

TRANSMISSION LINES
COAXIAL TRANSMISSION LINES AND CONNECTORS
DESCRIPTION

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The inner conductor is enclosed by an outer tubular conductor which serves as a boundary or shield between internal and external electromagnetic fields. The insulator between these two conductors is designed to maintain constant spacing between conductors under conditions of normal use.

(A) Rigid and Semirigid Lines

2.02 Rigid and semirigid lines have an outer conductor of solid copper forming a cylindrical tube. The outer conductor is relatively inflexible and the line is classified according to the degree of stiffness as rigid or semirigid. Hard-drawn copper is used in the manufacture of rigid lines while semirigid lines are manufactured using soft-drawn copper. It should be noted that although semirigid lines are described as "soft-drawn," they are considerably stiffer than common soft-drawn copper tubing. The added stiffness makes the line more difficult to handle but reduces the tendency of the outer conductor to kink and ripple at turns.

2.03 The dielectric in rigid and semirigid lines is ordinarily air and separation between the conductors is maintained with insulating beads or pins of teflon or of a ceramic material such as steatite. The spacing of the beads along the conductors is one factor controlling the minimum bending radius of the line. Bead spacing also may impose restrictions on the frequency bands which can be transmitted satisfactorily since the beads constitute irregularities in the air dielectric. The effect is reduced in "compensated" lines by altering the diameter of one or both conductors at bead locations or by spacing the beads in sets in such a manner that the irregularities introduced by one set will be partially compensated, at specific frequencies, by the irregularities of another set.

2.04 The inner conductor of rigid and semirigid coaxial lines is of solid or tubular copper. Coaxial lines, having a radius in excess of 3/8 inch, usually have an inner conductor of tubular copper, while coaxial lines 3/8 inch or smaller have an inner conductor of

1. GENERAL

1.01 This section discusses the characteristics of coaxial transmission lines and connectors with respect to their application to radio services of the Bell System.

1.02 Coaxial lines and connectors are designed to satisfy a large variety of mechanical and electrical requirements. Since changes in physical structure are accompanied by changes in electrical properties, some compromise is often necessary between the desired characteristics and the characteristics that can be obtained in commercially available lines. In making such compromises, the relative importance of the various desired characteristics must be weighed in the light of the specific situation involved.

2. PHYSICAL STRUCTURES

2.01 The coaxial lines discussed in this section are composed of two concentric conductors which are circular in cross section.

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solid copper. The physical characteristics of rigid and semirigid coaxial lines are shown in Fig. 1.

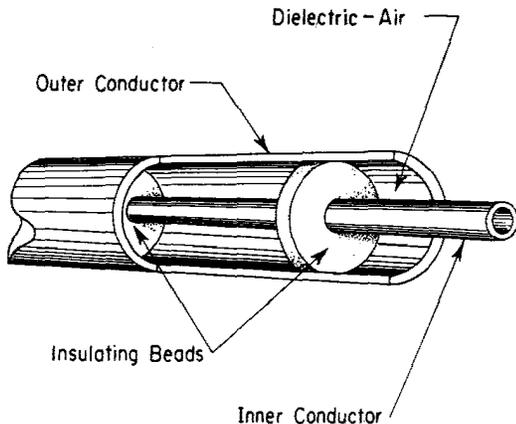


Fig. 1 - Rigid and Semirigid Air Dielectric Coaxial Cable

2.05 Lines with an outside diameter of 7/8 inch are available in both rigid and semirigid types. Larger lines are classified as rigid and are manufactured in standard unit lengths of 20 feet. Semirigid lines are ordinarily manufactured in lengths of 100 feet. Continuous length of semirigid lines, spliced at the factory, may be shipped in sections up to 2000 feet long.

2.06 The insulation of air dielectric lines is affected by moisture. In order to prevent the entrance of moisture by breathing and condensation as a result of temperature changes, the lines must be dried and hermetically sealed after installation. As a means of checking the subsequent tightness of the seal, it is common practice to fill air dielectric lines with dry air or nitrogen gas at a pressure of 15 pounds per square inch.

(B) Flexible Coaxial Lines

2.07 Flexible coaxial lines gain their flexibility by the use of a braided outer conductor, a flexible dielectric, and an inner conductor of small gauge wire or of several small wires stranded together. The physical characteristics of flexible coaxial cable are shown in Fig. 2.

2.08 The conductor material most frequently used is copper. In some flexible coaxial lines the copper is tinned, principally to facilitate soldering. A silver coating on the copper improves aging stability and improves the electrical conductivity at frequencies above about 1000 megacycles. To conserve copper

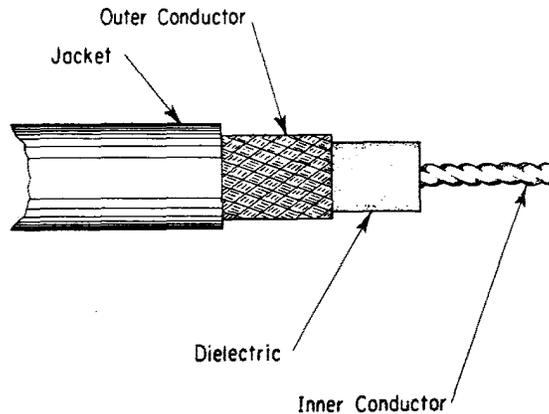


Fig. 2 - Flexible Coaxial Cable

and to provide additional tensile strength during manufacture, copper-coated steel (copper-weld) is sometimes used for the inner conductor of small size cables. Lines designed to have high attenuation may use a center conductor of nichrome or similar high resistance material. In some cables, designed for special purposes, the inner conductor is formed by winding a small gauge wire as a helix around a cylindrical, insulating core.

2.09 The dielectric of most flexible coaxial lines consists of a solid tube of polyethylene, teflon, or rubber, enclosing the inner conductor. The dielectric gives form to the outer conductor braid and determines its diameter. Teflon is capable of withstanding relatively high temperatures in comparison with polyethylene and rubber. Rubber insulated lines have little application in Bell System radio services because of their high attenuation. The constants of teflon and polyethylene dielectrics are given in Table I.

**TABLE I
Constants of Dielectric Materials**

Dielectric	Polyethylene	Teflon
Specific Gravity	0.92	2.2
Water Absorption	0.005%	Negligible
Cold Brittleness	-94°F	-100°F
Dielectric Constant, K (60 cycles to 10,000 mc)	2.26	2.1
Power Factor (60 cycles to 10,000 mc)	0.0003	0.0003
Volume Resistivity (ohm/cm)	10 ¹³	10 ¹⁶
Softening Temperature	220°F	500°F

The dielectric material used in a specific cable depends upon the flexibility, temperature, voltage, and frequency requirements to be satisfied.

