END FED AERIALS

THEORY AND PRACTICE

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AS the author has several acres available for aerials, it is natural that many end fed wires have been tried. This type of aerial is simple and can work effectively on several bands. It is hoped the details following will be of use especially to those who are awaiting their transmitting licences, and wondering what kind of aerial to erect.

Advantages of the end fed aerial may be summarised briefly—the same aerial may be used on all bands, the length is not critical, it is inexpensive and often easily erected, and may provide some gain over a dipole, on the h.f. bands.

Its main disadvantages are an increase in receiver static when conditions are poor, and its tendency to cause TV interference, especially when incorrectly coupled to the transmitter. With correct coupling, TVI should not be exceptionally troublesome.

Materials

Hard drawn 14 gauge copper wire is generally used, and may be obtained in any suitable length. Enamelled wire is preferable, to reduce the surface losses eventually likely from oxidization of bare wire. Stranded 7/26 wire, with weatherproof covering is available in coils up to 100ft. The 7/26 wire is cheaper and lighter than 14G. and no reduction in aerial efficiency was apparent when it was used. Necessary joints were made by twisting the wire together for about 2in., soldering, and painting with bitumen.

One 3in. ribbed glass insulator can be used at each support point, or a pair, if available. The polythene line sold for aerial erection is ideal between insulators and supports, though any thin strong cord, for outdoor use, would be suitable.

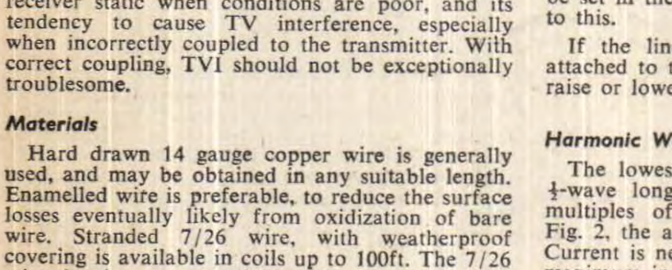


Fig. 1: Typical end-fed aerial system.

With an end fed aerial, the transmitter end is usually supported at the house. The line should be taken to the highest possible point, and is of such a length that the down-lead is at least 2ft. from the walls for most of its descent, as in Fig. 1. In many cases the whole aerial can be a single, uncut wire. Its length is made up by the horizontal top, down-lead, and connection to the transmitter or tuner. That is, from A to B in Fig. 1.

Only one other support is required, again as high as can be arranged. It may be possible to take a line to another building, or to a tree, or to a pole fitted vertically in a tree, or attached to a building. Or a 6ft. 4in. x 4in. or similar post may be set in the ground, and the pole may be bolted to this.

If the line is run through a spare insulator attached to the top of the pole, it will be easy to raise or lower the aerial, or adjust its tension.

Harmonic Working

The lowest frequency at which the aerial is a ½-wave long is its fundamental frequency, and multiples of this frequency are harmonics. In Fig. 2, the aerial is a ½-wave long for 40 metres. Current is nearly zero at each end, and reaches a maximum in the centre. Voltage is at a maximum at each end, and low in the centre.

If the aerial were used for 20m. it would accommodate two ½-waves, as at B. If used on 10m, the length would be four ½-waves, as at C. The length of wire for a ½-wave aerial may be found from the following, the result being in feet:

$$\frac{468}{\text{Frequency in Mc/s.}}$$

The lengths thus found are 0·95 of a ½-wave in free space, to allow for end effects. A length near the centre of an amateur band is sufficiently accurate for the whole band. Suitable ½-wave lengths are:

1·8Mc/s band		...	...	246ft.
3·5Mc/s	,,	...	...	128ft.
7Mc/s	,,	...	...	66½ft.
14Mc/s	,,	...	...	33ft.
21Mc/s	,,	...	...	22ft.
10Mc/s	,,	...	...	16¼ft.

