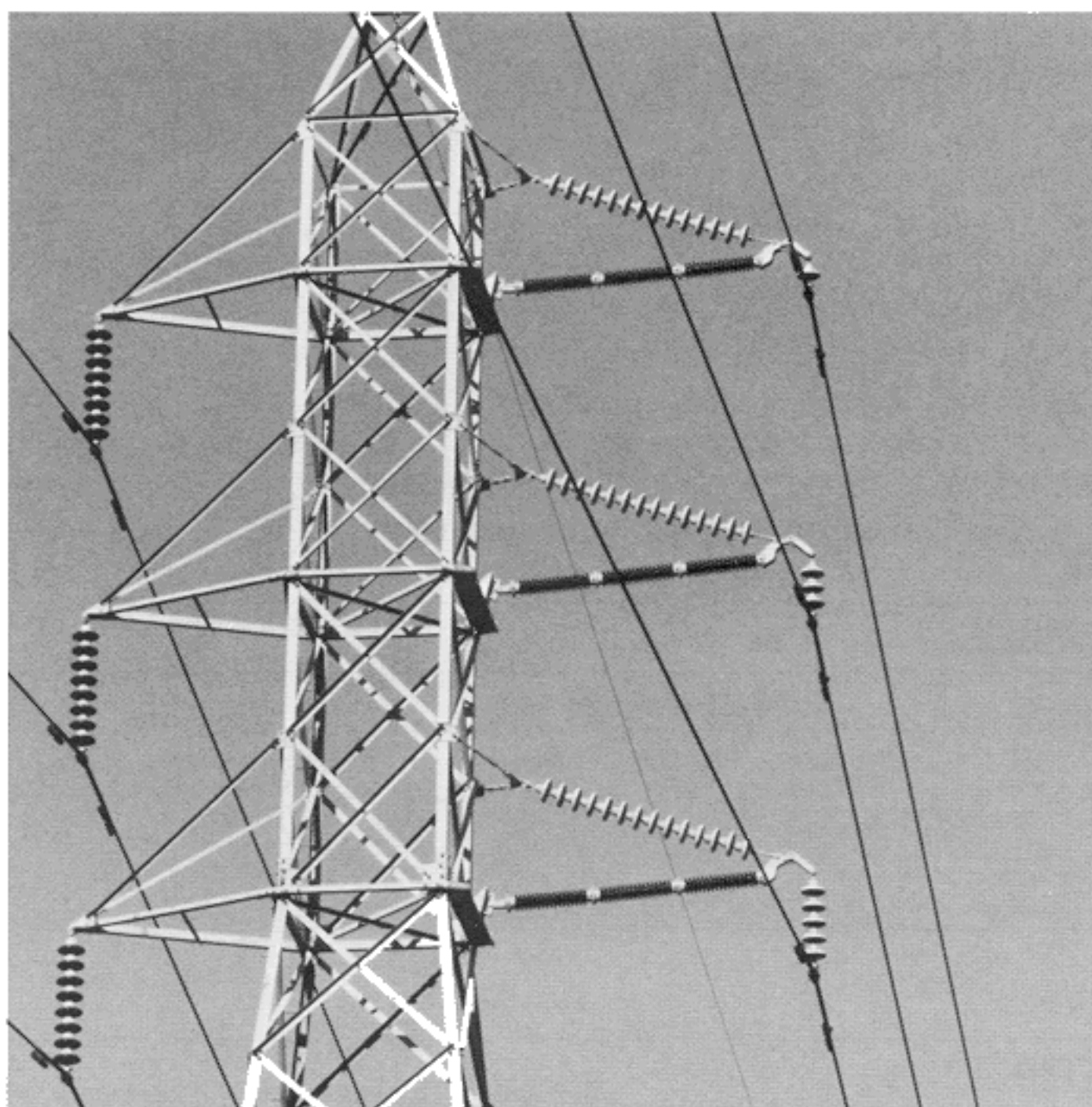




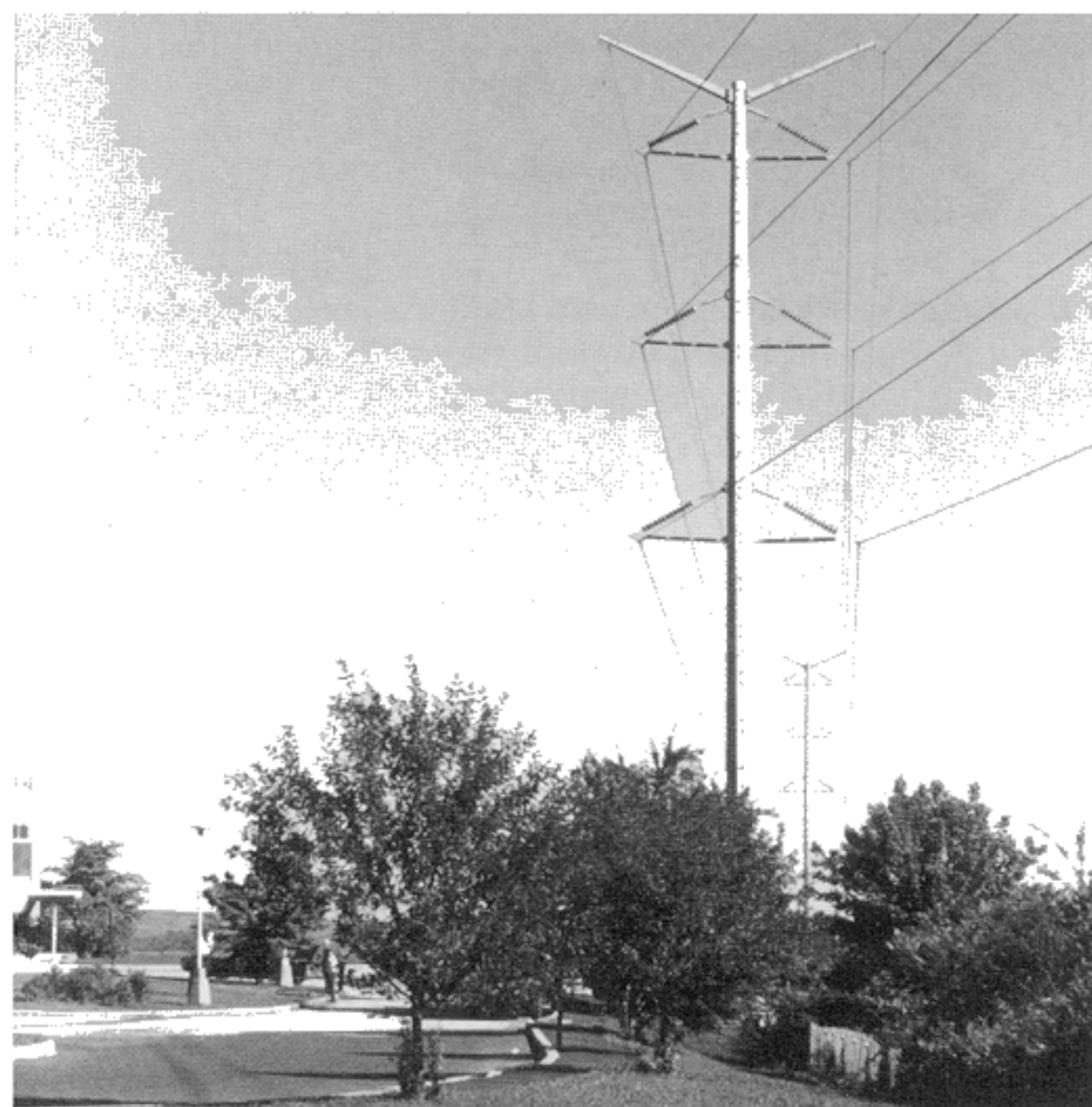
Steel Pole or Concrete Mounting



Wood Pole Mounting



Horizontal Vee construction made it possible to upgrade one side of a double circuit 115 kV line to 230 kV. Capacity was increased from 200 MVA to 400 MVA on same structures at minimal cost.



Neat appearance of double circuit Horizontal Vee design on tapered steel poles helped gain public acceptance for this 230 kV transmission line through an attractive residential area.

\*Linkage made up of standard fittings to hold overall length.



# HORIZONTAL VEE ASSEMBLIES

## 345 kV and 500 kV

Horizontal Vee assemblies are available for 345 kV and 500 kV installation in a choice of several insulation levels comprising strings of the required number of suspensions with matching strut insulators.

