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Two Filters and a Diplexer for 23cm

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This article describes two interdigital bandpass filters for 23cm that have been made and tested to information contained in the ARRL publication UHF Microwave Experimenters Manual. The article also describes a diplexer that uses one type of filter to enable transmission and reception via a single antenna.

1. INTERDIGITAL FILTER DESIGN

Filter A is a fairly simple design of modest performance with three active elements. It has a -3dB bandwidth of 8.2%, or 105 MHz, centred on 1282.5 MHz and thus covers the whole 23cm amateur band. It has a VSWR of 1.5:1 and, when constructed from aluminium, an insertion loss of approximately 1dB.

Filter B is a somewhat more complex design, with five active elements and a much better performance. It has been designed to have a -3dB bandwith of 1.1%, or 14.5 MHz, centred on 1316 MHz and thus covers the RMT-2 amateur television repeater output channel, although it can be tuned to cover any other 14.5 MHz segment of the band, for instance a repeater input channel. This filter also has a VSWR of approximately 1.5:1 and, when constructed from aluminium, a slightly higher insertion loss of 1.5dB.

The measured amplitude frequency responses of these filters are shown in Fig.1, while the measured response of Filter B is shown with an expanded frequency scale in Fig.2.

It should be mentioned that the ARRL information covers the design of 23cm filters from three to eight elements and percentage bandwidths from 1 to 10%. In total four filters have been constructed by the author using the ARRL