2.10 A jacket of insulating material, such as rubber, polyethylene, or synthetic resin, is usually provided over the outer conductor of flexible lines as a protection against moisture and mechanical damage to the conductor braid. Jacket materials vary in their susceptibility to heat, cold, and sunlight. In some older types of polyethylene insulated cables with synthetic resin jackets, the vinyl plasticizer in the jacket tends to migrate into the polyethylene under certain temperature conditions, contaminating the dielectric and increasing the attenuation to several times the original value. Two types of noncontaminating synthetic resin jackets are now available. The two types differ in their ability to withstand bending at low temperatures without cracking. Clear

polyethylene jackets are not suitable for outdoor installations because of deterioration caused by sunlight. Types of jacket materials are classified, according to the above characteristics, in Table II.

2.11 An armor of braided aluminum or galvanized steel is provided over the jacket of some flexible cables as added protection against mechanical damage.

2.12 Most flexible cables of recent manufacture are made in accordance with specifications prepared by a committee representing the manufacturers, the armed services, and other users of coaxial lines. Such specifications are coordinated by the Armed Services Electro Standard Agency (ASESA) and cables manufactured in accordance with those specifications are identified by an RG/U-type number which is marked along the length of the cable at suitable intervals.

TABLE II

Characteristics of Jacket Materials

<u>Type</u>	<u>Color</u>	<u>Material</u>	<u>Low Temp.</u>	<u>Comments</u>
I	Black	Polyvinyl Chloride	-40°F	Limit to 10' in any one system because of aging.
II	Gray	Polyvinyl Chloride, noncontaminating	-13°F	Support rigidly if exposed to temp. below -13°F.
IIA	Black	Polyvinyl Chloride, noncontaminating	-40°F	Standard
III	Natural	Polyethylene, noncontaminating	-	Not satisfactory for outdoor use.
IV	Black	Synthetic Rubber	-40°F	Not satisfactory at high frequencies.
T	White	Teflon tape and fibreglass braids impregnated with silicone varnish	-40°F	For high temperature, low loss application.

Note 1: Low temperatures are the temperatures at which the cables can be bent around a mandrel having a diameter ten times the cable diameter without the appearance of cracks or fractures in the jacket.

Note 2: Maximum operating temperatures should not exceed about 160°F for teflon insulated cables or 158°F for other types.

Note 3: At the high temperatures indicated by Note 2, conductor loads in excess of 75 pounds may be expected to cause trouble.

(C) "Semisolid" Dielectric Lines

2.13 Coaxial transmission lines are available in a form combining the properties of both semirigid air lines and flexible solid lines. "Semisolid" dielectric lines are constructed by wrapping a string of dielectric material around the inner conductor and then covering the helix, so formed, with a thin tube of the same dielectric material. Cables constructed in this manner have approximately the same flexibility as semirigid lines and provide a compromise between the electrical properties of air and solid dielectric lines.

2.14 An example of a "semisolid" dielectric coaxial line is shown in Fig. 3. This line is identified as STYROFLEX coaxial cable and is distributed by the Communication Products Co. The physical design of STYROFLEX cable enables the inner conductor to remain centered at bends as well as in straight runs. Long continuous lengths can be provided, thus ensuring relatively constant electrical properties due to the absence of joints. Because of the aluminum outer conductor, STYROFLEX cable is relatively light in weight.

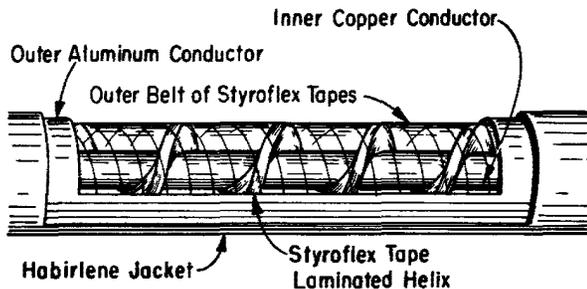


Fig. 3 - STYROFLEX Coaxial Cable

2.15 STYROFLEX coaxial cable is available in sizes from 3/8-inch to 6-1/8-inch with a characteristic impedance of 50 ohms and from 1/2-inch to 3-1/8-inch with an impedance of 70 ohms. A Habirlene (polyethylene) jacketed STYROFLEX cable is available for installations requiring corrosion protection.

2.16 Another type of coaxial cable, shown in Fig. 4, having a "semisolid" dielectric, is the HELIAX, Type HX-0, manufactured and distributed by the Andrew Corporation. HELIAX coaxial cable consists of a corrugated steel outer conductor copper clad on the inside and seam welded. The outer surface of the sheath is protected against corrosion by a layer of bituminous material, over which is extruded a vinyl jacket. The copper tube inner conductor is supported within the sheath by a spirally wrapped polyethylene strip. HELIAX coaxial cable is available only in a 7/8-inch size.

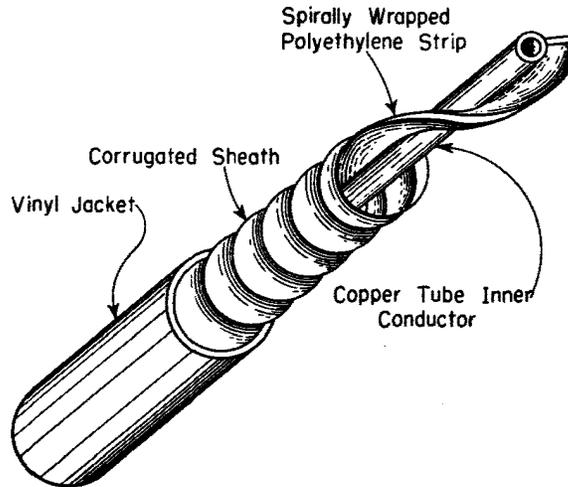


Fig. 4 - HELIAX, Type HX-0 Cable

3. ELECTRICAL CHARACTERISTICS

3.01 The principal electrical characteristics of coaxial transmission lines are the series resistance of the conductors, the inductance, capacitance between conductors, and the leakage conductance of the dielectric. As a practical matter, these characteristics are seldom used directly. Instead, use is made of factors derived from the physical characteristics which show a more direct relationship to the effects on high-frequency signals impressed on the line. These factors are the characteristic impedance, attenuation, velocity of propagation, voltage and power ratings, and standing waves.

(A) Characteristic Impedance

3.02 The characteristic impedance of an air dielectric line, practically speaking, depends upon the ratio D/d when D is the inside diameter of the outer conductor and d is the outside diameter of the inner conductor. Lines varying in size thus have the same characteristic impedance if the ratio of the dimensions, D/d is held constant.

3.03 Dielectrics, other than air, reduce the impedance by a factor which is equal to the reciprocal of the square root of the dielectric constant. Solid dielectric lines, therefore, would have a lower characteristic impedance than air dielectric lines having the same conductor ratio. In lines with a continuously uniform dielectric, such as polyethylene, the characteristic impedance remains nearly constant over the range of radio frequencies for which the attenuation is low enough for ordinary use. In bead-insulated air dielectric

lines, the characteristic impedance may drop as much as 10% when the frequency limits of the bands for which the lines are recommended are approached. This is principally due to bead spacing which results in reflections from individual beads being returned in phase within certain frequency bands. This condition imposes restrictions on the frequency bands which may be transmitted satisfactorily over some types of bead-insulated lines.

