‘Technical Shorts’

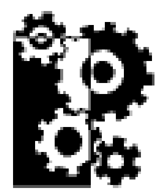
by Gerry O’Hara, G8GUH

‘Technical Shorts’ is a series of (fairly) short articles prepared for the Eddystone User Group (EUG) website, each focussing on a technical issue of relevance in repairing, restoring or using Eddystone valve radios. However, much of the content is also applicable to non-Eddystone valve receivers. The articles are the author’s personal opinion, based on his experience and are meant to be of interest or help to the novice or hobbyist – they are not meant to be a definitive or exhaustive treatise on the topic under discussion…. References are provided for those wishing to explore the subjects discussed in more depth. The author encourages feedback and discussion on any topic covered through the EUG forum.

Aerial Matching

Introduction

‘*A receiver is only as good as its aerial’* is a maxim often used, even though it is strictly incorrect. It would be better written as ‘*All things being equal, a receiver is only as good as its aerial and the match thereto*’. So, what do we mean by ‘*matching*’ and what can be done to ensure the best match possible between our receiver(s), feeder(s) and aerial(s)? As Peter Lankshear notes in Lighthouse Issue 72, p22 “…*Matching is to electronics what a gearbox is to a motor car. If you cannot have the right gear ratios your car won’t go as well, and by the same token an unmatched feeder will cause an aerial installation to be very inefficient*.” Arguably, aerial matching is even more important when a transmitter is being used - if a receiver is mismatched to its aerial, the only result is a weaker than possible signal, maybe with more interference than could be had otherwise. If a transmitter is mismatched, then not only will all the available transmitter output power not be transmitted, but damage can occur to the transmitter output stage.

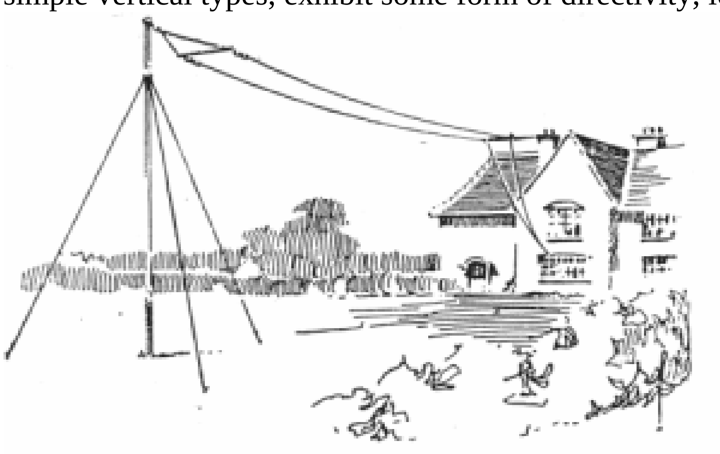


As this series of articles is aimed squarely at receivers only, I will not be dealing with transmitting-specific aerial matching problems and solutions, although some issues common to both are addressed. In this brief article, I superficially discuss typical aerials used with Eddystone receivers, their impedance, transmission lines/ lead-in arrangements (feeders) and ways of optimizing the connection of this hardware to Eddystone receivers. Due to the limited depth that such a ‘Short’ can go into such a vast subject, I also provide several references and web links that the interested reader can explore to provide more depth and understanding of this subject, as it is ideal for experimentation - each of us has a unique site, shack location within it, interference issues, receiver types, listening interests, etc (eg. I live near the top of a hill, but with power lines within 200 metres of my house and my shack is located in the basement, which is fitted with a mix of fluorescent lights and incandescent lights with dimmers, and which contains routers and switches for up to seven computers and game machines operating at any one time in the house, as well as several TV's and all manner of appliances/other potential RF interference sources).

Aerial Types, Impedance and Balanced v Unbalanced

Discussion of aerial theory and the many, many types of aerials available is beyond the scope of this article, however, a basic appreciation and awareness of some fundamental issues associated with aerials is essential to help understanding matching issues and how to get the most out of your aerial/feeder/receiver system. The reader is referred to the many books covering this subject, eg. many excellent RSGB and ARRL publications (see Reference section at the end of this article), this subject being one of the main areas of the radio hobby most often experimented with by SWL's and radio amateurs for the reasons given above and the fact that if the right combination is attained, it can provide a very significant amount of 'bang for your buck' in terms of receiving enjoyment.

HF radio aerials are usually a variation of either a two-wire 'balanced' form (dipole or 'doublet[1]') or a single wire 'unbalanced' form (termed 'end-fed', or 'long-wire', although the latter term is strictly only correct if the length of the wire is equal to or greater than a full wavelength of the received signal). Aerials of either form can be of resonant or non-resonant type, ie. be cut to be length that has a relationship to the wavelength of the signal being received (or transmitted). It should also be noted that most aerials, other than simple vertical types, exhibit some form of directivity, ie. they will receive/transmit signals preferentially in one, two or more directions (see discussion on this in the References).



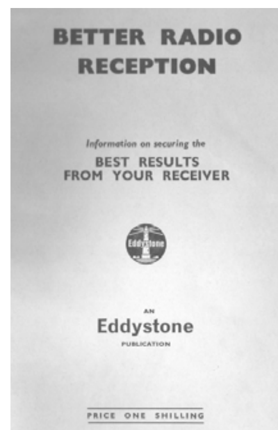
A simple half-wave dipole has an impedance of around 73 ohms *at its resonant frequency and if connected at its centre*, however, if used at a multiple/divisor of its resonant frequency, this impedance changes significantly. For example, this could increase to 5,000 ohms in the case of a 14MHz half-wave dipole being used as a full-wave dipole at 28MHz, or drop to 12 ohms if used as a quarter-wave system at 7MHz, thus requiring some method of matching this to the feeder system, which remains at a relatively constant impedance. An end-fed wire aerial, depending on

[1] The term 'doublet' has different meanings to different people and is often used as a synonym for dipole. Graeme Wormald provides a definition in Lighthouse Issue 86, p13 '…a doublet is fed by resonant feeders and may be of virtually any length [ie. is non-resonant and therefore useful on a wide range of frequencies]. Such an all-band aerial will outperform any other type of wire aerial erected in the same space. However, it does require a properly balanced matching unit to perform properly…'. G4NSJ has no less than six definitions on his website (http://www.g4nsj.co.uk/balance.shtml), ranging from being a dipole to an article of clothing!

its length, height above ground and the frequency it is being used at can vary significantly in impedance, up to several thousand ohms.

'Earth' or 'Ground'

An 'earth' or 'ground' connection provides the signal 'return' or 'counter' in a single-wire (unbalanced) aerial system. Yes, it is true that an unbalanced aerial will still produce signals without a dedicated earth being connected - this is because any receiver has some form of earth inherent in stray capacity or inductive coupling to ground, eg. the mains wiring and stray coupling through the receiver power supply circuits. The mains electrical earth (present for electrical safety purposes) is often very noisy and far from ideal as an RF earth. A separate RF earth connection, eg. a thick copper wire connected to a low resistance path to the earth, say a long copper spike driven into the ground, will often help to reduce interference. In particular, end-fed aerials work best when a good earth is provided – this is sometimes undertaken by a specially engineered system rather than a simple ground spike or buried plate, eg. a 'counterpoise' wire or 'ground-plane' installed proximal to the ground but not necessarily connected physically to it.


BETTER RADIO RECEPTION

Information on securing the BEST RESULTS FROM YOUR RECEIVER

AN Eddystone PUBLICATION

PRICE ONE SHILLING

These days, however, if a separate RF earth is contemplated, care must be taken to avoid causing a potentially dangerous situation due to the way power is delivered into the home and the house wiring/utility company provisions for providing an electrical safety-related grounding system. These arrangements vary from country to country and even within jurisdictions (eg. building and electrical codes), and I will therefore not discuss these here - please check with your utility provider if you are unsure. Some references commenting on this subject are provided at the end of this article. Avoid connecting the earth connection of the set to a water pipe as per many older radio book recommendations, and even as suggested in the 1966 Eddystone pamphlet '*Better Radio Reception*', as these pipes often do not provide a good earth connection in many modern homes, like mine, where virtually all the pipework is plastic, with only some small sections of copper pipe present. The '*Better Radio Reception*' pamphlets do, however, provide many useful tips and suggestions and are well worth a read – they can be downloaded from the EUG site. For some more thoughts and comments on earth/ground issues, visit '*The RF Earth System*' page on Ray Heffer's (G4NSJ) website (http://www.g4nsj.co.uk/earth.shtml).

Aerial Feeders and Their Characteristics

Whatever type of aerial you have, a means of connecting it to your receiver is needed – this part of the system is called the aerial *feeder* (or transmission line if a transmitter is being used). As with aerials, there are two basic forms of aerial feeder: unbalanced and balanced.

Unbalanced Feeders

The unbalanced variety of feeder has two different forms:

Single wire: probably the most common for many 'casual' broadcast and shortwave band SWL's – simply an extension of the aerial wire. Although simple and cheap, for reception, this type of feeder has the disadvantage that any noise induced into it is picked up by the receiver – certainly an issue when the wire feeder has to be run inside the home past sources of potential interference such as fluorescent lights, electrical appliances, computers, network wiring etc (as per my basement). The return path for such a single wire feeder is the ground connection to the receiver, if present, itself often poorly-made and as-such itself prone to pick up of electrical interference.

Concentric: the ubiquitous 'coaxial cable' is the most popular form of commercially-available unbalanced feeder in aerial systems. In a coaxial feeder, the current passes along the central conductor and returns along the inside of the outer metal sheath. Due to the 'skin effect', whereby electrical currents travel in the surface of conductors, the fields are held inside the cable when matched. Coax cables are available commercially in many different specifications and are very convenient for routing and connecting equipment components using a variety of commercially available connectors (see below): different loss characteristics, diameters, dielectric types, sheath types etc. are available, generally with characteristic impedances of 50, 72 or 75 ohms. Check-out Peter Lankshear's '*A Beginners Guide to Coaxial Aerial Feeders*' in Lighthouse Issue 72, p22, and the '*Coax-Fed HF Aerials*' page of G4NSJ's site (http://www.g4nsj.co.uk/coax.shtml) as well as the multitude of RSGB and ARRL publications.

