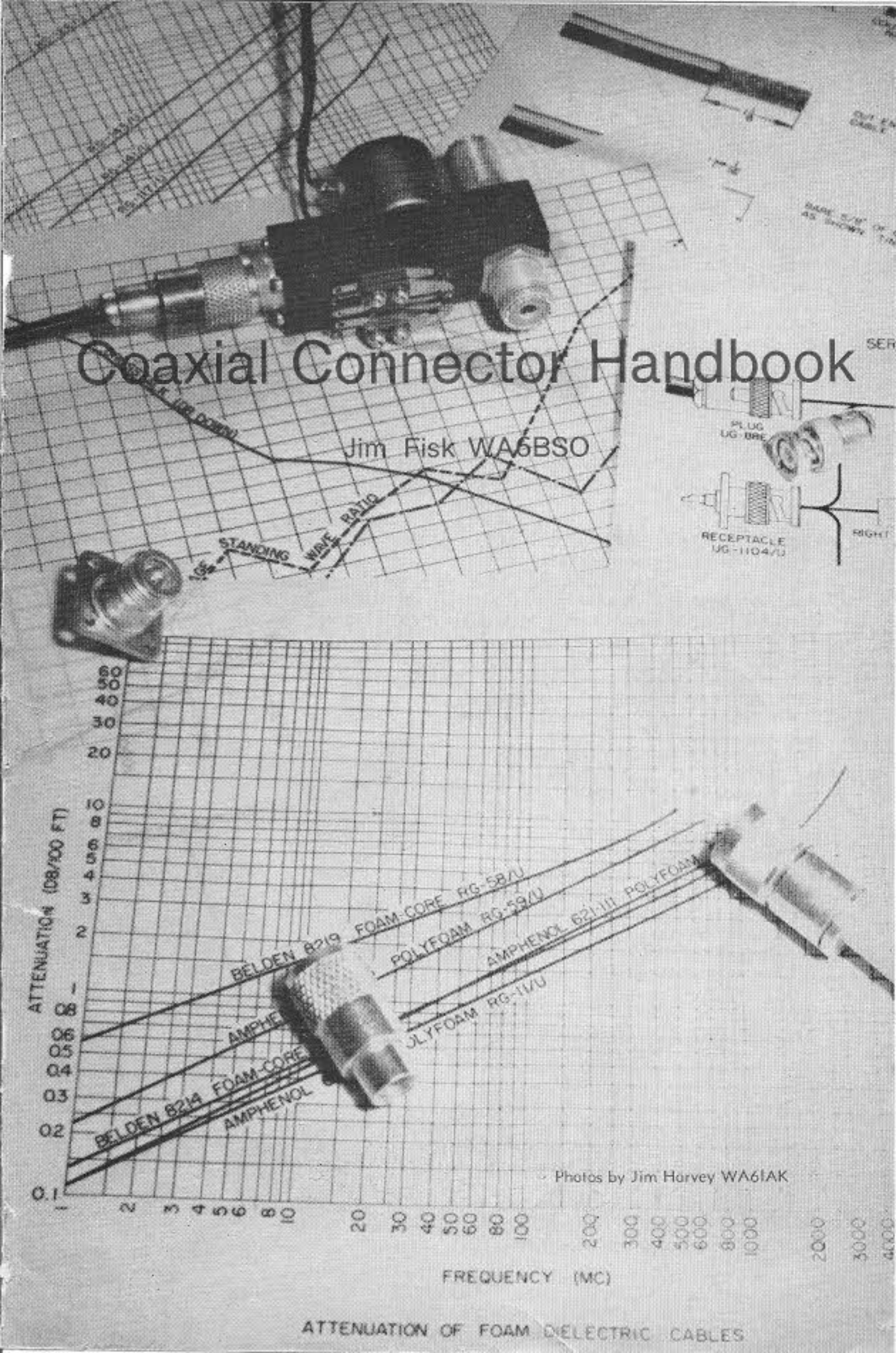
Coaxial Connector Handbook

Jim Fisk WA6BSO



Photos by Jim Harvey WA6IAK

ATTENUATION OF FOAM DIELECTRIC CABLES

Coaxial Connector Handbook

At the lowest audio frequencies and dc, coaxial cable connections consisting of simple solder joints to both conductors are sufficient in many cases. However, as the frequency of operation is increased into the low megacycle range, such connections allow leakage of rf energy and it is necessary to provide 360° contact with the outer conductor to completely contain the conducted electromagnetic field within the confines of the cable. At these frequencies the characteristic impedance of the section of line represented by the inner and outer diameters of the connector is generally not too important; the familiar series UHF connectors or "phono" connectors are illustrative of connectors suitable for these frequencies.

As the frequency of operation is increased beyond 150 mc, it becomes increasingly important that the characteristic impedance of the connector be the same as that of the cable. Also, any physical discontinuities such as the pin diameter of the connector differing from the cable inner conductor diameter must be held to a minimum. Common physical discontinuities such as steps or radial grooves in conductors act like shunt capacitors or series inductors respectively.

The adverse effect of these reactive components increases with frequency; therefore, to maintain a given standard of performance, the physical size of the discontinuities must be effectively made smaller and smaller as frequency is increased. Unfortunately it is not always possible to avoid all discontinuities and at the same time maintain a strong mechanical joint. In those cases where it is impossible to avoid discontinuities in the connector, they are compensated for by deliberately placing another compensating discontinuity in the same vicinity.

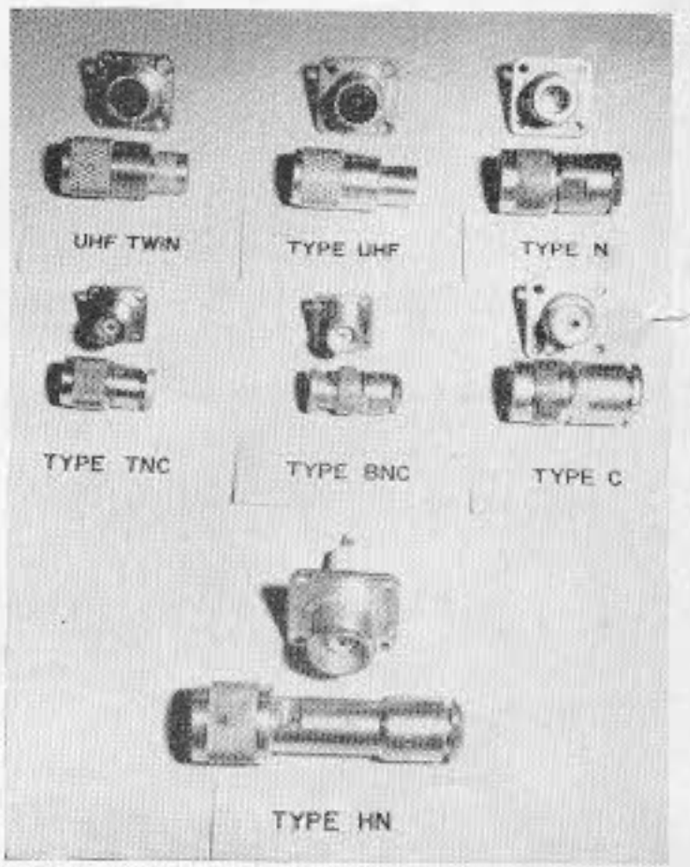
Types of coaxial connectors

Standardization of coaxial connectors has immeasurably aided in the selection and use of these devices. A direct result of this standardization is that a connector made by one manufacturer is directly interchangeable with similar connectors made by any other company.