3.04 When the line and terminating impedances are the same, the impedances are said to be matched. The sending end impedance of a line, but not its characteristic impedance, is affected by voltages and currents reflected from a mismatched impedance at the receiving end. This may result in improperly loading the sending end equipment and affect its operation or cause damage to the equipment.

(B) Standing Waves

3.05 Standing waves on a coaxial line are the result of irregularities in the transmission line caused by displacement of the inner conductor or of a termination not matching the characteristic impedance of the line. The energy traveling along the line reaches the termination, and under mismatched conditions, is not entirely absorbed, thus a portion of the energy is reflected toward the sending end. Theoretically, the reflected voltage and current will diminish continuously as the distance from the termination increased toward the source. In practical situations, the attenuation is always made as small as possible to reduce power loss and the reflected voltage and current may be considered to be nearly uniform along the line. The voltage along the line at any point will thus be the sum of the incident and reflected waves. The ratio of maximum to minimum voltages, occurring on a line, is called the voltage standing wave ratio, VSWR. An abnormally high standing wave ratio on a coaxial line may result in a reduction of the output power and possibly even affect the operation of the radio equipment. Generally, the standing wave ratio on a transmission line should be maintained below 2:1.

(C) Voltage and Power Ratings

3.06 Voltage and power ratings of coaxial lines represent the safe operating voltage or power at which a line can operate continuously without causing injury to the cable. The voltage required to break down the insulation depends upon the type and thickness of the dielectric. The maximum voltage that will exist on a line for a given power flow will be

increased if the load impedance does not match the characteristic impedance of the line, because of the presence of standing waves which cause peaks and nulls of voltages. Excessive standing waves on a line results in the line becoming heated. Heating of the cable may be detected simply by feeling of the line while it is in operation. Under conditions of imperfect impedance match, the safe power or voltage may be determined by dividing the power or voltage rating by the square root of the standing wave ratio.

(D) Attenuation

3.07 Attenuation in coaxial lines results from the loss of electrical energy in the form of heat. Heat is developed in the series resistance of the conductors and increases with the square root of frequency because of the skin effect. Some heat is also developed in the dielectric. The dielectric loss increases directly with frequency; but with dielectrics such as polyethylene and teflon, the conductor losses predominate at the highest frequencies likely to be used.

3.08 A loss of 3 db in a line represents a loss of half the power delivered to the line. It is thus apparent that the use of a line with high attenuation can waste a great amount of the advantage gained by higher antenna towers, for example, or by increasing transmitter power.

(E) Velocity of Propagation

3.09 Velocity of propagation is a term which applies to the speed in which electrical energy travels along a coaxial line. Due to the inductance and capacitance of the line, the electrical energy travels at a speed less than the speed of electrical energy traveling in free space. The velocity of propagation within a coaxial line is expressed in per cent of free space velocity. A knowledge of wave velocity is useful principally for determining the length of cable corresponding to some particular fraction of a wave length.

3.10 Tables III, IV, and V, Pages 8, 9, and 10, give information helpful in determining electrical as well as physical characteristics of some of the flexible, rigid, semirigid, and "semisolid" coaxial cables most commonly used in Bell System radio services.

4. COAXIAL CABLE CONNECTORS

4.01 Connectors are the means used to join sections of coaxial lines, or to terminate coaxial lines so as to facilitate the

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interconnection of lines and equipment. They are made in a great variety of forms and sizes depending upon the functions which they perform in the coaxial circuit and upon the sizes and types of coaxial lines with which they are used. It is desirable that connectors be able to perform their mechanical functions without introducing electrical irregularities in the circuit. For this reason, they are designed to meet, as nearly as practicable, the impedance, voltage, and current requirements of lines with which they are intended to be used. In most cases, even the best connectors introduce some electrical irregularity and the magnitude of the irregularity ordinarily increases with frequency. For this reason it is desirable to keep the number of connectors at a minimum, particularly in lines operating at the higher frequencies.

4.02 Connectors are generally soldered to rigid and semirigid lines; but in flexible lines, electrical contact with the outer conductors frequently depends upon mechanical pressure provided by the connector fittings. Connectors for the larger flexible lines are designed to clamp firmly to the jacket or armor so that tensile stresses are not applied wholly to the conductors.

4.03 Coaxial connectors perform several mechanical functions. They provide for the expansion of rigid lines and for the differential expansion between the inner and outer conductors. They seal lines that are maintained under pressure and provide the means for introducing gas. Through junction boxes, elbows, and tees, they provide the means for interconnecting lines which meet at sharp angles. Some coaxial connectors permit coaxial lines to pass through panels or pressurized bulkheads.

4.04 Most connectors for flexible lines are standardized to a relatively high degree. They are classified according to mechanical features and electrical characteristics, by series types which are identified by Army-Navy letter symbols. Connectors within a given type series have essentially the same electrical properties and connecting features regardless of the manufacturer. Army-Navy or Signal Corps type numbers applied to individual connectors have no apparent relation to the series classifications or to the functions of the connectors; but they refer to specifications which are generally recognized in the radio industry.

4.05 Table VI, Page 11, lists, in part, commonly used connectors and the various types of flexible coaxial cables with which the connectors may be used. Reference is made

in Table VI to Figs. 6, 7, 8, 9, 10, 11, and 12 which show the physical design of various types of coaxial connectors.

4.06 Connectors for rigid and some semirigid lines are frequently bolted together through flanges while other types of connectors for such lines may be joined entirely by a soldered connection. The variety of connectors for rigid and semirigid lines is less than for flexible lines and there is less standardization. Each manufacturer of coaxial lines generally has a favored design for connectors as well as for supporting hardware and their catalogs should be consulted for details.

4.07 Connectors are often provided as an integral part of antennas and other equipment. In providing coaxial lines for such equipment, care must be exercised to see that any new connectors will mate with the connectors already provided.

5. APPLICATION

5.01 Coaxial transmission lines are used for a variety of purposes; however, the most common of these uses is to carry radio frequency energy between a radio transmitter or receiver and an antenna. The type of line selected for this purpose must, of course, transfer energy from one point to another with minimum attenuation. The line must have, as nearly as possible, a characteristic impedance matching the impedance of the terminating load. In practical situations a given line might be found which ideally meets the electrical and physical requirements, but the cost of such a line might be prohibitive. In such cases, compromises must be reached in some electrical or physical requirements.

5.02 The use of a transmission line not having a characteristic impedance equal to the terminating load impedance will result in standing waves being set up on the line. The mismatch may result in the standing wave ratio exceeding the permissible limits. To correct this condition, stub sections of transmission line may be connected across the line at an appropriate point near the load to compensate for the mismatch. Such stubs must be of a certain length and must be connected at a certain point on the line as determined by the position of a maximum voltage point and the magnitude of the standing wave ratio. The amplitude of the voltage standing wave is proportional to the ratio of the terminating resistance to the characteristic impedance of the line, or vice versa, whichever is greater than unity. Thus, a 72-ohm line terminated by either a 24-ohm or

a 216-ohm resistance load will show a voltage standing wave ratio of 3:1. The standing wave ratio thus serves as a convenient measure of the degree of match existing between the line and its load.