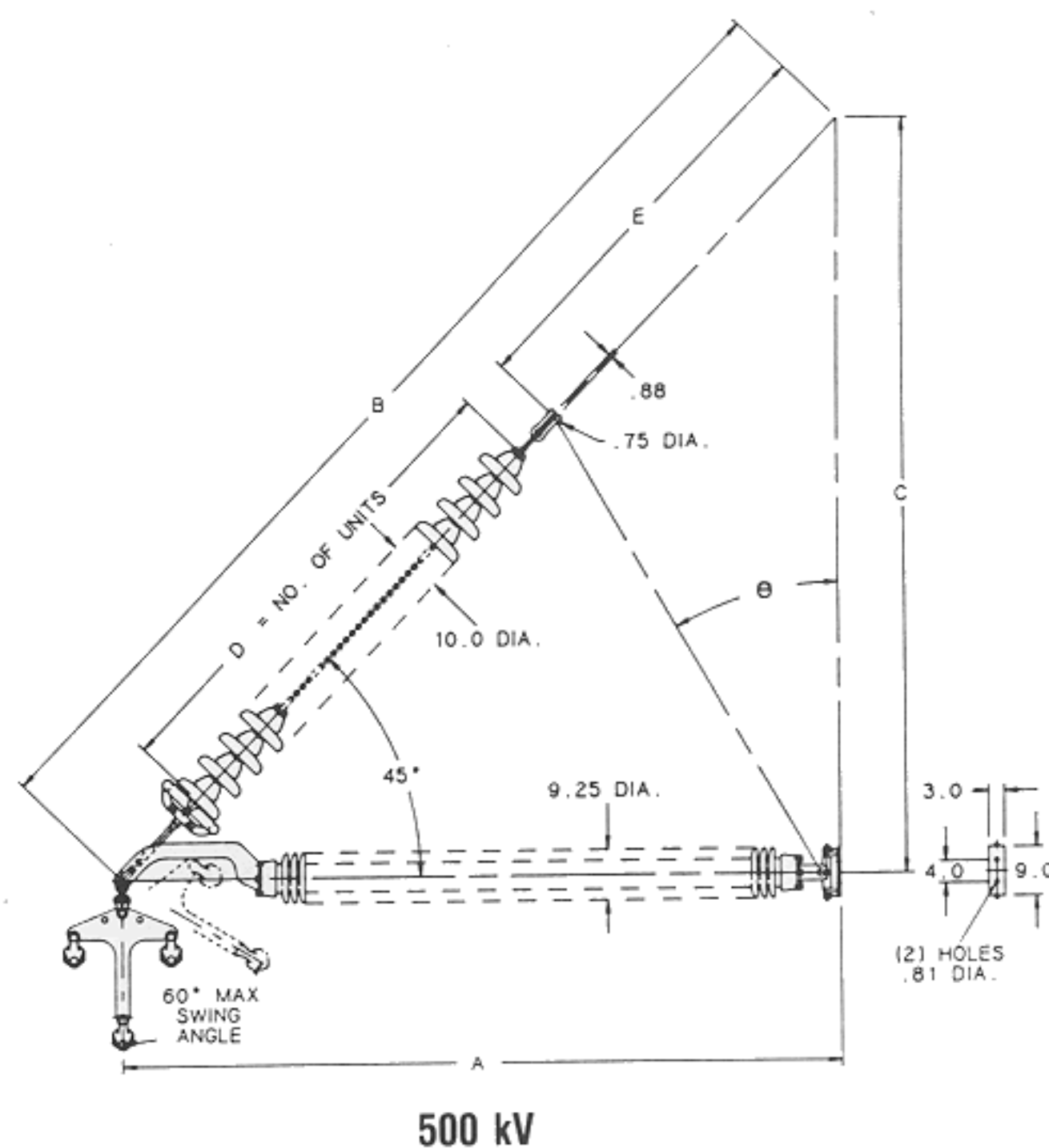
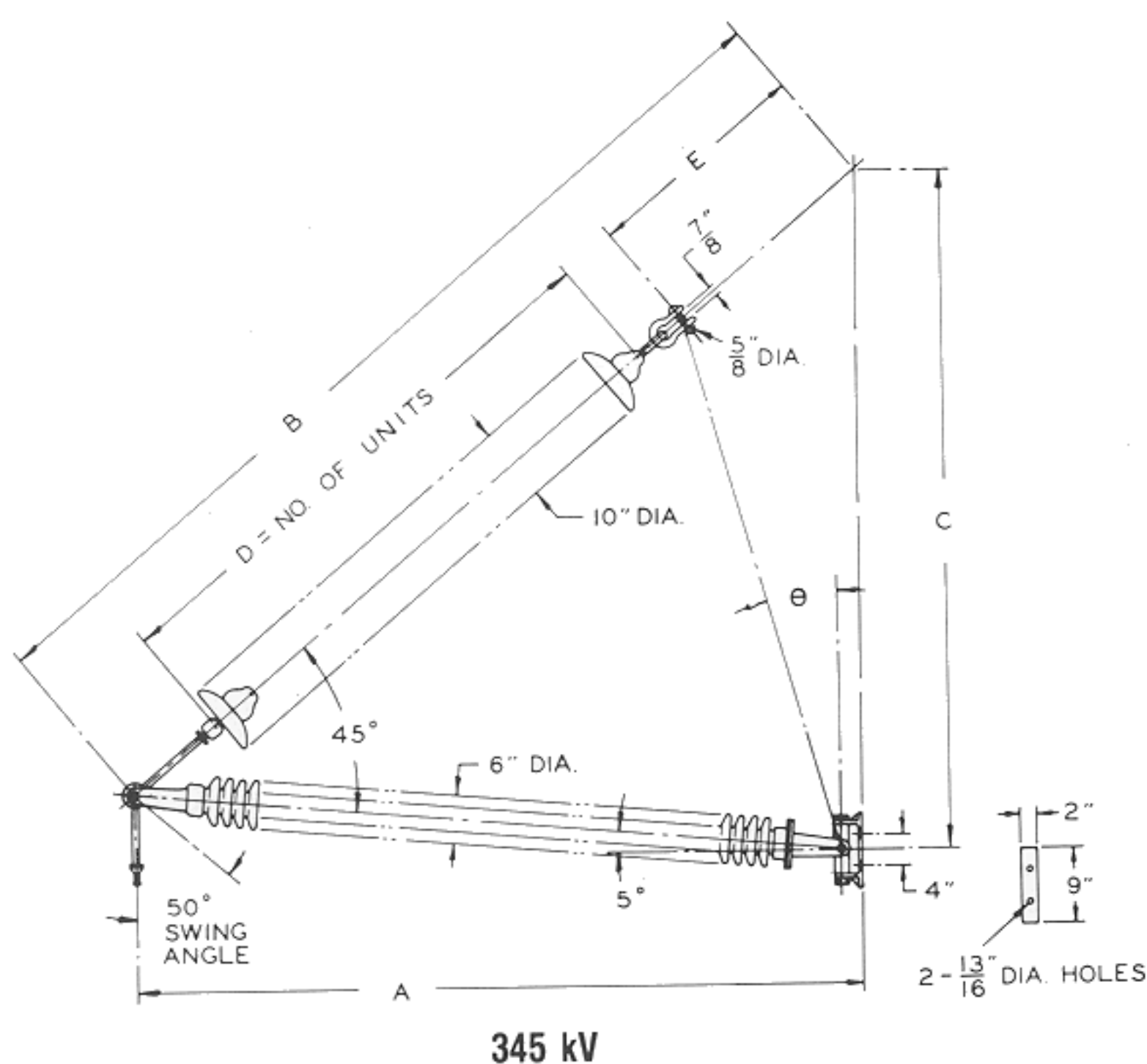
The 45° included angle is retained for these assemblies. They are cataloged without the stub arm or bracket for top attachment to the structure, as the stub arms are generally supplied by the structure manufacturer for these high strength assemblies. Stub arms, however, are available from Lapp.