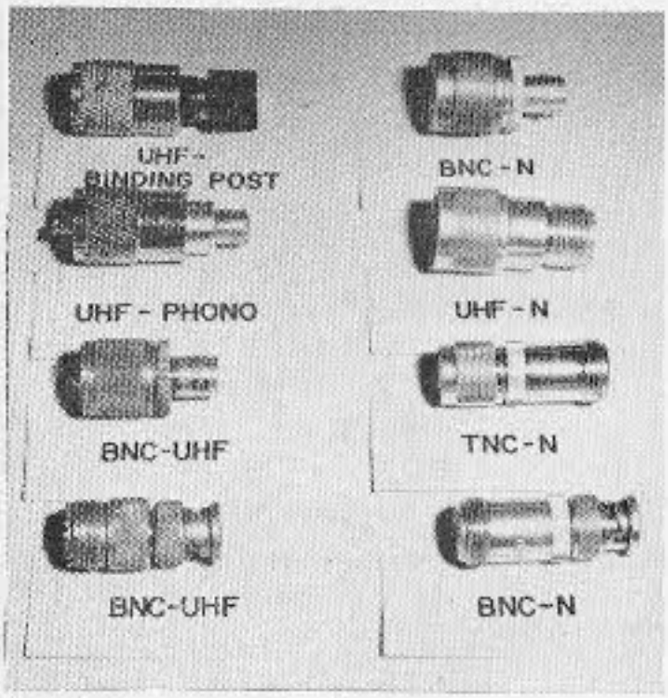
Coaxial connectors may be categorized by the method of coupling and cable size with which they may be used as shown in **Table 1.** Essentially, there are three methods of coupling; threaded, bayonet, and push-on. The five major cable sizes are subminiature, small, medium, medium-large and large. Although the various coaxial connectors were designed specifically for the cable sizes shown in **Table 1,** some types may be used with other cables. The Type N for instance, is available in configurations that are suitable for small, medium, medium-large and large coaxial lines.

Most major types of connectors are available in several different configurations within the series, based upon contact arrangement and cable clamping mechanisms. The three main divisions are "standard," "improved," and "captivated contact."

The "standard" connector employs a sleeve type or grooved silicone gasket which allows metal-to-metal braid clamping. The "improved" type used a "V" groove silicone rubber gasket which also provides metal-to-metal clamping but provides a better grip on the cable with minimum braid deformation and better SWR. In most cases the improved connectors may be used at considerably higher



Various coaxial connectors.



Straight between-series adapters.

frequencies than the standard versions. For example, standard Type N connectors have an upper frequency limit of 3500 mc whereas the improved version may be used to 10,000 mc.

"Captivated contact" connectors were designed to keep the center contact in a fixed position within the connector. This type is recommended for cables using Teflon dielectric and Teflon or fiberglass jackets. These cables, although excellent for high temperature applications, are difficult to use because the inner conductor has a tendency to shift when subjected to rapid environmental changes or mechanical stresses. The technique for captivating the contact provides protection against undesirable equipment disconnections.

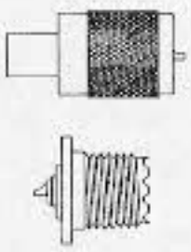
Connectors are also available with clamping devices for subminiature cables and semi-flexible cables such as Phelps Dodge Foamflex. Coaxial connectors are attached to these cables through the use of barbed collets or clamps within the connector. The barbs may be machined into the clamp or a helically grooved sleeve is screwed over a barbed, helically coiled wire wound around the cable. The barbs are embedded in the cable's outer conductor and provide a rigid base for mounting the desired connector.

In addition to these variations, many manufacturers have "polarized" connectors available for the more popular types. These connectors are used to prevent careless or improper connections. The polarization is accomplished by reversing the normal insulation and inner contact assemblies. These connectors will not mate with normal connectors and the selected mating connector must also be polarized.

Two other types of connector construction that are worthy of mention are the crimped and wedged clamping types. The crimped connectors require no soldering and assembly time is reduced as much as 60%. These connectors are often used in large production facilities, and are the least expensive and simplest to assemble of all the connectors that require special tools. Unfortunately, the tools required are quite expensive and the crimped connectors are economical only where large quantities are involved.

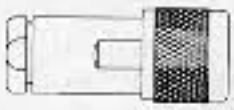
One type of wedged clamping connector available is Automatic Metal Products "Wedge-eze" illustrated in **Fig. 1.** This connector is economical, simple to assemble and does not require special tools for assembly. Another advantage over standard crimp types is that these connectors may be reused whereas the crimp styles are usable only once. In the Wedge-eze connector, the wedge-body assembly is placed over the cable dielectric, forcing the braid and outer jacket up over the conical section of the body. The nylon wedge cap then effectively clamps the braid and jacket to the connector as it is screwed on.

Types of connectors



UHF The UHF series was originally designed for use with medium sized cables such as RG-8/U, but reducing adapters were later introduced to permit usage with smaller cables. These non-constant impedance, non-weatherproof connectors are generally satisfactory for use up to about 200 mc and in some specific non-critical cases up to 500 mc. They may be used at peak voltages up to 500 volts. These connectors are made in two sizes, UHF small which is ⅝ inch in diameter and UHF large, one inch in diameter. Plugs, receptacles and adapters were included in the original design, but jacks were not in demand and were not developed. This series also includes twin contact connectors (both large and small) for use with twin coaxial cables such as RG-22/U.

Although this series is the most common coaxial connector found in amateur equipment, it is no longer approved for use on any new equipment built for the Armed Services. The complete family of UHF (single contact) connectors is illustrated in **Fig. 2.**

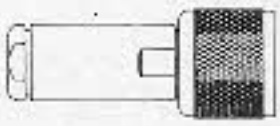


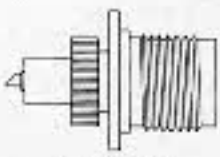
SERIES N

SERIES N Series N connectors are recommended where a medium size, weatherproof connector with a screw type coupling is desired and it is one of the most widely used series of connectors. They are general purpose connectors with constant impedance characteristics and may be used in 50 ohm circuits employing medium sized cables such as RG-8/U. However, when matching requirements are not critical, they may also be used with larger or smaller cables.

The original Series N design used a polystyrene bead as the dielectric material and the connectors were widely used because they were made in 50 ohm, 70 ohm, weatherproof and non-weatherproof varieties. The 50 ohm connectors will not mate with the 70 ohm connectors; however, 50 ohm connectors may be used with 70 ohm coaxial cables where impedance matching is not important. These connectors have a maximum voltage rating of 1500 volts and a practical upper frequency limit of 10,000 mc. They are gasketed for weatherproof operation and are available with various types of metal-to-metal clamping devices.

The complete family of type N connectors is shown in **Fig. 3.** This drawing rather graphically illustrates the versatility of this series with the many configurations available.





SERIES HN

SERIES HN Series HN connectors are medium-large weatherproof connectors for the same size cable as series N. The difference being that the dielectric material is tapered to permit their use at higher voltages. The latest version of these connectors employs a step design in lieu of tapering the cable dielectric. These connectors have a nominal impedance of 50 ohms, screw-type coupling and metal-to-metal braid clamping in standard, improved and captivated contact types.

Series HN connectors were originally designed for use in high voltage applications up to 5000 volts peak; however, results of tests conducted by the U. S. Navy indicate that at rf frequencies, the voltage characteristics of the HN connectors are no better than those of the C or N series. Consequently, HN connectors should be used for replacement purposes only.

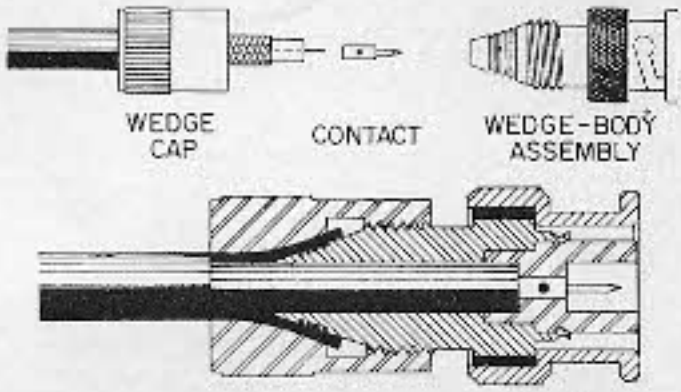
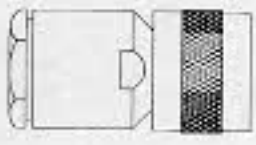
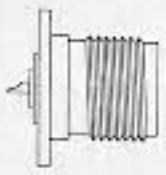


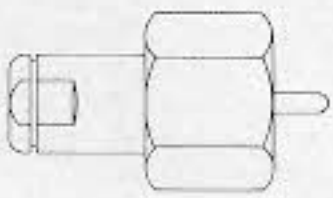
Fig. 1. Typical Wedge-eze construction.