Balanced Feeders

300 ohm twin-wire or 'flat' feeder

A pair of parallel wires separated at a specific distance by an insulator forms a balanced feeder system. In such a 'twin-wire' system, the two conductors carry equal, but oppositely-directed signals (currents and voltages), balanced with respect to ground. An immediately obvious advantage of such a system is that any interference induced in these conductors will be self-cancelling when fed into a balanced input on a receiver. Twin-wire feeder is available commercially in many different specifications: different spacings, solid/slotted web, lower-loss plastic foam insulated etc., generally with characteristic impedances of 75, 80, 150 or 300 ohms, though feeders of other impedances can easily be constructed with spacers and air as the dielectric. Check out the '*Balanced Feeders*' section of G4NSJ's website (http://www.g4nsj.co.uk/balance.shtml).

A 'special case' of a balanced aerial/feeder system was included in many domestic valve receivers in the mid-1930's through the 1960's, ie. the 'loop aerial', often installed in the back panel of smaller sets and sometimes on a swivel-frame in consol sets, allowing the directional properties of this type of aerial to be exploited. Loop aerials of this type were usually part of the RF input stage design specific to the set on which it was fitted.

Feeder Impedance

The 'characteristic impedance' of a feeder is the equivalent resistive load presented by that feeder, assuming no other losses or storage of energy within that feeder occurs (refer to sidebar, right, for more details). This condition can be attained either by an infinite length of feeder or by terminating the feeder with a purely resistive load of the same value as its characteristic impedance: in this condition, the feeder is said to be 'matched'. In the case of a transmitter being fed into a feeder, matching is very important to avoid both wasted power and potential damage to the transmitter output stage. In a receive-only situation, however, the degree to which the load impedance and feeder impedance can be mismatched without introducing appreciable (noticeable) loss of signal is fairly large.

Another characteristic of feeders is the velocity factor, which I need not describe in relation to HF receiver aerial systems as this property is of interest only in a transmitter application. Again, interested readers are directed to the References for greater depth and insight into feeders.

Attenuation and Loss

All feeder systems have some degree of signal loss associated with them, caused by resistive losses in the conductors, leakage losses in the insulators, radiation, and mismatches through connectors. The amount of loss depends on the materials used and construction of the

Characteristic Impedance

The characteristic impedance (Zo) of a feeder is determined by the dimensional ratios of the cross-section of the line, not by its actual size. For a concentric feeder, the formula for calculating this is:

$$Z_o \text{ (ohms)} = 138 \log (D/d)$$

where d and D are the inner and outer diameters respectively and the dielectric constant (permittivity) is unity (= 1).

For example, a coaxial feeder with a diameter ratio of 2.3:1 with air as its dielectric will always have a 50 ohm characteristic impedance, whatever the actual size of the feeder. For dielectric materials other than unity, eg. polythene (permittivity = 2.25), the characteristic impedance must be divided by the square root of the dielectric constant.

For twin wire feeders, the characteristic impedance is related to the wire diameter and the spacing, approximating to:

$$Z_o \text{ (ohms)} = 276 \log_{10} (2S/d)$$

where d is the wire diameter and S is the spacing. Insulation on the wires and the material between the wires has an effect on the characteristic impedance in a similar way to concentric feeders.

feeder, eg. regular ‘thin’ coaxial cable (eg. RG58 or RG59) will typically exhibit a loss of around 2 to 3dB per 30m at HF, whereas a good quality ‘thick’ coaxial cable (eg. RG-8) will typically exhibit losses in the order of 1dB per 30m (approximately 10% loss of the signal voltage) at similar frequencies, when perfectly matched to the aerial and receiver. A well designed 300 ohm twin line will typically exhibit a loss of <0.5dB at HF. Although not as critical as when a transmitter is involved, I would advise buying a good quality feeder cable for your receiver set-up.

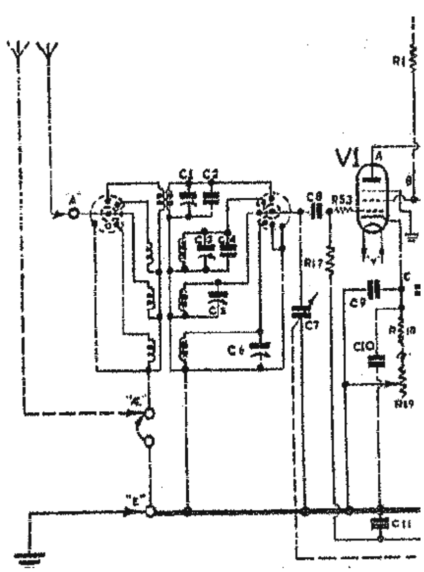
Connectors

It is one thing having selected an appropriate aerial/feeder/matching system for your receiver(s), but in practice these have to be connected together – often in a way that allows rapid disconnection/re-connection to be made (eg. to change a receiver) – this introduces another component in the system: the RF connector. The various types of RF connectors available, primarily for use on coaxial cable, are not discussed in detail here, and the reader is referred to the References at the end of this article for further discussion on this subject, including the article by Michael O’Beirne, G8MOB, in Radio Bygones Issue 103, and response letters in Issue 104.

Connector types in common use include the PL259 (‘UHF connector’), BNC and N-Type. All have their pros and cons: the N-type has the best reputation for the larger diameter coaxial cables and the BNC for the smaller diameters. Both are available in 75 and 50 ohm impedances and offer good matching characteristics through the connection up to low microwave frequencies.

PL259, BNC and N-Type RF Connectors

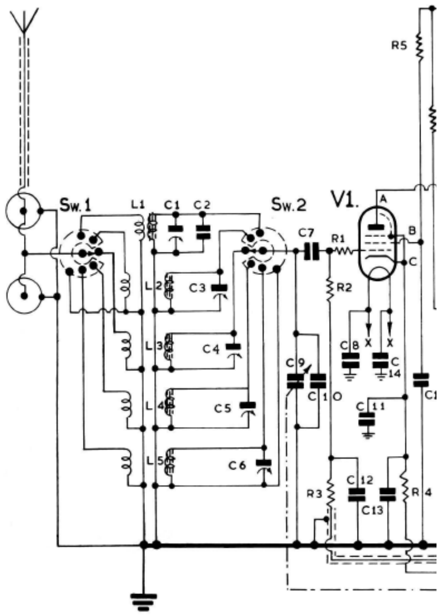
The PL259 is perhaps the most widely used, though is generally inferior to the other types in terms of impedance matching and reliability, particularly at VHF and higher frequencies. Having said that, for general purpose HF receiver use, I have never experienced any problems with the PL-259 type, providing the plug is of good quality and is attached to the cable in the correct way.



S.750 balanced aerial input

Input Arrangements On Post-WWII Eddystone Valve Sets

Eddystone valve receivers varied in their aerial input arrangements over the years: many early models had a 400 ohm balanced input, with provision to short one of the connectors to ground to allow use of an unbalanced wire feeder (use it if appropriate – it can make a huge difference) – sets with this type of input arrangement include the S.640, S659, S.680/680X, S.670/670A, S.680, S.740, S.750, S.840/840A/840C and S.870/870A. Sometimes a 75 ohm unbalanced input is provided, as in the S.504 (actually 70 ohm is quoted in this set's specification), S.550, S.730/4, S.830 series, S.880 series and EA12, while the S.888 has a 75 ohm balanced input, and the S.850 series VLF sets have both a 75 ohm unbalanced and 300 ohm balanced inputs. In line with virtually all VHF and UHF sets, the Eddystone VHF and UHF receivers, the S.770R and S.770U series, have unbalanced (75 ohm coaxial) input arrangements.



S.730/4 unbalanced aerial input

These variations occurred for a variety of reasons, eg. many professional and military sets for domestic UK and overseas markets were made to meet a pre-determined specification, of which the aerial input arrangements were specified to suit aerial and feeder systems in use within those markets. In addition, technical 'trends' during the period covered by these sets were towards coaxial (unbalanced) feeders, due to increased availability, improved performance and simplicity/convenience of using coaxial feeders. Some typical Eddystone aerial input arrangements are shown in the diagrams above.

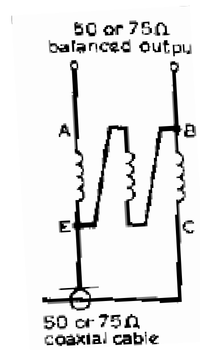
Matching Devices

So, having identified what sort of aerial impedance you have and the aerial input arrangements on your receiver(s), and having selected your preferred/appropriate feeder type, it may be that the correct impedance can be maintained from the aerial right through to your set – if so, great, as this will ensure a 'perfect' match and, consequently, the maximum input signal to your set that your aerial is capable of delivering. In practice, it is very difficult (impossible?) to maintain such a 'perfect' system, especially across a wide range of frequencies that are not harmonically related – therefore help is needed...

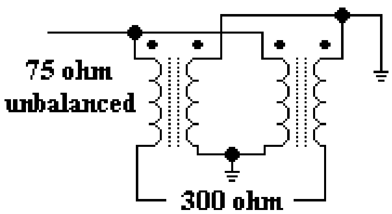
Transformers

If there is an impedance mismatch between the aerial and the feeder, there are many ways of constructing a suitable transformer to provide an improved match. Such transformers are, physically, not like the normal concept of a transformer, but comprise various ways of connecting/tapping the feeder into the aerial including folded dipoles, 'stubs', 'delta', 'tee' and 'gamma' match arrangements, depending on the aerial and feeder types and the frequencies of interest. For general shortwave reception only, it would not normally be necessary to use such a matching system, close matching really being an issue in transmitter applications to avoid the development of lossy standing waves in the feeder.

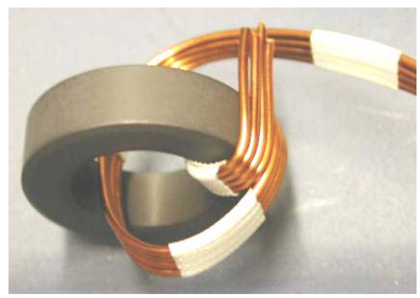
Baluns

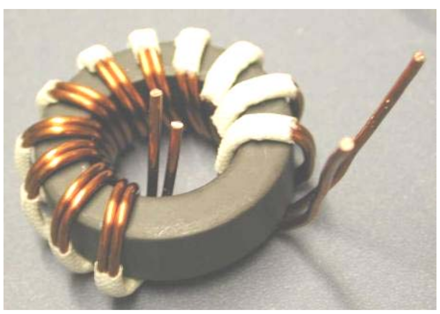


It is sometimes desirable to connect an unbalanced feeder, eg. coaxial cable, to a balanced aerial, eg. a dipole. This cannot be done without imparting signal into the outer conductor unless the signal is prevented from doing so by insertion of an RF choke or transformer in the outer line. The term 'balun' is an abbreviation used to describe such an RF transformer when used to convert a **bal**anced circuit condition to an **un**balanced one.