Custom-made stub arms designed to fit the particular type of structure make these assemblies suitable for both new

construction and for upgrading to higher voltages on existing structures.

All 345 kV assemblies adapt to single conductors or bundled conductors when used with appropriate hardware. Corona rings can be added to both 345 kV and 500 kV assemblies if desired, depending on conductor size and configuration. A wide range of clamp sizes in aluminum with socket fittings are available from Lapp. Order by separate catalog number for clamp size required as shown on page 9.

Insulators are light gray glaze, Lapp No. 70. Hardware is ferrous, hot-dip galvanized.



345 kV

500 kV

### BASIC ASSEMBLIES\*

Catalog Number	Hinge Angle	Dimensions in Inches					Strength Ratings Lbs.		Aprx. Net Weight/Assy. (Lbs.)
		A	B	C	D	E	Suspensions	Struts	
307316	20°	117 1/4	153 1/8	108 1/2	16	41 7/8	20K	25K	420
307317	20°	123 5/16	161	114	17	44	20K	25K	445
307318	19°	127 1/2	166 1/2	117 15/16	18	43 3/4	20K	25K	465

500 kV

### BASIC ASSEMBLY\*

Catalog Number	Hinge Angle	Dimensions in Inches					Strength Ratings Lbs.		Aprx. Net Weight/Assy. (Lbs.)
		A	B	C	D	E	Suspensions	Struts	
305963	30°	192 10/16	278 3/16	200 3/4	25	104 13/16	40K	30K	1075