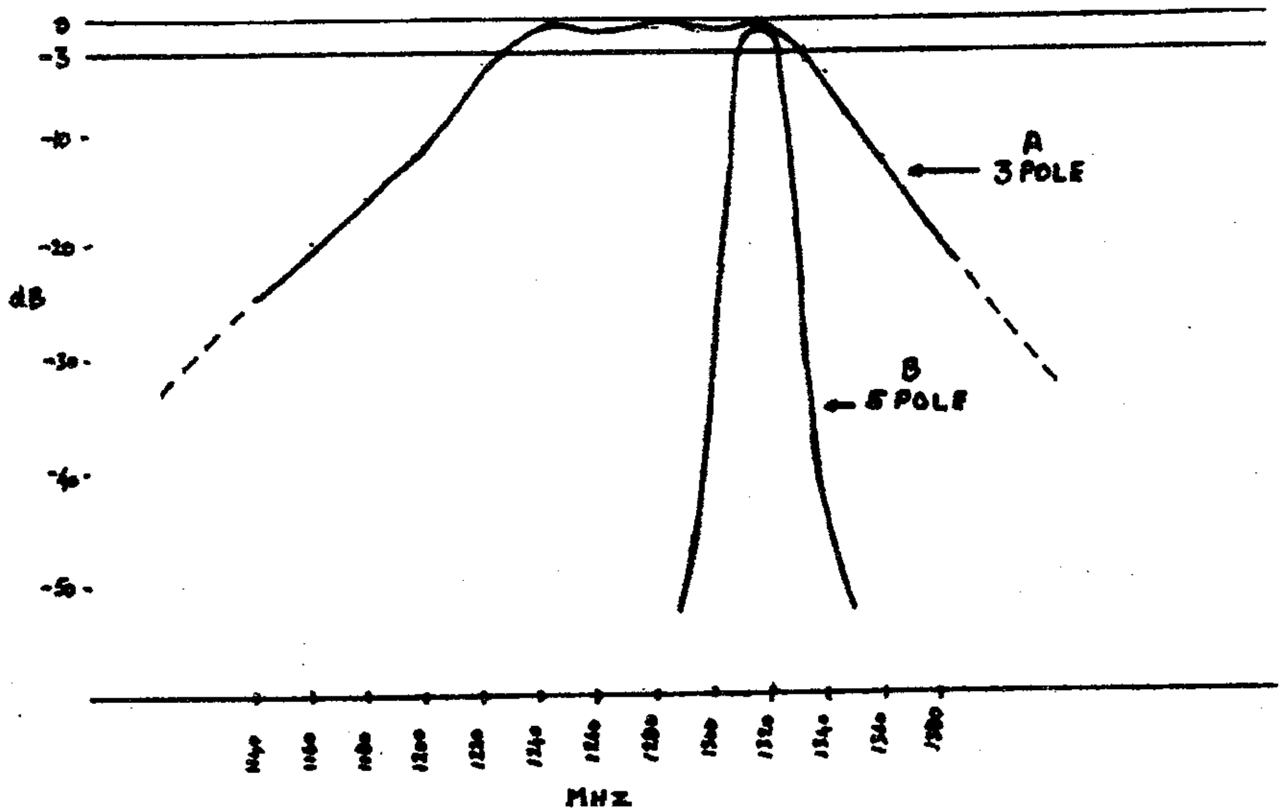


Fig.1: Amplitude Fequency Responses of Filters A and B

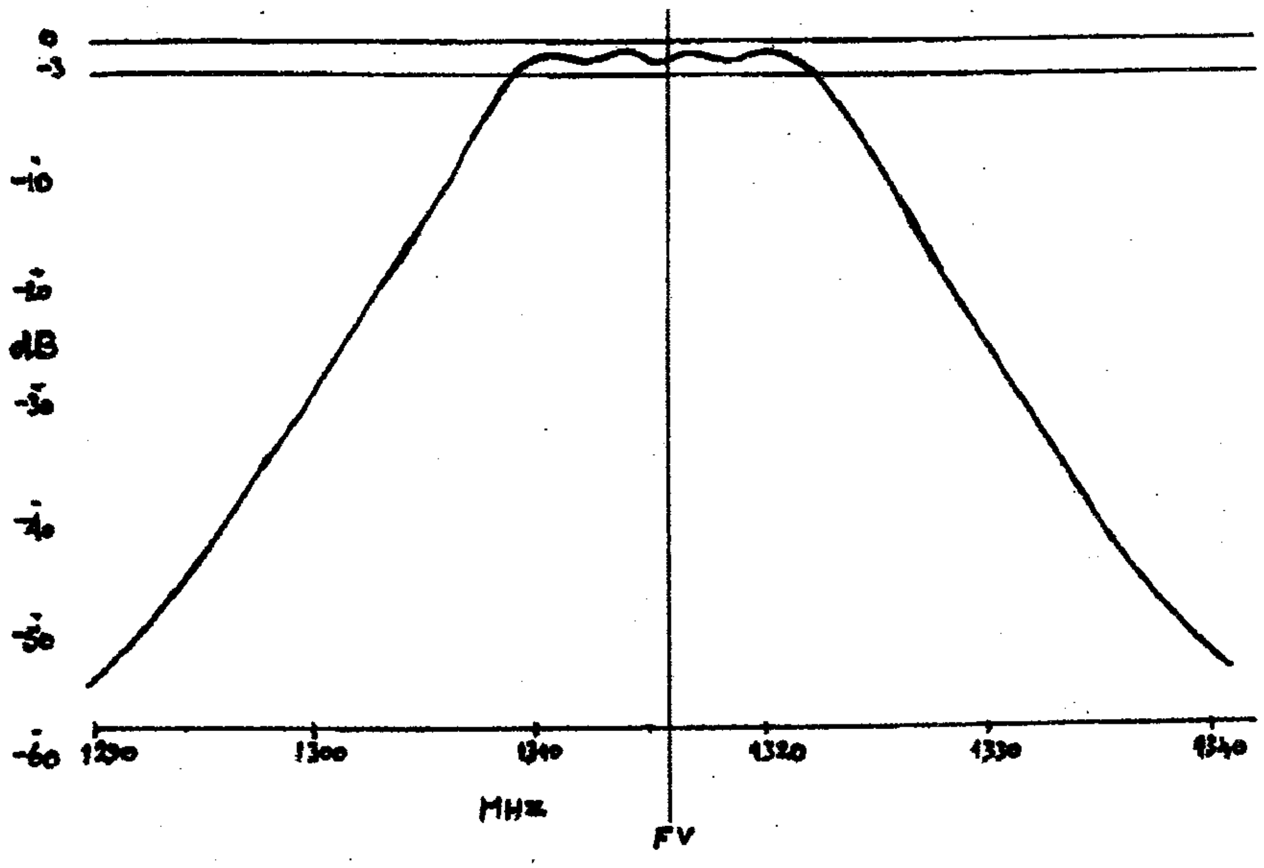


Fig.2: Response of Filter B with an Expanded Frequency Scale

data and they have all performed as expected and have tuned up without difficulty

2. CONSTRUCTION

The filters can be constructed from aluminium or silver-plated brass. Plated brass would give better performance, although it is difficult to say how much better, but would be much more expensive.