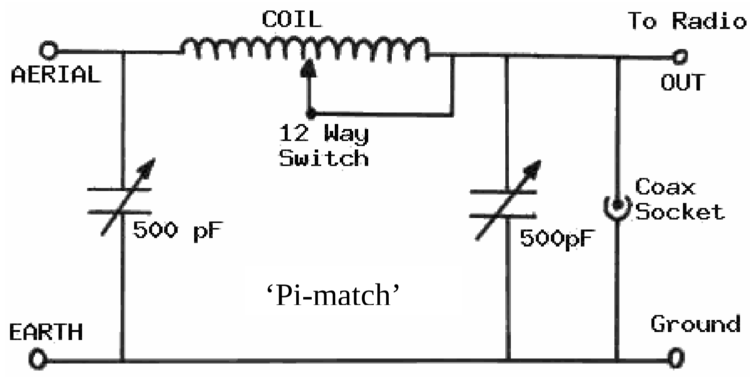
Designs for baluns are varied, depending on the impedances of the aerial/feeder being matched and on the frequency for which it is being used. For aerial systems where only a narrow band of frequencies are of interest (or are harmonically related, as in several HF amateur bands) a simple balun can comprise a ¼ or ½ wavelength section of the feeder material used as a parallel resonant circuit, this representing a high-impedance path to the outer line of the feeder. The larger the ratio of impedances that have to be matched, the narrower the bandwidth of the balun, however, if only a low ratio of impedance transformation is required (4:1 is typical, eg. for matching a 75 ohm dipole to a 300 ohm twin feeder or 75 ohm coaxial cable to 300 ohm twin feeder), baluns having sufficient bandwidth to cover 3 to 30MHz can easily be constructed from a few turns of insulated wire wound on suitable ferrite or powdered iron cores, eg. as shown on the photos above and described by N1HFX (http://www.rason.org/Projects/balun/balun.htm) and similar articles. The interested reader should refer to the many excellent texts dealing with this subject (see References at the end of this 'Short').





Aerial Matching or Tuning Units (ATU's)

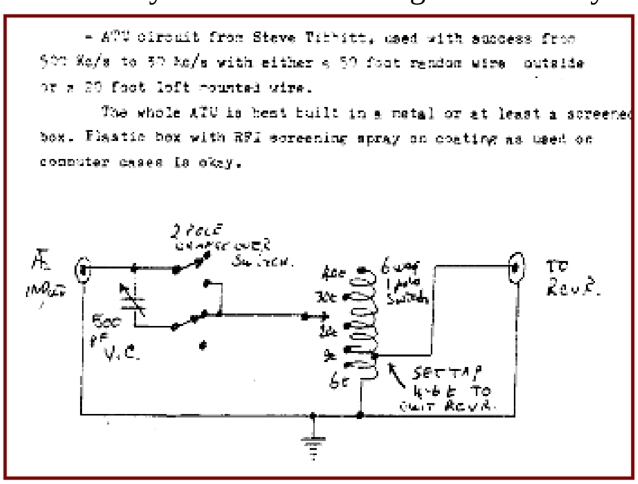
For normal receiver-only use, an 'aerial tuning unit' (ATU) is generally used to provide impedance transformation and provides a method of attaining a good match for end-fed wire and vertical HF aerials over a wide range of frequencies, as well as dipoles and other aerial configurations. Many designs for receive-only ATU's have appeared in the literature over the years, most being a variation on



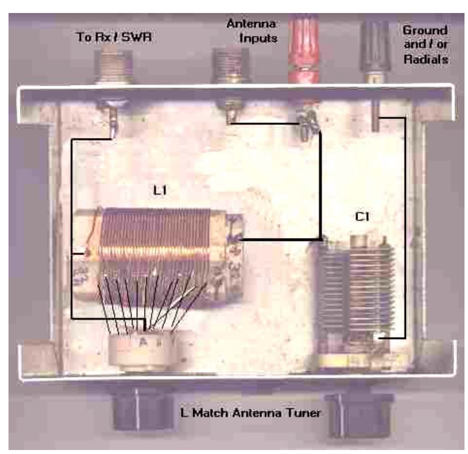
the 'L' or 'Pi' matching circuit, comprising a coil, a switch or two and one or two variable capacitors. Regarding the use of the term 'ATU', G4NSJ makes the following interesting, and I think very true, observation (refer to 'The *ATU Exposed!*' page on his website, http://www.g4nsj.co.uk/atu.shtml for more discussion) - I quote:

> **The term ATU has become extremely popular over the years. But this device is *not* an aerial tuning unit. It does *not* tune the aerial. It's a matching device, matching one impedance to another. Hence, aerial matching unit or AMU. The output impedance of most amateur transmitters is fifty ohms. The impedance of an end-fed wire could be anything between twenty and several thousand ohms. If the impedance of your end-fed aerial is two-thousand ohms, it doesn't change. The matching unit doesn't miraculously change the aerial feed impedance to fifty ohms. Neither does it change the fifty ohm output impedance of the radio to two-thousand ohms. The AMU transforms the impedance from two-thousand ohms to fifty ohms. In other words: two-thousand ohms in, and fifty ohms out. A mains transformer transforms 240 volts to, say, 12volts. It doesn't somehow alter the mains supply voltage. That remains at 240 volts no matter what you do. *Remember, an AMU does NOT improve the performance of an aerial.* A crap aerial is a crap aerial, no matter what you do at the feed point. Frightening stuff? Not really. What *is* frightening is the misconception, the myths, surrounding this impedance matching device.**

Suitable ATU designs for use with Eddystone receivers have been published in Lighthouse over the years, eg. Issue 39, p23, and some are appended to this article for convenient reference. Other suitable designs have appeared over the years in periodicals, such as Practical Wireless (eg. October, 1978, also appended to this article) and RadCom, and in many books. These designs are all very simple and straightforward to construct – I recall building my first ATU when I was about 15 (I think it was my second construction project, after an OC71 audio pre-amp). That ATU comprised a wooden box containing a Pi-match: a multi-tapped coil wound on a cardboard tube, the taps connected to a switch that progressively shorted them out and a 500pf variable capacitor on either end connect to ground. It probably took a couple of hours to construct and I recall that it worked fairly well with my 19-Set, Murphy B40D and EC10 for many years.


- ATU circuit from Steve Tibbitt, used with success from 500 Kc/s to 30 Mc/s with either a 50 foot random wire outside or a 20 foot loft mounted wire.

The whole ATU is best built in a metal or at least a screened box. Plastic box with RFI screening spray on coating as used on computer cases is okay.



Typical construction of a home-brew receive-only ATU

Conclusion

An Eddystone receiver working at (or near to) its factory-specification will usually receive signals, after a fashion, on the proverbial ‘piece of wet string’, or at least a few feet of wire, connected to its aerial input, with or without a ground connection. However, to attain the best performance from the receiver, an appropriate aerial, feeder and matching device, ie. aerial *system*, is very desirable, both to increase the signal strength being fed to the receiver circuits and to reduce the level of undesirable signals and interference: remember, a good aerial system provides significant ‘bang for your buck’, the whole system for general-purpose shortwave receiving costing only a few tens of dollars. Finding the most appropriate system for your particular needs can also be fun, especially is you have ‘tinkering’ or experimental tendencies (and a decent-sized garden).

Gerry O’Hara, G8GUH, Vancouver, BC, Canada, January, 2007

Postscripts

The following topics are related to matching and may be of interest to the reader.

1. Active Aerials

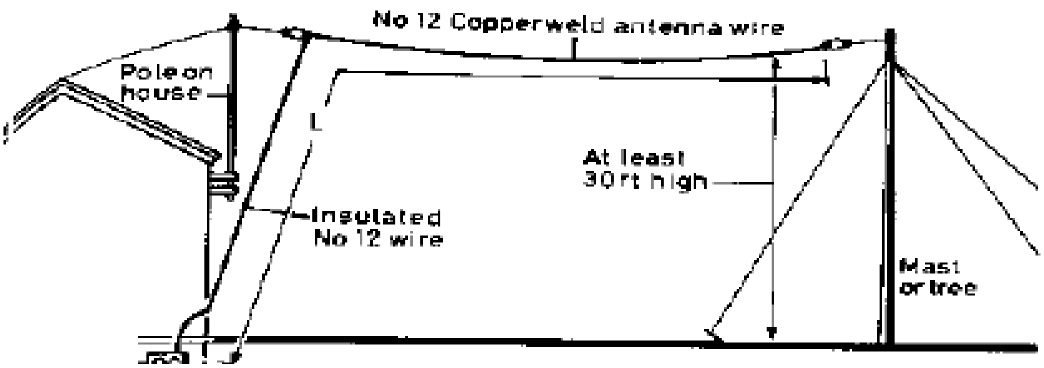
For those who like to experiment and build gadgets, you might like to try your hand at an ‘active aerial’. This usually comprises a solid-state wideband RF amplifier (often an FET) presenting a very high resistive load connected directly to the aerial, usually a short whip or small loop, followed by a low impedance bi-polar output stage (emitter-follower), matching to a coaxial cable impedance of 75 or 50 ohms. Such a device eliminates the need for any additional matching circuitry (ATU) and, although I have never tried one, they reportedly provide good results. Eddystone manufactured an active aerial, Type LP3382, in the mid-1970’s that had a telescopic whip feeding an FET front end (2N3819), the circuit of which was given in Lighthouse (Issue 75, p25) in an article by Graeme Wormald. Graeme also penned an excellent article on a ‘*Tunable Active Aerial*’ using a Loop or Ferrite Rod aerial (copy appended), and Peter Lankshear wrote an article on ‘*Active Aerials*’ in Lighthouse Issue 72, p28.

2. Eddystone Aerials

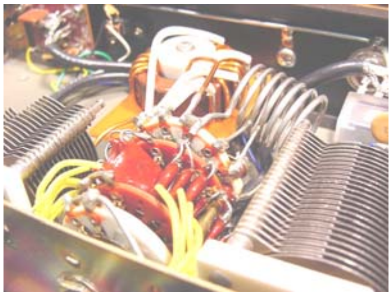
Apart from the active aerial noted above, Eddystone published aerial designs and produced and sold aerials/parts to construct conventional aerials for use with their receivers from the 1930’s through 1960’s (see Eddystone Short Wave Magazine references below). Graeme Wormald discusses two Eddystone published designs in Lighthouse Issue 72, p25, and describes the ‘*Marconi general coverage doublet Type 1818*’ in Lighthouse Issue 79, p32 (appended here), as first detailed in the Technical Handbook for the Marconi re-badged version for the S.750 (I must give it a go with mine…). Graeme also authored an article on an all-band HF receiving aerial with a delta-feed arrangement suitable for 400 ohm input sets in Lighthouse Issue 90, p40.