When the aerial is operated upon harmonics, end effects only apply to one ½-wave. As a result, the aerial length is more nearly that of the number of ½-waves in free space. For harmonic working, the length is easily calculated as follows:

$$\frac{492 \times (\text{No. of } \tfrac{1}{2}\text{-waves} - 0{\cdot}05)}{\text{Frequency in Mc/s}}$$

As example, suppose an aerial is four ½-waves at 21·2Mc/s. The length is:

$$\frac{492\ (4 - 0{\cdot}05)}{21{\cdot}2} = 91.7\text{ft.}$$

Feed Impedance

If the aerial is a ½-wave long, or any multiple of ½-waves, as in A, B or C, Fig. 2, high voltage but low current will be present at the end connected to the transmitter or tuner. The feed point (end) will thus be at high impedance. The actual impedance can easily be 1,000Ω, or higher.

Should the aerial be only long enough to be a ¼-wave, as at A in Fig. 3, low voltages but high currents will be present at the transmitter end, which will thus be low impedance. In these circumstances, the feed point impedance may be 50Ω or even less.

When the aerial is some intermediate length, such as at B in Fig. 3, its feed point impedance will also be some intermediate figure. The feed impedance will also be of some intermediate value when the aerial does not accommodate an exact number of ½-waves, at some harmonic frequency, as at C in Fig. 3.

It is thus apparent that provision must be made at the transmitter to operate into a wide range of impedances. This can be done by using a pi-output tank circuit, or an aerial tuner. The latter is often preferable, because it allows the whole aerial system to be tuned to resonance, and helps suppress TVI.

Aerial Lengths

Methods of calculating the length for fundamental and harmonic use have been given. The length of the aerial will also help influence the gain (if any) which the end fed aerial will have over an ordinary ½-wave dipole.

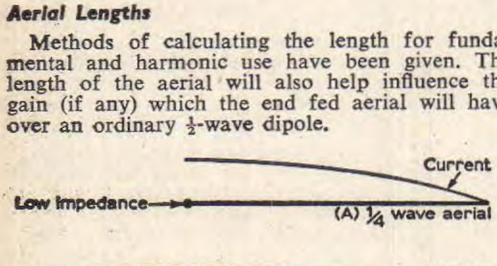


Fig. 3: Current in odd-length aerials

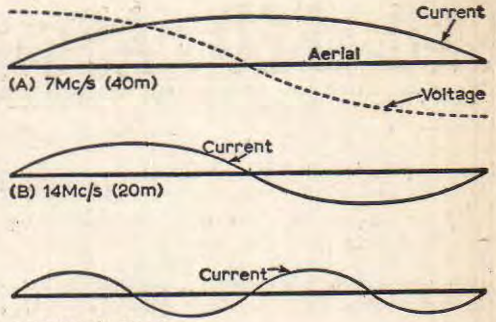


Fig. 2: Fundamental and harmonic operation, showing distribution of current and voltage.

When the aerial is sufficiently long to accommodate a number of ½-waves, the strength of the signal radiated is increased in some directions. The power gain, for aerials of several ½-wave lengths long, is approximately as follows:

No. of ½-waves	*Gain in dB*
4	1·5
6	2·3
8	3·2
10	4·2
12	5

As example, suppose the aerial is 138ft. long. This could be used as a ¼-wave on 160, and a ½-wave on 80m. It would be two ½-waves on 40. On 20m. it would be four ½-waves, with 1·5dB gain over a dipole. On 15m. it would be six ½-waves, with about 2·3dB gain, and on the 10m. band it would be eight ½-waves, with a gain of just over 3dB.

When the aerial is fairly long, useful gain is obtained. It is generally found that the aerial is also a good radiator in other directions. For general purposes, lengths between about 90ft. and 246ft. have all been found effective. The directivity and increased gain are most likely wanted on the 14 and 21Mc/s bands, and suitable lengths for these are as follows:

14Mc/s Two ½-waves, 68ft. Three ½-waves, 103ft. Four ½-waves, 138ft. Six ½-waves, 207ft.