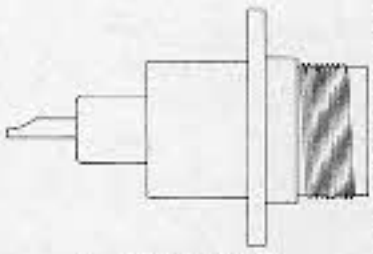




SERIES LN

SERIES LN The series LN connectors are essentially nothing more than an oversized "N" connector originally used with the larger rf cables such as RG-14, -74, and -94/U. These weatherproof connectors have a nominal impedance of 50 ohms and an approximate peak voltage rating of 1000 volts. This series has been replaced by two plugs, UG-204A/U in the N series and UG-494/U in the HN series. Consequently, very few LN connectors are found in present day equipment.





SERIES LC-LT

SERIES LC-LT LC connectors are large-size weatherproof, 50 ohm connectors for RG-17, -18, -19 or -20/U coaxial cables employing screw-type coupling. They are intended for high power rf transmission up to 1000 mc. A jack was not originally designed for this series and it wasn't until the early 1950's that one was introduced.

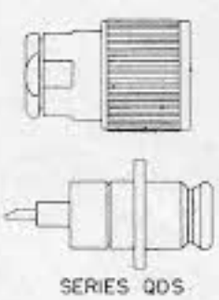
Two groups of LC connectors are available; group LC-1 which will withstand peak voltages of 500 volts and the slightly larger LC-2 which will withstand voltages in excess of 10,000 volts. Where it is desired to operate

	THREADED COUPLING				BAYONET COUPLING				PUSH-ON COUPLING			
Cable Size	Type	Thread	Imped-ance (ohms)	Max Freq (mc)	Type	Coupling	Imped-ance (ohms)	Max Freq (mc)	Type	Coupling	Imped-ance (ohms)	Max Freq (mc)
Sub-miniature	SM	¼ X 32	50	1000	TPS	3 prong	50	10000				
Small	BN	⅜ X 32	50	200	BNC	2 prong	50	10000	Phono	Not Detented	Not Matched	200
	TNC	7/16 X 28	50	10000	MHV	3 prong	50	50				
	SKL	⅜ X 32	50	—								
Medium	N	⅝ X 24	50	10000	C	2 prong	50	10000	QDS	Ball Detent	50	10000
	UHF (Single)	⅝ X 24	Not Matched	200								
	UHF (Twin)	⅝ X 24	Not Matched	200								
	SC	11/16 X 24	50	10000								
Medium-Large	UHF (Single)	1 X 20	Not Matched	200								
	UHF (Twin)	1 X 20	Not Matched	200								
	LN	¾ X 27	50	1000								
	HN	¾ X 20	50	3500								
Large	LC-1	1¼ X 18	50	1000					QDL	Ball Detent	50	1000
	LC-2	1¾ X 16	50	1000								
	LT	1¼ X 18	50	2500								

Table 1. Coaxial connectors charted by cable size and coupling method.

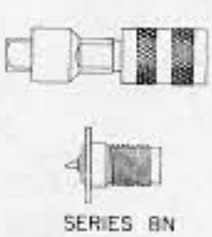
the LC series as a low voltage connector, the cable dielectric is butted flush against the dielectric in the mating connector. For high voltage applications, a counterboring operation is performed on the end of the cable dielectric with a special tool. Ignition sealing compound, such as Dow-Corning No. 4 should always be used on the faces of the dielectric mating parts of these connectors.

LT series connectors are actually an extension of the LC series designed to accept RG-117 and -118/U size cables. They have been improved greatly by specialized design, and several models are now manufactured for use at elevated frequencies. It should be noted that the LT series is similar to but not interchangeable with the LC series; an adapter is available which allows connection of this series to the LC series.



SERIES QDS

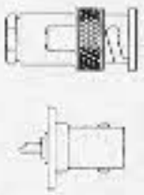
SERIES QDS The QDS series of connectors is an advanced version of the QDL series which was designed primarily for use aboard submarines to replace the LC series. This series uses a "push-pull" locking ball coupling arrangement similar to that found on air line hoses. This arrangement reduces coupling-decoupling time considerably. The QDS series are weatherproof, 50 ohm connectors for use with medium sized coaxial cables such as RG-8/U. These connectors are rapidly connected and disconnected and overcome the "rocking" tendency found in the bayonet type C and BNC series. QDS connectors employ an improved metal-to-metal cable clamping mechanism that provides a practical upper frequency limit of 10,000 mc.



SERIES BN

SERIES BN BN series connectors are small, lightweight connectors designed for use with small cables such as RG-58 and -59/U. Actually, they might be called small-size "N" connectors. They may be used for video, *if*, and other low power rf applications. These connectors are not electrically matched or weatherproof, and therefore are not recommended for applications at frequencies in excess of approximately 200 mc unless the electrical requirements of the circuit are not critical. They may be used at peak voltages up to 250 volts. Since the advent of the BNC

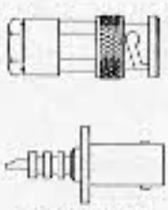
connector, their use has been virtually eliminated except for replacement purposes on very old equipment.


SERIES BNC

SERIES BNC This small connector design is probably the best known series in use at the present time. It was the first reliable quick connect and disconnect series; all the other connectors in early use used screw coupling. The bayonet coupling permitted rapid connections to be made and as such they made a tremendous hit in the test equipment field. These connectors are similar in size to the BN series but electrically they are greatly improved; original designs showed them to have an SWR of 1.15 from 1 to 3000 mc.

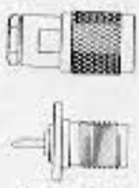
BNC connectors are of constant impedance with a nominal value of 50 ohms, and introduce little discontinuity in 50 ohm coaxial circuits employing small cables such as RG-58/U. Where some electrical mismatch is allowable, they may be used with other small and medium sized cables.

These connectors are fully weatherproofed and rated for use where the maximum voltage does not exceed 500 volts. They are available in standard, improved and captivated contact clamping arrangements. The improved connectors have been redesigned to give low standing wave ratios up to 10,000 mc in 50 ohm circuits. They are available with Teflon insulators which allow high temperature operation, and feature heat-treated beryllium copper spring fingers for both inner and outer contacts. There connectors are also available in polarized and pressurized versions.


SERIES MHV

SERIES MHV MHV series connectors are miniature high voltage connectors employing a bayonet-lock coupling similar to the BNC series. They are designed for small cables such as RG-58/U, and may be used at frequencies up to 50 mc. They may be used at peak voltages up to 5000 volts with a maximum current rating of 5 amps.

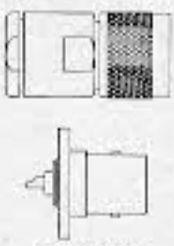
These connectors are similar to, but will not mate with, the series BNC connectors. They are weatherproofed with silicone rubber gaskets and feature the same metal-to-metal cable clamping mechanism used in the improved BNC series.


SERIES TNC

SERIES TNC Where in previous years great emphasis was put on ease of connection, the advent of high speed aircraft and missiles with their inherently stringent environmental requirements forced a return to the more positive vibration-proof threaded coupling. As a result the TNC series was created. Originally merely a threaded version of the BNC series prescribed for moderate frequency applications, increased usage at elevated frequencies through 10,000 mc has required manufacturing techniques far beyond those originally required for the BNC series.

The threaded coupling and safety wire provisions of the TNC series insure locking and secure mating under the most severe conditions of vibration and shock. Heat-treated beryllium copper spring fingers are used for both inner and outer contacts, thus providing positive contact during vibration and a substantial reduction in noise level.

These connectors are rated at 500 volts and have been designed to give low standing wave ratios at frequencies up to 10,000 mc in 50 ohm circuits. They feature clamping of the improved BNC type and are gasketed for weatherproof operation. Normally the TNC series is not used except in the stringent environmental conditions encountered in high speed aircraft or missiles.


