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Author: Gerald Hall, K1PLP

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Off-Center-Loaded Dipole Antennas

BY JERRY HALL,* K1PLP

IN THESE TIMES when much of our amateur population lives in urban areas, the subject of shortened antennas for the lower frequency amateur bands is a very popular one. Physically short ground-mounted vertical antennas with lumped-constant loading to make them resonant can be quite efficient radiators, if a good radial system has been installed. This has certainly been evidenced in Sevick's series of recent *QST* articles.† To many amateurs, however, the "hitch" in constructing such a system is the installation of a *good* radial system. It must be admitted that for the "top" amateur bands, 160 and 80/75 meters, an efficient system of buried radials requires a sizable amount of real estate, even for a physically short radiator. On the average city-size lot, 50 or 75 by 120 to 150 feet, it's almost impossible to install a highly efficient radial system for 80/75 meters, much less for 160 meters, when structures like a house and perhaps a separate garage exist. Or to some amateurs, just the thought of burying hundreds or maybe thousands of feet of wire is enough to turn off any enthusiasm for the project. What's the alternative? A dipole type of antenna with lumped-constant loading. At modest heights, 30 or 40 feet, such an antenna will prove to be quite satisfactory if it is physically longer than about 0.2 wavelength. *Shorter lengths may also be used, at reduced* efficiency. Such an antenna can be fed directly with 50-Ω coaxial line, and it can be operated with no earth ground. (Of course the chassis of the transmitter and/or receiver should be grounded adequately for protection against shock hazard.)

Nearly *all* of us are familiar with the concept behind the use of inductive loading. A vertical antenna which is shorter than a quarter wave (or a dipole antenna which is shorter than a half wave) will exhibit capacitive reactance at its base (or center) feed point. To cancel such capacitive reactance, a coil having the proper inductive reactance may be connected in series with the base feed point of the vertical. The same result will be obtained through the use of two such coils for a dipole, one coil connected in series with each half. It is not necessary for the inductor to be installed at the feed point, however. In fact, greater radiating efficiency results through improved current distribution if the inductor is located along the radiator some distance away from the low-impedance feed point, *viz*, in the manner of a center-loaded mobile whip antenna. Fig. 1 shows this concept extended to a dipole element, with off-center loading. The inductors resonate the antenna to the operating frequency, but do little actual radiating themselves. (This is in contrast to helically wound or continuously loaded elements, where a long thin inductor is the radiator as well as the loading element.)

In the antenna represented by Fig. 1, there are many variable factors to be considered when a practical antenna for a given frequency is being constructed. Of primary consideration from an efficiency standpoint is the overall length, shown as dimension A. Another consideration for efficiency is the distance of the coils from center, dimension B. The longer the overall length (A), up to a half wave, and the farther the loading coils are placed from the center (B), the greater is the efficiency of the antenna. However, the greater is distance B (for a fixed overall antenna size), the larger the inductors must be to maintain resonance. Theoretically, if the coils were placed at the outer ends of the dipole, they should be infinite in value to maintain resonance. Capacitive loading of the ends, either through proximity of the antenna to other objects or through the addition of capacitance hats, will reduce this requirement to a more practical value.

What Inductance Values?

As a matter of personal interest, this writer has been doing experimental work for a number of years with off-center-loaded antennas. One big drawback to such experimentation was the ever-present need for a large amount of cut-and-try work to arrive at resonance whenever a new set of dimensions was to be used. Probably the number of pruned-off turns from coil stock from such experiments, if straightened out and soldered end to end, would make up several full-sized half-wave antennas for the 160-meter band. Therefore, most of the writer's work of late in this area has been in going through paper-work exercises, looking for a way whereby at least "ball-park" values of inductance needed for a particular system could be calculated.

The equation contained in the Mobile chapter of *The ARRL Antenna Book* for determining the capacitance of a vertical antenna shorter than a quarter wavelength looked promising in early computations, and, indeed, it became the basis for the calculation procedure which finally resulted.