5.03 Stub sections of coaxial transmission line are also used as lightning protection devices for radio frequency transmission systems. Shorted stubs of a length equal to one-quarter wave length at the operating frequency are connected at the antenna end of the transmission line. At the operating frequency, this quarter-wave stub looks like an open circuit and therefore has no appreciable effect on the performance of the system. To static charges picked up on the antenna, however, the stub appears as a short circuit, thus, these static charges are effectively diverted to ground.

5.04 A quarter-wave section of line connected in series with the transmission line can be made to serve as an impedance matching device. The characteristic impedance of the quarter-wave section must be equal to the square root of the product of the generator and load impedances. Because of the difficulty in obtaining a section of coaxial line with the appropriate characteristic impedance this method of impedance matching is of limited use.

5.05 Two or more urban land station receivers operating from a common antenna may be bridged together using solid dielectric cables and standard coaxial fittings. In the bridging network, a short section of transmission line (labeled A, Fig. 5) connected to each receiver input acts as an impedance transformer. The transformed receiver impedance is about 50 ohms when the receiver is tuned and increases when

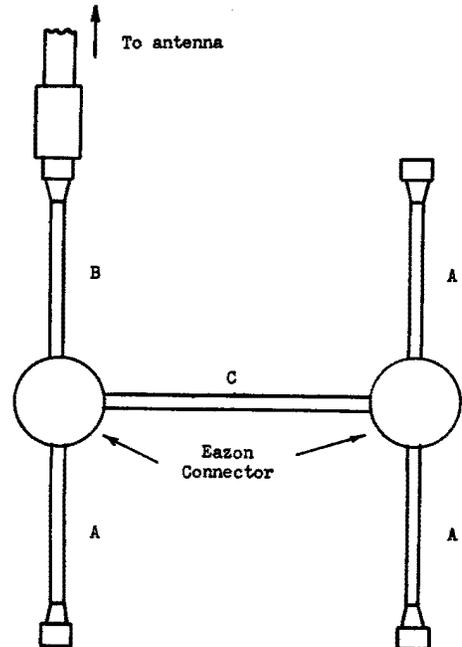


Fig. 5

the receiver is detuned. A number of receivers with their associated impedance transformers are effectively bridged at half-wave length intervals along the transmission line (labeled C, Fig. 5) and then the combined impedance is transformed by a quarter-wave line of approximate characteristic impedance (labeled B, Fig. 5) to provide a satisfactory match to the antenna transmission line.

Attenuation in Db/100 ft.		Conductor Materials:														Dielectric Materials:																							
Power Ratings in Watts for: (VSWR = 1 Ambient Temp. = 104° F. Center Cond. Temp. 175° F.)		19A/U 20A/U		17A/U 18A/U		11A/U 7A/U		8A/U 10A/U		9B/U -		5B/U -		58C/U -		117/U 118/U		87A/U -		8A/U -		35A/U -		3A/U -		11A/U 12A/U		13A/U -		6A/U -		59A/U -		63B/U 79B/U		62A/U -		21A/U -	
		Attenuation (A), Power (P)	(A)	(P)	(A)	(P)	(A)	(P)	(A)	(P)	(A)	(P)	(A)	(P)	(A)	(P)	(A)	(P)	(A)	(P)	(A)	(P)	(A)	(P)	(A)	(P)	(A)	(P)	(A)	(P)	(A)	(P)	(A)	(P)	(A)	(P)	(A)	(P)	
Frequency - Mc																																							
1	0.03			0.066		0.08		0.13		0.13		0.2		0.24						0.04		0.038		0.11		0.16		0.16		0.2		0.31		0.17		0.28		1.5	
2	0.05			0.1		0.13		0.2		0.2		0.3		0.58						0.06		0.062		0.17		0.23		0.23		0.3		0.45		0.25		0.40		2.1	
4	0.08			0.18		0.19		0.3		0.3		0.44		0.9						0.1		0.097		0.27		0.34		0.34		0.44		0.65		0.37		0.57		3.0	
8	0.12			0.21		0.29		0.45		0.45		0.65		0.98						0.16		0.15		0.4		0.5		0.5		0.65		0.96		0.53		0.81		4.1	
10	0.14	10,000		0.24	6800	0.32	3000	0.52	2200	0.52	2200	0.75	1300	1.04	560	0.2		0.61		0.18		0.18	6750	0.46	4450	0.57	2150	0.57	2100	0.75	860	1.1	800	0.59	0.90		4.6		
15	0.2	8700		0.3	5500	0.44	2400	0.66	1800	0.66	1800	0.94	1100	1.35	460	0.26		0.77		0.24	5500	0.23	5500	0.58	3600	0.72	1800	0.72	1750	0.94	740	1.37	720	0.73	1.13	860	5.6		
30	0.3	5300		0.45	3800	0.67	1650	1.0	1260	1.0	1260	1.4	770	2.2	310	0.4		1.15		0.38	3800	0.38	3800	0.9	2500	1.05	1260	1.05	1250	1.4	530	2.0	520	1.05	1.60	600	7.8		
60	0.5	3600		0.68	2600	1.05	1150	1.55	900	1.6	900	2.1	540	3.3	230	0.61		1.67		0.61	2600	0.6	2600	1.35	1750	1.56	900	1.56	880	2.1	380	2.95	370	1.51	2.30	400	11.0		
100	0.7	2800		0.94	1950	1.5	880	2.1	680	2.2	680	2.8	410	4.6	175	0.83		2.2		0.86	1950	0.8	1950	1.9	1350	2.15	680	2.15	670	2.8	300	3.95	290	2.0	3.05	300	14.0		
160	0.98	2200		1.3	1500	2.0	700	2.8	530	3.0	530	3.8	320	6.25	140	1.12		2.9		1.19	1500	1.19	1500	2.5	1020	2.8	540	2.8	520	3.8	230	5.05	225	2.5	4.10	220	17.9		
200	1.13	1900		1.5	1300	2.3	620	3.2	480	3.5	480	4.3	280	7.2	125	1.28		3.15		1.39	1320	1.39	1320	2.8	900	3.2	470	3.2	450	4.3	200	5.75	200	2.8	4.70	200	19.8		
400	1.85	1300		2.4	875	3.5	420	5.0	320	5.2	320	6.5	190	11.2	85	2.0		4.8		2.22	870	2.22	870	4.3	600	4.75	320	4.75	290	6.5	137	8.5	135	4.0	6.30	130	28.0		
800	3.02	840		3.84	580	5.5	280	7.8	220	8.0	220	9.8	130	17.5	59	3.15		7.2		3.54	560	3.54	560	6.5	400	7.15	215	7.15	180	9.8	90	12.5	90	5.7	9.20	85	41.0		
1000	3.56	700		4.45	490	6.3	250	8.9	190	9.1	190	11.2	110	20.0	52	3.65		8.1		4.18	450	4.18	450	7.6	350	8.2	190	8.2	150	11.2	77	14.3	75	6.5	10.40	77	46.0		
2000	6.00	440		7.15	300	10.2	150	13.9	125	14.0	125	17.0	72	31.0	34	5.7		12.3		7.4	256	7.4	256	12.0	225	13.2	125	13.2	90	17.1	50	21.0	50	9.4	15.60	50	66.0		
3000	8.30	330		9.4	220	13.8	125	18.0	95	18.0	95	22.0	57	40.0	27	7.6		16.0		11.0	200	11.0	200	16.0	170	18.0	95	18.0	70	22.0	40	28.0	40	12.0	20.00	40	82.0		
Char. Impedance - Ohms	52		52		52		52		51		50		50		50		50		71		71		75		75		74		76		73		125		93		53		
Max. Operating Volts - rms	11,000		11,000		5500		4000		4000		3000		1900		6000		3000		10,000		10,000		5200		4000		4000		2700		2300		1000		750		2700		
Vel. of Prop. - % Free Space	65.9		65.9		65.9		65.9		65.9		65.9		65.9		69.5		69.5		65.9		65.9		65.9		65.9		65.9		65.9		65.9		84		84		65.9		
Dielectric	P		P		P		P		P		P		P		T		T		P		P		P		P		P		P		P-AIR		P-AIR		P				
Diameter of Dielectric, Ins.	0.910		0.680		0.370		0.285		0.280		0.181		0.116		0.620		0.280		0.680		0.680		0.455		0.285		0.280		0.185		0.146		0.285		0.146		0.185		
Inner Conductor	0.250		0.188		10 AWG		7/21 AWG		7/21 AWG		16 AWG		19/0.0068"		0.188		7/20 AWG		9 AWG		9 AWG		7/21 AWG		7/26 AWG		7/26 AWG		21 AWG		22 AWG		22 AWG		7/32 AWG		16 AWG		
Nominal Capacitance-uuf/ft.	29.5		29.5		29.5		29.5		30.0		28.5		28.5		29		29.5		21.5		21.5		21.5		20.5		20.5		20		21		10		13.5		29		
Conductor Materials	C		C		C		C		SC		SC		TC		C		SC		C		C		C		TC		TC		SC-C		CW		CW		CW		N		
Inner	C		C		2C		C		2SC		2SC		TC		C		2SC		C		C		C		TC		TC		SC-C		CW		CW		N				
Outer	C		C		2C		C		2SC		2SC		TC		C		2SC		C		C		C		TC		TC		SC-C		CW		CW		N				
Jacket Type	IIA		IIA		IIA		IIA		IIA		IIA		IIA		T		T		IIA		IIA		IIA		IIA		IIA		IIA		IIA		IIA		II				
Diameter	1.120		0.870		0.545		0.405		0.420		0.332		0.195		0.73		0.425		0.870		0.870		0.625		0.405		0.420		0.332		0.242		0.405		0.332				
Weight/100 ft. - pounds																																							
Unarmored Cable	74		46		21.6		10.6		15		8.7		2.5		-		-		-		-		22.4		9.6		12.6		8.2		3.2		8.32		2.83		8.7		
Armored Cable	92.5		58.5		31.0		14.6		-		-		-		61		-		-		132.5		52.5		-		-		-		-		13.6		-		-		
Minimum Bending Radius-Ins.	12		9		6		5		5		4		2		-		-		-		9		7		5		5		4		3		-		-				
O.D. of Armored Cable	1.195		0.945		0.615		0.475		-		-		-		0.79		-		-		1.0		0.945		-		-		-		0.475		-		-				

