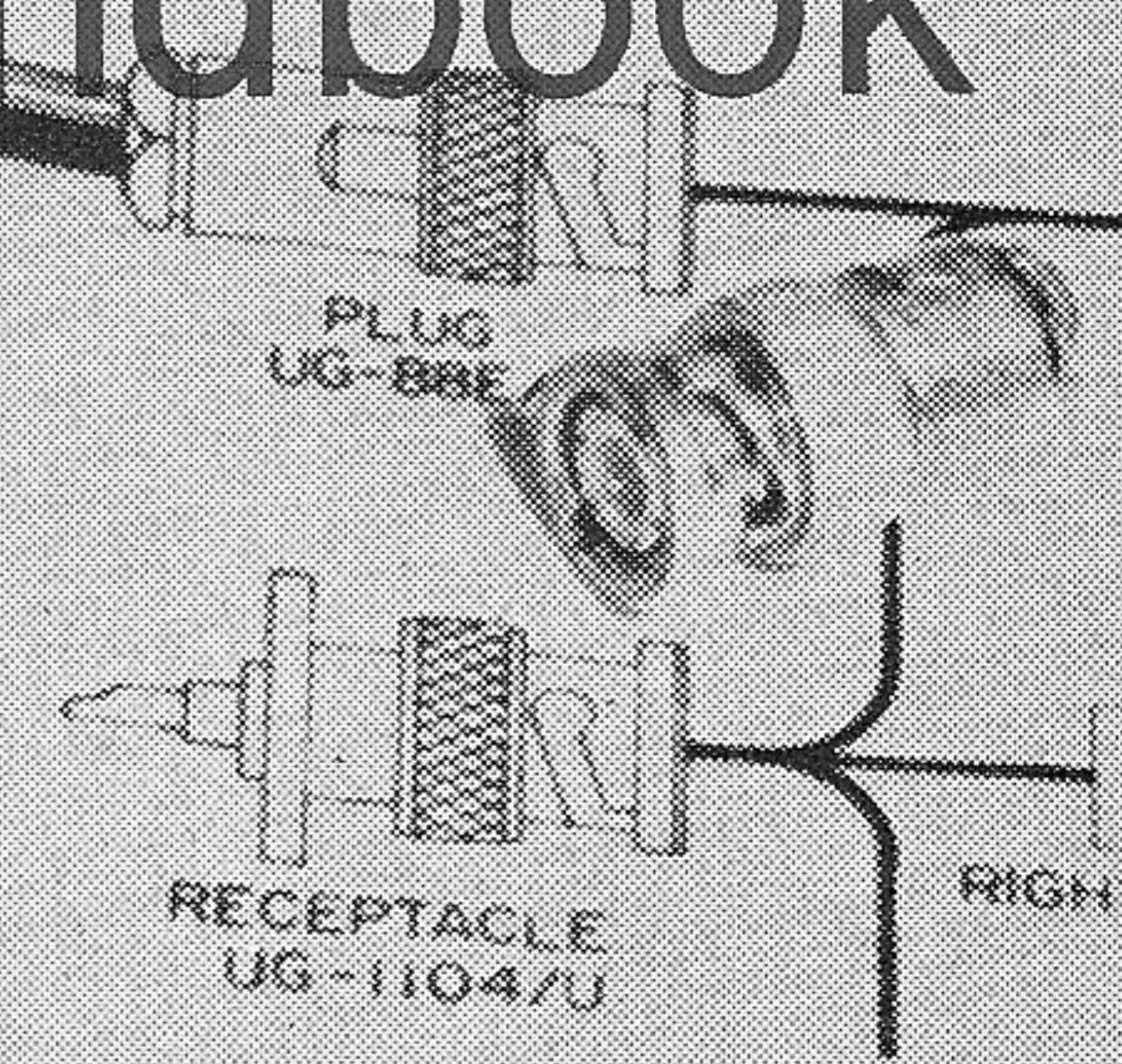
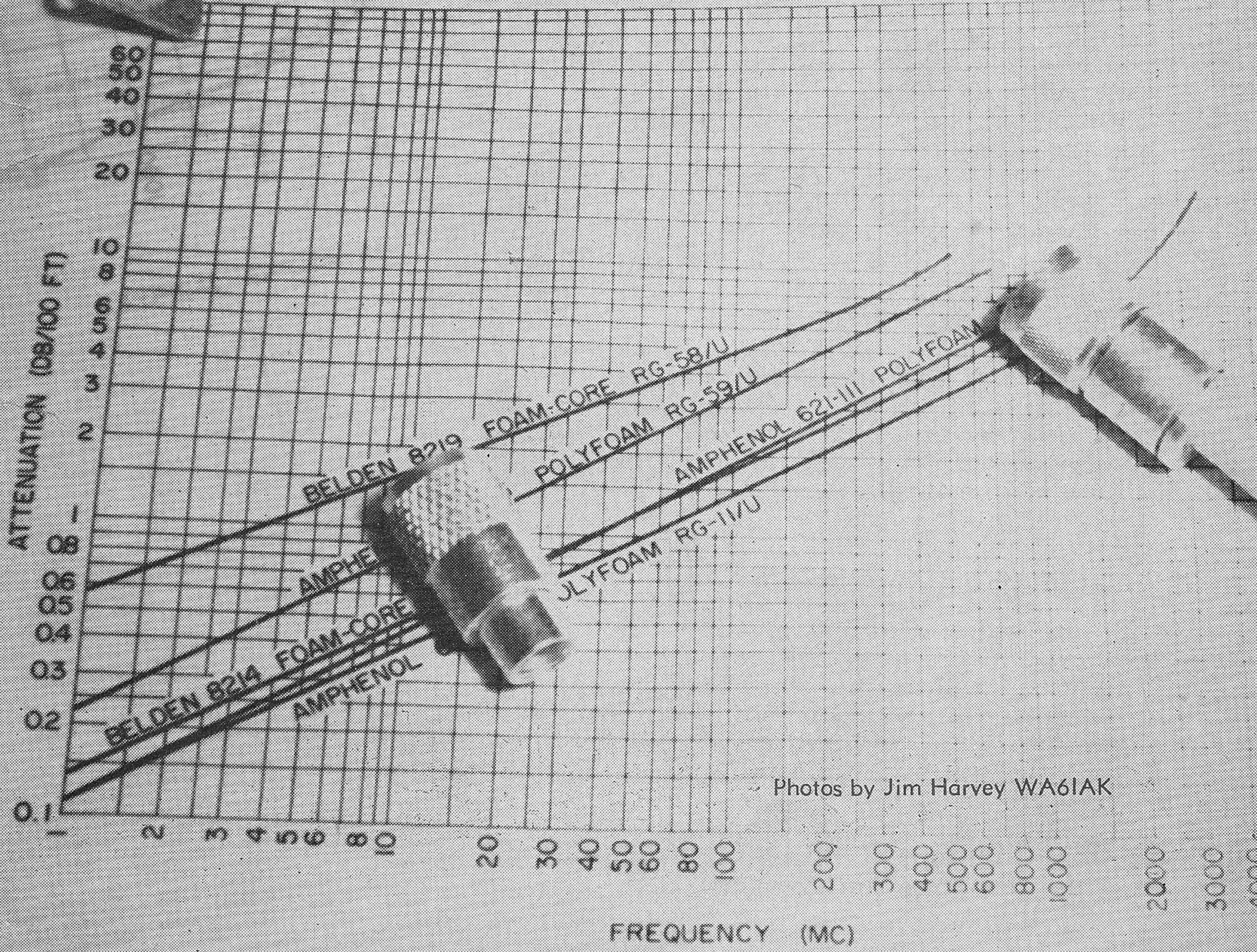


