<u>VHF Twin Dipole Antenna Combiner and tuning stub for Climie 730</u>
<u>by John M. Wysocki ZL2TWS. November2025.</u>

The Hi-Tec FDE3-SA twin dipoles were removed from Mount Climie 730 antenna mast after five years of service.
The reason for removal was an increased SWR (8 db return loss) and water evident at the coax feeder cable connector.
Trustee inspections had showed a performance decline since May 2024 after four years of service.

The dipole combiner unit, supplied by Hi-Tec, was found to have faulty weather sealing quality.
It was probably leaking after the first year in service but not checked until year four in service as it was never expected to be a problem. It was all new commercially made after all. The combiner was not sealed with epoxy resin, as Hi-Tec claimed, but instead used silicon rubber. The silicon was not a good seal and the combiner suffered water ingress. The water travelled to the lowest dipole cable and main feeder. The dipoles have not leaked or failed but one feeder had water in the first 500 mm of cable.
<u>Note:</u> Both dipole feeder cables must be identical lengths before connection to the combiner.

Both dipoles, removed from Climie in May 2025, then needed fresh coax cable ends and were cut back until clean copper was found and re-terminated with Huber+Suhner plugs supplied by Intelcom, Lower Hutt.
At least the dipoles were still usable and can go back into service with identical, but shorter tails.
Branch 63 was interested in moving on with an "Amateur" solution that would return the twin dipole stack to service.

If the dipoles presented exactly 50 ohms to the combiner then 25 ohms is seen at the 50 ohm feeder cable.
The resulting mis-match will give poor results. This is typically 2:1 or 9db return loss.
Hi-Tec claimed better than 14 dB was what we should expect with two dipoles and using their combiner.
Really? Can't we do better here?

When the new Hi-Tec FDE3-SA dipole stack was installed 15th February 2020 the SWR was noticed to be poor at around 1.4:1. (return loss was only 15.5 db) and as expected by Hi-Tec better than 14 db.
Yes all is OK?
Hi-Tec were asked about this and replied that no matching section and tuning stub was required for the FDE3-SA. So why was the SWR high anyway? Or was it? Now we know why!

Vector Network Analyser (VNA) measured the best SWR of 1.025:1 (38 dB return loss) of one dipole at 151 MHz and the other at 150.6 MHz showing 41 db return loss.
At 147.6 MHz (half way between 147.300 MHz and 147.900 MHz) the individual dipole SWR was about 1.08:1 (28 dB)
This is very acceptable so the dipoles are good to match up and use again as single dipoles.
After mounting pole spacing tests the return loss improved even more. Read on Page-3 below.

<u>The search for a combiner splitter solution started so both dipoles could be used:</u>
Branch 63 was offered a new version of the Hi-Tec combiner including an assurance from the new Hi-Tec owner that the new combiner would be filled with epoxy resin to seal it.
Branch 63 has decided to not trust the design of the combiner anyway as technically it didn't seem to be as good as it could be based on previous experienced technical sources and enquiries.
<u>Note:</u> We also heard from reliable sources that other overseas commercial suppliers, who export to New Zealand, have also had dipole antenna and splitter production quality control issues.

The original Sky Mast antenna stacks from UK purchased for 5425 and 860 are still running well after 10 years of service. These have proved to be cost effective and good performers.
The shipping costs, over recent years, persuaded us to support local manufacturers and we ending up with a resulting water leak.
The FDE3-SA was a connector less harness system that leaked water and Branch 63 now returns to a "home brew" all connector harness, that we hope will not leak, but probably more repairable in the future.