*Associate Technical Editor, *QST*.
†These and all other references are listed at the end of this article.

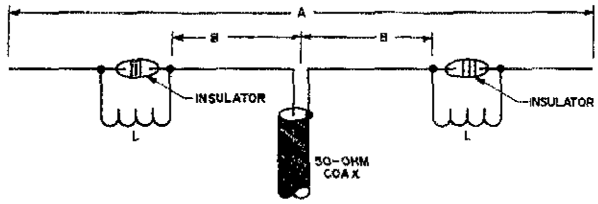


Fig. 1 — A dipole antenna lengthened electrically with off-center loading coils. For a fixed dimension A, greater efficiency will be realized with greater distance B, but as B is increased, L must be larger in value to maintain resonance.

This procedure has been found to produce results much closer than mere "ball-park" values for the necessary inductance — for wire antennas "in the clear" at moderate heights, the final inductance values found by cut-and-try pruning for lowest SWR at the desired frequency have been so close to the value from calculations that a laboratory bridge was necessary to measure the difference. The results are equally good for elements using tubing. Once the needed inductance value is determined by calculations, it is generally found sufficient to obtain coil dimensions from an ARRL L/C/F Calculator (see LaPlaca†) or by equation. Any significant pruning which has been found necessary could always be attributed to objects in proximity to the ends of the antenna.

The complete set of calculations is expressed in the mathematical relationship below as Eq. 1, presented here primarily for mathematics buffs or those having access to electronic computers.

This equation yields the inductance required, in microhenrys, for single-band resonance of a shortened antenna of a particular physical size at a given frequency, for a specific position of the loading coils from the center of the antenna. To spare the reader the task of performing some rather tedious calculations, Fig. 2 has been prepared from Eq. 1. The curves of the chart have been normalized, and may be used for any frequency of resonance. The chart is based on a half-wavelength/diameter ratio of the radiator of approximately 24,000. (This corresponds to No. 14 wire on 80 meters or No. 8 wire on 160 meters.) For "thinner" conductors, the required inductance will be somewhat greater than that determined from Fig. 2, and less inductance will be required for "thicker" conductors.

The use of the chart is as follows: At the intersection of the appropriate curve from the body for dimension A and the proper value for the coil position from the horizontal scale at the bottom of the chart, read the required inductive reactance for resonance from the scale at the left. Dimensions A and B are shown in Fig. 1, and for use with the chart are expressed as percentages. Dimension A is taken as percent length of the shortened antenna with respect to the length of a resonant half-wave dipole of the same conductor material. Dimension B is taken as the percent of coil distance from the feed point to the end of the shortened antenna. For example, resonating an antenna which is 50% or half the size of a half-wave dipole (one-quarter wavelength overall), with loading coils positioned midway between the feed point and each end (50% out), would require loading coils having an inductive reactance of approximately 950 ohms at the operating frequency. If the antenna is hung "in the clear," and if the length/diameter ratio of the conductor is near 24,000, inductance values as determined from the chart will be very close to actual values required. (Eq. 1 above takes the diameter of the radiator into account, and thus may be used for any length/diameter ratio.) For practical purposes, dimension B may be taken as that distance from the center of the feed-point insulator to the inside eye of the loading-coil insulator, and dimension A

(Eq. 1):

$$L_{\mu H} = \frac{10^6}{68\pi^2 f^2} \left\{ \frac{\left[ln \frac{24\left(\frac{234}{f} - B\right)}{D} - 1 \right] \left[\left(1 - \frac{fB}{234}\right)^2 - 1 \right]}{\frac{234}{f} - B} - \frac{\left[ln \frac{24\left(\frac{A}{2} - B\right)}{D} - 1 \right] \left[\left(\frac{\frac{fA}{2} - fB}{234}\right)^2 - 1 \right]}{\frac{A}{2} - B} \right\}$$

where

$L_{\mu H}$ = inductance required for resonance
ln = natural log
f = frequency, megahertz
A = overall antenna length, feet
B = distance from center to each loading coil, feet
D = diameter of radiator, inches