\*Stub arm supplied by pole manufacturer

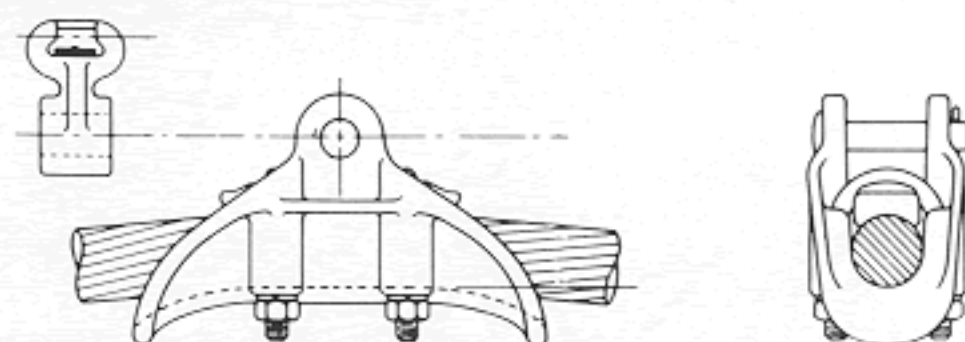


# HORIZONTAL CLAMPS AND FITTINGS

## SUSPENSION CLAMPS

Lapp has a wide choice of aluminum suspension clamps for use with ACSR or all-aluminum conductors. Clamps will accommodate all popular conductor sizes, with or without armor rods, in a range of .20" up to, and including, 3.53", and must be ordered separately by catalog number for use on Horizontal Vee assemblies.

Clamps in the 306029 series are 356-T6 aluminum alloy non-magnetic and are designed to reduce power loss and eliminate excessive heating of clamp and conductor. Ball-socket fittings for attachment to NEMA standard insulators connect clamps to the Horizontal Vee assemblies. For a complete range of sizes for these clamps, plus other aluminum and ferrous suspension and strain clamps, contact Lapp.



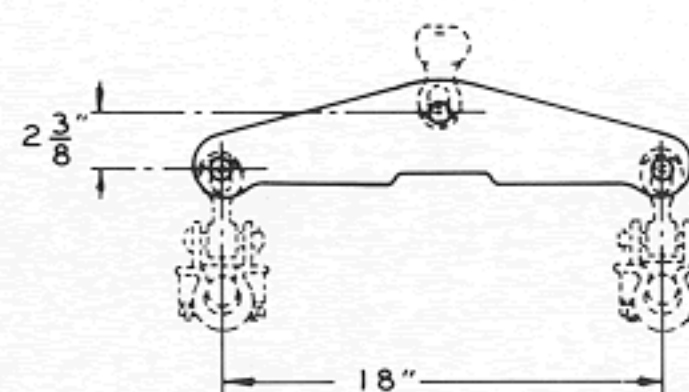
**306029 Series**

## YOKE ASSEMBLIES

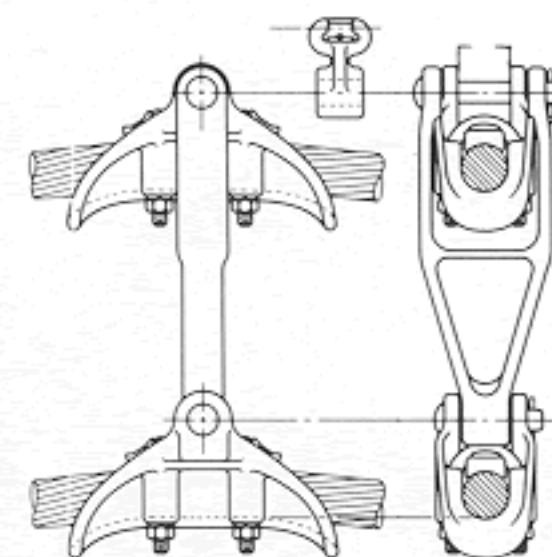
Yoke assemblies for two-bundle conductors are available for use on Lapp Horizontal Vee assemblies in a choice of horizontal or vertical conductor alignment.

Catalog No. 305466 is a high strength triangular yoke plate cut from steel plate, hot dip galvanized. Yoke plate accommodates standard suspension clamps in a two subconductor bundle horizontal arrangement with 18" spacing. Order clamps and fittings separately.

Catalog No. 306073 is a vertical bundle assembly with aluminum clamps and spacer yoke, with ductile iron fittings, hot dip galvanized. Sold as a complete assembly for all standard conductor sizes for conductor spacings of 8, 9, 12 and 18 inches. Contact Lapp for a listing of this series of vertical bundle assemblies.