The solution:
In 2005 John ZL2TWS with help from Terry ZL2BAC built a twin dipole matching harness for the 700 Lower Hutt repeater.
This was based on a March 1987 Break-In article written by Terry where he used the same combiner harness to combine two satellite VHF 50 ohm antenna. Pages 7 and 8.
The article points out that the antenna cables present 50 ohms to the combiner (25 ohms combined) and the 123 mm matching section and stub then transform the impedance back up to 50 ohms. The matching section and stub coax is using high quality RG-213.
75 ohm coax can be used as mentioned in the article and here: https://benelec.au/ds/10322YB_Datasheet.pdf
The stub coax length from open end to the centre solder pin of the elbow connector is 105 mm.
Keep in mind that the remainder of the connector also forms part of the stub.

Picture-1. Matching section 123 mm connector tip to tip.

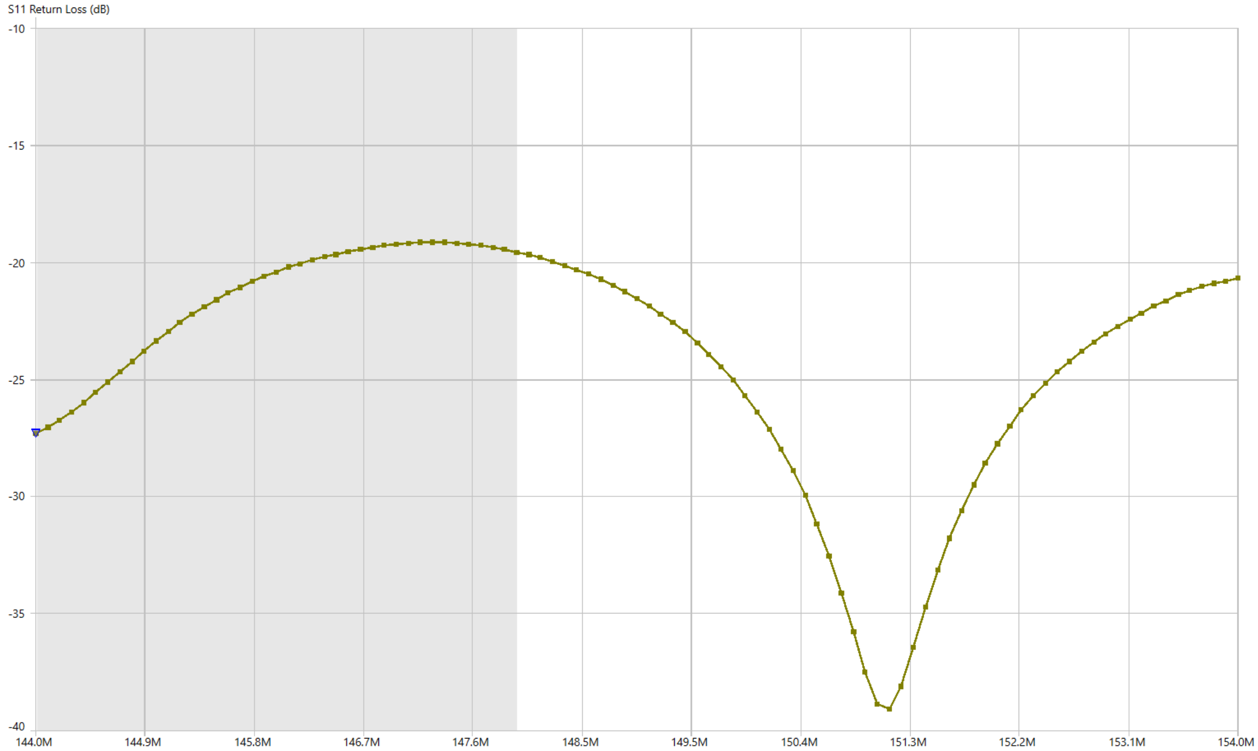
Picture-2. Tuning open circuit stub 105 mm to centre of elbow.

Picture-3. Both dipoles connected and return loss of -23.5 db measured without 8 m feeder cable.