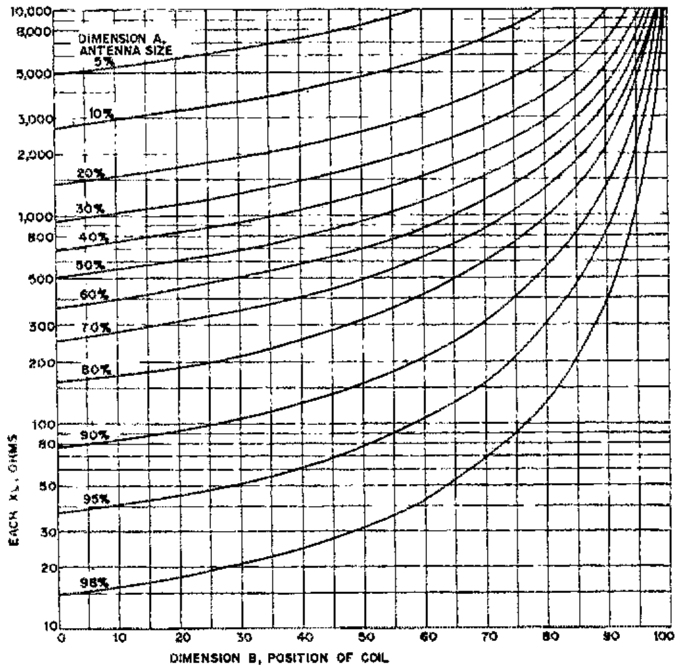


Fig. 2 — Chart for determining approximate inductance values for off-center-loaded dipoles. At the intersection of the appropriate curve from the body of the chart for dimension A and the proper value for the coil position from the horizontal scale at the bottom of the chart, read the required inductive reactance for resonance from the scale at left. See Fig. 1 regarding dimensions A and B.

as the eye-to-eye distance inside the end insulators (which are not drawn in Fig. 1).

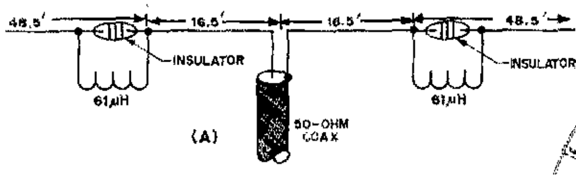
Proximity of surrounding objects in individual installations may require some pruning of the coils, and the exact amount of final inductance required should be determined experimentally. If the antenna is hung in inverted-V style, with the ends brought near the earth, the required inductance will almost always be somewhat less than that determined from the chart or equation. A grid-dip meter, Macromatcher (see Hall and Kaufmann†), or SWR indicator may be used during the final adjustment procedure.

Practical Antennas

Although one might erect an inductively loaded antenna that is cut for a single amateur band, it is possible to use the antenna itself for two, three, or more bands of operation, if provision is made to lower the antenna for band changes. A simple rope halyard and pulley arrangement at one of the supports will do the trick. Fig. 3A shows a 3-band antenna of this nature, for 160, 80, and 20 meters. If the insulators shown are left open, with nothing bridging them, the antenna is a simple half-wave dipole cut for 14.18 MHz. (The 48.5-foot lengths act merely as support wires, and have negligible effect on operation of the antenna.) If the insulators are bridged with short lengths of antenna wire, the antenna becomes a center-fed 80-meter dipole, resonant at about 3.6 MHz. For 160-m operation the 20-meter insulators may be bridged with loading coils to resonate the antenna at 1.8 MHz, as shown in Fig. 3A. Burndy or other manufacturers' "Servit" type of electrical connectors may be used for ease in making band changes quickly, as shown in Fig. 4.