3. 'Magic Length' Aerials

Many so-called 'magic lengths' of end-fed and doublet aerials that work well on a wide range of frequencies have been noted to be very effective through the years, eg. 84ft (25.6m) and 97ft (29.6m) long end-fed aerials for use on amateur bands, and 66ft (20.1m) for a broadband doublet fed with 300 ohm twin-line feeder. These are certainly worth a try if contemplating erecting a simple aerial for general HF and/or amateur band listening (note: the total length of the end-fed wire, 'L' in the figure below, includes the length of wire running to the ATU or receiver).



Some Useful References



- The ARRL Antenna Book, 20th Ed. (plus many other aerial-specific publications available from the ARRL, or through the RSGB in the UK)
- The Radio Experimenter's Guide (plus many other aerial-specific publications from the RSGB) as well as 'Technical Topics' and other articles in RadCom, eg. April, 2005, June, 2000 (broadband baluns), July, 1997 (T-Match ATU), January, 1996 (Simple ATU)
- Radio Communications Handbook, RSGB (eg. 4th Ed. Ch. 13 (80pp), 6th Ed, Ch. 12 (108pp) – this Handbook is now in its 8th Ed.
- Radio Data Reference Book, RSGB, 5th Ed., 1985, Part 5 'Antennas and Transmission Lines' – coax cables and baluns, & Part 8 'Materials and Engineering Data' - ferrites
- Radio Amateurs Handbook, ARRL (eg. 31st Ed. Ch.s 13 & 14 (53pp), 57th Ed. Ch. 20 (23pp) – this Handbook is now in its 84th Ed.
- Radio Engineering, F. Terman, 1947, (3rd Ed. Ch.s 3 & 14)
- Radio Bygones, Issue 103, and response letters in Issue 104 (coaxial connectors)
- Neutral Wire Facts and Mythology (APC Technical Notes, 2003)

- Various sections of Eddystone manuals downloaded from the EUG web site and specific articles in Lighthouse including:

Subject	Issue	Page
V-Doublet Aerial	73	30
Single wire multi-band aerial	94	42
Active Aerials	72	28
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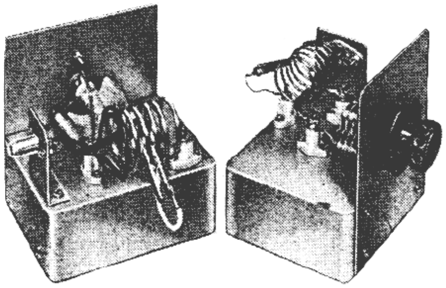
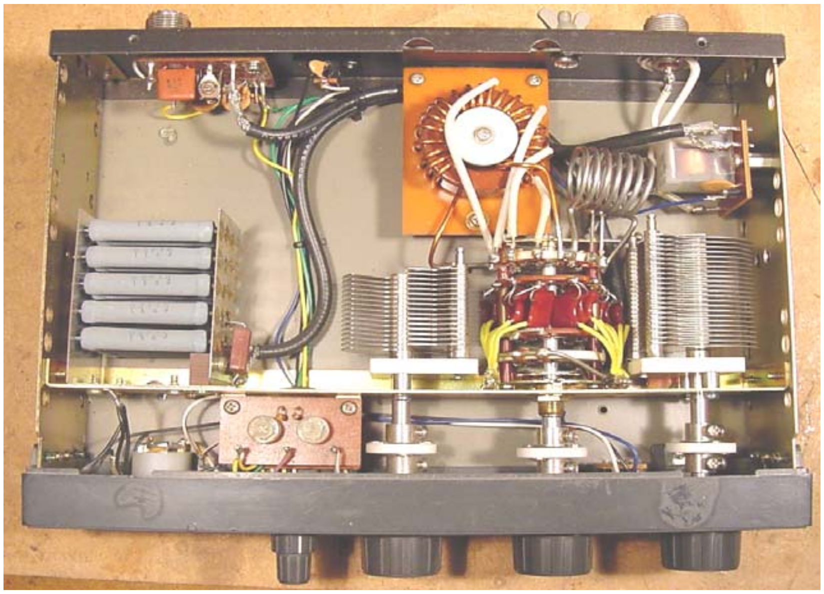
- Articles in the Eddystone Short Wave Magazines downloaded from the EUG web site:
  - Crossfeeder Aerial System, ESWM #2, pp16 – 19
  - Short Wave Aerials, ESWM #3, pp12 – 14
  - Aerial Systems, ESWM #6, pp 9, 13, 18 & 24
- Some web-based articles/resources on subjects covered in this article include:
  - http://guide.aoruk.com/old.asp
  - http://guide.aoruk.com/g3.asp#11
  - http://guide.aoruk.com/tuner.asp
  - http://www.brainz90.karoo.net/bastuner.htm
  - http://www.brainz90.karoo.net/atu.htm
  - http://www.brainz90.karoo.net/mwloop.htm
  - http://www.g3ycc.karoo.net/g4rgn.htm
  - http://www.g4nsj.co.uk
  - http://w4cox.hypermart.net/page3.html
  - http://www.ese.upenn.edu/rca/instruments/misctutorials/Ground/grd.html

Left and below: my Yaesu FC-707: a compact (unbalanced) commercial HF amateur bands transmit-receive ATU from the 1980's



Above: '*Suitable aerial coupling units for use with long wire aerials…*' (from 'Aerial Systems' ESWM #6).



AERIAL TUNER

F.G. RAYER G3OGR

This tuner can be used with end-fed or balanced feeder systems, either for reception or transmission. When used with a receiver, a substantial improvement in signal strength is obtainable. For transmission, it allows the usual pi-tank to be matched to end-fed, Zepp, and other aerials.

Construction

L1 is wound with 20 s.w.g. tinned copper wire, and L2 is of well-insulated wire, on top of L1, as in Fig. 2. The former is 89mm x 44mm and 34 turns are used in all. Taps are equally spaced at six turns, two turns, four turns, and five turns from the centre tap. They are made by passing short lengths of 16 s.w.g. wire into holes in the former, and securely

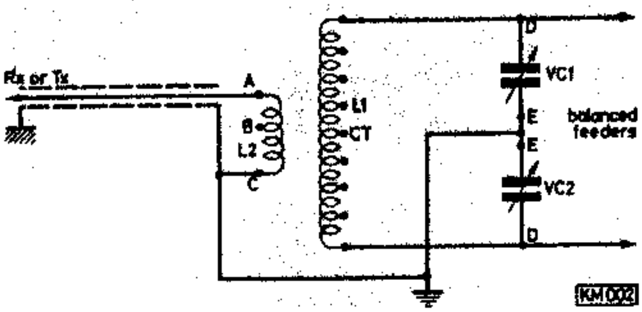


Fig. 1: The circuit diagram of the aerial tuner

soldering these to the winding turns as required. Nine 6BA bolts with tags, mounted on a piece of paxolin about 102mm x 102mm (as in Fig. 2), support the coil. Below these taps fit three bolts for A, B and C. A to B is three turns, and B to C has four turns, so that three, four, or seven turns may be selected. Two further bolts are for E, E, Fig. 2.

Provided plenty of taps are available, other coils may be suitable.

Methods of Coupling

It is possible to find a suitable coupling method by trial only, especially for reception alone. Fig. 3 will help clarify some of the more usual configurations.

"A" is a pi-coupler, and adjustment of the capacitors allows a wide range of impedances to be matched, either to load the transmitter correctly, or to give best reception.

"B" is a popular method for high impedance aerials. With a transmitter, a co-axial lead is generally used, with outer conductor to the chassis. This, shown at "B" may be fitted for any circuit.

"C" employs the link for coupling. For low frequencies, the two capacitors may be put in parallel as shown, and this is useful if they are not of very large value.

"D" is a somewhat similar arrangement to using a centre-tapped coil and having the capacitors in series in this way is most appropriate for a high frequency band.

"E" shows the aerial tapped down, which is useful with parallel tuning when aerial loading prevents proper tuning with "B".

"B", "C" and "D" are appropriate for high impedance. "E" suits many intermediate lengths. "F" is for low impedance (quarter wave) with one capacitor used for series tuning.

Parallel tuning of balanced feeders is shown in Fig. 1. This is satisfactory when the feeder termination is high impedance. For low impedance feeders, "G" in Fig. 3 is necessary. The best balanced system is a tuned doublet. The top is divided into equal lengths, and the twin feeders are spaced about 102mm by spreaders. High impedance feed is expected if one-half the top, plus the feeder, equals a half-wave or multiple of half-waves. Should one-half the top plus feeder be a quarter wave or odd multiple, low-impedance coupling "G" is anticipated.

★ components

VC1 and VC2 350pF Jackson 5021/2 or similar. Ceramic or paxolin former, 100 × 100mm. Aluminium base 165 × 100 × 9mm, aluminium panel 203 × 152mm, Case 203 × 152 × 102mm. Tinned copper and insulated wire.