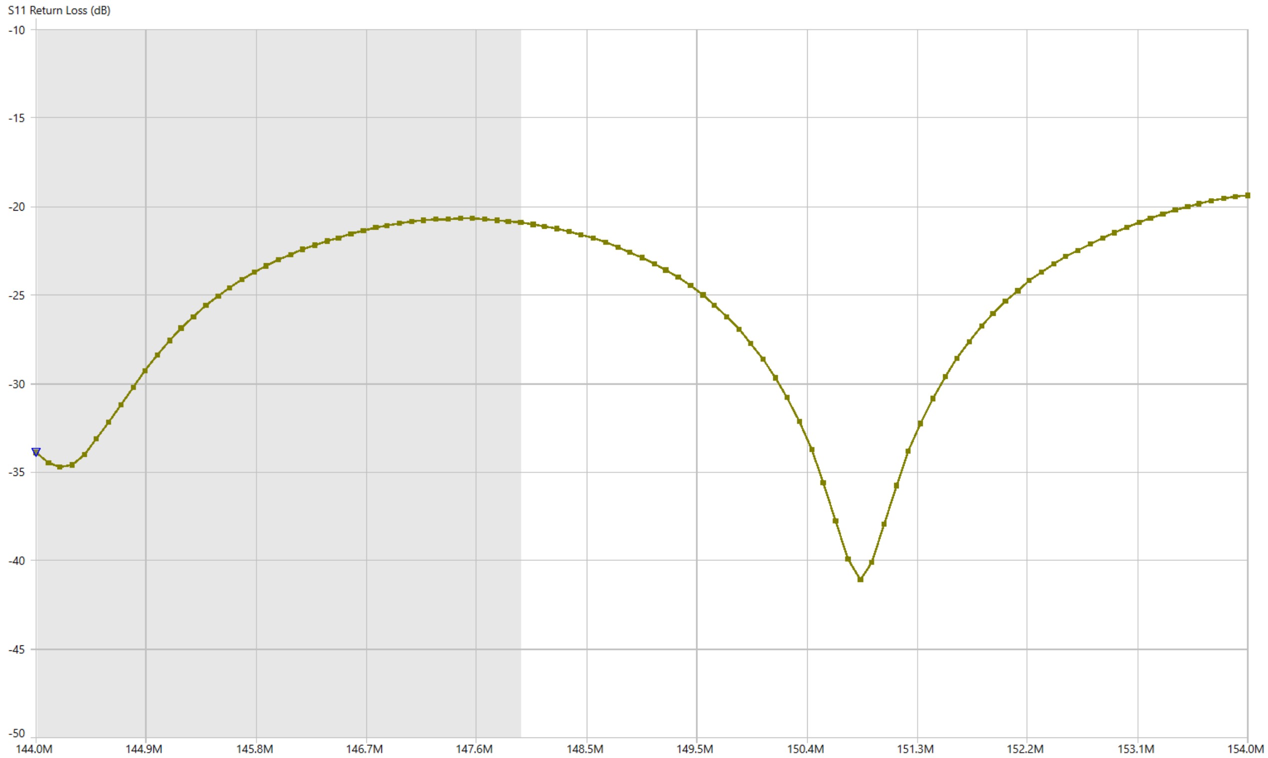
The type of FDE3 dipole design uses a coaxial transformer match inside one arm of the folded dipole.
This has been a commercial practice for many years instead of the Amateur radio traditional 4 to 1 coaxial balun as detailed in the March 1987 article.
I have personally built many of these 4:1 coaxial baluns with always excellent results.
They are harder to seal up and require more work than the commercial internal coaxial 1/4 wave transformer.
The commercial transformer does not always give 50 ohms and is often a higher impedance.
To compensate for this manufacturers use variable wavelength spacing from the mounting pole depending on pole diameter. This of course off sets the radiation pattern and is often a compromise.
I found that moving the dipole pole spacing from 1/2 a wave length of about 1000 mm to about 420 mm changed dipole return loss from 17 dB (1 m spacing) to 33 dB (420 mm spacing)
This means optimal spacing was found for our overall tuning.
It is also known that distance spacing between dipoles is important to achieve optimal radiation pattern and to prevent interaction between the dipole pair.
This was recommended to be between 1500 mm and 1700 mm.
Our tests settles on 1650 mm where there was no interaction and the return loss stayed at 33 db for each dipole.
With both dipoles connected to the combiner without matching section and stub the return loss was bad and as expected at around 2:1 or 9 db return loss.

