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COAXIAL COMPONENTS FOR U.H.F TELEVISION TRANSMITTERS

INTRODUCTION

Current u.h.f television transmitters employ low-level modulators and separate power amplifiers for the sound and vision signals. After amplification of the modulated signals to the required power level, both the sound and vision signals require further processing before radiation.

Non-linearity of the power amplifier generates signals at harmonic frequencies and regenerates the unwanted lower sideband produced by the colour sub-carrier signal. These signals fall outside the channel limits and must be attenuated to the level permitted by the particular system being used.

By combining both the sound and vision signals into a common transmission system, a substantial economy can be achieved in the aerial and aerial feeder system. Thus a unit is required to combine the outputs of the sound and vision amplifiers while maintaining a high degree of isolation between them. Suppression of the colour subcarrier image signal is effected in this combining unit and a separate filter is provided for harmonic attenuation.

In the most simple system the output of the combining unit is connected directly to the aerial feeder. Split aerial, parallel transmitter, and multiplex transmitter systems avoid complete shut down in the event of partial breakdown. Diplexers permit the operation of parallel transmitters into a common load and the high degree of isolation between transmitters provided by the diplexer allows continuous operation if one transmitter fails. Such systems require extensive inter-connection and coaxial switches and patching links enable rapid changes to be made to these r.f power circuits. The arrangement of a simple combining unit is shown in figure 1.

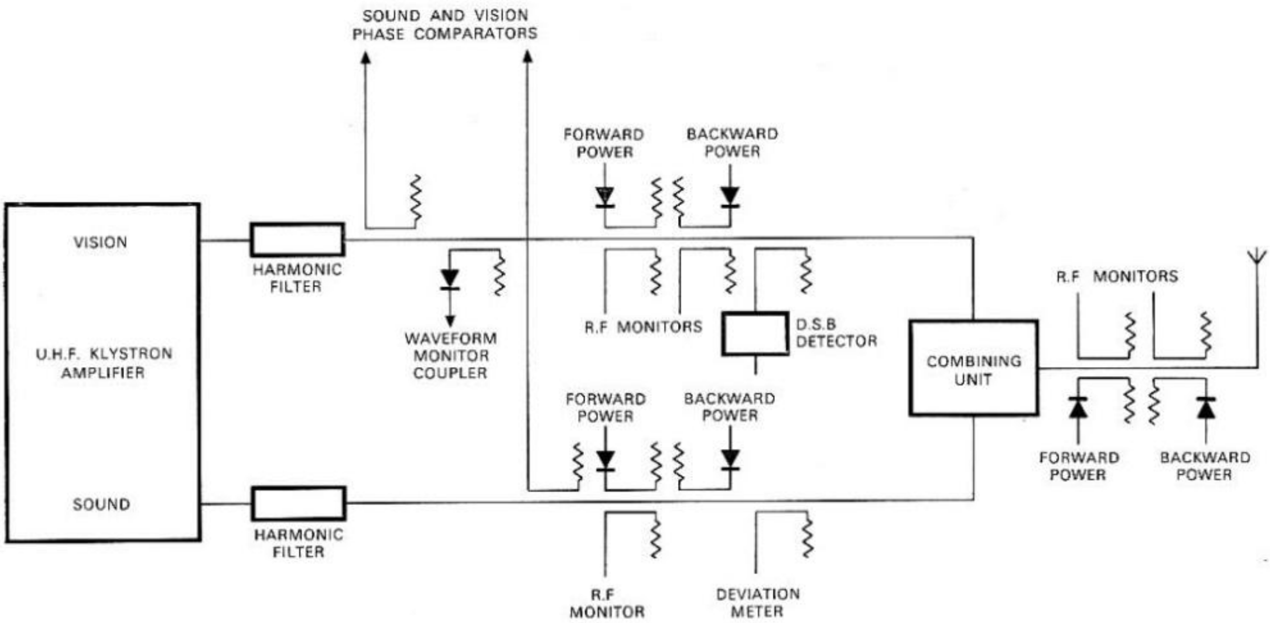

Fig.1 Simple combining unit.

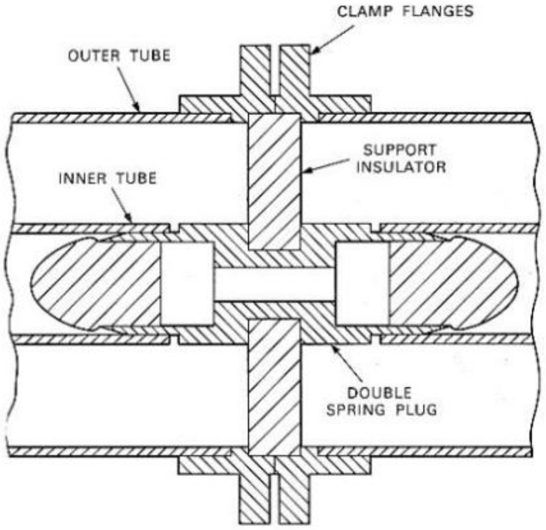

Fig.2 A section through a connection between two lengths of coaxial line.