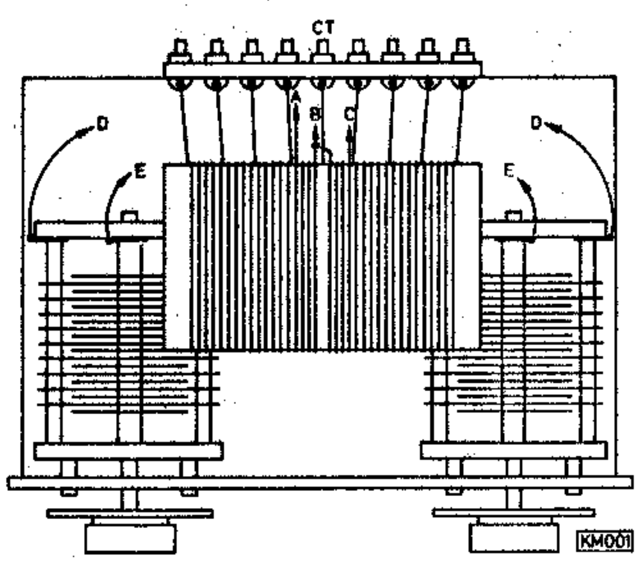
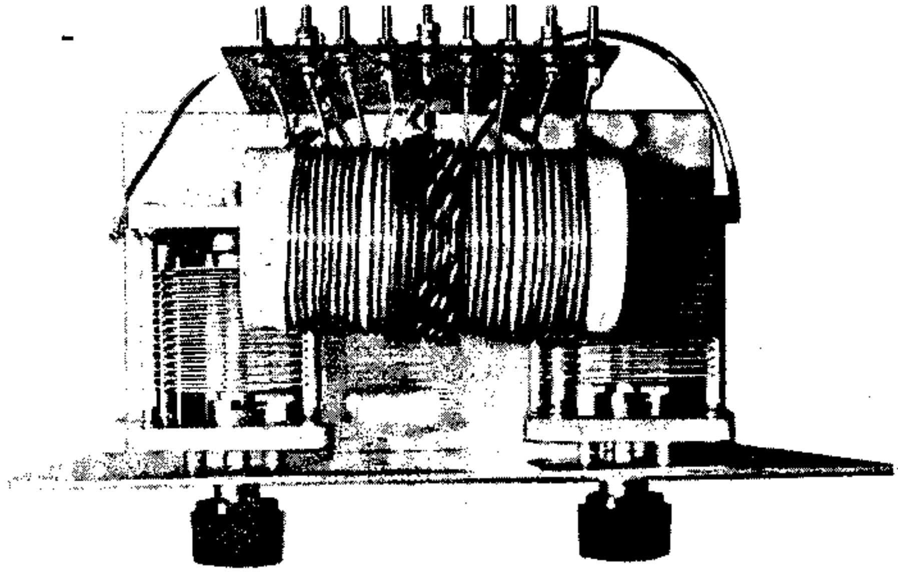


Fig. 2: General layout, showing connections to screw terminals



A view of the unit showing L2 (p.v.c. covered wire) wound *over* L1

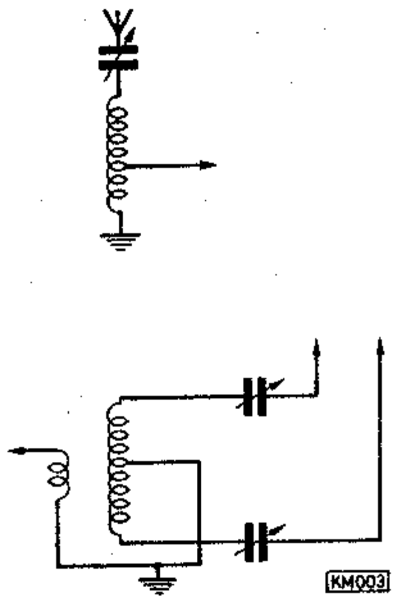


Fig. 5: Coupling circuits F (upper) and G (lower); details of all coupling circuits are given in the text

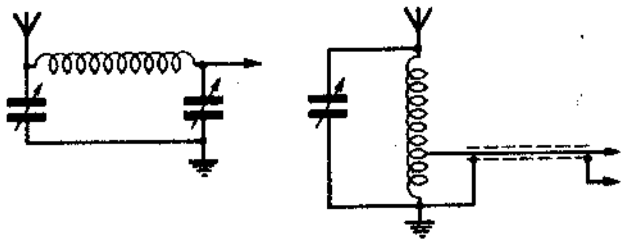


Fig. 3: Coupling circuits A and B

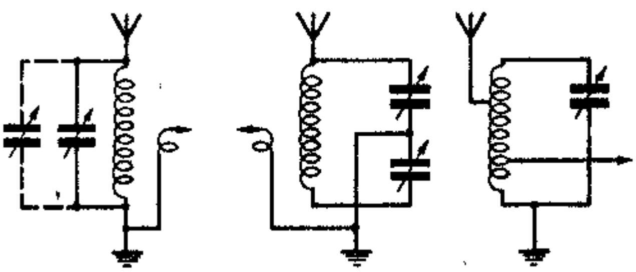


Fig. 4: Coupling circuits C to E

Frequency

Circuits showing the whole of L1 in use, above, are for the 80m band. For higher frequencies, fewer turns are used. With "A" short out unwanted turns. Circuits such as "B", "C", "E" and "F" are used at higher frequencies by moving the aerial and capacitor connections down the coil.

With balanced circuits, Fig. 1, "D" and "G" in Fig. 3, move taps in equally from each end.

There is sufficient latitude to allow tuning up for reception on 25m, 31m and other broadcast bands, if required.

Reception

For reception purposes only, it is an easy matter to try various tappings or circuits, to find which peaks up signals best. This can be done with the aid of the S-meter, selecting a signal not subjected to fading. "B", "E" and "F" will cover most conditions likely to be met with a single wire aerial. The improvement is greatest when the original match with no tuner was poor.

Fig. 1 or "G" will be used with twin tuned feeders (doublet or Zepp) or Fig. 1 with feeders tapped in equally from each end of L1.

Transmission

The points already mentioned apply, plus the fact that for correct operation and loading, suitable matching is essential. Mis-matching may in fact cause damage to the transmitter output stage.

An excellent method of matching is to place a standing wave indicator in the co-axial lead from tuner to transmitter, and adjust the tuner for minimum SWR, with reduced power. An indication of 1·5:1 or lower is normally satisfactory. Adjustment to a very low SWR (virtually 1:1) is generally simplified by placing a variable capacitor in series with the link or tap—e.g., between A and the co-axial inner conductor in Fig. 1. A 500pF component is suitable for h.f. bands, and 2×500pF for 80m, receiver type capacitors having adequate spacing. "A" Fig. 3 does not require this item, and can generally provide virtually 1:1 SWR.

Capacitor settings and tappings used for each band should be noted so that re-tuning is possible with a minimum of trouble. ●

TUNABLE ACTIVE AERIAL

ANOTHER WEAPON IN THE EDDYSTONE USERS' ARMOURY

Have you ever seen a device so simple that you think it's not worth bothering about? Well here's one that's so *KISS** you'll wonder why you never had one years ago.

Wideband active aerials have had a bad press for three perfectly valid reasons. One, they're expensive to buy; two, they're complicated to make; three, they cause birdies and spuriosities from strong signals. So what's the answer? Make it tunable, that's what! OK, I can hear the groans already. "I haven't got enough hands to cope with the matching unit, the set tuning, and now active aerial tuning!" Forget the matching tuning, you don't need it. This machine will go straight into 400 ohms or 75 ohms without turning a hair

It was the culmination of a search for the best aerial for medium-wave DXing with my 680X. (And it can be used for HF as well.) I live ten miles from Droitwich with four MF/LF transmitters powering up to 500kW. My 275ft end fed can pull *4 volts* peak to peak from them. A decent preselector can have up to three controls. All too much. A giant tuned loop was constructed from a hula-hoop and multicore cable. It worked very well but it was suspended on a swivel from the shack ceiling. Turning it to null-out strong stations meant crouching in a corner. It had to shrink, but so did the DX, which wasn't all that strong to start with.

This was the answer:- A ferrite rod aerial with a mosfet amplifier and a bipolar impedance matcher. An aerial is salvaged from an old AM radio. All windings are removed except the medium-wave coil. A rotating unit is then constructed from plastic overflow pipe and a standard jack plug. It's easier to make than to describe, look at the picture. Plugged into a jack socket mounted vertically it rotates easily.

The unit uses a tuning condenser of about 500pf. This may be an old junk-box item, a miniature air-spaced twin-gang from a 'sixties set, or a midget solid dielectric. Each half is usually about 250pf so connect them in parallel. A 40673 (or similar) mosfet is a low noise, high impedance amplifier. Both gates are strapped and the source earthed. High impedance output from the drain is directly coupled to the base of a bipolar emitter-follower (BC109 or similar), giving high-to-low impedance with unity gain. The device is a lot simpler than the description. Just look at it; a tuned circuit, two transistors, two resistances and two condensers, there's nothing to it and it works every time!

It can be constructed 'ugly' style on a couple of stand-offs, or on a piece of five by six *Veroboard* (make it ten by ten if you've big fingers!), or a little etched board if you're into that sort of thing.

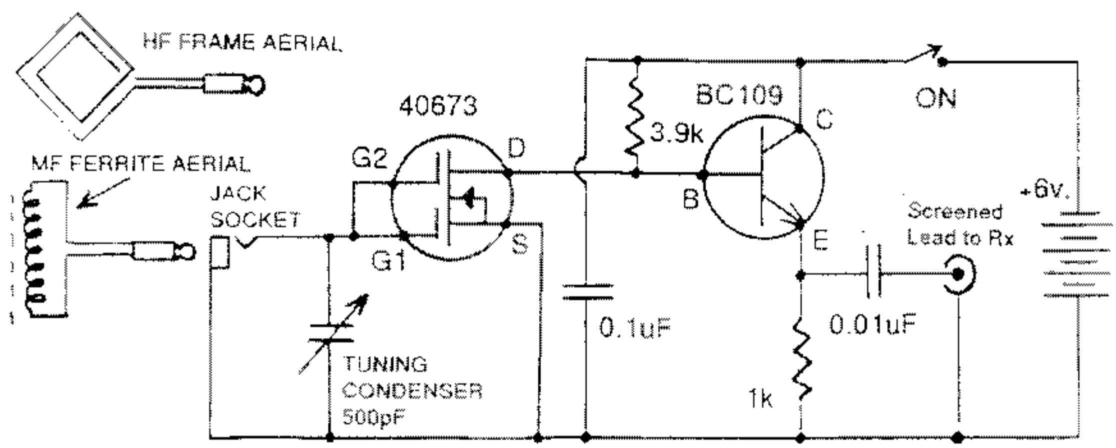
For HF use a mini frame aerial, about six inches square, with a few turns (one to ten) wound in slots in the corners of a plastic or thin plywood sheet. It's effective up to about 20 Megs. You could use one with a dozen or two turns instead of a ferrite rod for MW. For LF beacon-hunting wind some extra turns on a ferrite or fifty or so on a mini-frame. Plenty of room for enjoyable experiment here.