With the matching section and stub we got 23.5 db. Feeder cable and connectors will add 1dB more to this.

As mentioned above the best SWR of 1.025:1 (38 db return loss) of one dipole at 151 MHz and the other at 150.6 MHz showing 41 db return loss. At 730 frequencies the SWR was about 1.08:1 (28 dB)
The dipole spacing from mounting pole had been decreased to 420 mm to achieve this but we felt more could be done to get even better results at 730 frequencies using a tuned stud combiner.
With both dipoles combined, without a matching harness and stud tuner, an SWR of 2:1 (9 db return loss) was measured so a matching section is required.

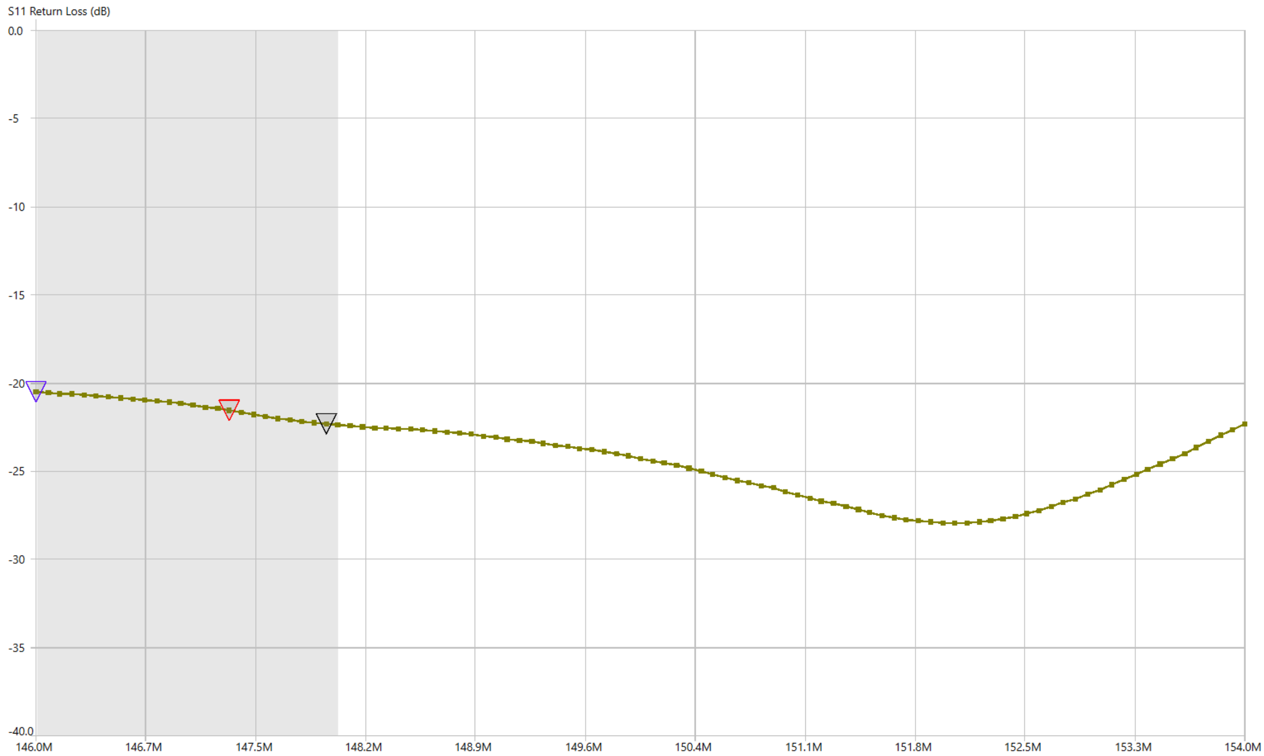


Picture-4. Top Dipole 151 MHz and 38 db return loss at resonance on the 8 m RG-213 coax feeder cable.