The calculation procedure for determining loading-coil values for the antenna of Fig. 3A, using the chart of Fig. 2, goes like this. If operation is desired on 1.8 MHz, the length of a full-sized half-wave dipole is found from the relationship $468/f$ to be 260 feet. The 130-foot length of Fig. 3A represents 50% of this size, meaning that the dimension-A curve marked "50%" in Fig. 2 is to be used. The position of the coils is $16.5/(16.5 + 48.5) \times 100$ or 25% of the distance out from center, dimension B. From the intersection of 25 (horizontal scale at bottom) and the 50% curve, the required inductive reactance is read from the scale at the left of Fig. 2 to be 650 ohms. The inductance, L_s is $650/2\pi f$ or 57.5 microhenrys, if No. 8 wire is to be used. For smaller diameter wire, the inductance should be somewhat larger. (Calculations from Eq. 1 for No. 12 wire indicate the required inductance is 60.99 μH.)

The radiation resistance of a shortened antenna loaded to resonance is less than that of a full-sized antenna. Further, the shortened antenna is "sharper," meaning that the change in reactance versus frequency is greater. In other words, the shortened antenna acts as a tuned circuit having a higher Q than a full-sized antenna. To check these characteristics, the line input impedances for the antenna of Fig. 3A were measured with a laboratory bridge and the electrical line length at the measurement frequency was then taken into account to determine the impedance at the antenna feed point. The antenna was constructed of No. 12 wire and hung at a height of 50 feet as a "flat-top" radiator.



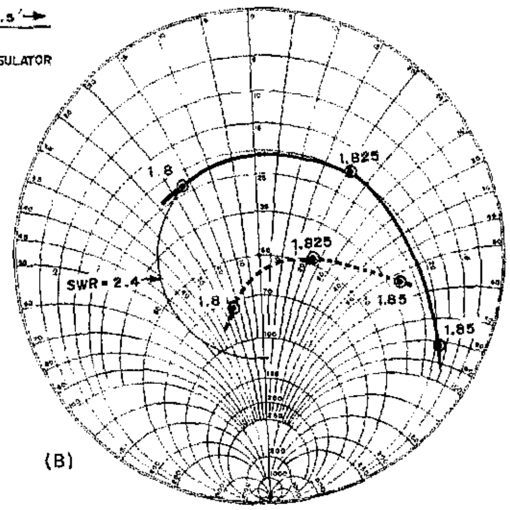


Fig. 3 — At A, an 80-meter dipole loaded for 160-meter operation. The inductors are 37 turns of coil stock having a 3-inch dia and 10 turns per inch (B&W 3035). At B, the impedance plot of this antenna installed at a height of 50 feet (solid curve), and the plot of a 160-m half-wave dipole (broken curve).

The solid curve of Fig. 3B is a plot of the feed-point impedance versus frequency for this antenna. The plot on Smith Chart coordinates is more meaningful than a simple SWR-vs.-frequency curve because the magnitudes of the resistive and reactive components are shown, as well as the sign of the reactance. (Capacitive reactance is negative, plotted to the left of the vertical center line, and inductive reactance is positive, plotted to the right.) In this presentation, a 50-ohm nonreactive impedance will appear at the exact center of the chart. The SWR in 50-ohm line for a given frequency may be determined by first noting the distance from the center of the chart to the particular impedance plot on the curve, and next measuring this same distance down the vertical center line from chart center (a drawing compass is helpful for this task), and finally dividing 50 into the value read at that point on the center line. For example, the SWR at 1.8 MHz equals 120/50 or 2.4, as indicated by the segment of the 2.4 SWR circle in Fig. 3B. It may be seen that resonance (zero reactance) occurs at approximately 1810 kHz, where the resistance is about 22 ohms. The SWR at resonance is 2.33:1, and climbs to 3:1 at 1825 kHz. At 1850 kHz, the SWR is 10:1. Without any matching provisions the antenna is relatively sharp, as mentioned earlier. If one sets the usable bandwidth as the frequency range where the SWR is 3:1 or less, it is approximately 35 kHz, or 1.9% of the resonant frequency. As far as efficiency is concerned, ohmic losses are low, and the antenna is a good performer on 160 meters. Because of its horizontal polarization, it has proved to be most effective at night, and stations several hundred miles away have been worked with S-9 reports received for the 50-watt signal.