Coaxial Connector Handbook

Jim Fisk WA6BSO



STANDING WAVE RATIO



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

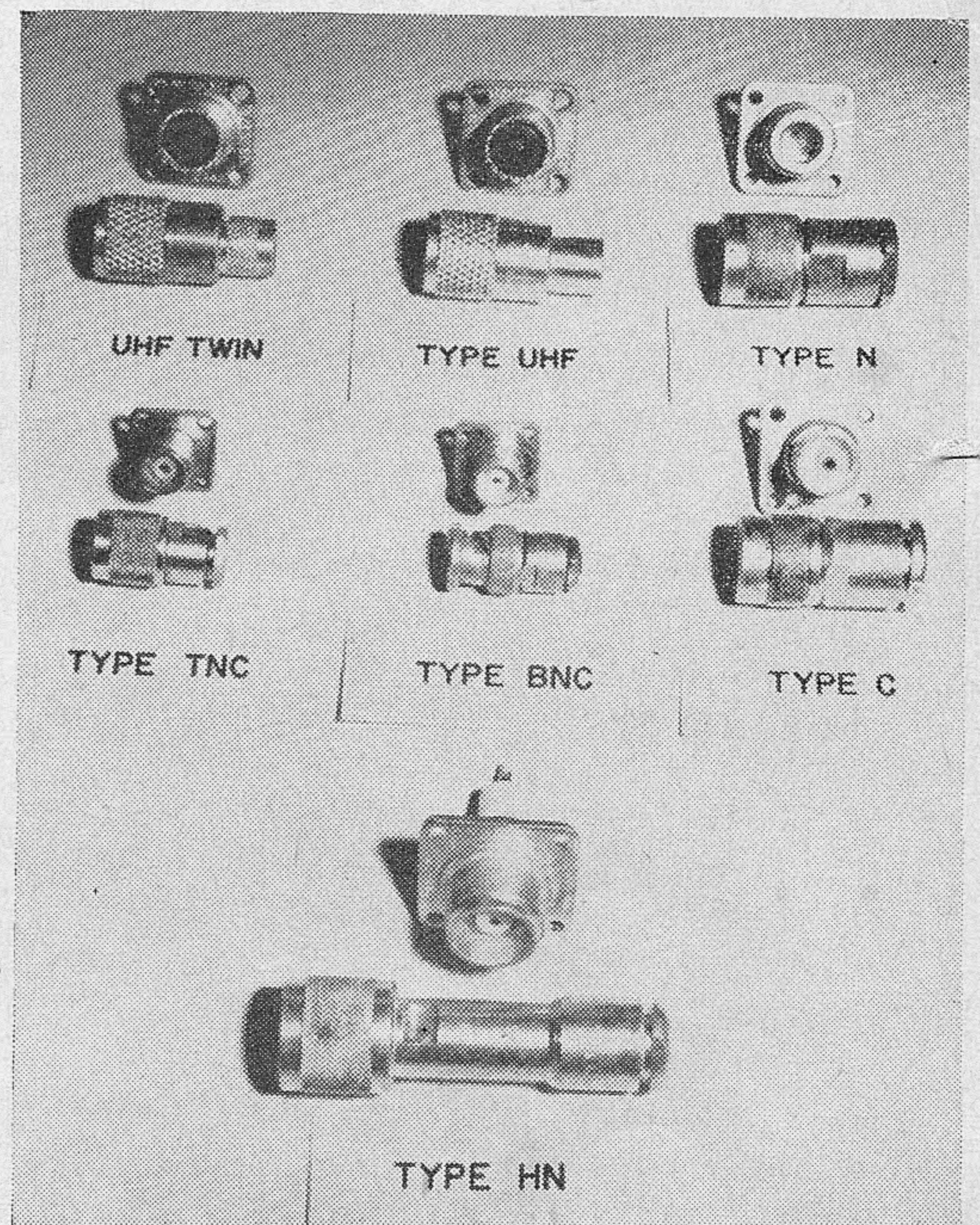
Standardization of coaxial connectors has immeasurably aided in the selection and use of these devices. A direct result of this standardization is that a connector made by one manufacturer is directly interchangeable with similar connectors made by any other company.

Coaxial connectors may be categorized by the method of coupling and cable size with which they may be used as shown in Table 1.