**305466**

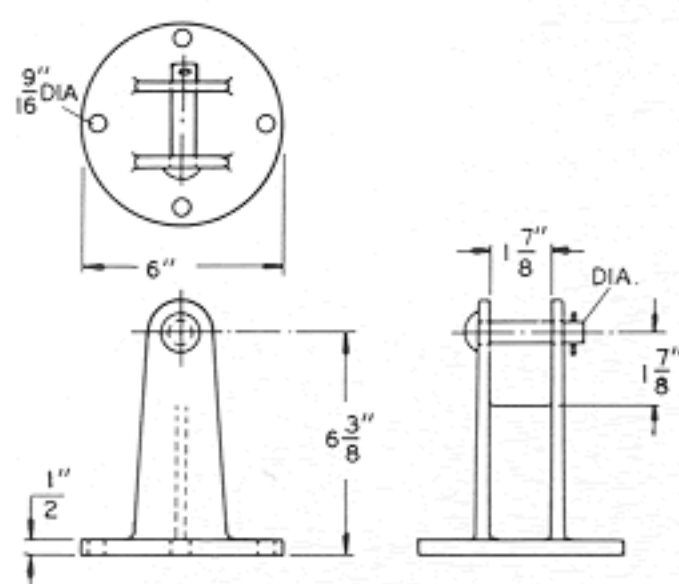


**306073 Series**

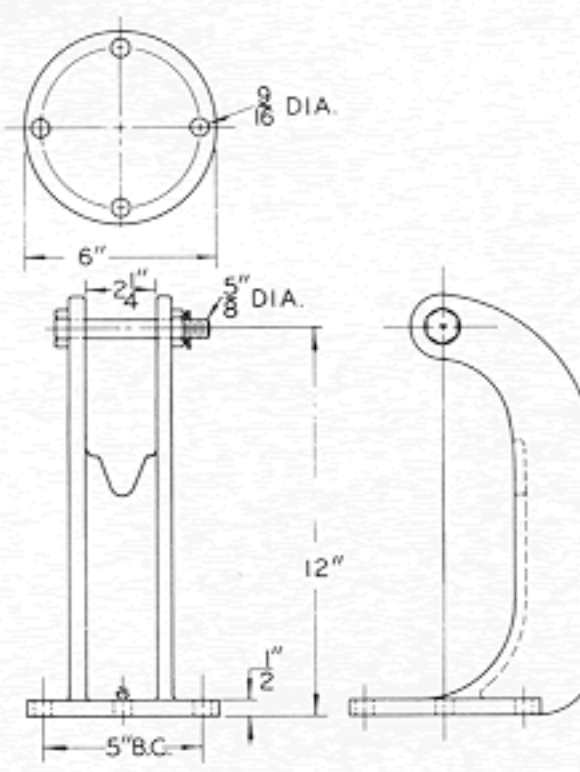
## CLEVIS ADAPTERS

Clevis adapter fittings bolt to the strut leg at the conductor end and attach to a connector fitting on the suspension string. A socket fitting supports the clamp on the adapter. Clevis adapter No. 78869 is standard for most assemblies, but for large angles or where hurricane wind forces must be designed for, special clevis adapters No. 301801 or No. 97398 are recommended.

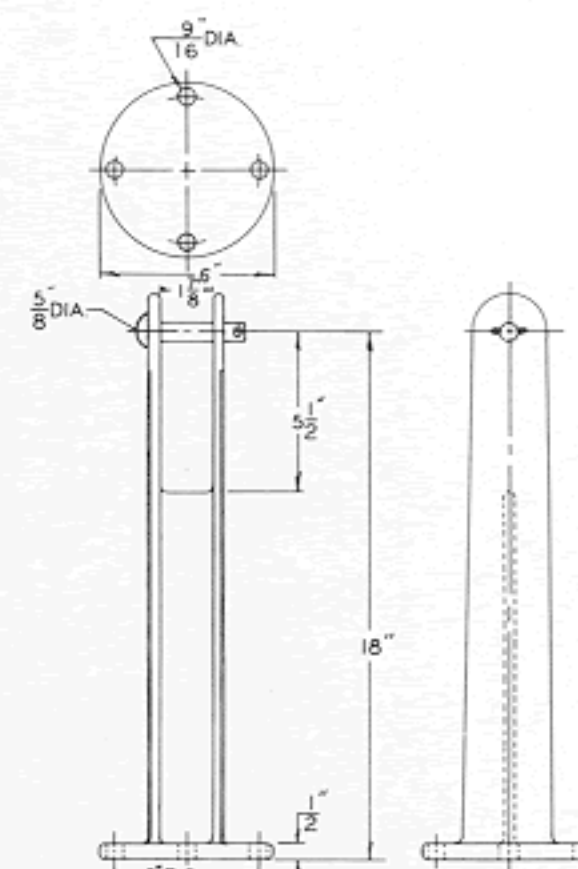
The special clevis adapters may require additional linkage to ensure clearance between the two insulator legs. A shorter clevis ball between the apex point and socket fitting of suspension clamp may be required.