SERIES C

SERIES C When originally designed the C series represented a big step forward in electrical performance at the higher frequencies. These connectors are for use with the same size cables as the N series but employ the mechanical advantage of bayonet coupling. This series introduced the new improved cable clamping mechanism wherein the cable gasket is actually cut when the clamp nut is tightened. This action gives good electrical contact for the cable shield and improves cable retention.

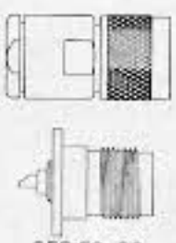
The C series is recommended where fast connection and disconnection by means of the bayonet lock coupling is required. For these purposes, this series is ideal. They are of constant impedance and may be used with minimum mismatch in 50 ohm circuits employing medium size cables such as RG-8/U. However, where matching requirements are not critical, they may also be used with either

Description					Military Number	Engineering Data
BNC	Female	to	C	Male	UG-636A/U	
BNC	Female	to	HN	Male	UG309/U	
BNC	Female	to	N	Male	UG-201A/U	
BNC	Female	to	N	Female	UG-606/U	
BNC	Female	to	QDS	Male	UG-1146/U	
BNC	Female	to	SM	Female	UG-690/U	Not Weatherproof
BNC	Female	to	SM	Male	UG-691/U	Pressurized
BNC	Female	to	UHF	Female	UG-255/U	Not Weatherproof
BNC	Female	to	UHF	Male	UG-273/U	Not Weatherproof
BNC	Female	to	Banana Jacks		UG-1035/U	
BNC	Male	to	C	Female	UG-635/U	
BNC	Male	to	HN	Female	UG-559B/U	Right Angle
BNC	Male	to	N	Female	UG-335/U	Flange Mounting
BNC	Male	to	N	Female	UG-349B/U	
BNC	Male	to	N	Male	UG-1034/U	Not Weatherproof
BNC	Male	to	QDS	Female	UG-1136/U	
BNC	Male	to	Banana Jacks		UG-978/U	
BNC	Male	to	Banana Plugs		UG-987/U	
BNC	Male	to	Binding Post		UG-282/U	
N	Female	to	BN	Male	UG-605/U	
N	Female	to	BNC	Female	UG-606/U	
N	Female	to	BNC	Male	UG-335/U	Flange Mounting
N	Female	to	BNC	Male	UG-349B/U	
N	Female	to	C	Male	UG-565/U	
N	Female	to	HN	Female	UG-1107/U	
N	Female	to	HN	Male	UG-1108/U	
N	Female	to	LC	Male	UG-999A/U	
N	Female	to	LN	Female	UG-108A/U	
N	Female	to	QDS	Male	UG-1144/U	
N	Female	to	UHF	Male	UG-83B/U	Not Weatherproof
N	Male	to	BNC	Female	UG-201A/U	
N	Male	to	BNC	Male	UG-1034/U	Not Weatherproof
N	Male	to	C	Female	UG-564/U	
N	Male	to	LN	Male	UG-213A/U	
N	Male	to	QDS	Female	UG-966/U	
N	Male	to	UHF	Female	UG-318/U	Not Weatherproof
N	Male	to	UHF	Male	UG-146A/U	Not Weatherproof
UHF	Female	to	BN	Male	UG-241/U	Not Weatherproof
UHF	Female	to	BNC	Female	UG-255/U	Not Weatherproof
UHF	Female	to	N	Male	UG-146A/U	Not Weatherproof
UHF	Female	to	Twin	Male	UG-970/U	Right Angle
UHF	Female	to	Banana Jack		UG-1017/U	
UHF	Female	to	Brittish 10H588		UG-197/U	
UHF	Male	to	BNC	Female	UG-273/U	Not Weatherproof
UHF	Male	to	C	Female	UG-637/U	Not Weatherproof
UHF	Male	to	N	Female	UG-83B/U	Not Weatherproof
UHF	Male	to	N	Male	UG-318/U	Not Weatherproof
UHF	Male	to	Binding Post		UG-332/U	
UHF	Male	to	British 10H365		UG-171/U	

Table 2. Coaxial connector guide adapters between different series.

larger or smaller cables.

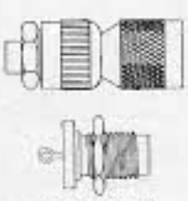
These weatherproof connectors have a maximum peak voltage rating of 1500 volts and a practical frequency limit of 10,000 mc. There is a high voltage version made for use up to 4000 volts peak, but this connector should not be used in applications above 2000 mc.



SERIES SC

SERIES SC SC Connectors are a threaded coupling version of the C series and represent an upgrading of the C connectors similar to the BNC-TNC improvement. The threaded coupling and safety wire provisions insure locking and secure mating under the most extreme conditions of vibration and shock.

This series has a maximum peak voltage rating of 1500 volts and provides low standing wave ratios at frequencies up to 10,000 mc in 50 ohm circuits. Like the TNC series, these connectors are not ordinarily used except under the stringent environmental conditions found in high speed aircraft and missiles.



SERIES SM

SERIES SM This series was designed for use inside equipment which does not require the weatherproof features found in present connectors. They employ the screw type design similar to the old BN series and in some ways could be called improved BN connectors. They were developed to fulfill the

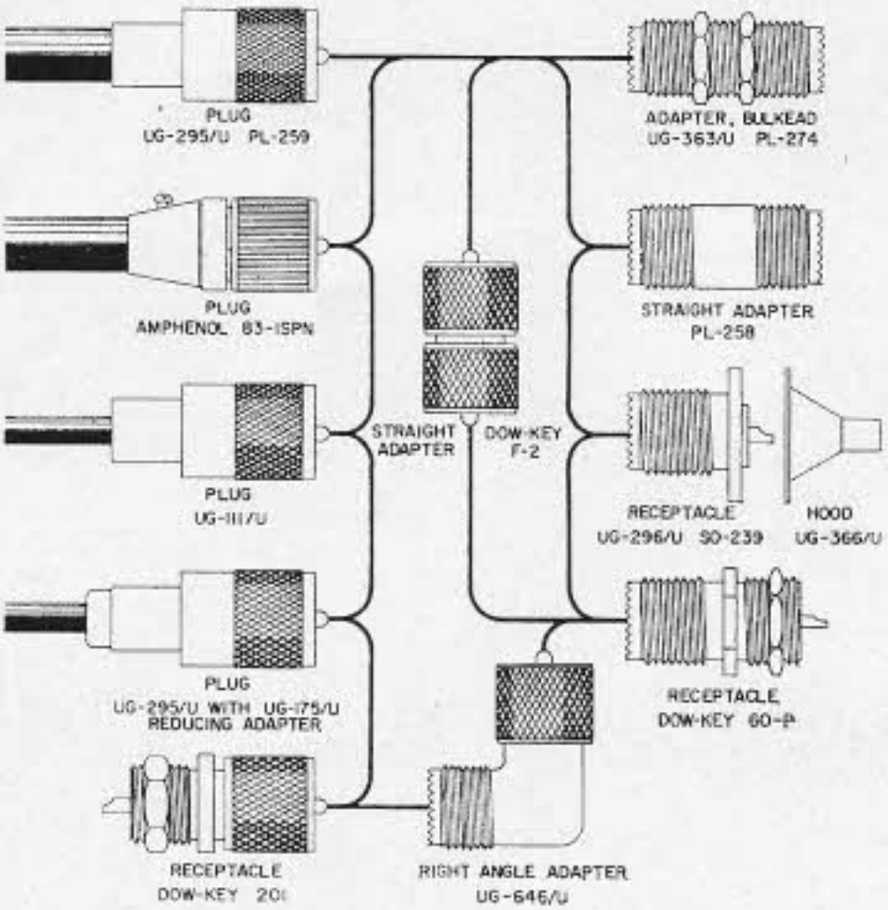
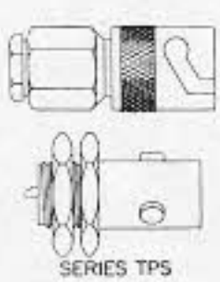


Fig. 2. UHF connector family.

need for a small rf fitting for use with coaxial cables of ¼ inch overall diameter and smaller. They should not be used where electrical matching is required.