The mechanical details of Filter A are given in Fig.3 and those of Filter B in Fig.4. They are both quite simple to construct, provided that a small lathe and the usual hand tools are available. However, the work for Filter B is quite time consuming. If no lathe is available then the services of a friendly model engineer might be obtained.

The top and bottom plates are constructed from 1 inch and ¼ inch aluminium strip. The side plates are cut from 16 SWG or preferably 14 SWG aluminium sheet. The top and bottom plates should be drilled and tapped M3 or 4 BA and the sides attached with screws at 1 inch intervals. Care should be taken to remove any burrs and ensure good contact.

The rods are turned down from the next largest size of stock aluminium rod. They should be accurate to within +/-0.002 inches. They are centre drilled and tapped for attachment to the top and bottom plates using any suitable screws. The tapped ends are countersunk slightly to ensure that electrical contact is at the circumference. The end rods, or input and output transformers, are drilled to accept the centre contacts of the input and output plugs. These are clamped by small screws in tapped radial holes at the ends of the rods.

The tuning screws may be of any size from ¼ to ¾ inch and can use any fine thread for which taps and dies are available. I have used 32 threads-per-inch which allows for a smooth and fine tuning adjustment. However, care must be taken as such fine threads can pick up stray material and seize quite easily. Plenty of cutting paste or oil is required. Lock nuts are also required, which are tightened once tuning is completed.

The connectors may be N, TNC or BNC to suit requirements and the method of fitting will depend on the connectors used.

3. TUNING UP

The author used a sweep oscillator with frequency markers to tune the filters, which permitted the passband to be set exactly as desired and the shape to be optimised with minimum ripple. One problem is to first tune the filter to allow enough sweep signals to pass through it to enable alignment to start. With the 3-element filter it is not too difficult to randomly turn the tuning screws until something is seen. The larger number of permutations possible