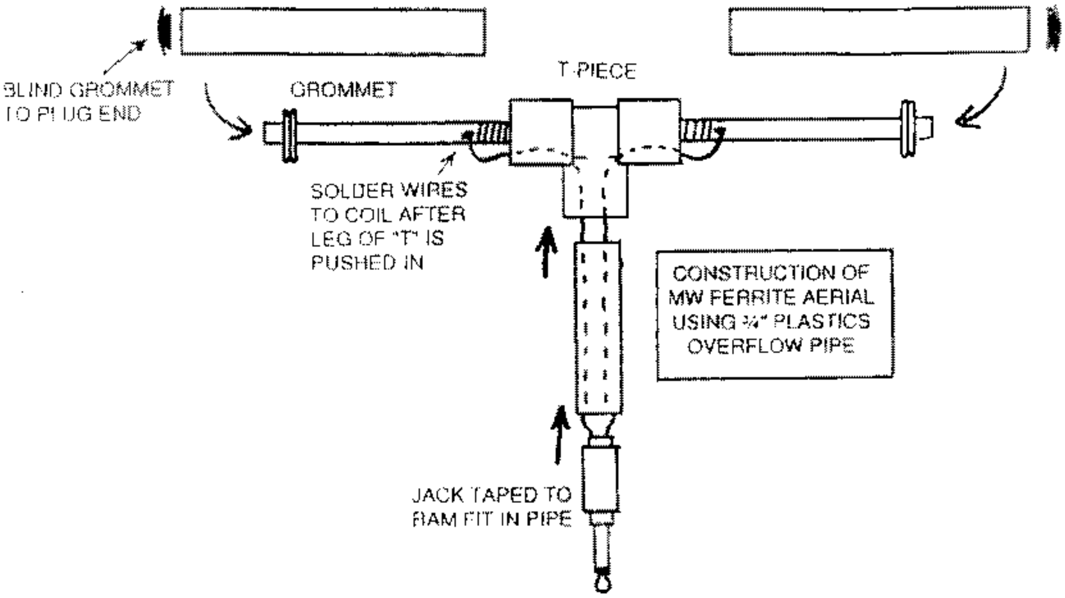
The current consumption is about 4mA, which means it's easy to run on dry cells and the whole lot can be fitted into an Eddystone die-cast box. The tuning condenser should have a fairly large knob on it, say 2 inches, for easy operation. It doesn't need a scale as long as you can remember which way is HF and which way is LF. (The air-spaced ones usually open to the left and the midget ones *vice versa.*) It takes a few minutes to learn to drive it; an S-meter makes it easier. Beware of tuning to a strong station off the desired frequency. The knack soon comes.

This little wonder has to be heard to be believed. OK, sometimes you'll get better results from your 50 foot vertical, sometimes you'll do better with your rhombic, but by golly, it'll lick the pants off most lesser things and it's the flat-dweller's salvation. . .

GRAEME G3GGL

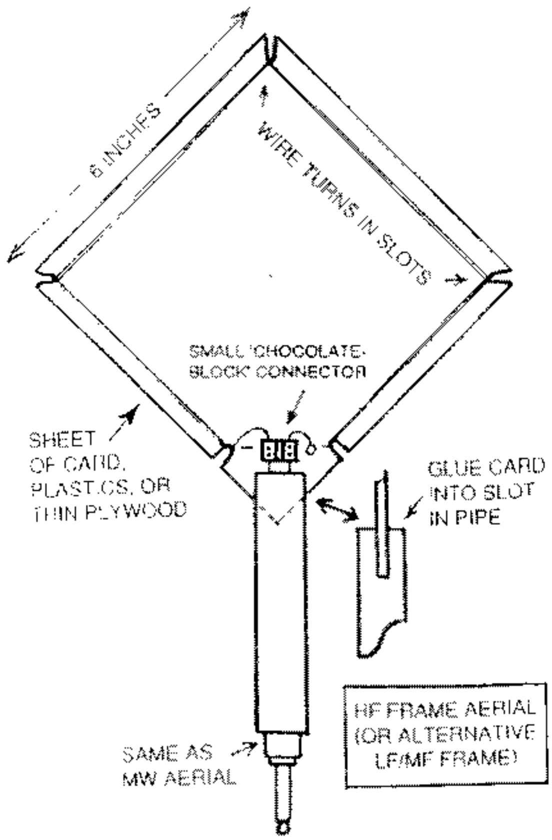
**KISS = Keep It Simple, Stupid!*



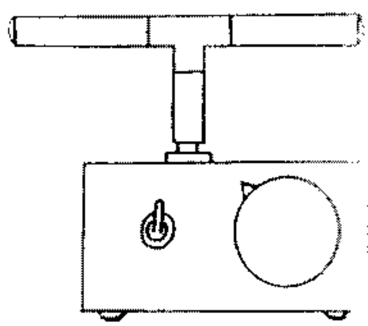


CONSTRUCTION OF MW FERRITE AERIAL USING ¾" PLASTICS OVERFLOW PIPE

ACTIVE AERIAL PLUG-IN ROTATING RESONANT ELEMENTS

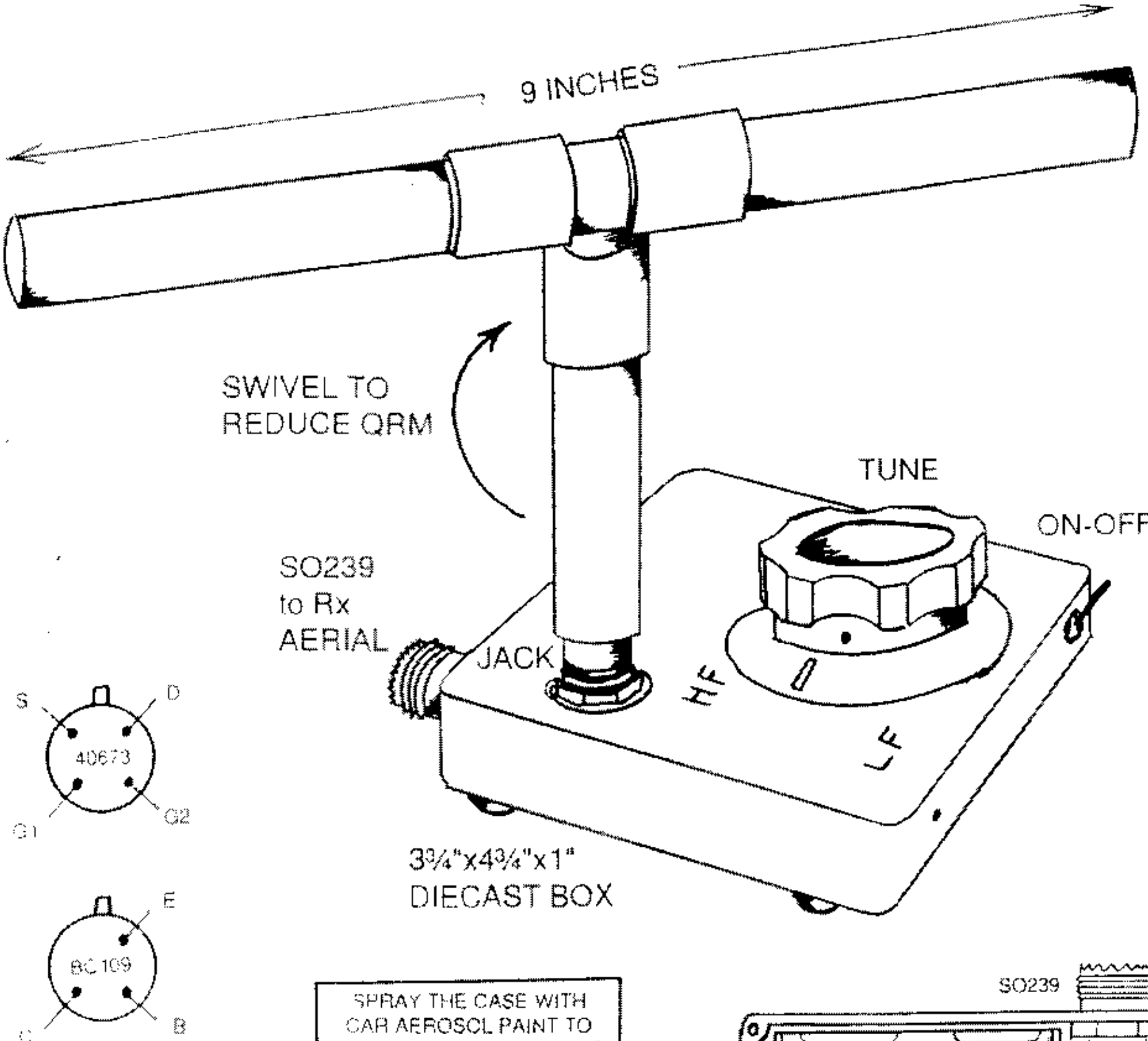


HF FRAME AERIAL (OR ALTERNATIVE LF/MF FRAME)

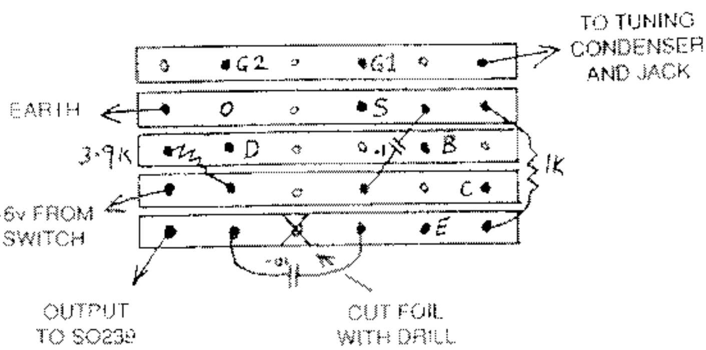


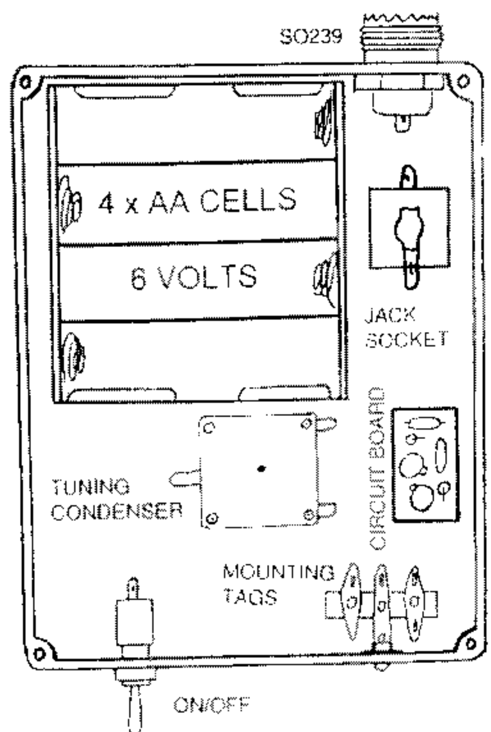
ALTERNATIVE PRESENTATION FOR L[illegible]ER TUNING CONDENSER AND/OR BATT[illegible]