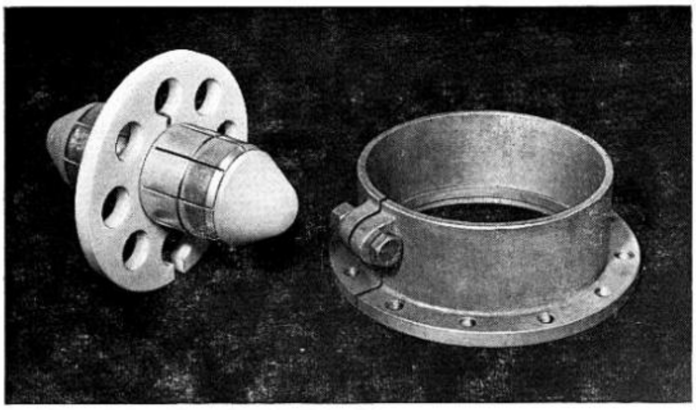

Fig.3 Clamp flange and a double spring plug.

Transmitter adjustments and performance checks are best made when the transmitter is connected to an artificial load. This load must be accurately matched to the characteristic impedance of the transmission line, be capable of dissipating the full power of the transmitter and provide an accurate indication of the power dissipated.

Samples of the signal at a number of points in the system are required for aural and visual monitoring, for forward and reflected power indication, and for feedback into the transmitter circuits. Directional couplers of adjustable sensitivity afford a means of obtaining accurate samples of the signals in the transmission lines.

The transfer of power from the amplifier to the transmission line is governed by the input impedance of the line and any variation of input impedance with frequency degrades the overall frequency response of the system. Furthermore, radical departures from the specified load can produce excessive voltages or currents within the amplifier. Discontinuities in the characteristic impedance of the transmission line are reflected and appear as a variation of impedance at the input. To minimize reflections in the system therefore, the characteristic impedance must be maintained through all components inserted in the transmission line.

TRANSMISSION LINE

Coaxial transmission line provides an efficient means of transferring r.f energy. Waveguide is not a practical alternative in the u.h.f range. At 470MHz a guide of approximately 15in×7in would be required and other components would also be bulky. Coaxial line has been used extensively in the v.h.f bands, component techniques have been evolved and standards relating to tube size and connecting flanges established. Components have now been developed for use in the u.h.f bands.

The American Electronic Industries Association standards for 50 ohm coaxial line have gained wide acceptance and have been adopted for the present range of components. The size of a transmission line or component is defined as the nominal outside diameter of the outer tube.

The size of transmission line used depends mainly on the frequency of the transmission and output power of the transmitter. Development of three sizes of line and components (1⅝in, 3⅛in, and 6⅛in) allows the selection of a line to provide an efficient and economical system. The 6⅛in line is suitable for average powers of 45kW at 860MHz.

By using aluminium tube as the outer conductor, lightness and economy are obtained without loss of rigidity, and clamp type outer tube flanges reduce assembly and installation times. High conductivity copper tube is retained as the inner conductor. Connections between sections of the inner tube are made with a double spring plug designed to accommodate the differential expansion in length between the inner and outer conductors. The inner conductor is supported by a P.T.F.E insulator which is fitted to the double spring plug and is located in the outer tube between the clamp flanges. Reflections from the insulator are reduced to negligible proportions by correctly dimensioning the depth of the groove which locates the insulator in the plug (Fig.2). A clamp flange and double spring plug assembly for 6⅛in line is shown in figure 3.

SEMI-FLEXIBLE LINE SECTIONS

Present day u.h.f power amplifiers consist of an integral assembly of a vacuum tube and tuned cavities mounted on a movable truck. To accommodate mechanical misalignment between the amplifier output connection and the rigid transmission line to which it must be connected, a semi-flexible coaxial line section, designed to allow ½in movement in the axial and lateral directions, has been developed (Fig.4).