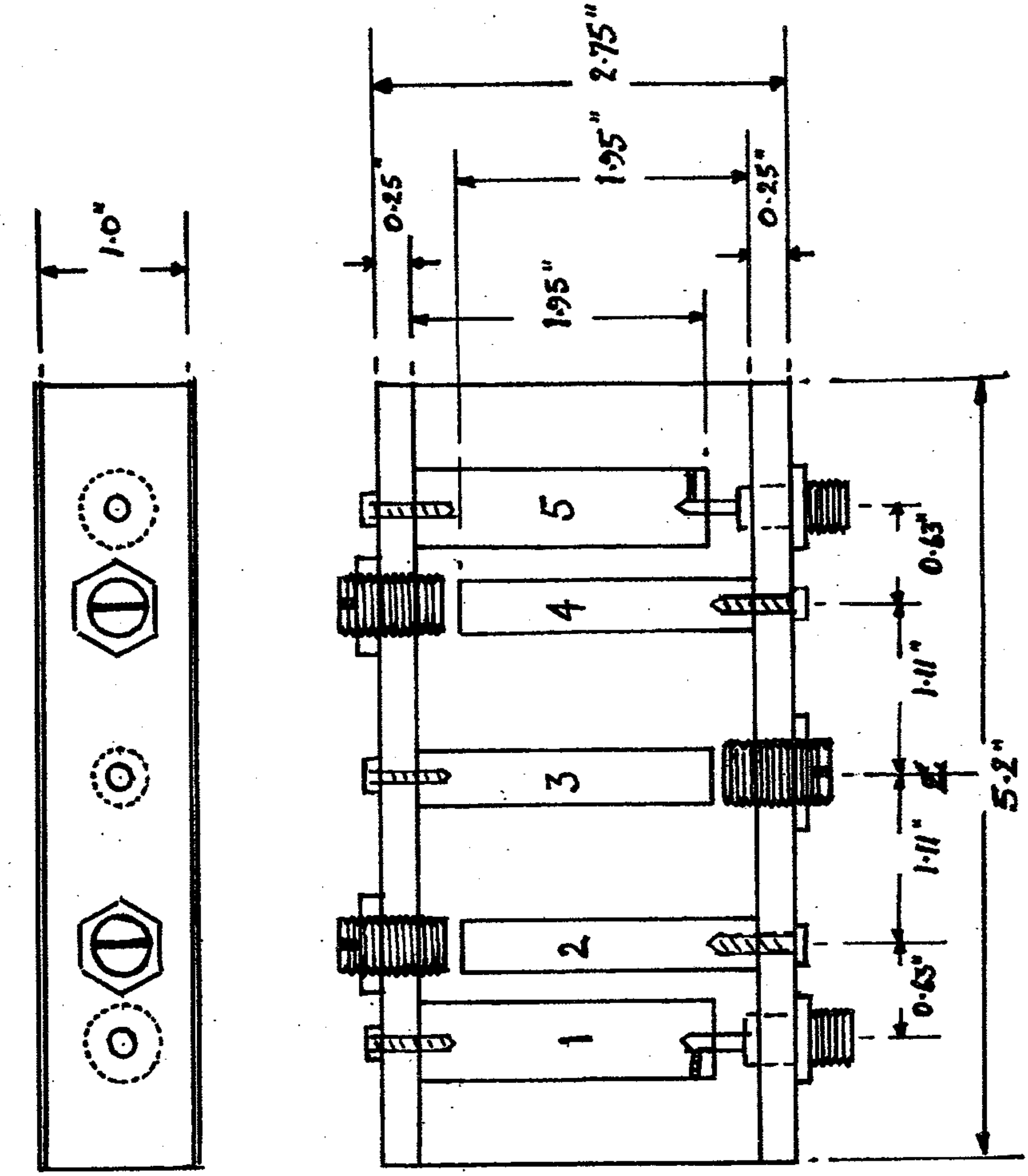


Fig.3: Mechanical Details of Filter A

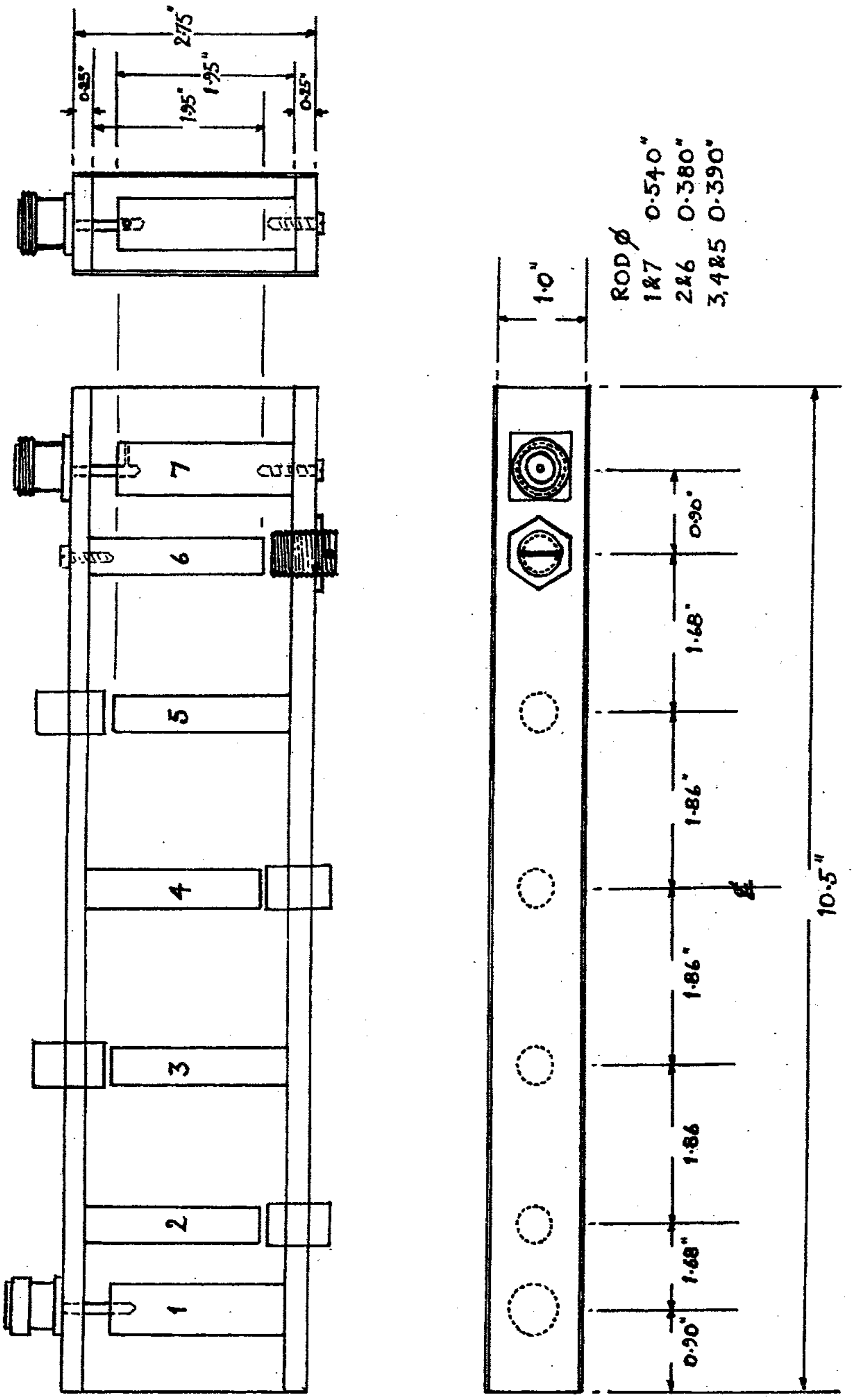


Fig.4: Mechanical Details of Filter B

with the 5-element filter make this much more difficult. One method to get a start is to inject a CW signal at the passband centre frequency and look for a signal at the output using a spectrum analyser. Once a signal is seen, even at -70dB, the tuning can be quickly optimised. Another method could be to use a communications receiver.

4. APPLICATIONS

Filter A was designed for use as an image noise filter placed between the RF stages and the mixer in a receiver, or after the up-conversion mixer in an IF modulated transmitter, to improve unwanted mixing products.