Table III - Flexible Coaxial Cables

Table IV - Bead Insulated Air Dielectric Coaxial Lines

ATTENUATION IN DB/100 FT. (VSWR = 1.75) POWER RATING - WATTS FOR (Outer conductor Temperature Rise of 41°F.)												
Nominal Impedance	70		70		50		50		50		50	
Rigid (R) or Semiflexible (SF)	(SF)		(SF)		(SF)		(SF)		(R)		(R)	
Attenuation (A), Power (P)	A	P	A	P	A	P	A	P	A	P	A	P
Frequency - mc												
1	0.10	300	0.038	2500	0.041							
2	0.15	300	0.055	2500	0.061							
4	0.21	300	0.079	2500	0.085							
8	0.29	300	0.115	2500	0.123							
10	0.33	300	0.128	2500	0.134							
15	0.41	300	0.161	2500	0.165							
30	0.60	300	0.237	2500	0.241	3700	0.201	2200	0.224			
60	0.89	300	0.357	2500	0.350	2700	0.280	2050	0.295		0.162	10,000
100	1.19	300	0.489	1800	0.468	2000	0.369	2000	0.410		0.208	8000
160	1.59	290	0.663	1350	0.630	1500	0.465	1900	0.510		0.265	6500
200	1.82	260	0.767	1100	0.730	1300	0.524	1800	0.580		0.296	5700
400	2.87	170	1.24	690	1.12	840	0.757	1250	0.838		0.409	4000
800	4.60	100	2.10	410			1.11	850	1.24		0.596	2800
900							1.19	790	1.33		0.635	2650
1000							1.28	740	1.40		0.665	2500
2000							2.13	510	2.22		0.964	1400
Impedance Compensated	No		No		No		No		Yes		Yes	
60 Cycle Pk. Voltage Test - KV	2.2		6		6		6		6		11	
Velocity of Prop. - % free space	86.6		91.8		87.2		97.8		99.2		99.8	
Capacitance mafd/foot	16.7		17.37		23.9		19.45					
*Maximum Frequency	1700		738		780		1270		4500		2300	
Dielectric - Material	Steatite		Steatite		Steatite		Teflon		Teflon		Teflon	
- Longitudinal Spacing	1.75 Ins.		4 Ins.		4 Ins.		4 Ins.		10.417		17.14-20	
Outer Conductor - OD inches	0.375		0.875		0.875		0.875		0.875		1.625	
- ID "	0.311		0.795		0.795		0.795		0.785		1.527	
Inner Conductor - OD "	0.0808		0.250		0.3125		0.3125		0.333		0.647	
- ID "	Solid		0.200		0.2625		0.2625		0.2625		0.569	
Minimum Bending Radius - Ins.	6 to 8		12 to 30		12		12		240		-	
Weight - Pounds/100 Feet	16		50 to 60		50		50		62		125	
Standard Length - Feet	100		100		100		100		20		20	
Max. Shipping Length	2000		1000		2000		2000		-		-	
- Without Reel	400		250		250		250		20		20	

* The maximum frequency is the frequency near which bead spacing may have an appreciable effect on impedance and attenuation. In ordering bead insulated lines, the frequency to be transmitted should be specified. This is particularly important for lines used at the higher frequencies.