ACTIVE NARROW-BAND LOOP AERIAL



SPRAY THE CASE WITH CAR AEROSOL PAINT TO MATCH YOUR EDDYSTONE



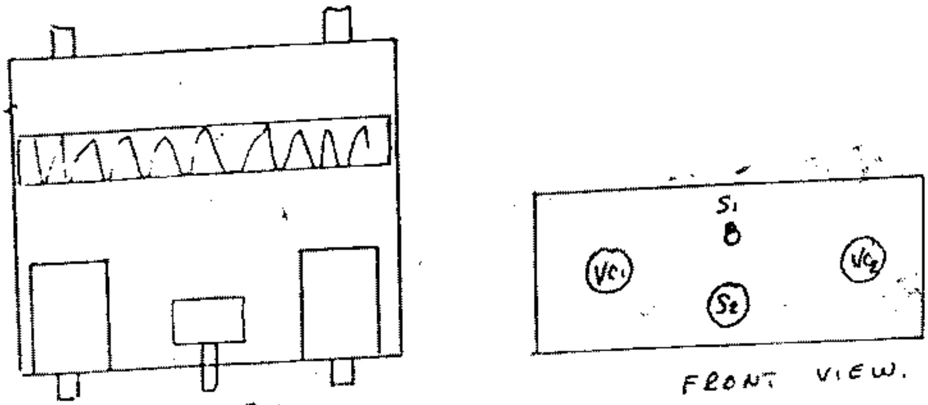


SUGGESTED LAYOUT ON VEROBOARD, FROM FOIL SIDE. COMPONENTS ON OTHER SIDE

GRAEME G3GGL

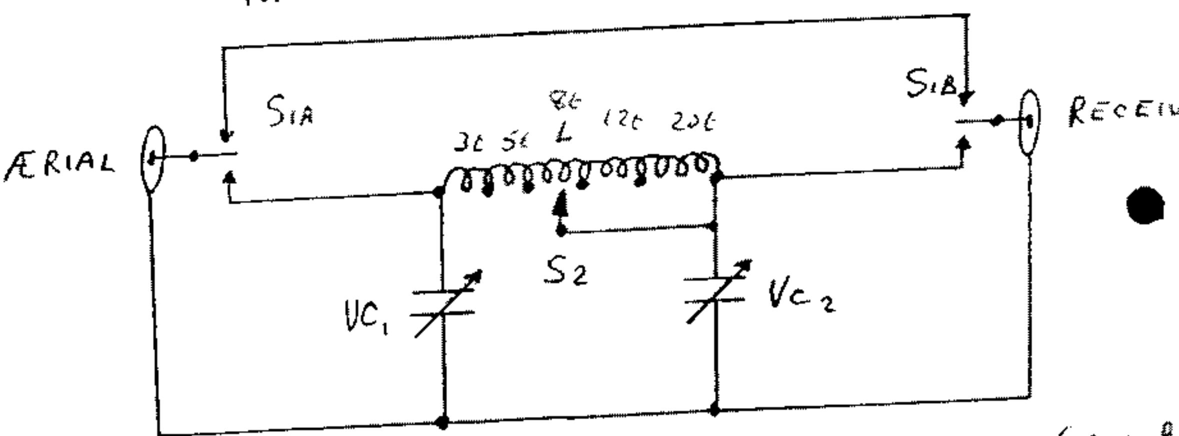
Aerial Tuning Unit for use with your Eddystone:-
Any kind of aerial, be it a piece of wire around the curtain rail of the room or a hundred yard long external aerial, will be resonant and most effective only on certain frequencies. This means that the operating impedance of it will vary enormously from very low to very high, it will only match into your receiver if used with a matching or tuning unit. Having said this, an aerial tuning unit cannot do miracles. It will bring up from out of the noise those very weak signals, it will also help to prevent spurious incoming signals from interfering with that one station you want to hear. This circuit is an old often copied favourite, nothing exotic but it does work.

A.T.U FOR RECEIVING ONLY.



TOP VIEW.

FRONT VIEW.



VC_{1+2} = 350 - 450 pF VARIABLE CAPACITOR. (FROM B... LINCO...

S_1 = DPCO SWITCH.

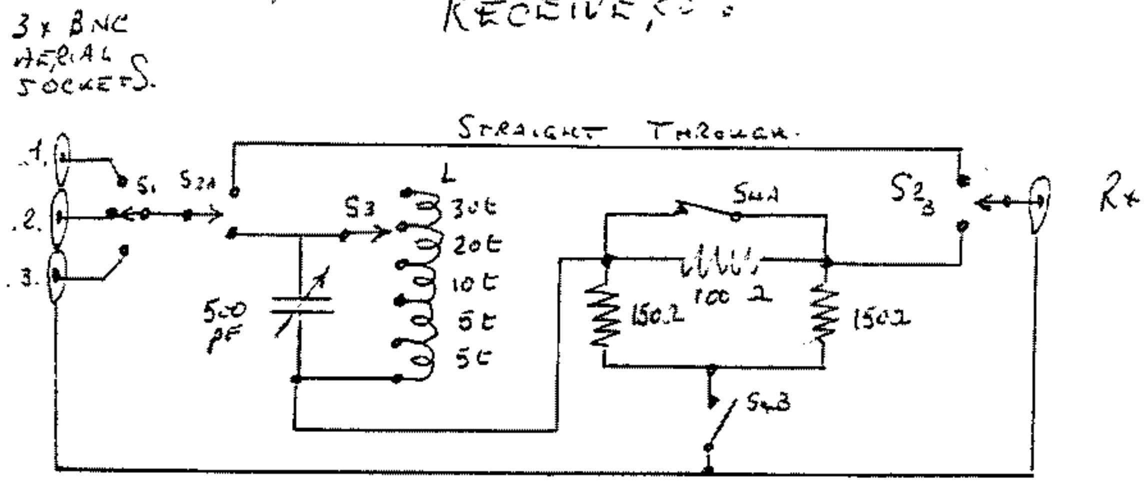
SOCKETS = BNC, OR YOUR CHOICE.

S_2 = 6 WAY 1 POLE ROTARY SWITCH.

S_{1A+B} WILL SWITCH THE ÆRIAL EITHER STRAIGHT THROUGH TO RECEIVER OR VIA THE A.T.U. THUS A DIREC... COMPARISON MAY BE MADE.

an internal [illegible] to an external [illegible], or anything in between these two the effects can change from an advantage to a disadvantage with a change of but several hundreds of kilocycles. For good reliable listening the SWL needs a minimum of two aerials, say one horizontal and one vertical. the two should be fed to the receiver through an ATU and it should be possible to switch from one aerial to another at will to select that which gives best results for a given frequency. Possibly two horizontal aerials at right angles to each other would be an added feature, with a three way aerial switch on the ATU. The ideal then would be three aerials fed to a three way switch into a 'PI' type ATU with a bypass switch to enable the ATU to be taken out of circuit to check its effectiveness. Of course ideally downleads to the ATU and from it to the receiver input should be in coax or screened lead. Protective diodes on the input to the ATU would be an added bonus. Instead of paying £60 or more build your own, easier than you think. See below.

THIS A.T.U. COURTESY OF ROBERT PYE WHO POINTS OUT THAT IT CAN IN FACT BE USED IN REVERSE, ONE AERIAL TO FEED ONE OF THREE RECEIVERS!



10 db PAD SWITCHED IN / OUT AS NEEDED, SHOWN OUT OF CIRCUIT.

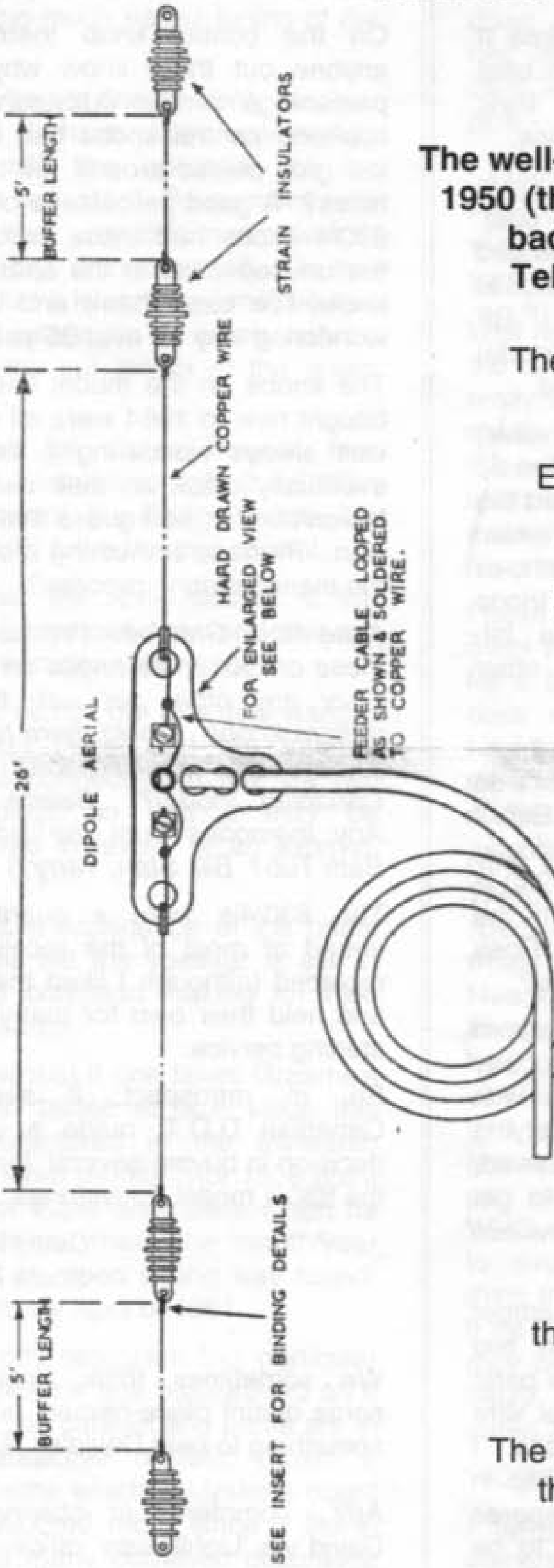
S_1 = 3 way 1 pole.
S_2 = 2 way 2 pole.
S_3 = 6 way 1 pole.
S_4 = 2 way 2 pole.
L = TOTAL 70 turns, 13 s.w.g. 1" diam;

[A VERY ODD CIRCUIT! HARDLY AN A.T.U, MORE OF A REJECTOR.... G.W.)