For a comparison of impedances, the broken curve of Fig. 3B is a plot of measured impedances of a full-size half-wave dipole, 260 feet long overall, hung in place of the shortened antenna. From this curve it may be seen that resonance occurs at 1810 kHz, where the resistance is 59 ohms. The 3:1-SWR bandwidth for the half-wave antenna is in the order of 60 kHz, or 3.3% of the resonant frequency. It is interesting to note on this curve that the SWR at resonance is 1.18:1, and that it is a somewhat lower value, 1.15:1, at a frequency a few kilohertz above resonance. (Measurements were made every 5 kHz across this band, but plot points are shown only for 25-kHz increments to avoid crowding of the data.) This evidence refutes the oft-heard statement that the SWR-vs.-frequency curve is *always* lowest at antenna resonance. Points to remember are that the SWR in a transmission line is completely dependent upon the characteristic-impedance value of the line in use. Using a line of different impedance may shift the position of the SWR curve along the frequency axis in a simple

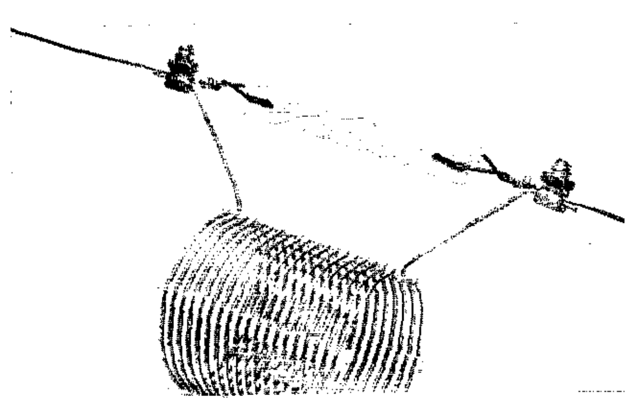


Fig. 4 — Copper electrical service connectors, sold under one trade name of Servit, provide a simple means of installing the loading coils. The antenna wire and the ends of the coil wires should be tinned to prevent corrosion. In addition, a protective coating of acrylic spray may be used at each connection.

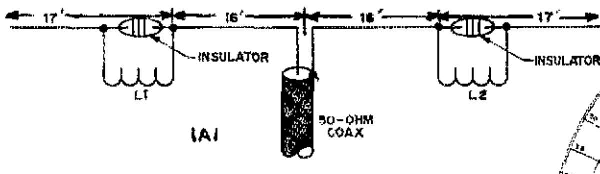
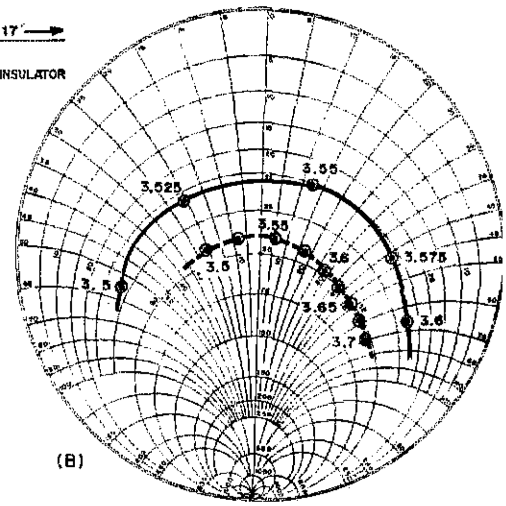