Flexibility is obtained by using short lengths of corrugated bellow tubing to form the line. The outer bellow tube is attached to a standard flange at each end and the inner is connected to spring plugs. Two P.T.F.E insulators support the inner conductor as previously described. Each support insulator is secured to the flange by a clamping plate allowing simultaneous connection of both the inner and outer conductors. Careful selection of bellow tube

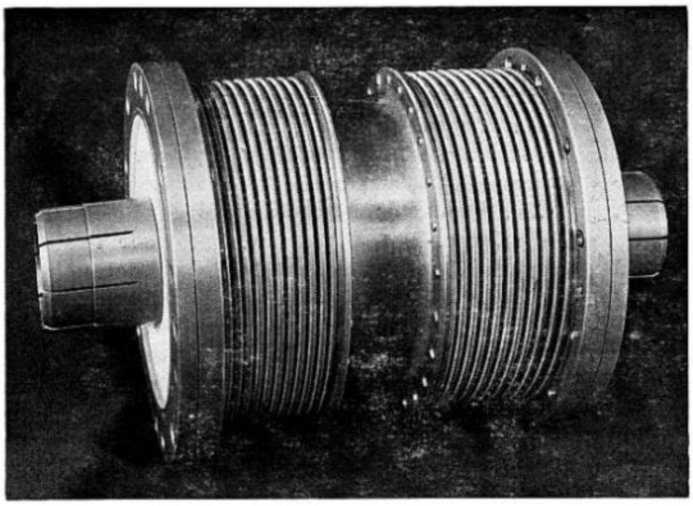

Fig.4 Semi-flexible line section.

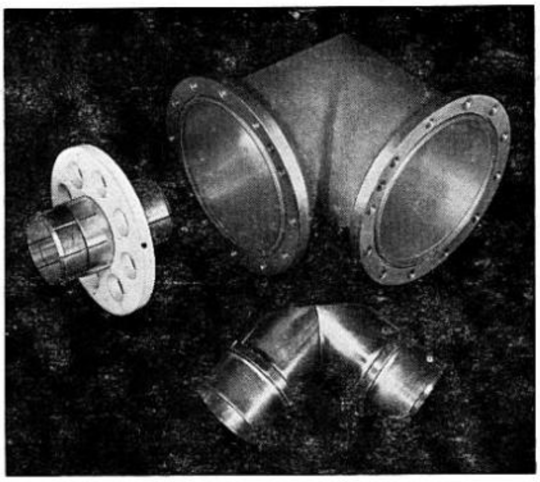

Fig.5 Right-angled connector showing one method of compensation.

dimensions and compensation of step discontinuities allow the characteristic impedance to be maintained and has resulted in a maximum reflection coefficient of 0·03 in the u.h.f range.

BENDS AND PATCHING LINKS

The construction of right-angled bends is similar for each of the three feeder sizes. The use of an aluminium casting, machined to maintain critical dimensions and to give flat surfaces to connect with adjacent components, provides an outer which is both light and free from the distortions often associated with fabricated bends. The connecting flanges are free to rotate so that they can be aligned with the flanges of adjacent components. Two double spring plugs with P.T.F.E insulators, similar to those used in the transmission line, support the inner conductor and retaining screws prevent the spring plugs being withdrawn from it.

In the region of the right-angled transition the field between the inner and outer conductors is distorted and the characteristic impedance is no longer maintained. Compensation for this discontinuity is achieved by reducing the capacitance between the inner and outer conductors in the region of the transition. Cutting the corner of the inner conductor as shown in figure 5 is a simple method of reducing the capacity and by this means the reflection coefficient of both 1⅝in and 3⅛in bends has been reduced to less than 0·005. In the 6⅛in bend this simple method of compensation is effective only at low frequencies. Because of the onset of waveguide modes in the corner region, the reflection coefficient rises to 0·05 at 700MHz and increases rapidly at higher frequencies. Further compensation, in the form of discreetly placed capacitance rings, reduces reflections at the higher frequencies. A reflection coefficient which does not exceed 0·02 is obtained when both forms of compensation are optimized.

The patching link consists of two modified right-angle bends as shown in figure 6 while figure 7 shows the panel-mounted connector. The rotating flanges are replaced by fixed bosses of tapered cross section and a mating clamp secured by two screws to allow rapid changing of the link position. The use of a solid, bullet-type connector reduces the risk of damage when the link is removed and the inner conductor exposed. A spigot fitted to the centre of the panel-mounted spring sockets assists alignment when engaging the link; it also supports the link and prevents damage to the spring sockets when the clamps are removed.