Bottom dipole 150.6 MHz and 41 db return loss at resonance on the 8m RG-213 coax feeder cable

Please note that neither dipole was on exact frequency we preferred at 147.6 MHz with one resonate at 150.6 MHz and the other at 151 MHz.
So the combined impedance will never be ideal but the matching section and stub makes this a better tuned antenna.



<u>Final tuned result at 147.3 MHz and 147.9 MHz and a compromise to get SWR of 1.15 :1 23 db return loss.</u>

Unfortunately the resonance of the dipoles are too high and if they were lower the combined result would be closer to SWR 1.1:1 26 db return loss, so we got as close as we will get..
One thing is for sure that the matched dipole result is better than the original Hi-Tec supplied combiner.
Once on the pole at Mount Climie results might be even better.

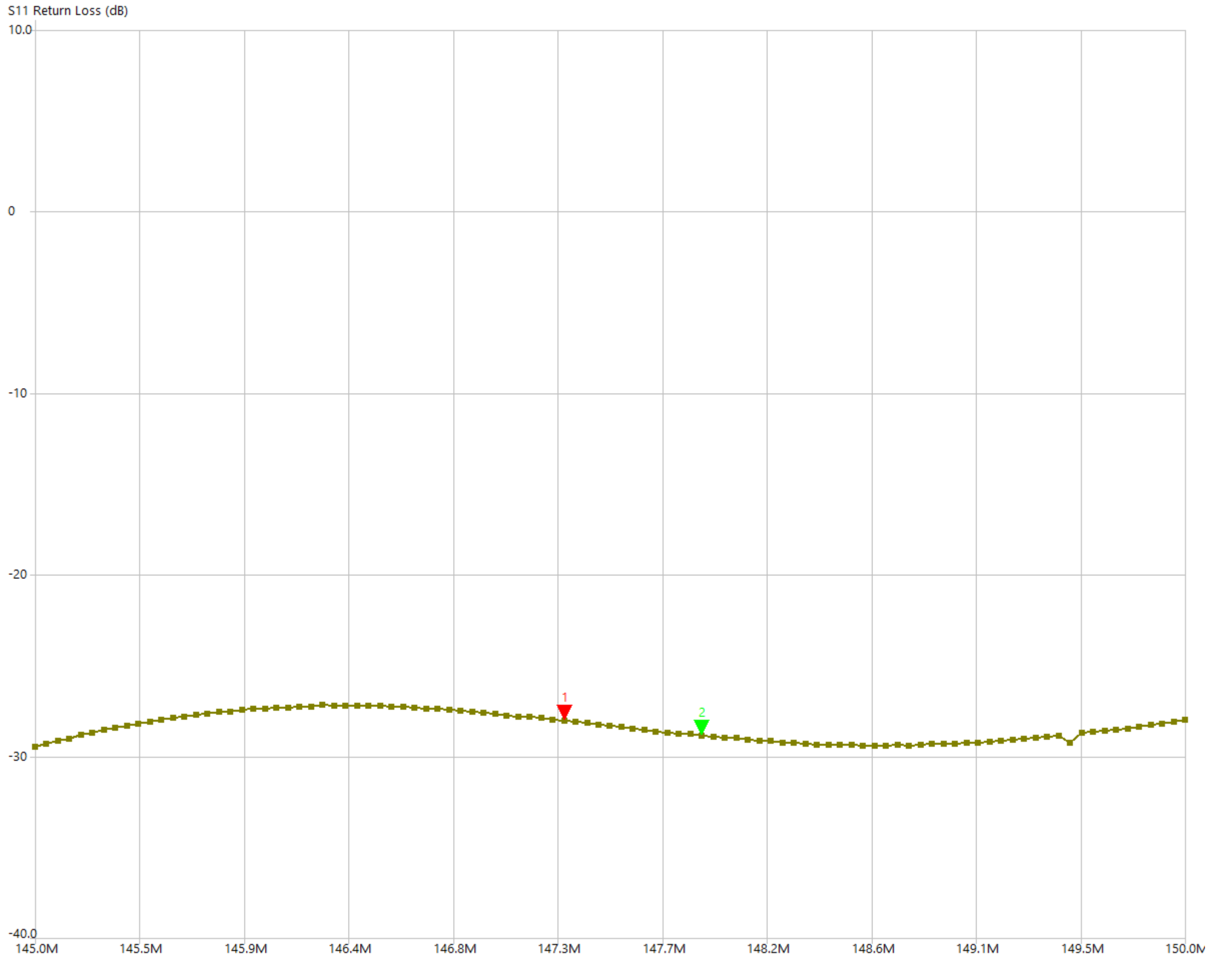
<u>Final results and installation at Mount Climie on the 17th November 2025.</u>