MARCONI general coverage doublet Type 1818

Graeme Wormald - G3GGL

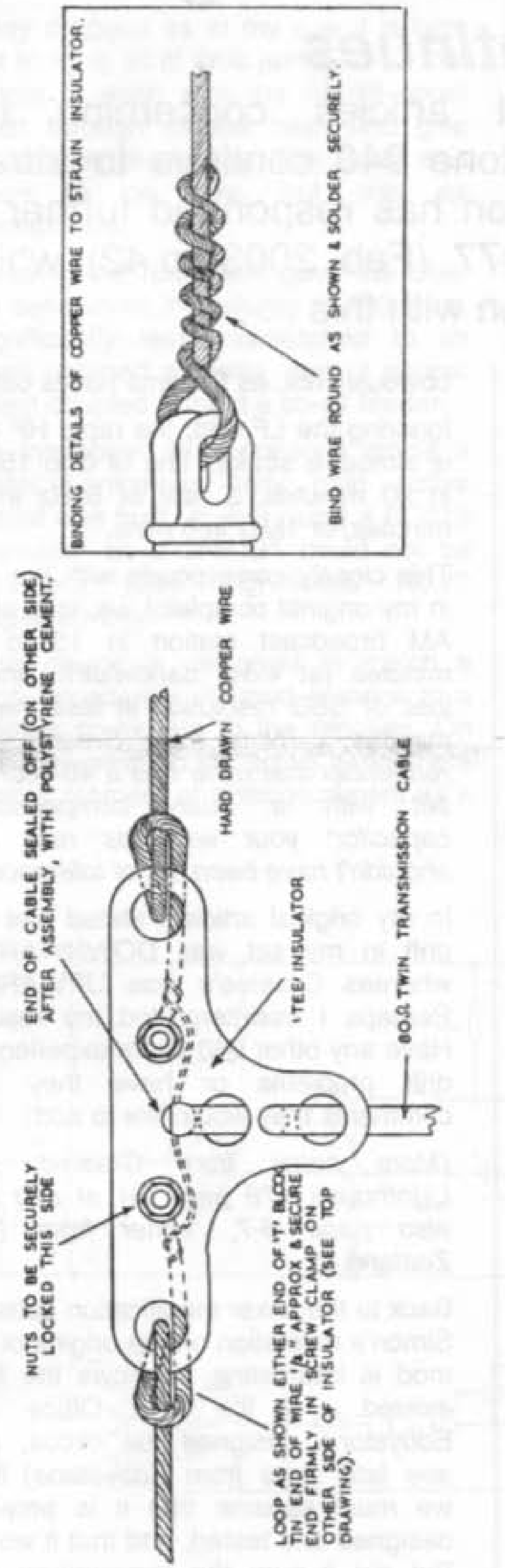
The well-known Eddystone S.750 of 1950 (the first 'slide-rule' dial) was badged by Marconi's Wireless Telegraph as the Type HR.100



The Technical handbook for this set was much more comprehensive than the Eddystone folder and included full details of operating and installing the set for professional communications use (on shore, I hasten to add, this was not a ship's receiver).

Among these details was a description of the M.W.T. untuned doublet aerial type 1818. Many people think a dipole (or doublet) is a one-band aerial, but this is not so. When it is erected away from local interference (ie, the house) and fed with balanced twin feeder it is essentially a low noise device and much 'cleaner' than the average end-fed bit of wire.

The hardware is still obtainable at the average radio rally, hidden between the old computers.



REAR VIEW OF 'TEE' INSULATOR (FULL SIZE).

If you cannot find 80-ohm flat twin feeder, ordinary 3-amp twin mains flex will do (or speaker cable).

Here's the entry from the Marconi handbook:-

"6. AUXILIARY EQUIPMENT

6.1 Doublet Aerial

The doublet aerial Type 1818 is designed to provide good reception over the whole receiver range (480 kc/s – 32 Mc/s).

The two arms forming the aerial proper can be slung between two high points at any convenient position and the flexible insulated feeder brought down to the receiver through any convenient aperture, a lead-in insulator being unnecessary. Pick-up of electrical interference is minimised, with a consequential reduction in noise. The peak efficiency is achieved at a frequency of approximately 18 Mc/s, and the aerial presents an impedance of approx. 400 ohms to the receiver."

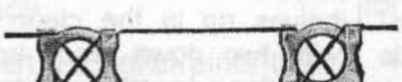
Readers wishing to use this aerial with a 50-75 ohm co-axial input should use a 4:1 balun to match it.

♠

Crossfeeder Block

FOR ELIMINATION OF MAN-MADE INTERFERENCE ON SHORT WAVE AERIAL SYSTEMS.

CAT. No. 1004.



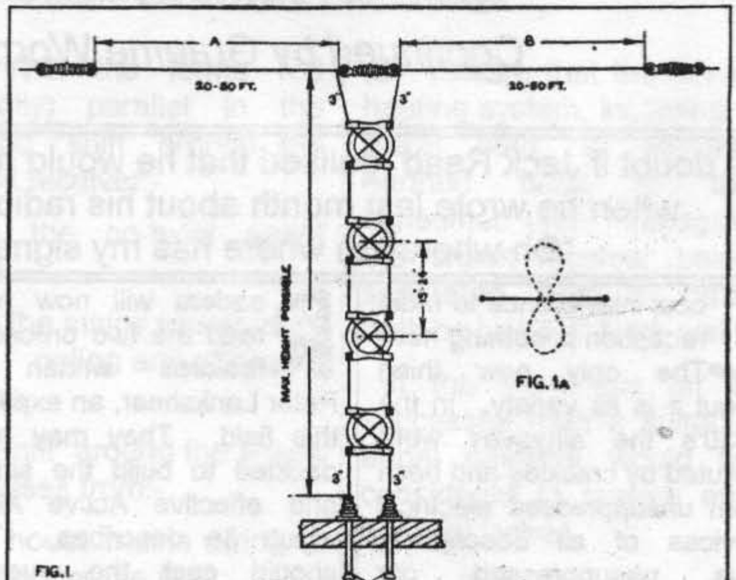


FIG. 1A

FIG. I
HORIZONTAL DOUBLET AERIAL.

In many cases reception of weak short wave signals is impossible owing to man-made interference from electrical apparatus in the near vicinity. By the use of a doublet type aerial as shown, erected as high as possible and out of the general field of interference, and the employment of the special "EDDYSTONE" Crossfeeder System of lead-in, this man-made static can be very largely eliminated. Full details will be supplied on request.

The Crossfeeder Block is made of high grade vitreous porcelain and is highly glazed so that it is suitable for prolonged outside exposure. The Block has also many other uses, including transmission lines in connection with transmitting aerials.

CAT. No. 1004. Code CROFE .. .. .. PRICE **8d.**

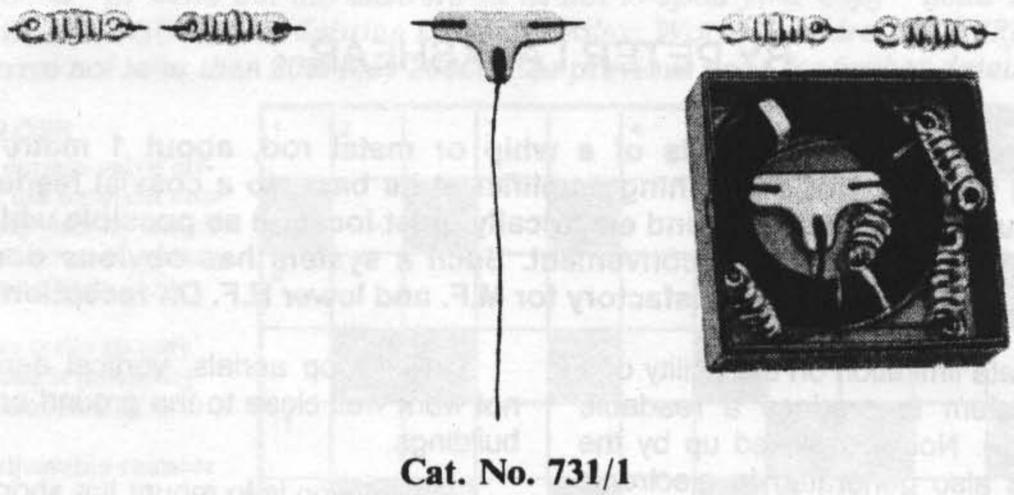
Coupling Unit for Crossfeeder Aerial Leads

This unit is for coupling the two leads of a Crossfeeder aerial system into the Receiver. The normal practice is to connect the two output leads from the unit to the primary coil in the grid circuit of the set, which must not be earthed. The unit comprises two resistances in series with each lead. Assembled in a suitable housing with terminals and input leads.

CAT. No. 994. Code REDRE .. PRICE **2/6**

Doublet from the Eddystone catalogue of 1936. There is no intention for the aerial to be resonant as may be deduced from the arbitrary leg-lengths of 20-50 feet and the feeder length of "max height possible". The coupling unit contains two 500Ω non-inductive resistors, one in series with each leg, presumably to reduce the "Q" of the aerial and help with its wideband properties.

RECEIVING AERIAL



Cat. No. 731/1

The doublet type of aerial is excellent for reception on short waves. The electrical interference and other noise picked up on the twin feeder is balanced out with a consequent reduction in background noise.

The two sections forming the aerial proper should be strung to any convenient supports, as high as possible and free of other objects. The flexible insulated twin feeder is taken to the receiver through a small hole or other opening, no additional insulation being necessary.

The aerial is supplied complete with end and centre insulators, and is ready for immediate erection. The length of feeder is 100 feet, to allow the aerial to be sited well in the clear.

EDDYSTONE DOUBLET AERIAL

On board ship the lead-in portion of a single wire aerial must necessarily be brought close to metal work and attention must be paid to providing adequate insulation. Electrical interference radiated off the ship's mains is liable to be picked up by the lead-in wire. The Eddystone Doublet Aerial has several advantages over a single wire aerial. The two arms forming the aerial proper can be strung in any convenient position (as high as posible), and the flexible twin insulated feeder brought in through a ventilator, porthole, etc., without the necessity of any additional insulation. The pick-up of electrical interference will be much reduced and first class reception becomes possible. The aerial may be taken down and re-erected many times with little possibility of damage.

Cat. No. 731 (50 ft. feeder) Price £2 : 17 : 9

Cat. No. 731/1 (100 ft. feeder) Price £3 : 3 : 3

Eddystone Doublet 1955. No intention of it being a single-band aerial. But how long are the legs now? It was intended to be fed directly into the balanced Ae terminals of all Eddystone sets of the era.