SWITCHES

Switches are a convenient method of changing feeder circuits when operational requirements do not allow time for link changing, or when remote or automatic control is necessary. Figure 8 illustrates a switch for inclusion in 6⅛in circuits. Similar switches have been developed for use in 3⅝in and 3⅛in installations. A central shaft carries both the moving contacts and a screening plate; rotation of the shaft through 90° is required to change the circuit. The outer body of the switch is machined from cast aluminium and the screening plate and moving contacts are manufactured from brass. Both the fixed and moving contacts are silver plated. All the insulators are made from P.T.F.E.

Isolation between circuits is an essential requirement of change-over switches and inadequate earthing of the screen can reduce isolation to very low levels. In the present range of switches the screen is earthed on all edges by closely spaced spring fingers. At frequencies up to 860MHz the isolation is not less than 60dB. The moving contacts supported by the P.T.F.E insulators, are free to move through a small distance in a radial direction. Leaf springs between the contact and the insulator exert a radial pressure on the contact and the contact face is shaped so that, as the switch is rotated, the moving contact rides smoothly onto the dome of the fixed contact. Experience has shown that this arrangement provides a reliable contact and maintenance of sufficient pressure by the leaf spring ensures a good self-cleaning action and a low-resistance contact. The mass of the solid contacts assists conduction of heat away from the contact area.

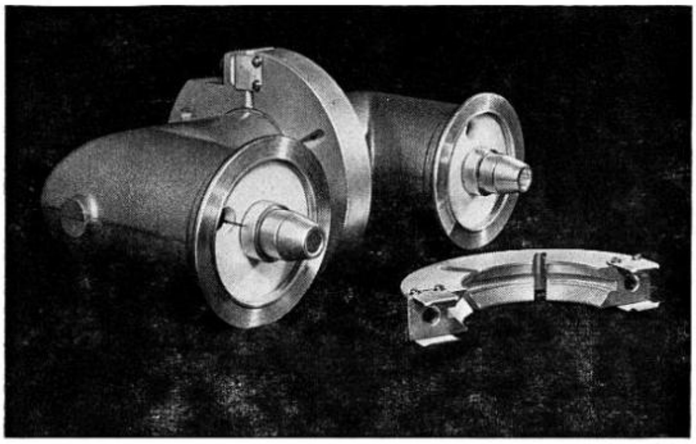

Fig.6 Patching link.

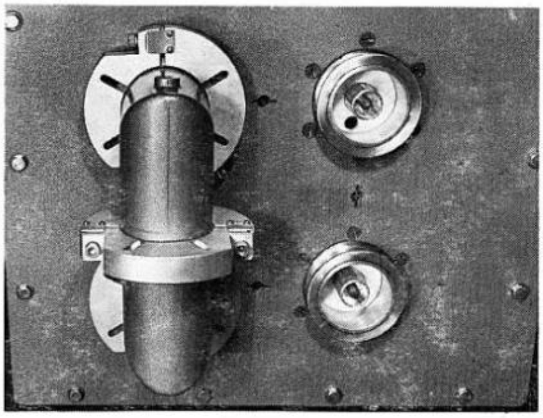

Fig.7 Patching link and panel-mounted connector.

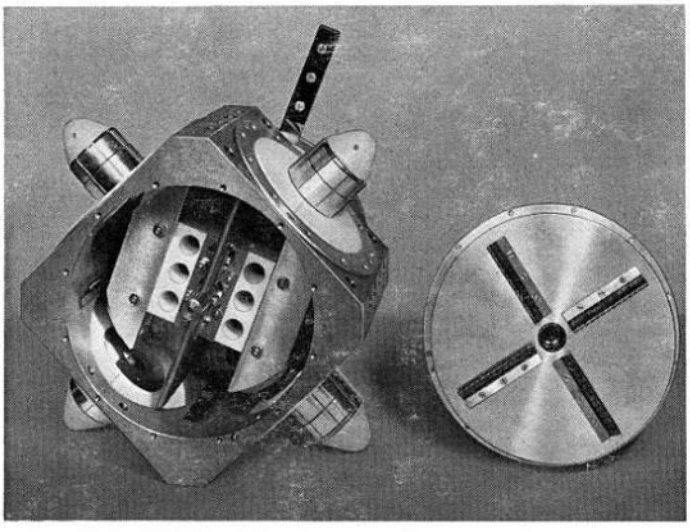

Fig.8 A 6⅛in switch

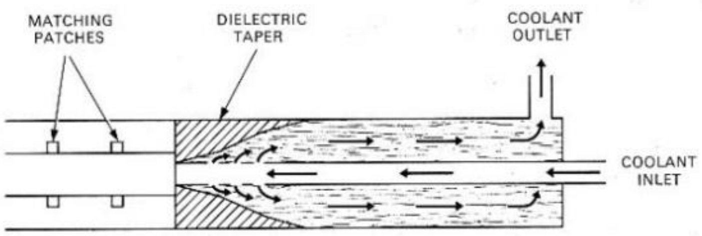

Fig.9 A section through a test load.