Dipole centre spacing was settled on 1650 mm and spacing out from the pole at 470 mm.
8 m coax cable feeder up the mast, the matching harness and stub fitted.
The pole was then winched into position.

VNA results can be seen on Page-6 and this was backed up by measuring forward and reverse power on a Bird 43 watt meter.
Forward power out of the duplexer is 34 Watts and Reverse power 0.06 watts (60 mW) resulting in an SWR or 1.08 to 1. Yep! we can live with that. No lost power more than 60 mW.

Signal reports received from regular users that good increases were seen and hand held operation was now possible where previously it was difficult.

Special thanks to Mark ZL2UFI and Mark ZL2UP for their help on a fine, but 29 knot windy day.
The loan of winch snatch block pulley from Mike ZL2NSA.
Gavin ZL2ACT for the VNA testing.
Intelcom - Lower Hutt for antenna cable termination and sealing.



Final installed sweep for 147.3 MHz and 147.9 MHz from 145 MHz to 150 MHz at 28 db return loss.

Pictures of the two dipoles with coverage 20 degree horizontal offset and secured matching harness and stub.

A Phasing Harness for Circular Polarisation

by **TERRY OSBORNE**, ZL2BAC

Having bought a crossed yagi antenna for 2 m I was faced with the problem of designing a phasing harness for circular polarisation for use on OSCAR Satellites.

The Satellite Experimenters' Handbook gives various methods of achieving this but they all use lengths of 75 Ω cable and soldered joints that are very difficult to weatherproof. I decided to use 50 Ω cable and standard connectors (about 3 m of RG213/U cable is required) and standard connectors as detailed below:

UHF series	N series
2 f/f/f Ts	2 f/f/f Ts
5 PL259 plugs	4 straight plugs
	1 elbow plug

It is also possible to use RG58/U or IEC 50 and BNC connectors.

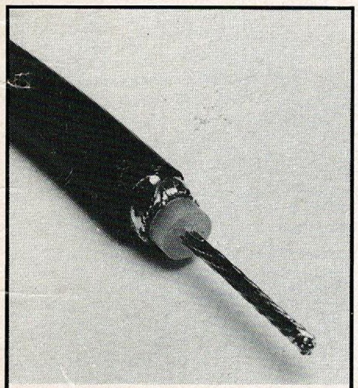
BNC series
2 f/f/m Ts
4 male cord plugs
2 female cord plugs

The harness conists of two baluns and a 1:1 splitter.

Constructing the Baluns

1. Using a sharp Stanley knife cut two 800 mm lengths of cable and remove the outer jacket 57 mm back from each end.
Remove the braid and dielectric. Cut off another 3 mm of outer jacket and braid from each end. Cut off yet another 3 mm of outer jacket from each end and tin the exposed braid. You should now have two lengths as per Figure 1.