Filter B has been applied in a number of ways. It can be used at the output of a transmitter, perhaps a repeater transmitter, to remove unwanted modulation sidebands. If the insertion loss of 1.5dB is too much to lose, then assuming that the PA is a class AB linear brick amplifier, the filter may be placed between the drive stage and the PA.

A class AB amplifier, if not overdriven, will not reinsert the removed sidebands and the loss of drive power can usually be made up quite easily.

This filter can also be used at the input of a receiver to protect against adjacent channel interference.

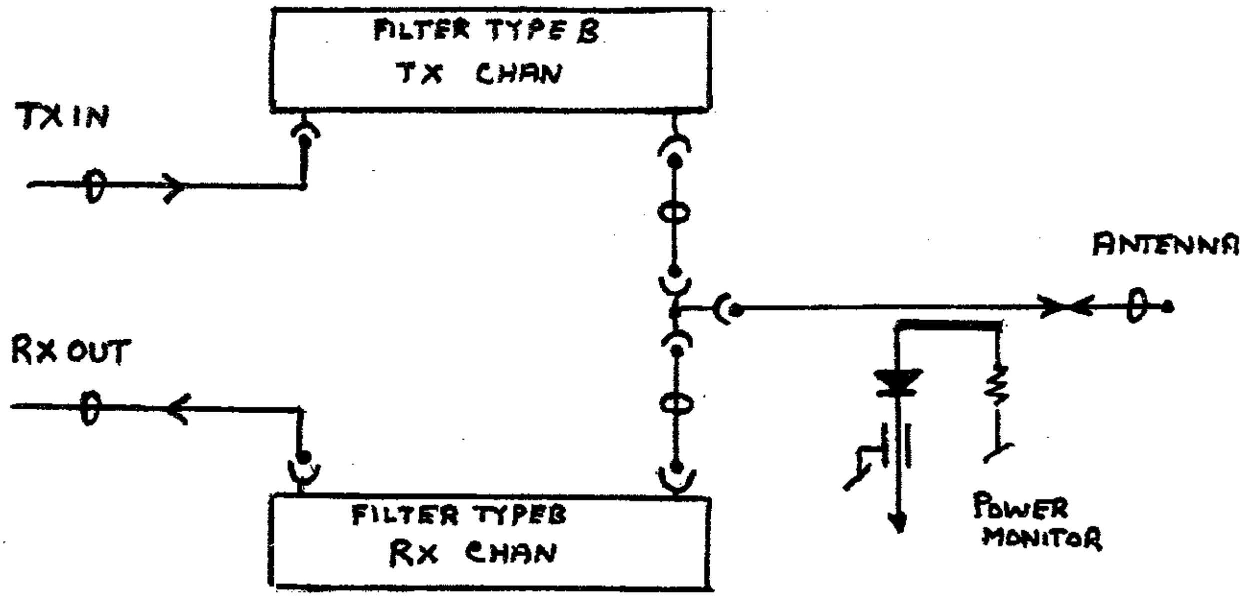
Another application of Filter B could be in the aerial feeder of a look-through antenna to reject the sidebands of the stations own transmission, that can degrade the look-through picture.