SM connectors are considerably smaller and contain fewer parts than the BNC series; for simplicity of design, they employ a female contact on the plug and a male contact on the jack and receptacle. The SM series has the advantage of positive braid clamping and does not use the inner conductor of the cable as the center contact. These connectors are not intended to replace the BNC series except for internal equipment connections where weatherproofness is not required. Its useful range is presently limited to frequencies below 1000 mc and peak voltages below 100 volts.



SERIES TPS A recent development of the Signal Corps, this three-pronged bayonet coupled series is slightly smaller than the BNC series and larger than the SM series. These connectors are weatherproof and produce minimum electrical discontinuities in small size solid dielectric 50 ohm coaxial cables up to 10,000 mc. They are rated at 1500 volts RMS at sea level. The method of cable clamping is a wedge type device that when used with RG-59/U type cables, provides a minimum cable retention of 45 pounds.

SUBMINIATURE Because of the tremendous number of subminiature connectors manufactured by the various connector companies, it is impossible to cover all of them here. The inset drawing is just representative of the many varieties available. The majority of these connectors are recommended for use in test equipment, video leads, communications receivers, *if* and rf circuits or wherever miniaturization is a factor. In fact, several manufacturers have printed circuit models of receptacles and terminations.

Subminiature connectors are available in threaded, bayonet, push-on and snap on versions with nominal impedances of 50, 75 and 93 ohms. Some units are weatherproof and various sizes are made to accommodate cables to ¼ inch in diameter. Because of their small

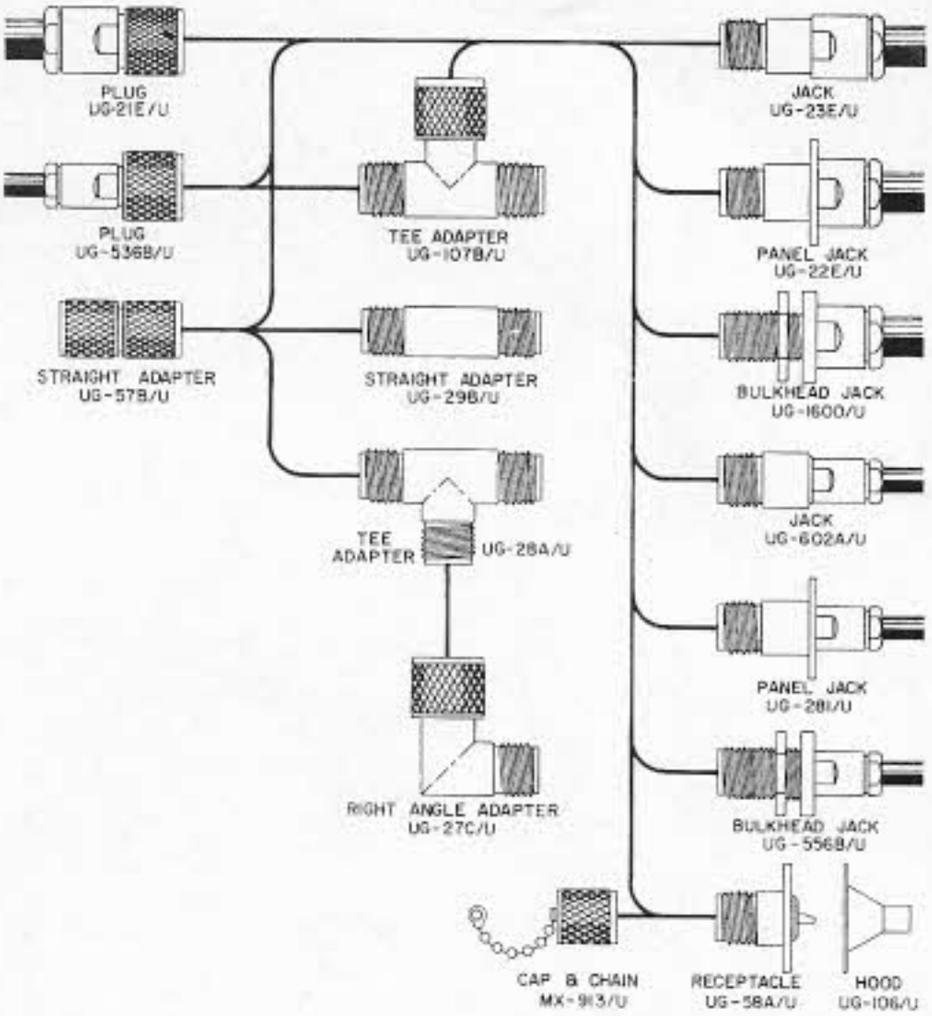
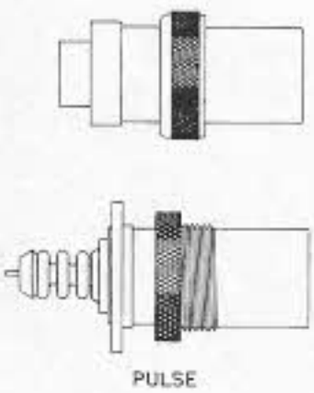
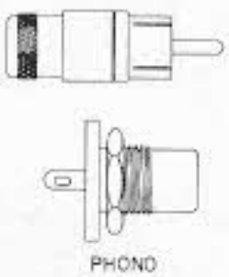


Fig. 3. Series N connector family.

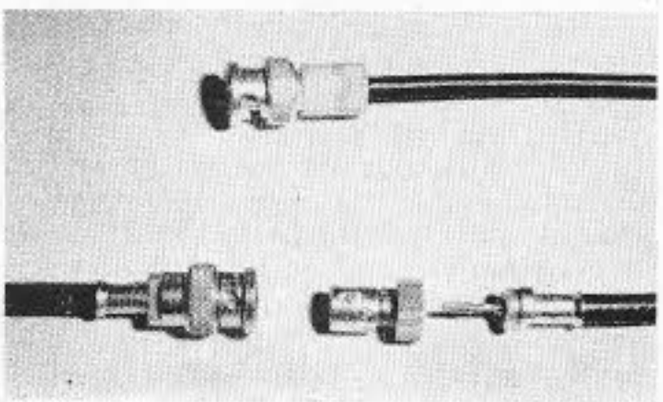
size, many of these connectors are usable up to 3000 mc. Typical of these connectors are the Sub Minax series by Amphenol, the BSM and MTM series by Automatic Metal Products and the OSM connector made by Omni Spectra, Inc.



PULSE Several varieties of connectors have been developed for high voltage pulse applications, particularly for radar. The pulse connectors with ceramic inserts are divided into two groups known as types A and B. The Pulse A connectors are widely used on U. S. Navy aircraft and at high altitudes they occasionally arc across the ceramic dielectric. However, as soon as the voltage stress is removed, they are again usable. The chief difficulty of the Pulse A connector is that inadequate bonding between mating connectors creates excessive noise when used near communications equipment. Pulse B connectors are considered standard for shipboard and ground equipment and may be used up to 15,000 volts peak. The Pulse B connectors also suffer from the tendency to leak noise.



PHONO Phono connectors were originally designed for interconnection of shielded audio cables, but modern versions with nylon and ceramic insulation are suitable for low-power rf applications. These connectors are somewhat limited in use,



Labor saving coax connectors. In the front is a crimped type. An automatic Metal Products "Wedge-eze" is in the rear.