**78869-B, Dia. 5/8"**  
**78869-C, Dia. 3/4"**



**301801**



**97598**



# COST COMPARISON OF VARIOUS 230 kV DESIGNS\*

Single Circuit

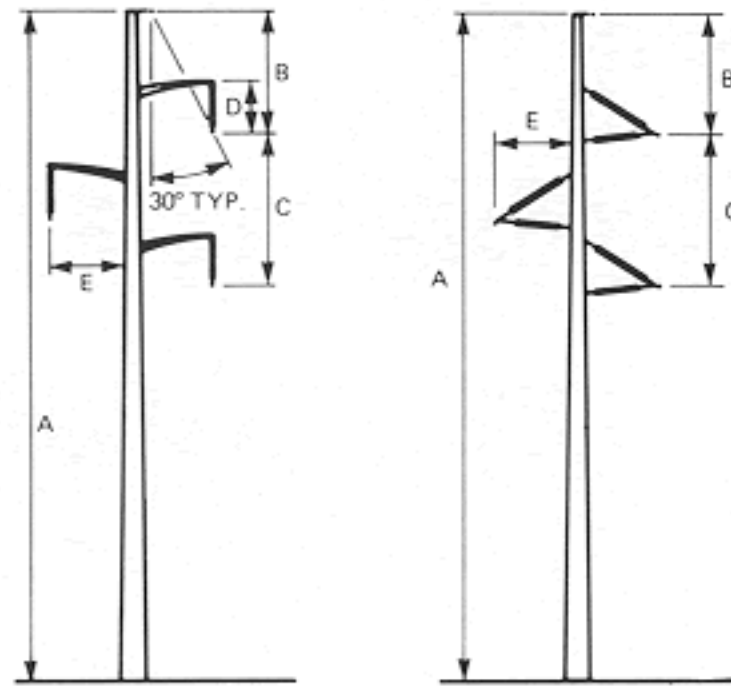


Figure 1

Figure 2

Double Circuit

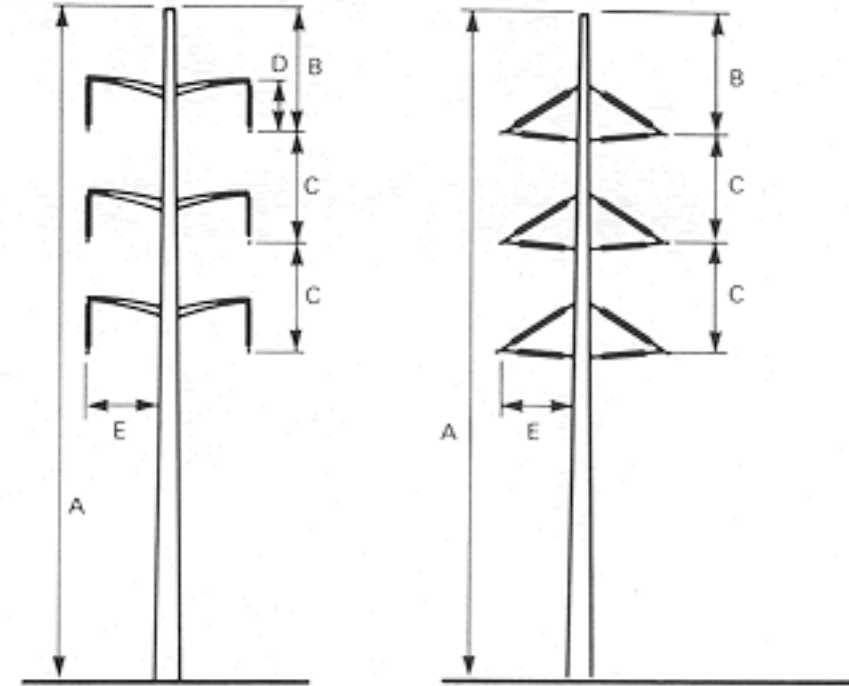


Figure 3

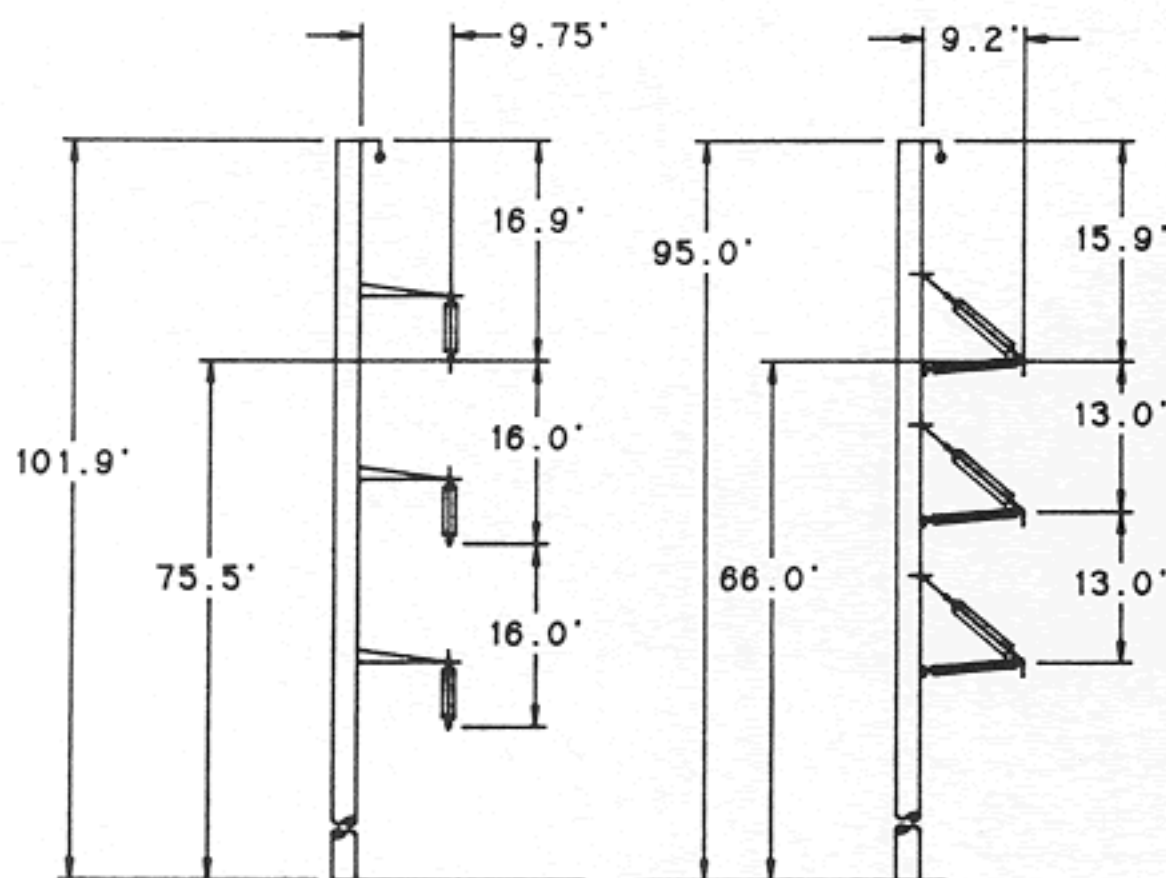
Figure 4

	Figure 1		Figure 2		Figure 3		Figure 4	
MEDIUM LOADING DISTRICT	Wood	Steel	Wood	Steel	Wood	Steel	Wood	Steel
Line Cost (\$ per Mile)	84,300	131,600	79,800	120,900	—	185,000	—	173,300
Span (ft.)	400	725	400	725	—	725	—	725
Right of Way Cost (\$ per Mile)	25,800	30,100	22,700	27,000	—	30,100	—	27,000
Right of Way Width (ft.)	66.4	77.6	58.4	69.6	—	77.6	—	69.6
A, ft.	70.0	81.5	70.0	78.0	—	95.0	—	90.0
B, ft.	17.5	18.5	16.5	16.5	—	18.5	—	16.5
C, ft.	13.0	13.5	12.0	12.0	—	13.5	—	12.0
D, ft.	6.4	7.0	—	—	—	7.0	—	—
E, ft.	10.0	10.5	9.5	9.5	—	10.5	—	9.5
LIGHT LOADING DISTRICT								
Line Cost (\$ per Mile)	—	137,500	—	130,800	—	203,700	—	191,600