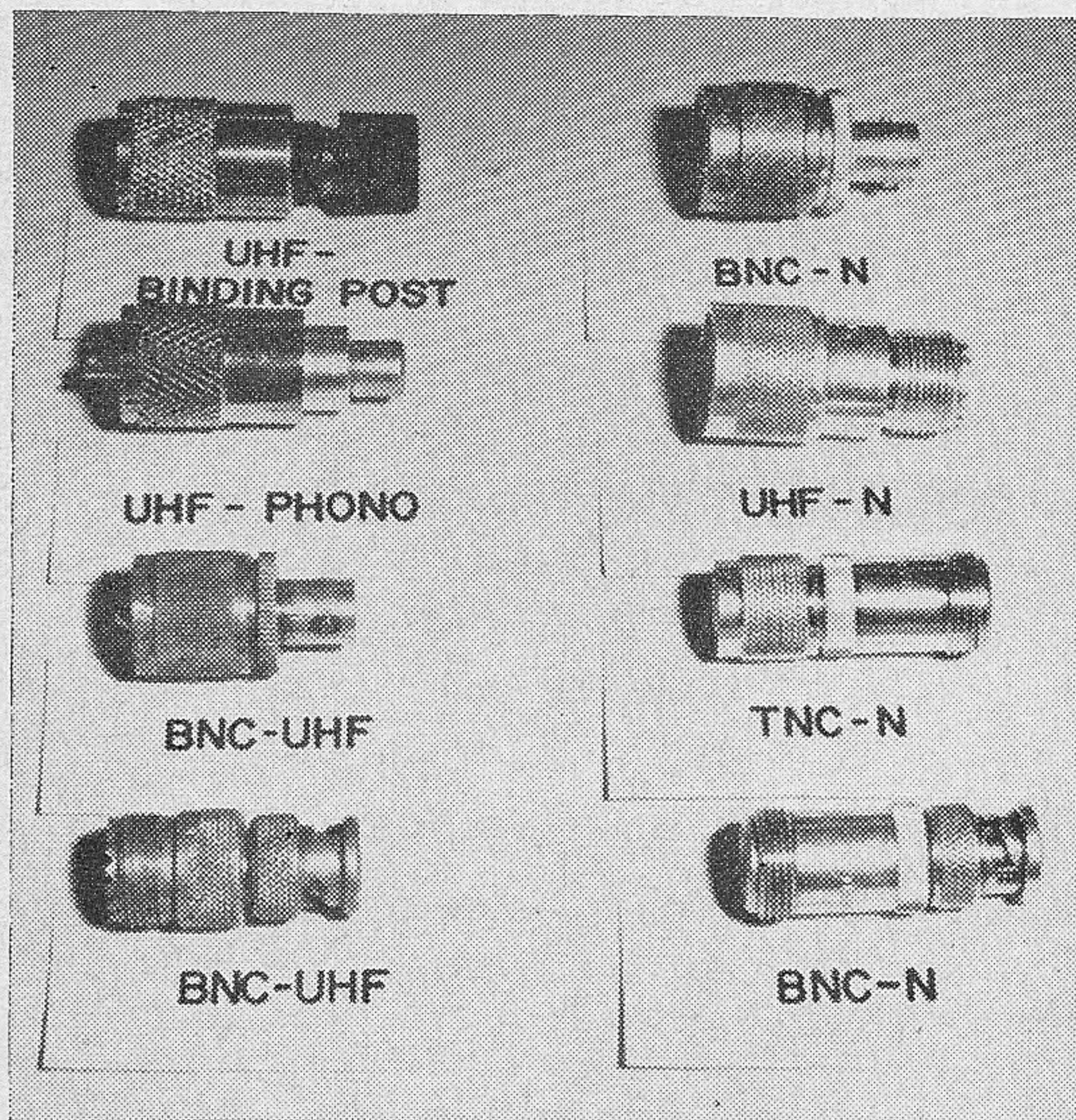
Essentially, there are three methods of coupling; threaded, bayonet, and push-on. The five major cable sizes are subminiature, small, medium, medium-large and large. Although the various coaxial connectors were designed specifically for the cable sizes shown in Table 1, some types may be used with other 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 semiflexible 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.

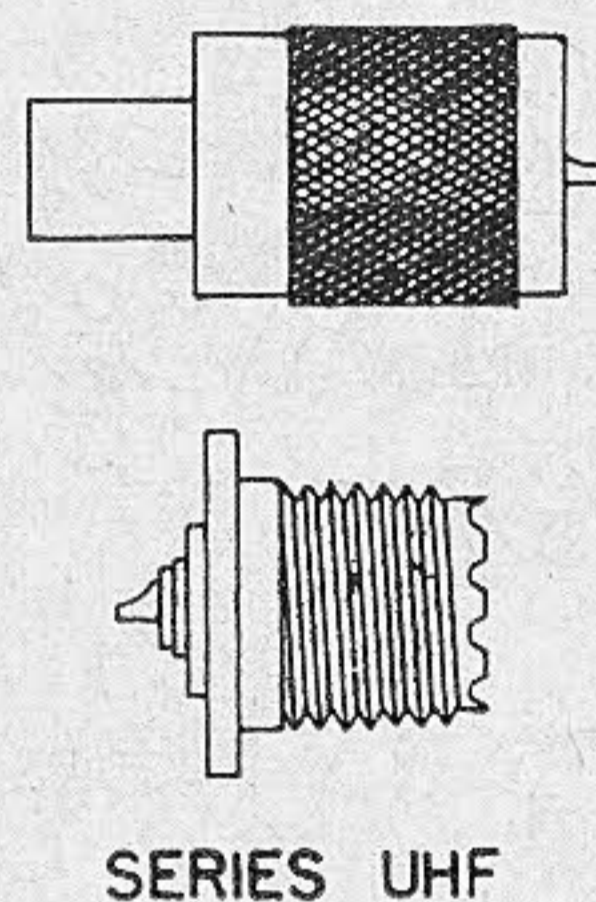
In addition to these variations, many manufacturers have "polarized" connectors available for the more popular types. These connectors are used to prevent careless or improper connections. The polarization is accomplished by reversing the normal insulation and inner contact assemblies. These connectors 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.

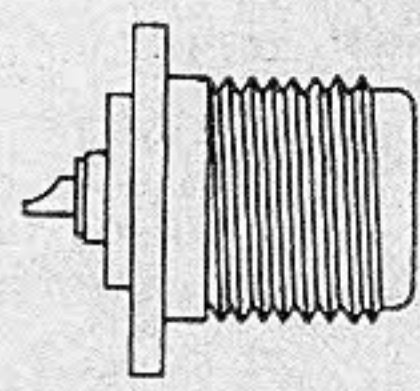
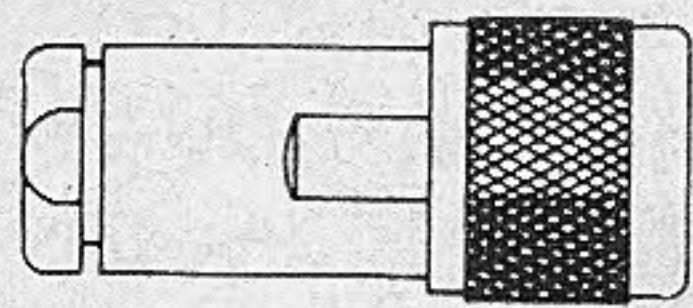
One type of wedged clamping connector available is Automatic Metal Products "Wedge-eze" illustrated in Fig. 1. This connector is economical, simple to assemble and does not require special tools for assembly. Another advantage over standard crimp types is that these connectors may be reused whereas the 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 $\frac{5}{8}$ 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.