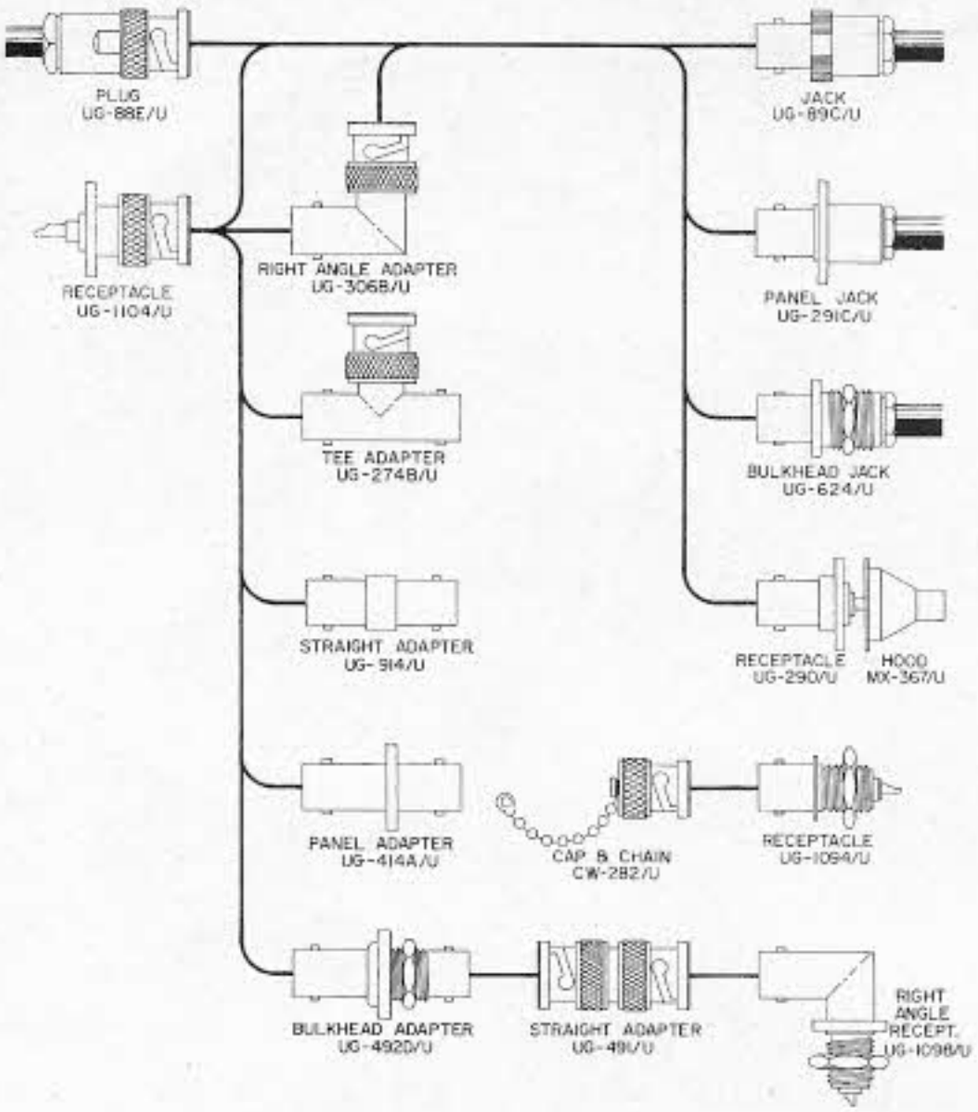


Fig. 4. Series BNC connector family.

but are economical, easy to assemble and provide a simple method for interconnection of receivers, VFO's, *if* strips, and other low-power equipment. These connectors do not provide 360° contact with the cable braid so there is some radiation loss at frequencies above one megacycle. They are not moisture-proofed and are intended only for indoor applications. Photo connectors have been used to a limited extent up to 150 mc, but the BNC, N or even UHF series do a better job and should be used instead of the photo connector in all but the least critical areas.

SERIES QL and QM (Not illustrated) These connectors are a recent development of the Signal Corps which feature a quick lead thread and are intended for high power, high voltage, low SWR connections with large size coaxial cables such as RG-217, -218, -219, -220, and -221/U where LC, LT, C and N connectors have been used in the past. These connectors provide a maximum SWR of 1.27:1 in mated pairs of cable assemblies up to 5000 mc.

SERIES SKL (Not illustrated) This type connector was originally designed to provide connections to klystron tubes, and various modifications were subsequently added to provide general-purpose cable to cable connections. Unfortunately, some of these connectors are still in use today even though the BNC would do a much better job. Furthermore, existing standard types such as the BNC and N perform the same function and are more generally available than the SKL series.

Special connectors

There are several special types of coaxial connectors and adapters that should be mentioned. Perhaps the most important of these are the between series adapters. These adapters provide an efficient electrical and mechanical transition between two different rf series. They are of non-constant impedance, but are designed so that the inherent electrical discontinuities are minimized. Although the straight adapter is the most common, other configurations are available to satisfy nearly any requirement; from straight and bulkhead adapters to angles, crosses and tees. A complete listing of between series adapters

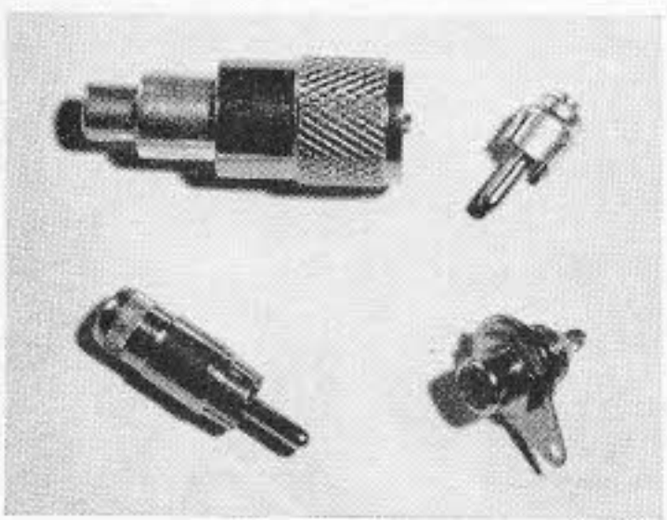
for BNC, N and UHF to other types is listed in **Table 2.**

Transitions and splices

Terminations or end seals are a very helpful class of connector not normally encountered by amateurs. These devices provide a convenient, mechanical method for securing the end of a coaxial cable. A neat, connector-type braid clamp grounds the braid to the chassis terminal and allows the cable dielectric and inner conductor to extend for any convenient length for direct connection to a component. A variety of mounting arrangements are available as shown in **Fig. 5.** BNC or N connector techniques are employed in the assembly of these units.

Cable end seals are usually used in one of two ways; either as a termination or for strain relief. The termination is designed so that the jacket and braid of the cable are clamped within the body of the connector, while the dielectric and inner conductor are allowed to continue through. The strain relief variety is used for support only and the entire cable is allowed to continue through the body of the connector.

Cable splices are another class of connector which is not too familiar. These special connectors provide a convenient and neat workmanship method of joining two, three or four coaxial cables with a minimum of impedance mismatch. Splices are available in three basic configurations: tee, cross and transition as shown in **Fig. 6.** The tee and cross versions provide an efficient junction point for three or four cables and are especially useful in antenna phasing assemblies or similar applications. They may be used for continuation of the cable shielding or for inserting instruments in the circuit. They are also used for locating resistors and other components within the splice, or simply to save time and work in the repair of defective coaxial cable. The transitions may be used for splicing two similar or dissimilar cables. Normally the tees and crosses are gasketed for weatherproof operation while the transitions are non-weatherproof.



Phono connectors. Clockwise from upper left: phono to series UHF adapter, cable plug, chassis receptacle and improved cable plug.

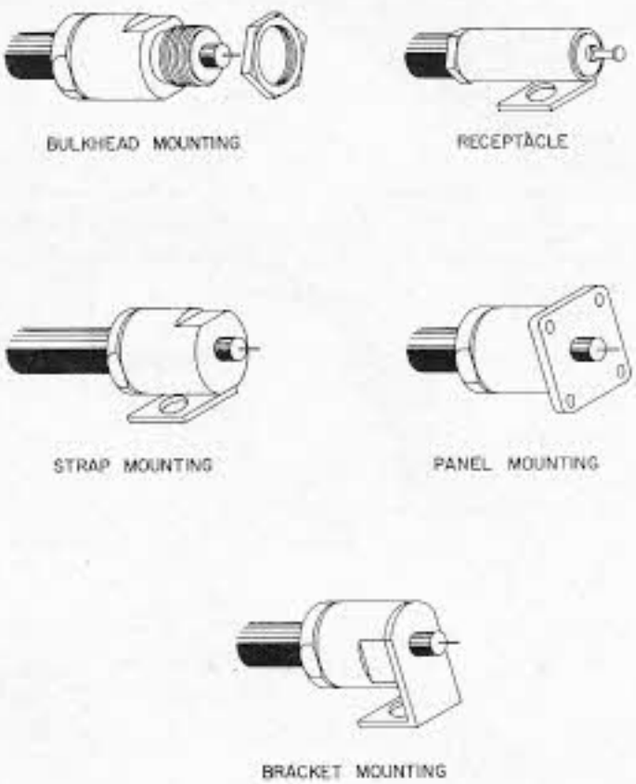


Fig. 5. Terminations.