21Mc/s Two ½-waves, 45¼ft. Three ½-waves, 68ft. Four ½-waves, 91¾ft. Six ½-waves, 137ft.

Some lengths will be a multiple of ½-waves on several or all bands. For example, 138ft. is suitable for 3·5, 7, 14, 21 and 28Mc/s. In experiments between G3OGR and Capetown, reliable contact was maintained with an aerial six ½-waves long, when attempts to cover this distance with a dipole had failed. When space is limited, 68ft. is useful for 7, 14, 21 and 28Mc/s bands.

Intermediate, odd lengths can be worked successfully provided the method of feeding the aerial is adjusted to suit. This is best done by using an aerial tuner. It is then not even necessary that the length is known, though this information can be useful.

Directivity

When the aerial is about ½-wave long at the working frequency, there is little directivity, though radiation is best at right angles to the wire. When the wire is two ½-waves long, strongest radiation is at about 54 degrees to the aerial. For three ½-waves, the best radiation is at about 44 degrees to the wire, and for four ½-waves the angle is about 36 degrees. The angle is about 28 degrees for six ½-waves, and 17 to 18 degrees for eight ½-waves.

It will be seen that radiation is more and more nearly in line with the wire, as the number of ½-waves is increased. For example, the 138ft. aerial would have lobes at 54 degrees on 7Mc/s, 36 degrees on 14Mc/s and 28 degrees on 21Mc/s.

This increased radiation may be pictured as a cone extending away from the ends of the wire, and the angles given are for radiation at approximately horizontal levels. At angles above and below the horizontal, the radiation is more nearly in line with the wire, when plotted on a map.

The aerial can thus give good coverage in directions other than those favoured by the angles of the four lobes in a horizontal plane. In addition, much of the low angle radiation obtained is extremely useful for long distance working. If it is wished to know bearings, these must be taken from a globe or great circle map.

Fig. 4 shows a wire four ½-waves long, with main and secondary radiation lobes. If the same wire were used on one-half the frequency, it would then be two ½-waves, and the lobes for this are also shown.

Aerial Feeding

The down-lead is brought into the house by means of an insulator or tube, insulation being as good as possible. A detachable earthing clip, or earthing switch, may be fitted here.

In some cases the aerial can be fed directly from the transmitter. If the transmitter has a pi-output circuit, such as that in Fig. 5, the aerial is taken to the tank coil at C2, as shown. C2 (usually a 2-gang or 3-gang 500pF capacitor) is fully closed, and the tank is tuned to resonance by C1.

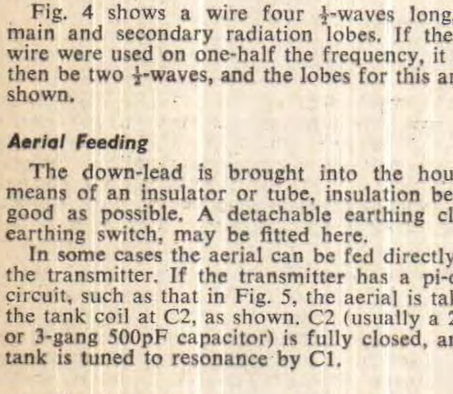


Fig. 4: Directional lobes at 2-waves and four ½-waves.