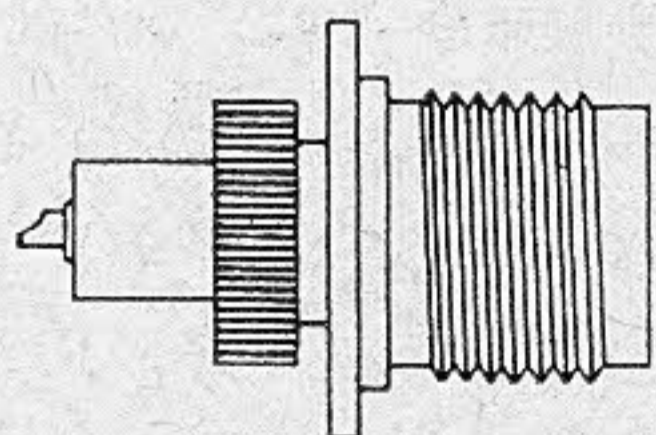
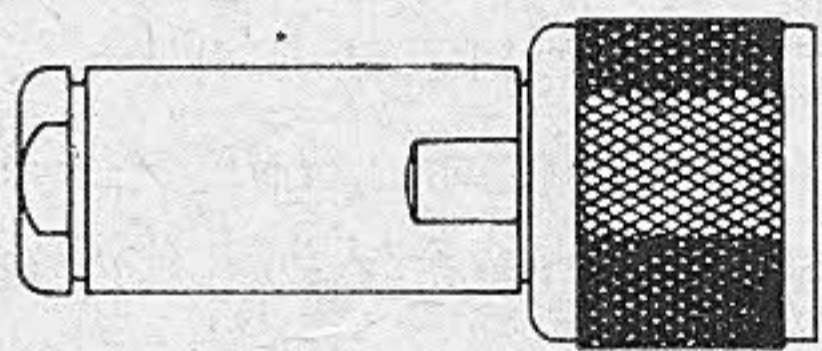
SERIES N

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.

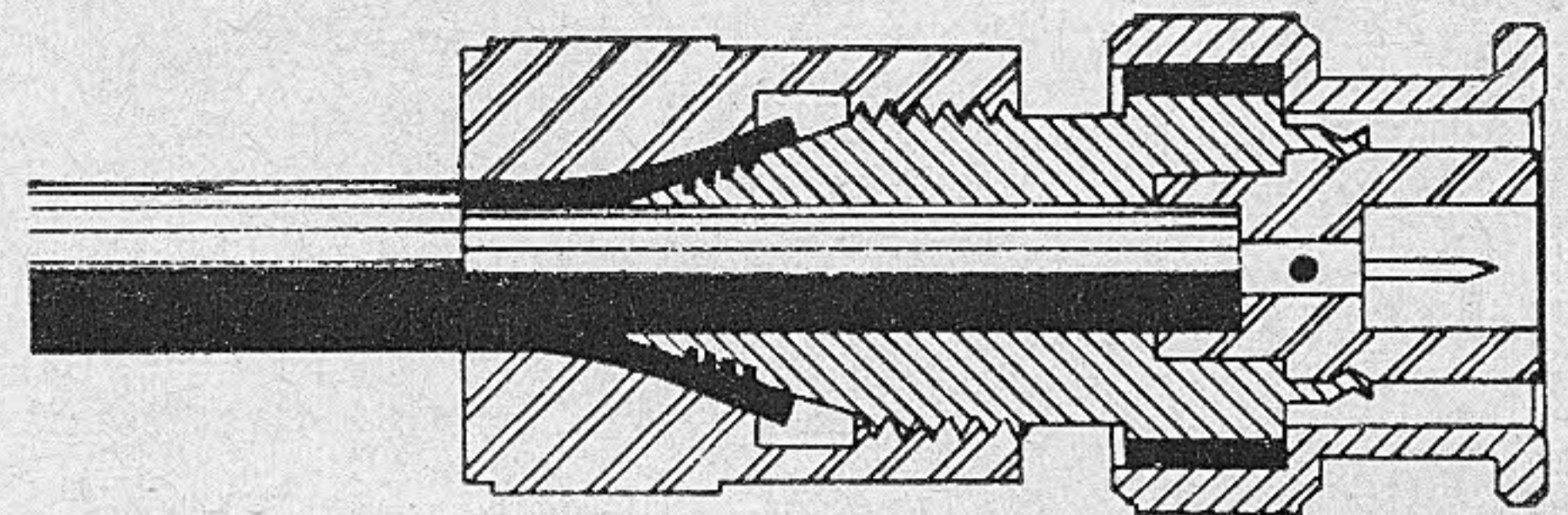
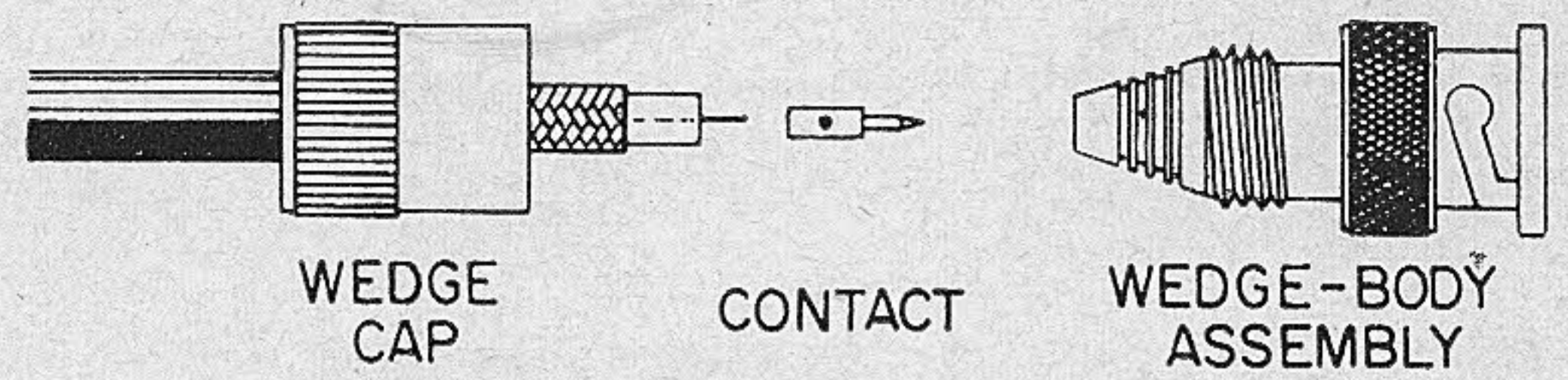


SERIES HN

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.