Coaxial connector selection

Because of their importance in high frequency connector work, a considerable amount of experimental data on coaxial cable discontinuities has been accumulated and rather

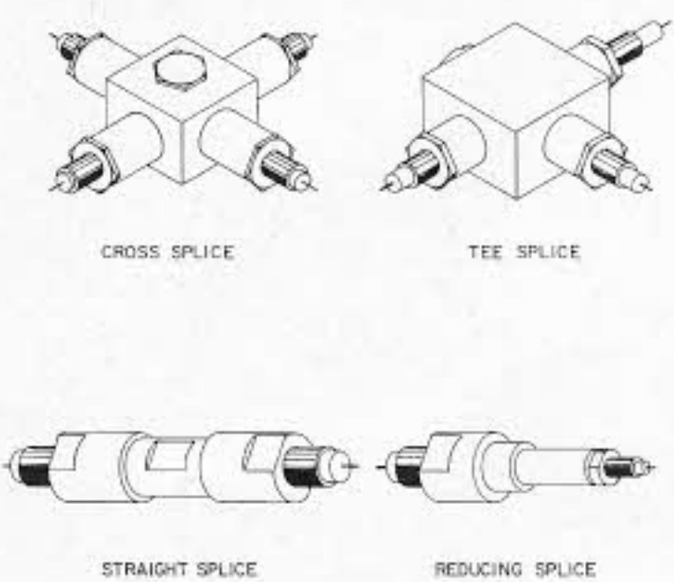


Fig. 6. Coaxial cable splicing hardware.

For RG/U Cables	Plug	Jack	Panel Jack	Bulkhead Jack	Hood	Engineering Data
RG-8/U	UG-959/U	—	—	—	—	
RG-58/U	UG-88E/U	UG-89C/U	UG-291/U	UG-909B/U	MX-195A/U	
RG-59/U	UG-260D/U	UG-261C/U	UG-262/U	UG-910B/U	MX-195A/U	Non-constant impedance
RG-122/U	UG-1082/U	UG-1056/U	UG-1055/U	—	MX-195A/U	

Table 3A. Coaxial connector selection guide for BNC series.

For RG/U Cables	Plug	Jack	Panel Jack	Bulkhead Jack	Hood	Engineering Data
RG-5/U	UG-626B/U	UG-633A/U	UG-629A/U	UG-630A/U	UG-570A/U	
RG-8/U	UG-573B/U	UG-572A/U	UG-571A/U	UG-937A/U	UG-570A/U	
RG-11/U	UG-573B/U	UG-572A/U	UG-571A/U	UG-937A/U	MX-1144/U	Impedance Mismatched
RG-17&U	UG-708B/U	—	—	—	—	
RG-58/U	UG-709B/U	—	—	—	MX-1870/U	
RG-59/U	UG-627B&U	—	—	—	MX-1870/U	

Table 4A. Coaxial connector selection guide for series C.

sophisticated matching techniques have been used by the connector manufacturers to produce connectors having high electrical and mechanical qualities for almost every coaxial cable in common use.

The large variety of connectors and cables, each designed to fit a specific need, and the almost infinite number of combinations available from them, indicates that the problem of selecting the proper connector is unique to the type of service required. Essentially, the selection of a cable connector boils down to the same requirements as the selection of the transmission line; i.e. SWR, attenuation, mechanical strength, and power and voltage limits. Since the desired operating requirements usually contain some conflicting requirements, such as long cable length and low attenuation, the most successful approach is very often to find the best compromise in available cables and connectors to fit the specific application.

One of the best criteria on which to base connector selection is that of the standing wave ratio at the frequency of operation. Fig. 7 charts the nominal standing wave ratio

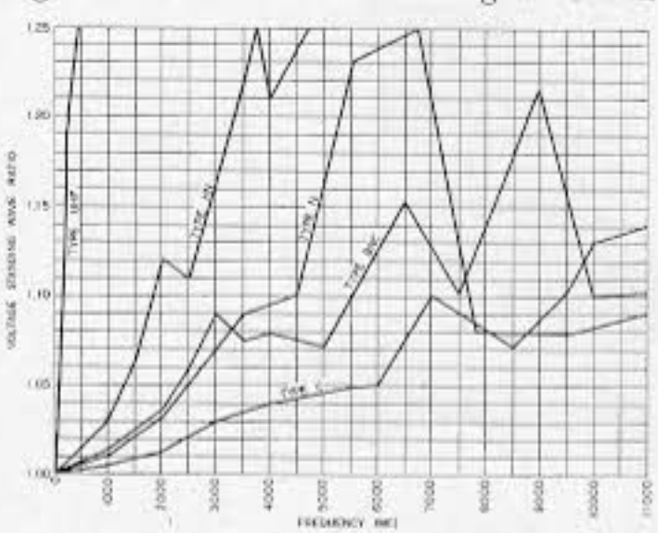


Fig. 7. Typical coaxial connector VSWR.

Description	Military Number	Engineering Data
Adapter, Binding Post	UG-282/U	
Adapter, Bulkhead (F-F)	UG-492D/U	Pressurized
Adapter, Feedthrough (F-F)	UG-914/U	
Adapter, Feedthrough (F-F)	UG-414A/U	Flange Mounting
Adapter, Right Angle (M-F)	UG-306B/U	
Adapter, Straight (M-M)	UG-491B/U	
Adapter, Tee (M-M-F)	UG-274B/U	
Cap and Chain (F)	CW-282/U	
Cap and Chain (M)	CW-123A/U	
Receptacle	UG-185/U	Flange Mounted
Receptacle	UG-290A/U	Teflon Insulation
Receptacle	UG-928/U	Rexolite Insulation
Receptacle, Bulkhead	UG-1094A/U	3/8" Thread Mounting
Receptacle, Male	UG-1104/U	3/8" Thread Mounting
Receptacle, Pressurized	UG-912A/U	7/16" Thread Mounting
Receptacle, Pressurized	UG-625B/U	1/2" Thread Mounting
Receptacle, Pressurized	UG-911A/U	Flange Mounted
Rectptacle, Right Angle	UG-535/U	3/8" Thread
Rectptacle, Right Angle	UG-1098A/U	Mounting

Table 3B. Miscellaneous series BNC connectors.

Description	Military Number	Engineering Data
Adapter, Bulkhead (F-F)	UG-701/U	Pressurized
Adapter, Bulkhead (F-F)	UG-1138/U	
Adapter, Right Angle (M-F)	UG-567A/U	
Adapter, Straight (F-F)	UG-643/U	
Adapter, Straight (M-M)	UG-642A/U	
Adapter, Tee (F-M-F)	UG-566A/U	
Cap and Chain (M)	UG-1142/U	
Cap and Chain (F)	UG-1143/U	
Receptacle, Bulkhead	UG-569/U	3/4" Thread Mounting
Receptacle, Bulkhead	UG-705/U	Presusrized
Receptacle, Panel	UG-568/U	

Table 4B. Miscellaneous series C connectors.