Span (ft.)	—	725	—	725	—	725	—	725
Right of Way Cost (\$ per Mile)	—	30,000	—	26,900	—	30,000	—	26,900
Right of Way Width (ft.)	—	77.2	—	69.2	—	77.2	—	69.2
A, ft.	—	81.5	—	78.0	—	95.0	—	90.0
B, ft.	—	18.5	—	16.5	—	18.5	—	16.5
C, ft.	—	13.5	—	12.0	—	13.5	—	12.0
D, ft.	—	7.0	—	—	—	7.0	—	—
E, ft.	—	10.5	—	9.5	—	10.5	—	9.5

\* Based on a study made in 1976/77 by the independent consulting firm of Gilbert/Commonwealth. Copies of complete study available from Lapp on request.

## 230 kV SINGLE CIRCUIT

Steel Poles



	Suspension	Horizontal Vee
Line Cost (\$ per Mile)	255,900	224,200
Spans (ft.)	700	700
GLM (ft.-kips)	853	750
Pole Weight (lbs.)	12,518	10,036
Anchor Bolts (lbs.)	750	707
ROW Width (ft.)	58.5	49.7
ROW Cost (\$)*	14,185	12,038

\*Included in line cost  
 GLM = Ground Line Moment  
 ROW = Right-of-Way  
 Data obtained from "Transmission Line Cost Comparison," a Computer Tool.  
 Version 2.0

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