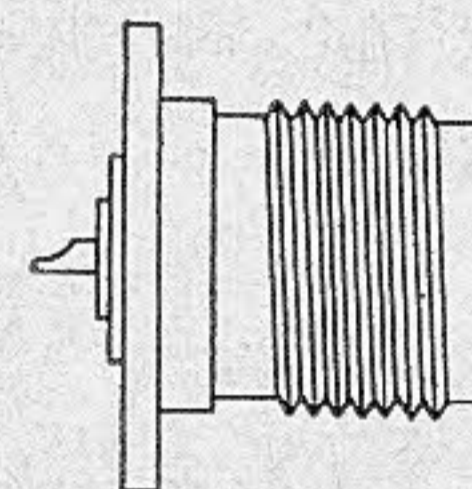
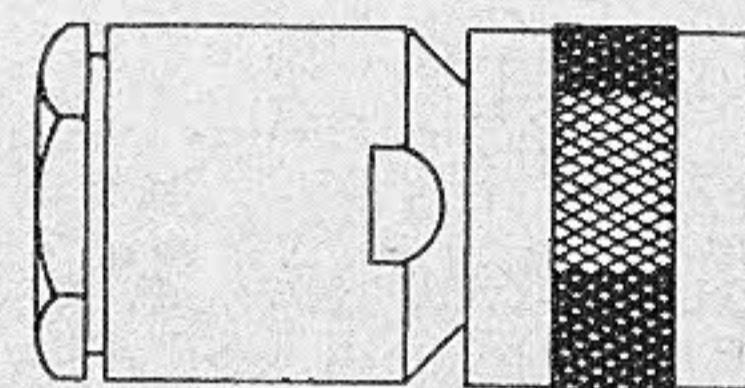
Series HN connectors were originally designed for use in high voltage applications up to 5000 volts peak; however, results of tests conducted by the U. S. Navy indicate that at rf frequencies, the voltage characteristics of the HN connectors are no better than those



ASSEMBLED UNIT

Fig. 1. Typical Wedge-eze construction.

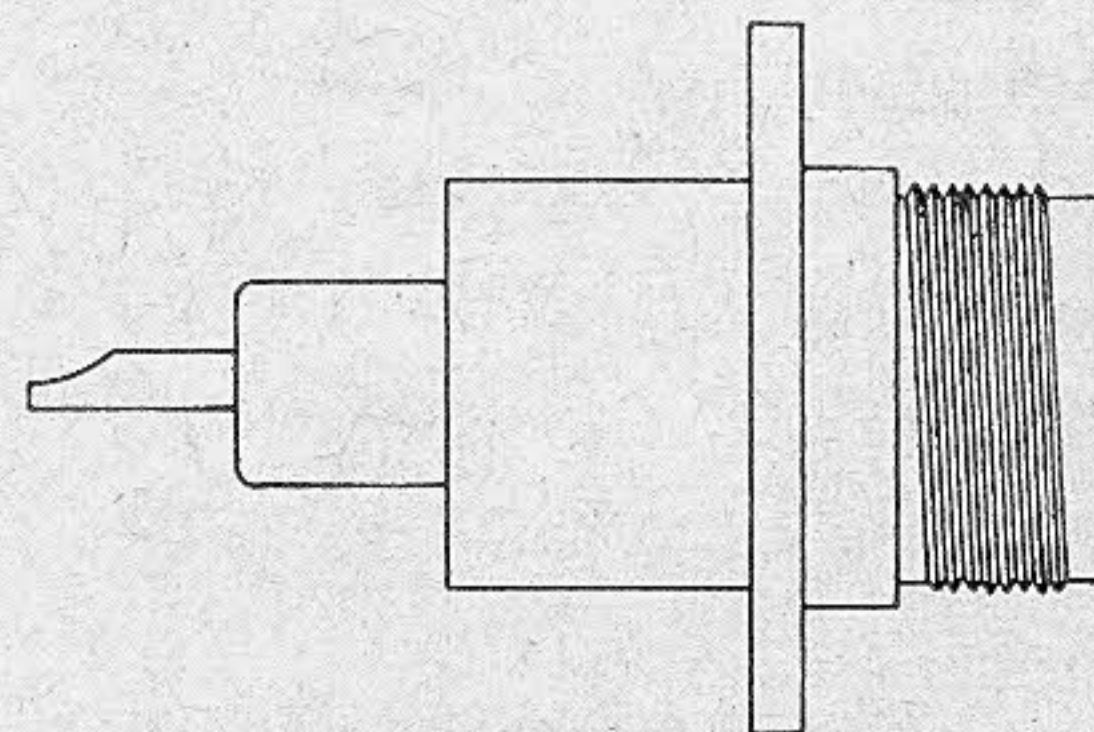
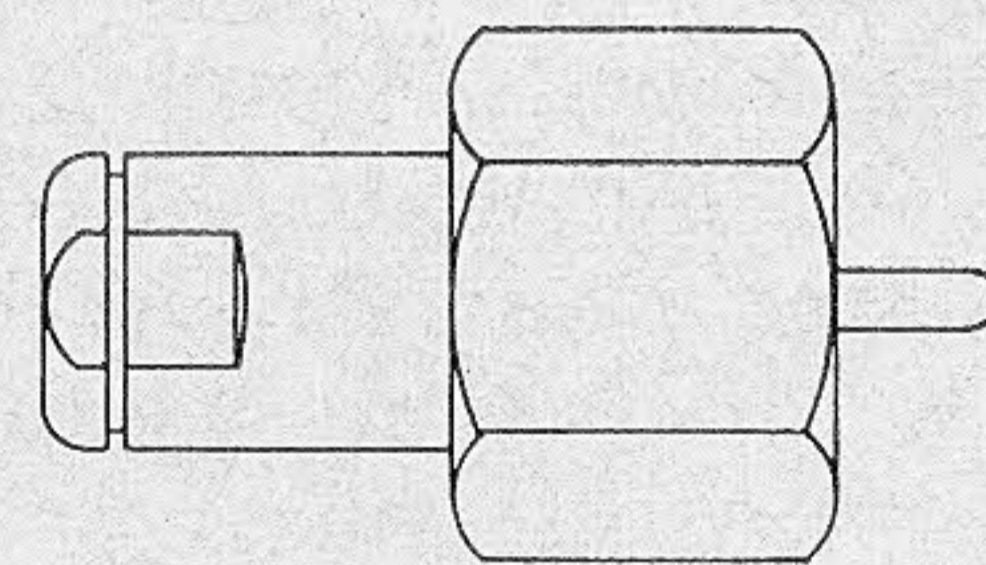
of the C or N series. Consequently, HN connectors should be used for replacement purposes only.



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.