2. Cut one 685 mm length and one 343 mm length of cable. Terminate one end of each length with a plug from the chosen series.
From the other end of the cables remove 25 mm of jacket, braid and dielectric. Remove 3 mm of jacket and braid, and 3 mm of jacket as done for the loops. Tin exposed braid (see Figure 2).
These balun feeds are of different lengths to obtain the 90 degree phase shift needed for circular polarisation.



A close-up photograph of the prepared coaxial cable.

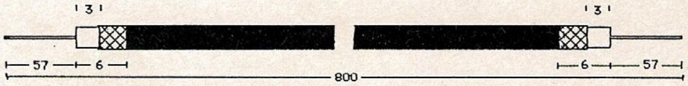


FIGURE 1 : BALUN LOOP (2 required)

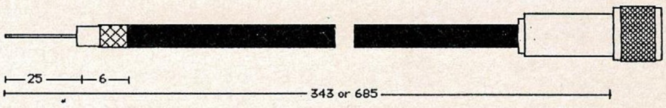


FIGURE 2 : BALUN FEED (2 required)

3. Bend the loops in half and tape a feed to each one. Bind the braids with tinned copper (fuse) wire and solder, taking care not to melt the dielectric. Bend the inner from the feed around one of the loop inners, solder and trim as per Figure 3.

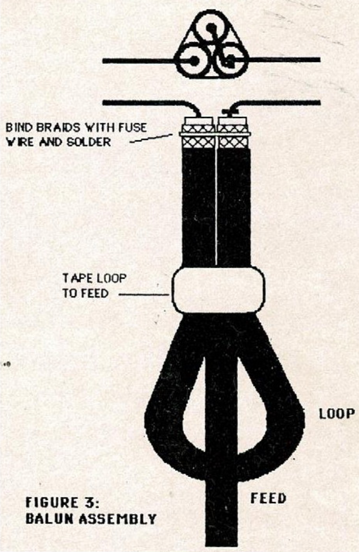


FIGURE 3: BALUN ASSEMBLY

To weatherproof this assembly mount it in a suitable plastic jar and pot in Araldite. Connect the baluns as per Figure 4 and check the VSWR.

Constructing the Splitter

4. Cut a 150 mm length of cable and terminate both ends to make a cable 123 mm long from connector to connector. This is the line. Cut another 150 mm of cable on the remaining plug to make the stub.

5. Connect the splitter as shown in Figure 4 (see next page).

6. Connect a 2 m transmitter and trim the stub for best VSWR (118 mm long for my one).

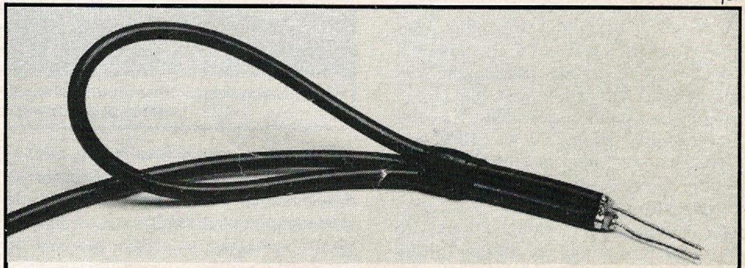
Testing

7. Check for received signal on OSCAR-10. If no signal is found then you have left hand circular polarisation or a faulty antennae. Disconnect the splitter and connect each antenna to the main feeder in turn. If the antennae are okay then reverse the balun connections to one antenna dipole. This reverses the sense of the circular polarisation. The signal should now be 3 dB stronger than when one antenna was connected to the main feeder.

This feed systm will work with well designed antennae that are already matched to 50Ω. If a good match in step 6 cannot be obtained this indicates a poor antenna match.

If you wish to make use of existing baluns which have identical length feeds construct a line 337 mm long as in step 4 and add this between the end of one feed and one splitter outlet. An f/f barrel connector will be needed. Carry out the test in step 7. If the wrong sense of polarisation has been produced swap the 337 mm line to the other balun feed.