5. DIPLEXER

Two filters type B, one tuned to the required transmit frequency and the other to the receive frequency, connected together by a coaxial T-junction as shown in Fig.5, can be used to make a very effective diplexer, thus enabling transmission and reception via a single antenna.

The T-splitter is constructed from a N-type coaxial connector and two lengths of semi-rigid coaxial line fitted into male N-plugs. The combined lengths of these lines and connectors is such that the effective length from the centre point of the T-piece to the start of the filter input transformers is one wavelength at the centre frequency, taking the velocity factor of the coaxial line into consideration.

The theory is, each filter has a reasonable match and so presents a low impedance at its passband frequencies, but a high impedance at the other channel, some 65 MHz away in a 23cm Amateur Television system. The one wavelength T arms transfer these impedances to the junction point. An incoming signal thus sees a low impedance path to the receiver, while the other path appears as a high impedance. Conversely, the transmitter sees a low impedance path to the antenna, but the route to the receiver appears as high impedance.



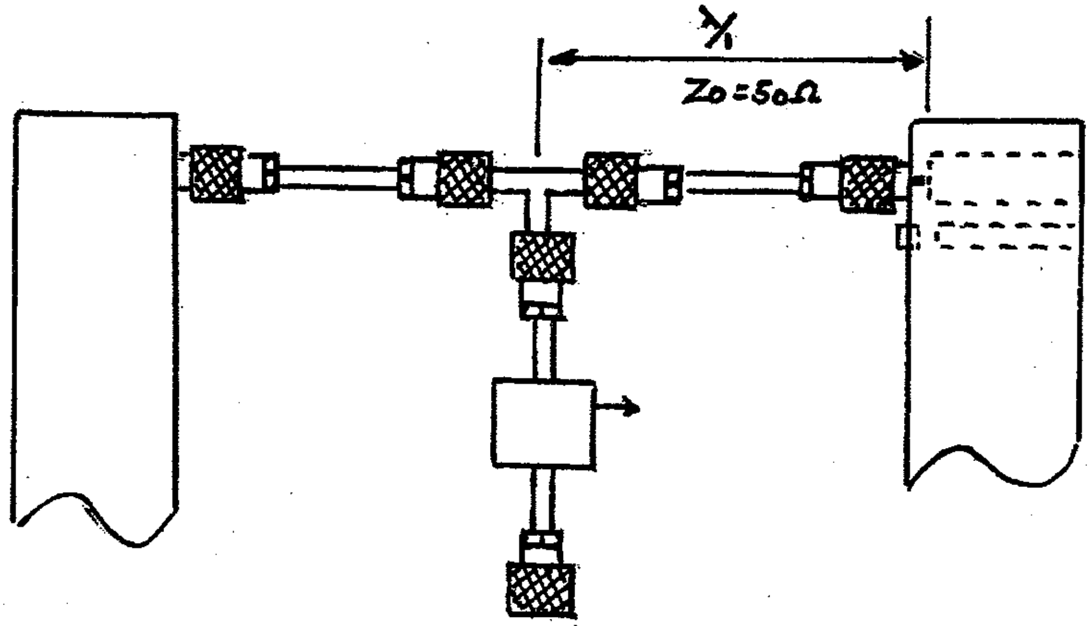


Fig.5: Construction Details for the Diplexer

The transmit filter suppresses out-of-band modulation products, particularly any that may be in the receiver pass-band. The receiver filter also suppresses the transmitted signal and any other signals beyond the wanted receiver passband. Although its insertion loss degrades the receiver sensitivity by 1.5dB, the improvement in received picture quality in the presence of interfering signals makes this well worth while.

The transmit/receive cross loss is beyond the limit of practical measurement. When receiving a full-strength (P1) picture it is possible to switch the transmitter on and off without seeing any change in the received picture quality.