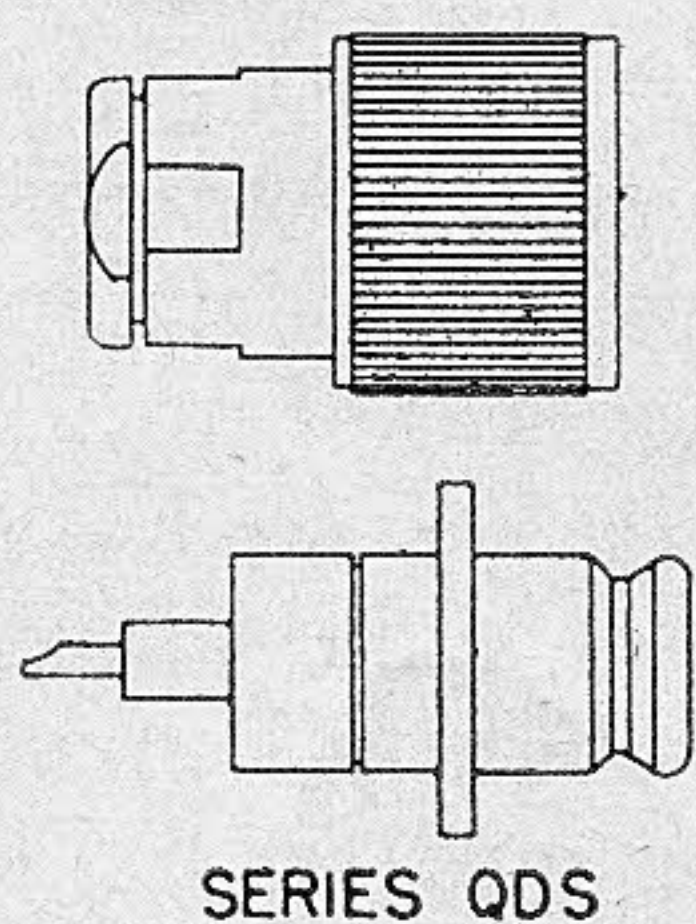
Two groups of LC connectors are available; group LC-1 which will withstand peak voltages of 500 volts and the slightly larger LC-2 which will withstand voltages in excess of 10,000 volts. Where it is desired to operate

Cable Size	THREADED COUPLING				BAYONET COUPLING				PUSH-ON COUPLING			
	Type	Thread	Impedance (ohms)	Max Freq (mc)	Type	Coupling	Impedance (ohms)	Max Freq (mc)	Type	Coupling	Impedance (ohms)	Max Freq (mc)
Sub-miniature	SM	1/4 X 32	50	1000	TPS	3 prong	50	10000				
Small	BN	3/8 X 32	50	200	BNC MHV	2 prong	50	10000	Phono	Not Detented	Not Matched	200
	TNC	7/16 X 28	50	10000		3 prong	50	50				
	SKL	3/8 X 32	50	—								
Medium	N	5/8 X 24	50	10000	C	2 prong	50	10000	QDS	Ball Detent	50	10000
	UHF (Single)	5/8 X 24	Not Matched	200								
	UHF (Twin)	5/8 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	3/4 X 27	50	1000								
	HN	3/4 X 20	50	3500								
Large	LC-1	1 1/4 X 18	50	1000					QDL	Ball Detent	50	1000
	LC-2	1 3/4 X 16	50	1000								
	LT	1 1/4 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.

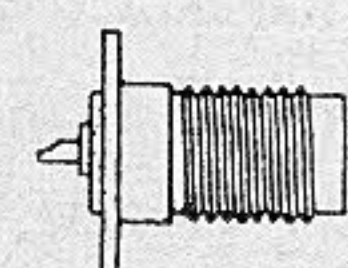
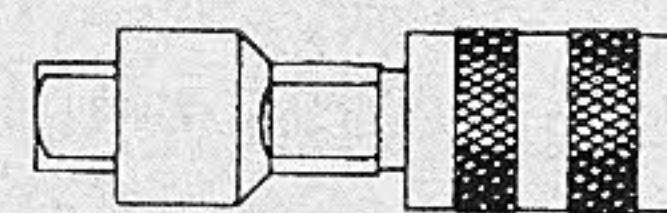
LT series connectors are actually an extension of the LC series designed to accept RG-117 and -118/U size cables. They have been improved greatly by specialized design, and several models are now manufactured for use at elevated frequencies. It should be noted that the LT series is similar to but not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

ment 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.

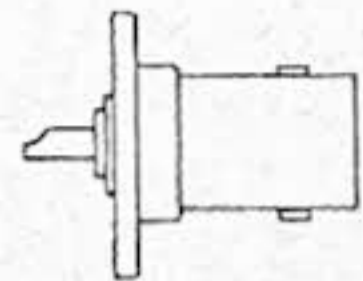
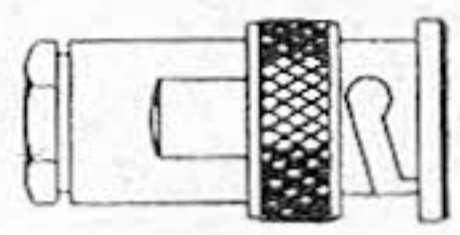


SERIES BN

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.



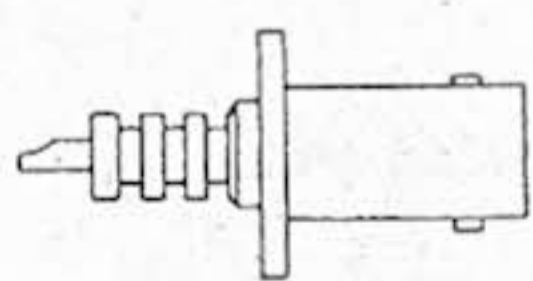
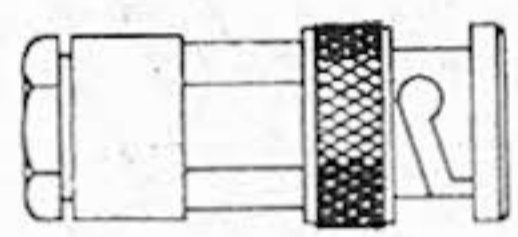
SERIES BNC

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. These connectors are also available in polarized and pressurized versions.

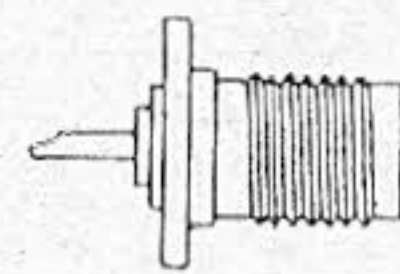
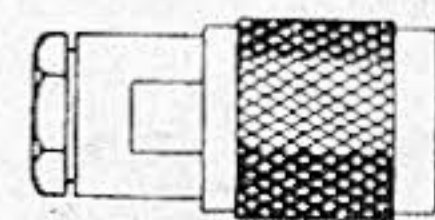


SERIES MHV

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.