The Wellington VHF Group has stocks of most of the connectors needed for this feed system.



The completed balun before potting.

March 1987 "Phasing Harness for Circular Polarisation" by Terry Osborne ZL2BAC (Page-1)

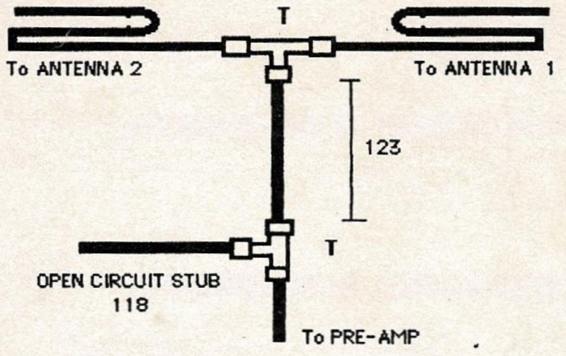
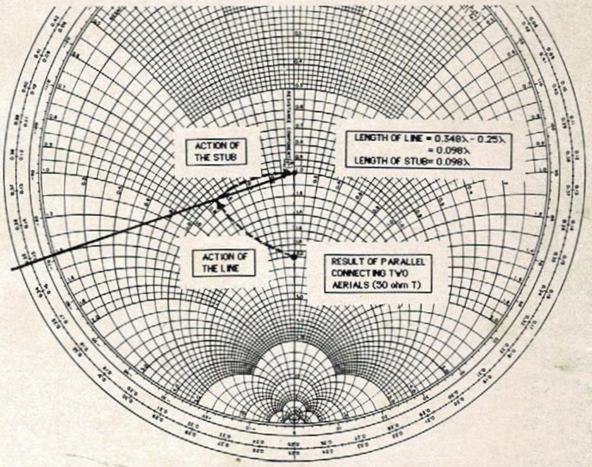
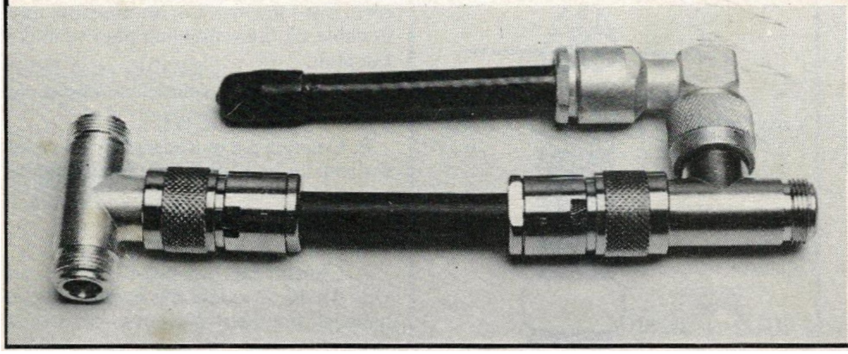


FIGURE 4 :
FINAL ASSEMBLY



Above: A Smith Chart depiction of the effect of the matching stub.



Left: The complete splitter assembly including stub.

March 1987 "Phasing Harness for Circular Polarisation" by Terry Osborne ZL2BAC (Page-2)

References:
1) March 1987 "Phasing Harness for Circular Polarisation" by Terry Osborne ZL2BAC
2) Hi-Tec FDE3-SA “VHF Folded Dipoles Stacked Array”
3) Benelec 02531/02530/02331 Side Mounted Dipoles - 2 Stack Array
4) https://www.repeater-builder.com/antenna/pdf/effects-of-structures-on-antennas.pdf
5) https://www.repeater-builder.com/antenna/pdf/kathrein-scala-radiation-patterns.pdf
6) https://benelec.au/ds/10322YB_Datasheet.pdf
7) https://www.rfiamericas.com/media/downloads/pdfs/phasing_side_mount_yagi_antenna_tech_notes.pdf
8) https://zl2vh.nz/