In the 1⅝in and 3⅛in versions of the switch compensation for impedance irregularities is achieved by optimizing the shape of the moving contact arm. By this means it is possible to achieve a reflection coefficient of less than 0·02. Compensation of the 6⅛in switch requires more elaborate methods. Small capacitor blocks are added to a basic switch unit and provide compensation in one of two ranges – either 470–700MHz or 675–860MHz. In both ranges the maximum reflection coefficient is 0·035.

Motor-operated versions of the two larger switches have been developed for applications calling for remote or automatic control. Manual override facilities are provided on all types.

All switches are fitted with auxiliary micro-switches for use in indication and interlock circuits.

TEST LOAD

The construction of the test load is shown in figure 9. A short-circuited length of test line, filled with a conductive, liquid coolant, forms the dissipative element of the load. Power transmitted through this section is rapidly attenuated and any power reflected at the short circuit is similarly attenuated. The choice of a suitable length for the liquid-filled section ensures a low reflection coefficient at its input. The length chosen is governed by the conductivity of the coolant.

Due to the high dielectric constant of the coolant, the characteristic impedance of the dissipative section is approximately 8 ohms. A dielectric taper functions as a transformer, matching the low impedance to the 50 ohm characteristic impedance of the transmission line. The use of an 'optimum' taper[1] minimizes the length of this section.

By maintaining a continuous flow of coolant through the load, it is possible to dissipate considerable power without an excessive increase in coolant temperature. The coolant is passed through a heat exchanger and returned to the load in a closed-circuit system. Provision of thermometers indicating the inlet and outlet coolant temperatures together with a coolant flow meter allow accurate measurements of the power dissipated in the load to be made.

Two versions of the load have been developed, one for use with a water/glycol coolant, and the other for use with a solution of copper sulphate in water. They are both capable of dissipating the combined output of a 45kW vision transmitter and its associated sound transmitter with a coolant flow of 10 gallons per minute. Two matching slugs in the section adjacent to the dielectric transformer allow fine adjustment of input impedance. The reflection coefficient is not greater than 0·02 over the selected channel.

DIRECTIONAL COUPLERS

The directional properties of a loop terminated in a resistance (Fig.10) are dependent on the equality of the electric and magnetic coupling. The magnitude of the coupling between the loop and transmission line, and hence the output voltage, is determined by

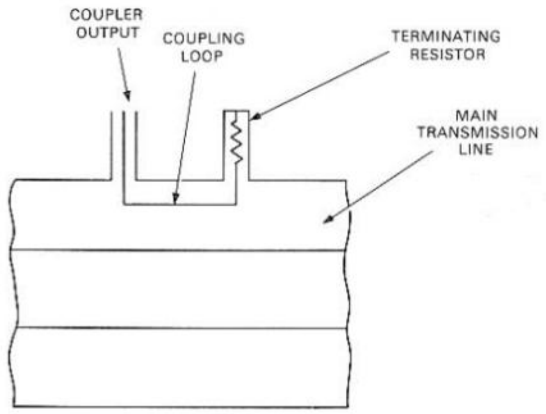

Fig.10 Diagrammatic representation of a directional coupler.

the penetration of the loop within the line. Rotation of the loop within the line allows variation of the magnetic coupling while maintaining constant electric coupling. When the characteristic impedance of the loop is matched to the terminating resistance, the coupler presents a source impedance equal to that of terminating resistor.

Figure 11 shows the coupler mounted in a housing for inclusion in 6⅛in line; similar housings are used for 1⅞in and 3⅛in lines. Angle and penetration scales engraved on the coupler assembly enable precise adjustment of the loop position within the transmission line to be made. The coupler has been designed to present a source impedance of 50 ohms and a directivity of not less than 30dB is obtained through a coupling range of −30dB to −60dB.

CONCLUSION

The performance of a transmitter system is dependent not only on the transmitter itself, but also on the feeder and aerial system. The development of the range of u.h.f feeder components described in this article allows a high standard of performance to be obtained from the overall system.

Fig.11 Directional coupler mounted in a 6⅛in housing.

REFERENCES

1 R. W. Klopfenstein: A Transmission Line Taper of Improved Design; *Proc. I.R.E.*, Vol.44, January 1956.

2 B. M. Sosin: Application of Directional Couplers to Amplitude and Phase Measurements at v.h.f, *Marconi Review*, 1951, Vol.XIV, No.100.