For RG/U Cables	Plug	Jack	Panel Jack	Bulkhead Jack	Hood	Engineering Data
RG-5/U	UG-18D/U	UG-20D/U	UG-19D/U	UG-159C/U	UG-106/U	70 Ohm Connectors Improved Type Captivated Contacts 70 Ohm Connectors
RG-6/U	UG-91A/U	UG-92A/U	UG-93A/U	—	UG-106/U	
RG-8/U	UG-21E/U	UG-23E/U	UG-22E/U	UG-160D/U	UG-106/U	
RG-8/U	UG-1185A/U	UG-1186A/U	UG-1187/U	—	—	
RG-11/U	UG-94A/U	UG-95A/U	UG-96A/U	—	UG-106/U	
RG-17/U	UG-167E&U	—	—	—	—	
RG-58/U	UG-536B&U	—	UG-1095B/U	UG-556B/U	UG-177/U	
RG-59/U	UG-603A/U	UG-602A/U	UG-593A/U	—	UG-366/U	

Table 5A. Coaxial connector selection guide for series N.

For RG/U Cables	Plugs	Reducing Adapters	Hoods
RG-8/U	PL-259, PL-259A, UG-295/U	—	MX-543/U, MX-372/U
RG-58/U	UG-175/U adater to PL-259	UG-175, UG-410/U	UG-177/U, MX-539/U
RG-59/U	UG-73/U, UG-111/U, UG-203/U	UG-176/U	UG-239/U, UG-366/U

Table 6A. Coaxial connector selection guide for series UHF.

Description	Military Number	Engineering Data
Adapter, Bulkhead (F-F)	UG-30D/U	Pressurized
Adapter, Right Angle (M-F)	UG-27C/U	
Adapter, Right Angle (F-F)	UG-202A/U	Panel Mounting
Adapter, Straight (F-F)	UG-29B/U	
Adapter, Straight (F-F)	UG-1018/U	Not Weatherproof
Adapter, Staright (M-M)	UG-57B/U	
Adapter, Tee (F-F-F)	UG-28A/U	
Adapter, Tee (F-F-M)	UG-464/U	
Adapter, Tee (F-M-F)	UG-107B/U	
Cap and Chain	MX-913/U	
Receptacle	UG-58A/U	70 Ohm Impedence
Receptacle	UG-231/U	With Hood
Receptacle	UG-367/U	
Receptacle	UG-680A/U	Pressurized
Receptacle, Right Angle	UG-997A/U	

Table 5B. Miscellaneous series N connectors.

Description	Military Number	Engineering Data
Adapter, Bulkhead (F-F)	UG-224/U	Rexolite Insulation
Adapter, Bulkhead (F-F)	UG-300/U	
Adapter, Bulkhead (F-F)	UG-363/U	Polystyrene Insulation
Adapter, Bulkhead (F-F)	PL-274	
Adapter, Right Angle (M-F)	UG-297A/U	
Adapter, Right Angle (M-F)	UG-646/U	Polystyrene Insulation
Adapter, Straight (F-F)	UG-299/U	
Adapter, Straight (F-F)	UG-360/U	Polystyrene Insulation
Adapter, Straight (F-F)	PL-258	
Adapter, Straight (F-F)	UG-307/U	Panel Mounting
Adapter, Tee (F-M-F)	UG-298/U	
Receptacle	UG-296/U	
Receptacle	SO-239	
Receptacle, Bulkhead	UG-223/U	
Receptacle, Pressurized	UG-266/U	Rexolite Insulation

Table 6B. Miscellaneous series UHF connectors.

of the more popular coaxial connectors at frequencies up to 11,000 mc. These curves are based on actual laboratory measurements of improved versions of connectors properly assembled to RG-8A/U cable except for the BNC connector which was assembled to RG-58/U cable. The non-constant impedance UHF series is shown for information purposes only, but it becomes quite obvious why this connector is not recommended for use at frequencies above 200 mc.

When selecting coaxial connectors, many factors must be considered; first of all, the coupling mechanism of the connector should be selected in accordance with the intended service. Where long, massive cables are to be joined, the coupling nut and associated retaining rings must be correspondingly strong such as those in **Fig. 8A**. When the completed assembly is to be used under conditions where frequent movement or vibration is anticipated, the connection must be strong, positive and vibration proof (**Fig. 8B** and **C**). For light duty where frequent connections and disconnections are required such as for test equipment, the connection should be quick and positive such as illustrated in **Fig. 8D**. Where severe space limitations prevent the use of threaded or bayonet mechanisms, push-on connectors with detent arrangements are useful (see **Fig. 8E**). In some applications "phono" connectors provide a simple and economical push-on connector (**Fig. 8F**).

Since final connector selection is essentially an electrical problem, transmission line practice is normally employed to determine the basic line parameters of impedance and SWR once the characteristic impedance of the system is known. When the ideal solution of these parameters has been found, average power, peak voltage and permissible power loss must be considered. In this phase, con-

For RG/U Cables	Plug	Panel Jack	Hood	Engineering Data
RG-22/U	UG-182/U	UG-183A/U	UG-106/U	Not Weatherprof
RG-22/U	UG-421B/U	UG-423B/U	—	Weatherproof

Table 7A. Coaxial connector selection guide for UHF twin series.

nector-cable combinations must be chosen that satisfy the operating requirements; at this point it is often necessary to make compromises in the final choice.

Connector-cable combinations that appear satisfactory from the standpoint of the electrical requirements should then be analyzed for operating temperature, mounting methods and coupling requirements. Many connectors that are employed internally do not require weatherproofing and a less expensive connector can frequently be used. In general, connectors which are used outside must be weatherproofed.

To reduce the SWR and impedance discontinuities to a minimum, coaxial connectors must be designed to have the same characteristic impedance as their mating cable. Actually, the objective is to make the connector a homogenous electrical extension of the cable itself. In this way the practical upper frequency limit of the complete assembly often exceeds 10,000 mc. Expansion, due to temperature, may cause a discontinuity by separating the cable from the clamp within the connector. For this reason, great emphasis is put on the metal-to-metal braid clamping mechanism using large contact areas. In some cases it is advantageous to insure that the center conductor is mechanically held in a fixed position by a captivated contact arrangement.

Additionally, coaxial connectors must be designed so that they operate safely at the maximum rating of the cables with which they are used. The most difficult of these requirements is the peak voltage rating. This is accomplished in several ways. First, physical changes where high voltage gradients might occur must be kept to a minimum; and second, a good high-quality dielectric must be used throughout the connector. Also, provisions should be made to avoid the development of air pockets at the mating boundaries of connector pairs.

Description	Military Number	Enginering Dat
Adapter, Right Angle (M-F)	UG-104/U	Not weatherproof
Adapter, Right Angle (M-F)	UG-931/U	Weatherproof
Adapter, Straight (F-F)	UG-105/U	Not weatherproof
Adapter, Straight (F-F)	UG-493A/U	Weatherproof
Adapter, Tee (F-M-F)	UG-196/U	Not weatherproof

Table 7B. Miscellaneous series UHF twin connectors.

Actually, connector selection is not nearly as complex as it might sound at first. For amateur application, there are only three types of connectors that are generally used; series UHF, BNC and N. These series will satisfy nearly any amateur requirement, but series C or phono connectors may be useful in some special applications.

The "Connector Selection Guides" in **Tables 3** through **7** were prepared as an aid in the selection of connectors for use with specific cables. The cables listed are those that are most apt to be used in amateur work. When selecting a connector for use with coaxial cables not listed in the "guide," reference to the "Coaxial Cable Assembly Groups" chart in **Table 8** may be helpful. In essence, there are fourteen main groups of RG-/U cables within the large number available. For example, RG-8A/U belongs to cable group "F" as do RG-9, -31, -87, -165, -213, -214 and -229/U. Therefore, connectors listed in the guide for RG-8/U may also be used with any of the other coaxial cables in the same assembly group.

Coaxial connector installation

It must be remembered that the primary function of the coaxial cable connector is electrical and every available provision should be made to support it mechanically. Occasionally, the mounting environment will prevent supporting the cable at intervals as often as desired and a larger, stronger connector must be used. In addition, the cable may be required to follow the contour of a building or corner or roof peak; in such a case, larger connectors should be used to preclude premature failures.

Many connectors are attached to panels or bulkhead partitions. There are three standard methods for attachment of these fittings. The most common is the "single hole mount"; the connector has an external thread and is locked to the panel with a hex nut and lock-washer. In some cases a method of keying the connector to the panel is employed. The three main types are single flat on the connector body requiring a "D" hole in the chassis, a