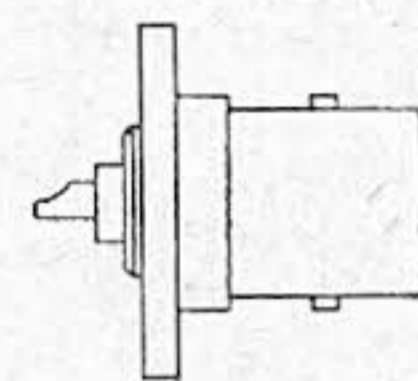
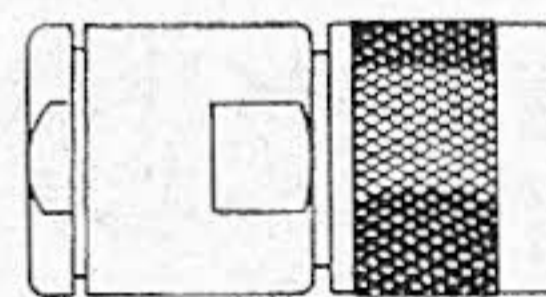
SERIES TNC

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.

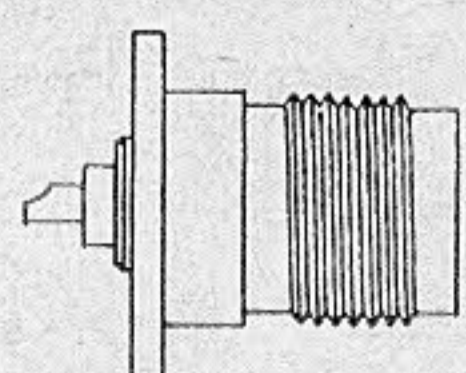
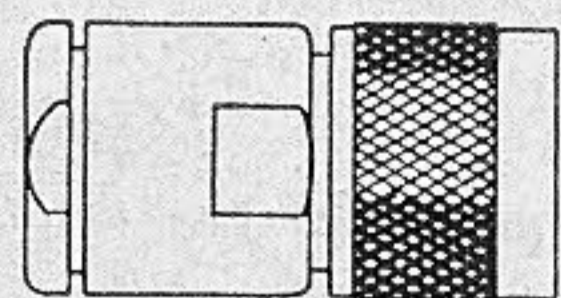
The C series is recommended where fast connection and disconnection by means of the bayonet lock coupling is required. For these purposes, this series is ideal. They are of constant impedance and may be used with minimum mismatch in 50 ohm circuits employing medium size cables such as RG-8/U. However, 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	
Z	Female	to	BN	Male	UG-605/U	
ZZ	Female	to	BNC	Female	UG-606/U	
ZZZ	Female	to	BNC	Male	UG-335/U	Flange Mounting
ZZZZ	Female	to	BNC	Male	UG-349B/U	
ZZZZZ	Female	to	C	Male	UG-565/U	
ZZZZZZ	Female	to	HN	Female	UG-1107/U	
ZZZZZZZ	Female	to	HN	Male	UG-1108/U	
ZZZZZZZZ	Female	to	LC	Male	UG-999A/U	
ZZZZZZZZZ	Female	to	LN	Female	UG-108A/U	
ZZZZZZZZZZ	Female	to	QDS	Male	UG-1144/U	Not Weatherproof
ZZZZZZZZZZZ	Female	to	UHF	Male	UG-83B/U	
ZZZZ	Male	to	BNC	Female	UG-201A/U	Not Weatherproof
ZZZZZ	Male	to	BNC	Male	UG-1034/U	Not Weatherproof
ZZZZZZ	Male	to	C	Female	UG-564/U	
ZZZZZZZ	Male	to	LN	Male	UG-213A/U	
ZZZZZZZZ	Male	to	QDS	Female	UG-966/U	
ZZZZZZZZZ	Male	to	UHF	Female	UG-318/U	Not Weatherproof
ZZZZZZZZZZ	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.

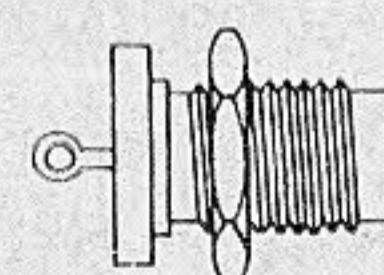
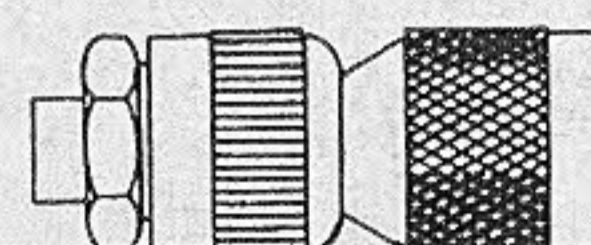