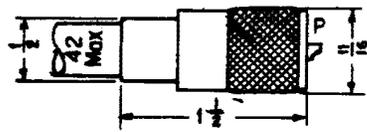
Attenuation in db/100 ft. (VSWR = 1.75)
 Power Rating in Kilowatts For : (Outer Conductor Temperature Rise of 40°F)

Type of Cable	STYROFLEX 3/8-inch		STYROFLEX 7/8-inch		STYROFLEX 1 1/8-inch		STYROFLEX 1 5/8-inch		HELIAX Type HX-0	
	(A)	(P)	(A)	(P)	(A)	(P)	(A)	(P)	(A)	(P)
Attenuation (A), Power (P)	(A)	(P)	(A)	(P)	(A)	(P)	(A)	(P)	(A)	(P)
Frequency in mc										
1	0.11		0.042		0.032		0.022		0.041	
2	0.16		0.060		0.046		0.032		0.052	
4	0.23		0.085		0.065		0.045		0.074	
8	0.32		0.120		0.095		0.065		0.100	
10	0.36	3.60	0.140	15.00	0.10	22.00	0.070	40.2	0.118	2.4
50	0.80	1.60	0.320	6.50	0.24	9.50	0.16	18.0	0.29	1.8
100	1.10	1.15	0.440	4.50	0.34	6.75	0.23	12.5	0.43	1.2
500	2.60	0.50	1.100	1.18	0.82	2.80	0.58	5.0	1.04	.53
1000	3.80	0.34	1.600	1.06	1.20	1.90	0.85	3.4	1.55	.36
2000	5.80	0.24	2.400	0.95	1.90	1.20	1.40	2.2	2.27	
Velocity of Prop.-%free space	91		91		91		91		91.6	
Capacitance mmf/foot	24		22		22		22		-	
60 Cycle PK. Voltage Test - KV	2.2		6.0		8.0		11.0		-	
Nominal Impedance - ohms	50		50		50		50		50	
Outer Conductor - OD inches	0.375		0.875		1.125		1.625		.795	
- ID inches	0.296		0.758		1.007		1.472		1.19	
- Jacketed	0.435		1.015		1.265		1.765		.3125	
Inner Conductor - OD inches	0.112		0.300		0.400		0.591		-	
- Wall	solid		solid		0.051		0.055			
Minimum Bending Radius - Ins.	4		10		17		25		10	
Weight/100ft. in Pounds										
- Plain	10.1		48.4		50.0		91.4		-	
- Jacketed	13.9		57.8		62.0		108.4		49	

Table V - Semi-solid Dielectric Lines

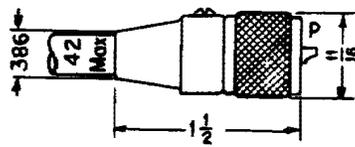
CABLE RG-U NO.	CONNECTORS	
	FIG	
		UHF
	6A	PL-259
	6B	PL-259A
	6B	UG-203/U
	6D	UG-176/U
	6D	UG-175/U
	6C	SO-329
	6E	M-359A
	6G	PL-258
	6F	M-358
	6H	UG-106/U
	6H	UG-177/U
		BCN
	7C	UG-88/U
	7C	UG-260/U
	7D	UG-89/U
	7G	UG-291/U
	7D	UG-261/U
	7G	UG-262/U
	7H	UG-290/U
	7H	UG-447/U
	8A	UG-254A/U
	8C	CW-123/U
	8C	CW-155/U
	8C	CW-159/U
	8D	UG-274/U
	8E	UG-306/U
		BN
	8F	UG-85/U
	8G	UG-114/U
	8H	UG-115/U
	9A	UG-87/U
	9B	UG-206/U
		N
	9C	UG-188/U
	9C	UG-21B/U
	9C	UG-21C/U
	9C	UG-94A/U
	9D	UG-167A/U
	9D	UG-204A/U
	9E	UG-19B/U
	9E	UG-22C/U
	9E	UG-96A/U
	9F	UG-20B/U
	9F	UG-23B/U
	9F	UG-23C/U
	9F	UG-95A/U
	9G	UG-159A/U
	9G	UG-160A/U
	9G	UG-160B/U
	9H	MX-564/U
	10A	UG-58/U
	10A	UG-58A/U
	10C	UG-30/U
	10D	UG-57B/U
	10E	UG-29B/U
	10F	UG-27B/U
	10G	UG-107B/U
	10H	UG-28A/U
	11B	MX-913/U
	11E	PL-274
		HN
	12D	UG-59B/U
	12E	UG-60B/U
	12E	UG-61B/U
	11C	UG-333A/U
	11C	UG-334A/U
	11F	UG-496/U
	12C	UG-212A/U
		AMPHENOL NO
	6H	83-1HP
	7E	83-2AC
	7A	83-21SP
	7A	83-787
	7B	83-21R
	7F	83-21J
		83-151

Table VI - Connector and Cable Combinations



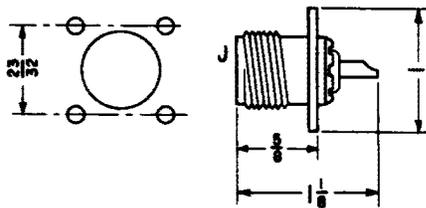
PL-259

A



PL-259A

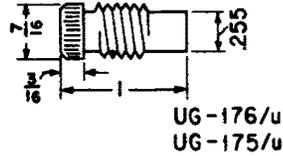
B



Amphenol
83-IR

C

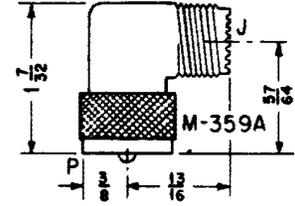
REDUCING ADAPTER
For PL-259



UG-176/u
UG-175/u

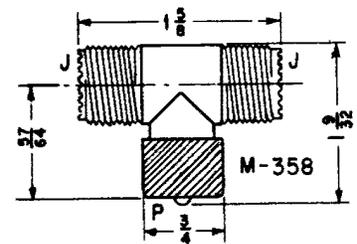
D

ANGLE PLUG ADAPTER



E

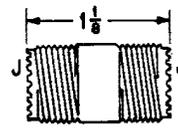
"T" CONNECTOR



P used with
83-IR Receptacle

F

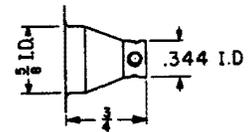
JUNCTION



PL-258

G

HOOD

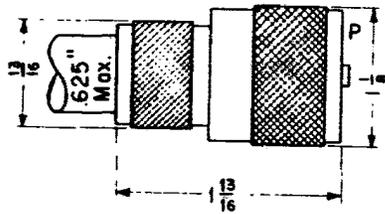


For back of
UG-58A/u-Rec.