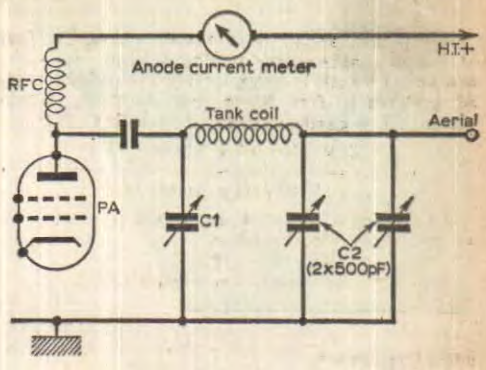
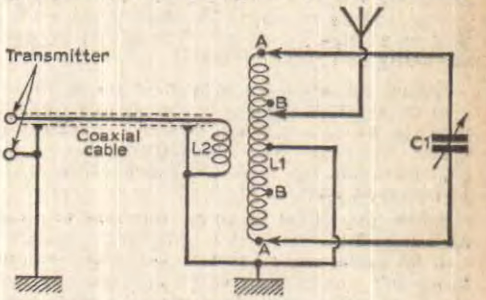


Fig. 5 (above): Typical pi-output circuit.

Fig. 6 (below): Tuner arrangement for end-fed aerials.



Resonance is indicated by a dip in anode current, as read on the meter. If the anode current is too low, C2 is opened slightly, and C1 re-tuned, this being repeated until the valve is drawing its expected anode current.

If the aerial impedance is very high, C2 will have to be opened very much, and the voltages developed will be high. In these conditions, C2 may spark over. If so, an aerial tuner is needed. In other cases, the setting of C2 for correct loading may make it impossible to tune the tank to resonance with C1. An aerial tuner will also avoid this.

When C2 is at a relatively low value, as it must be with a high impedance aerial, harmonics are more likely to reach the aerial itself, thus causing TVI. An aerial tuner will then also be of benefit.

If TVI does not arise, and if the transmitter can be loaded properly by the aerial then the latter is directly connected, then Fig. 5 may be used. But if there is insufficient loading, sparking over, or other troubles, some kind of aerial tuner is required.

Tuner

Any ordinary aerial tuner will be suitable. A circuit is shown in Fig. 6, and may be easily constructed in a separate case. The coil L1 is tuned to the operating frequency. For 3·5—28Mc/s, 26 turns of 18s.w.g. wire, on a former 2½in. in diameter and 5in. long (e.g., Eddystone 1090) will be

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satisfactory. Tinned copper wire is more easily tapped than enamelled wire.

Capacitor C1 should be wide spaced, and equipped with an insulated extension spindle. It can be 100pF to 200pF. Spacing equal to that of the p.a. anode capacitor (C1, Fig. 5) is usually sufficient. For the h.f. bands, fewer turns are needed, so the capacitor is tapped equal amounts towards the centre of the coil, by transferring clips from A-A to B-B, etc., or by using a double pole rotary switch.

L2 is three turns, adequately insulated, and overwound on the centre of L1. This number of turns should generally do for 3·5—28Mc/s, but if the 3·5Mc/s band is not worked, two turns may be used instead. A convenient length of 75Ω or similar co-ax goes from L2 to the transmitter pi output (C2 in Fig. 5).

When the aerial is of such a length that it is near a $\frac{1}{2}$-wave, or multiple of $\frac{1}{2}$-waves, on all bands, it may be connected directly to point C. It is then only necessary to change the taps A-A, when changing bands.

If the aerial impedance is low on some bands (due to its length) the aerial should be tapped down the coil. This is most easily done by moving the aerial tapping a turn at a time away from the centre, until sufficient transmitter loading is obtained. If possible, an aerial length that is fairly high impedance on all bands is recommended.

If the tuner is in circuit for both transmitting and receiving, C1 may be adjusted for maximum signal strength on the receiver. If the receiver aerial input impedance is low, and the aerial impedance high, an actual increase in signal strength will be obtained.

Loading of the transmitter is accomplished as previously described, but as the transmitter is working into the low impedance of L2, C2 will need to be at relatively high capacity for the l.f. bands. If a standing-wave indicator is used, it should be included between transmitter and L2, and tuning is adjusted for minimum reflected power. When an r.f. meter is favoured, it should be included in the aerial lead, *not* in the lead from transmitter to tuner. ■