SERIES SC

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

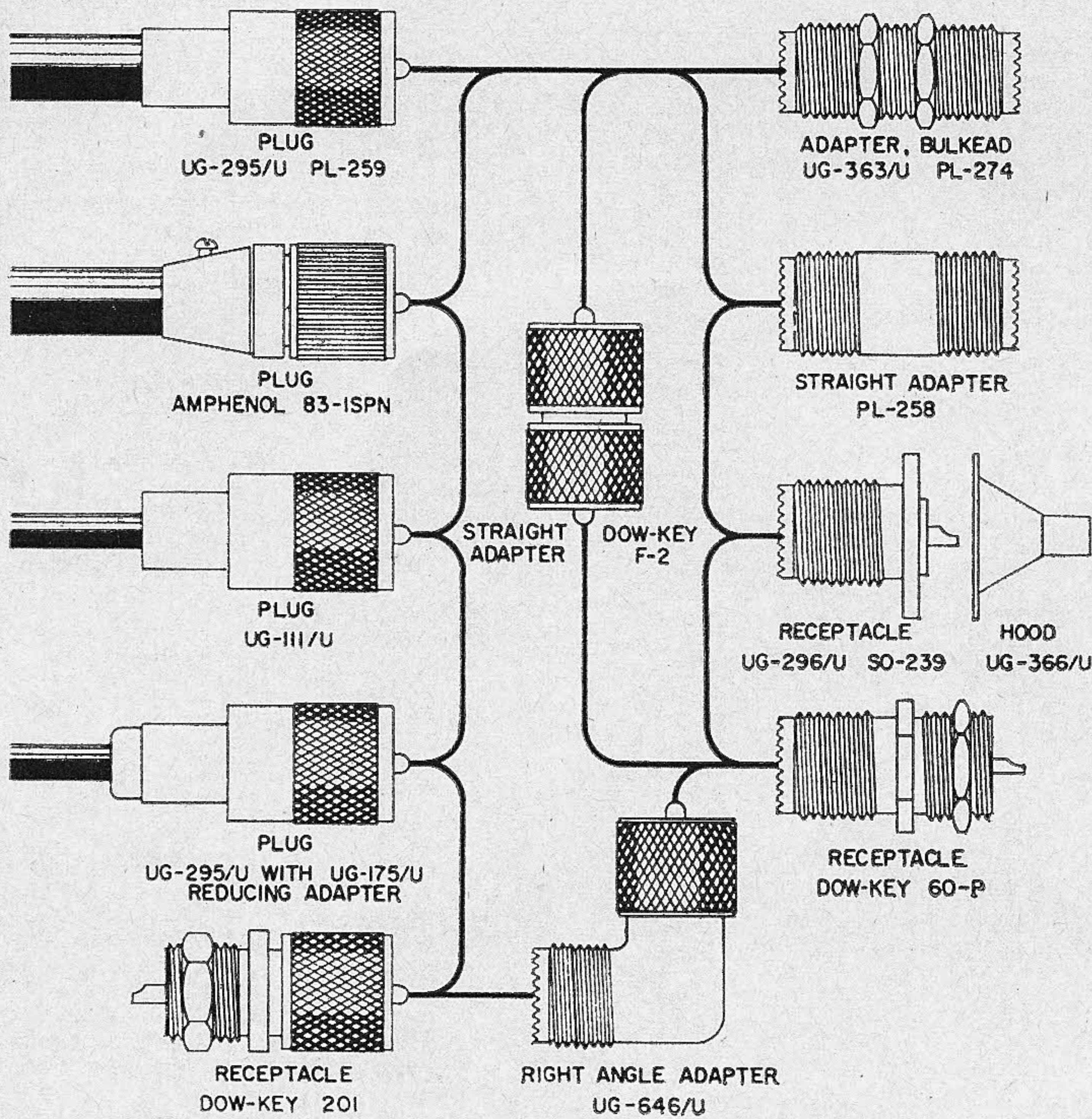
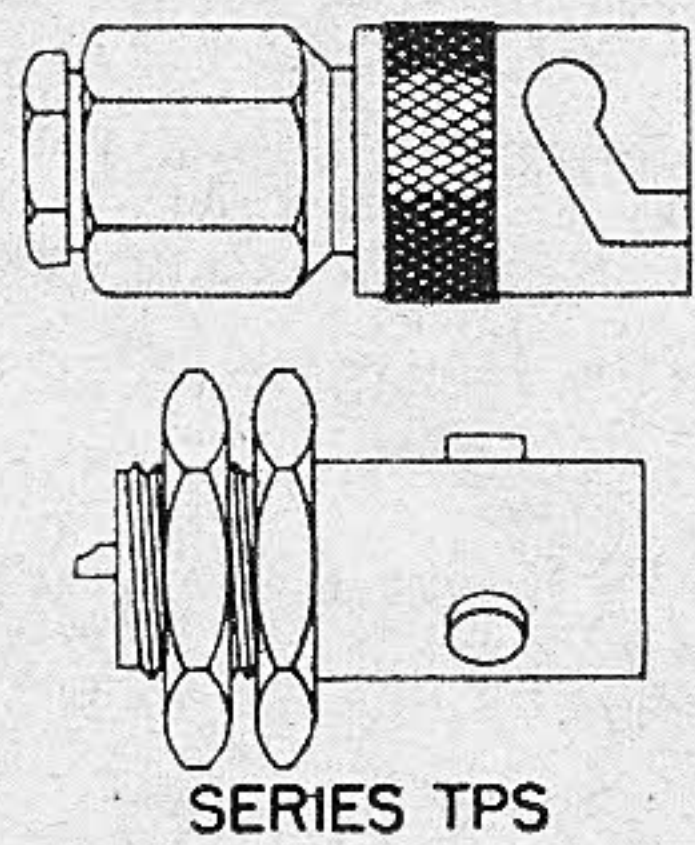


Fig. 2. UHF connector family.

need for a small rf fitting for use with coaxial cables of $\frac{1}{4}$ inch overall diameter and smaller. They should not be used where electrical matching is required.

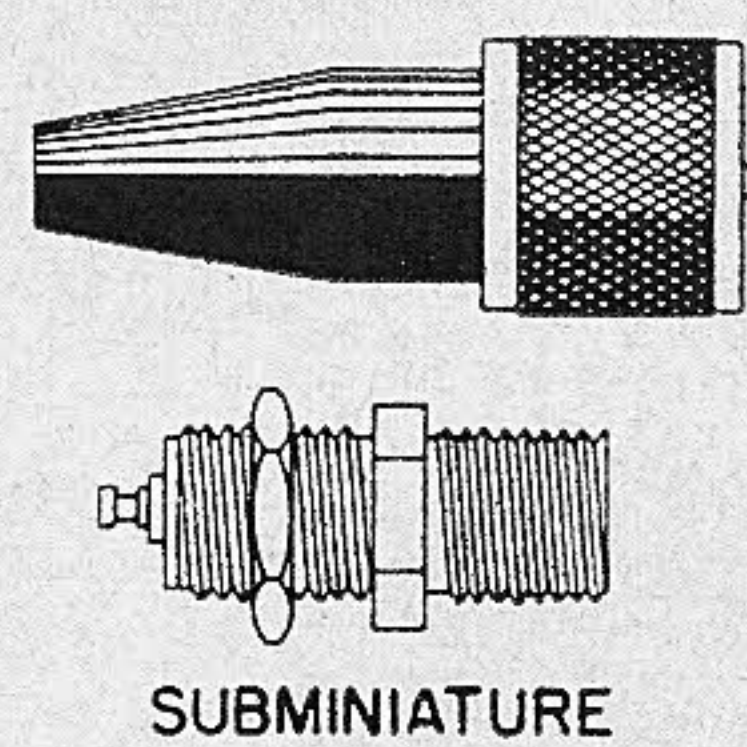
SM connectors are considerably smaller and contain fewer parts than the BNC series; for simplicity of design, they employ a female contact on the plug and a male contact on the jack and receptacle. The SM series has the advantage of positive braid clamping and does not use the inner conductor of the 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 $\frac{1}{4}$ inch in diameter. Because of their small