TYPE	ID
UG-106/u	.344"
UG-177/u	.145"
83-IHP (Amph)	.360

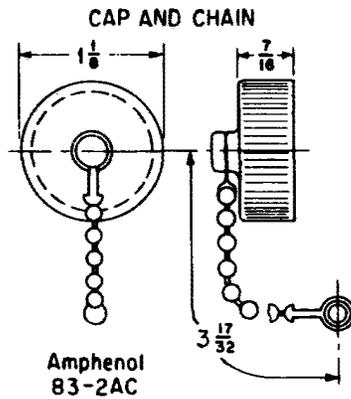
H

SECTION 402-100-100



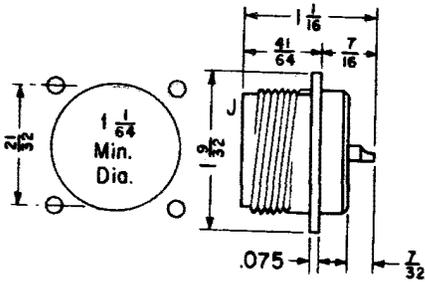
Amphenol
83-21SP
Amphenol
83-787

A



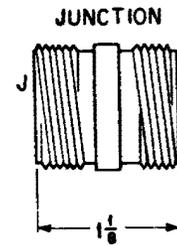
Amphenol
83-2AC

E



Amphenol
83-21R
With 83-2H Hood
For Shielding

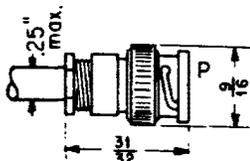
B



Amphenol
83-2W

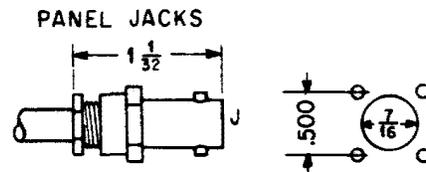
UHF - SERIES CONNECTORS

F



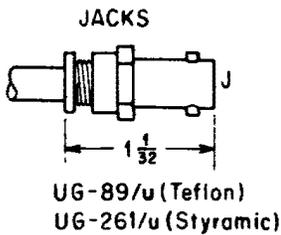
UG-88/u (Teflon)
UG-260/u (Styramic)

C



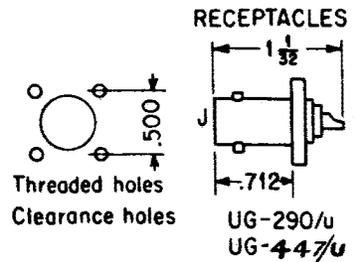
UG-291/u (Teflon)
UG-262/u (Styramic)

G



UG-89/u (Teflon)
UG-261/u (Styramic)

D

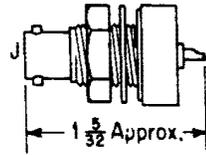


UG-290/u
UG-447/u

H

Fig. 7

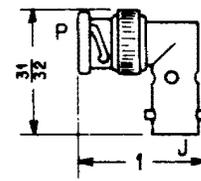
PRESSURIZED RECEPTACLE



UG-254A/u

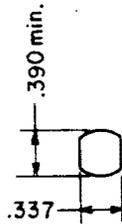
A

ANGLE ADAPTER

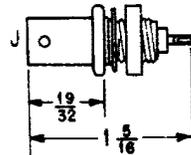


UG-306/u

E

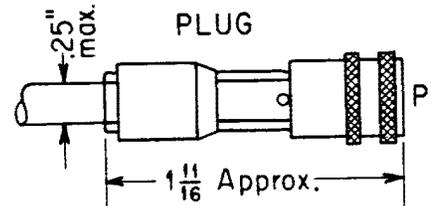


BULKHEAD RECEPTACLE
PRESSURIZED



Amphenol 31-102

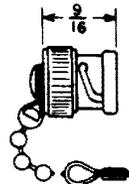
B



UG-85/u

F

CAP AND CHAIN

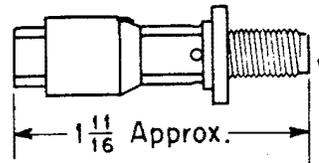


CW-123/u (with chain)
CW-155/u (without chain)

Shorting plug with
chain CW-159/u

C

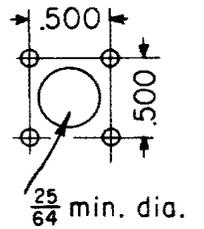
PANEL JACK



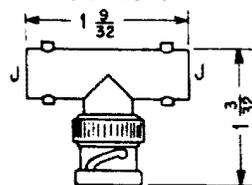
UG-114/u

Mates with UG-85/u plug

G

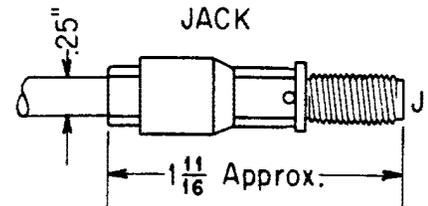


"T" CONNECTOR



UG-274/u

D

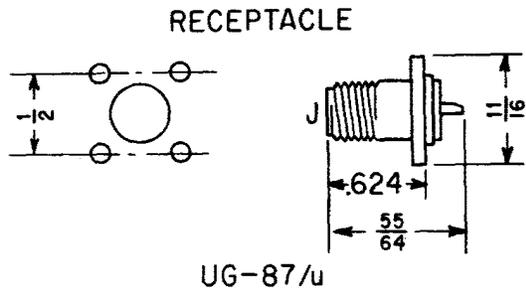


UG-115/u

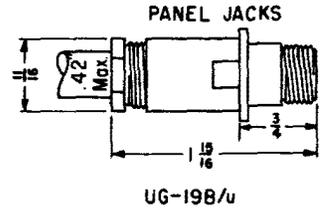
(Used with plug UG-85/u for
joining cables)

H

SECTION 402-100-100



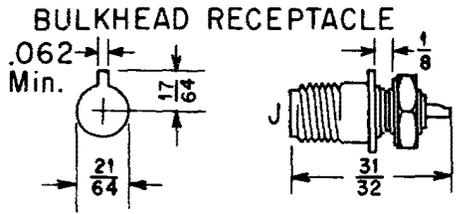
A



UG-22C/u

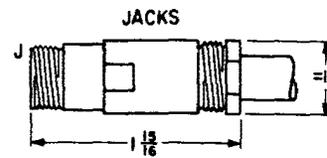
UG-96A/u

E



Used with shield grounding lug such as Amphenol 31-759 for shielded cables

B

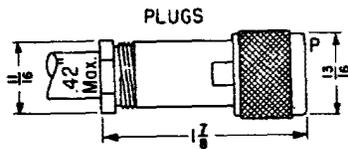


UG-238/u

UG-23C/u

UG-95A/u

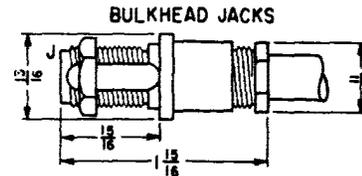
F



UG-21C/u

UG-94A/u

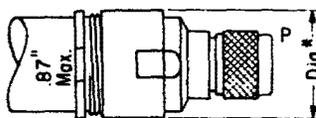
C



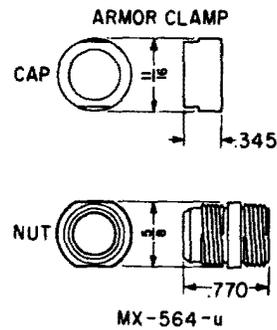
UG-160A/u

UG-160B/u

G



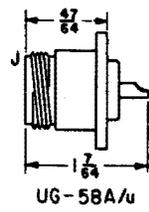
D



H

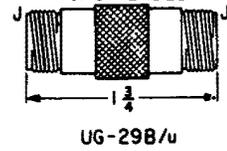
Figure 9

RECEPTACLE

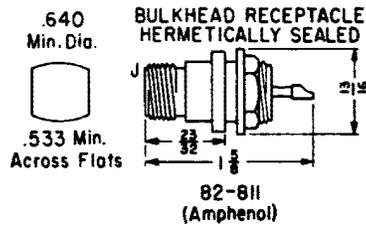


A

STRAIGHT ADAPTERS
JACK ENDED

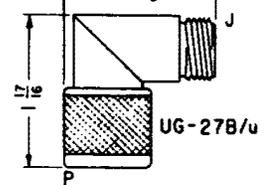


E



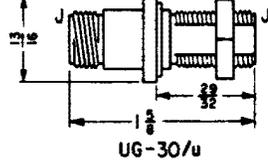
B

ANGLE ADAPTER



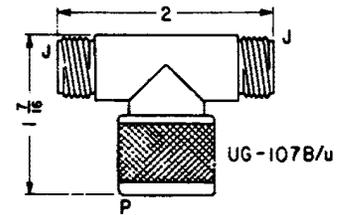
F

BULKHEAD FEED THRU
PRESSURIZED



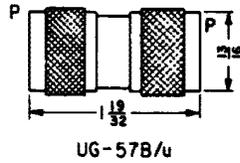
C

"T" ADAPTERS

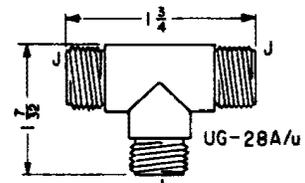


G

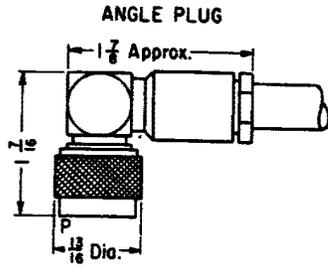
PLUG ENDED



D

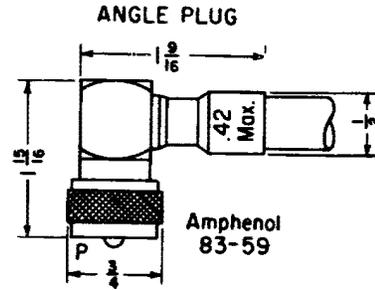


H



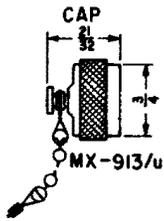
82-835
(Amphenol)

A



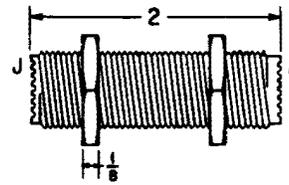
Amphenol
83-59

D



B

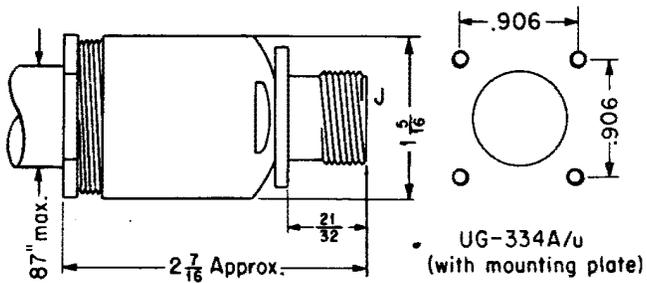
FEED THRU PRESSURIZED
CONNECTOR



PL-274

E

JACKS-LARGE CABLE

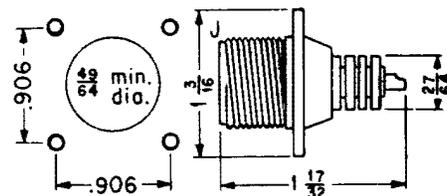


UG-333A/u
(without mounting)

UG-334A/u
(with mounting plate)

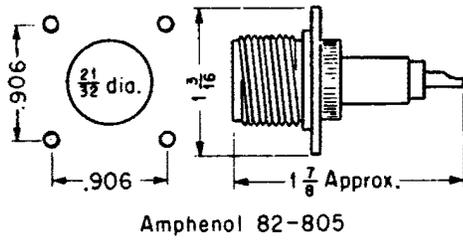
C

PANEL RECEPTACLES

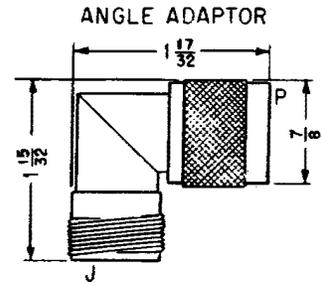


UG-496/u

F

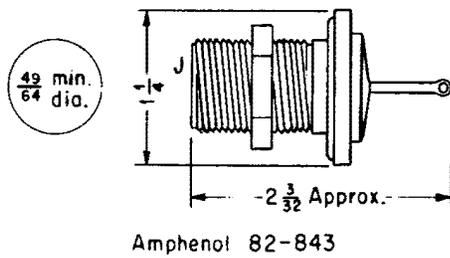


A



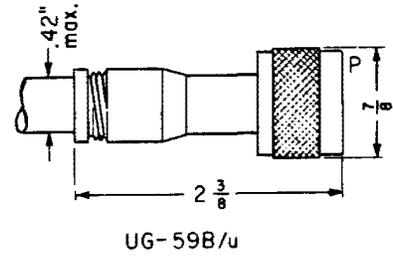
C

HERMETICALLY SEALED

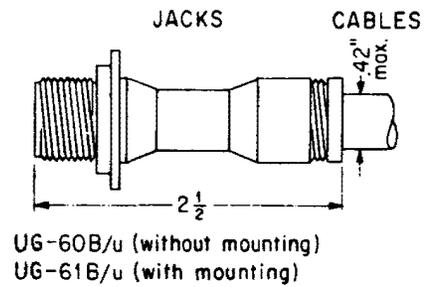
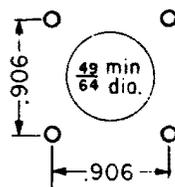


B

PLUGS



D



E

Figure 12