Fig. 5 — At A, a 40-meter dipole loaded for 80-meter operation. For resonance at 3.55 MHz *the coils should be approximately* 40 μH (27 *turns* of stock); 3.75 MHz, 35 μH (24 turns); 3.9 MHz, 31 μH (22 turns); and 4.0 MHz, 29 μH (21 turns). These are calculated inductance values for No. 12 antenna wire. Coil stock referenced above is 3-inch diameter, 10 turns per inch (B&W 3035). At B, the impedance plot of the 3.55-MHz version (solid curve) and of an 80-m half-wave dipole (broken curve).



SWR-vs.-frequency plot. This is definitely true in this case – if the 160-meter half-wave dipole were to be fed with 75-ohm line, the lowest SWR would occur at a frequency about 5 kHz *below* antenna resonance, whereas with 50-ohm line the lowest SWR is at a frequency slightly *above* resonance. The reason this happens is that the resistive component of the impedance, which consists of the radiation resistance plus any loss resistance, is not constant with frequency, even over a rather narrow frequency range. It must be acknowledged that the differences here are very slight, however, and for practical purposes the frequency of lowest SWR is (within a few kilohertz) the resonant frequency of the antenna.

Another point concerning the SWR values bears noting. The values as determined from the plots in the manner described above are quite accurate, having been determined by measurements with laboratory equipment. In contrast, measurements with simple SWR indicators usually cannot be relied upon for anywhere near the equivalent accuracy.

For example, the author owns a commercially manufactured SWR indicator of the Monimatch type (see McCoy†) which, under a particular set of conditions, indicates a 2.5:1 SWR in a line where laboratory measuring equipment shows the *true SWR to be 4:1.* A significant difference! Herein lies another reason why impedance plots on Smith Chart coordinates are more meaningful than a simple SWR-vs.-frequency curve – greater accuracy may generally be expected.

A Half-Size 80-Meter Antenna

Fig. 5A shows the 3-band concept described earlier as it can be applied to 80, 40, and 20 meters. Its overall length is 66 feet, not a difficult length to use on a small lot. This antenna was constructed for 80-m operation with a design-center frequency of 3.55 MHz, using No. 12 antenna wire and 40-μH loading coils – 27 turns of stock having a diameter of 3 inches and a pitch of 10 turns per inch (tpi). Feed-point impedances versus 80-m frequency for the antenna, hung at a height of 50 feet, are shown by the solid curve at B of Fig. 5. Actual resonance occurred at 3.54 MHz, where the resistance was about 26 ohms. The bandwidth within which the SWR is 3:1 is 60 kHz, or 1.69% of the resonant frequency.

Also shown in Fig. 5B, by the broken curve, are the feed-point impedances of a half-wave dipole, 132 feet overall length, hung in place of the shortened antenna. Resonance occurs at 3.54 MHz, where the resistance is 43.5 ohms and the SWR is 1.15:1. The broader nature of the half-wave antenna is exhibited by the "tighter" curve which swings closer to the 50-ohm center point of the chart than the shorter, loaded antenna. The SWR at 3.5 MHz is 1.6:1, and remains below 3:1 to 3.67 MHz.

Capacitive and Inductive Loading

One would assume that a combination o[f] capacitive and inductive loading might provide a different feed-point impedance than would induc[-]tive loading alone, because of different current distributions in the radiators. To check out thi[s] assumption, the antenna of Fig. 5A was used as a "test bed" for comparative measurements. Capaci[-]tance hats were attached at different points along the 17-foot lengths of wire outside the coils, and the coils were pruned to reresonate the antenna a[t] about the same frequency as before. The im[-]pedance measurements were then repeated.

Dangling End Sections:

First, "hats" consisting of 18 inches of No. 1[2] wire were affixed to the antenna ends and per[-]mitted to dangle. This lowered the resonant fre[-]quency to 3435 kHz. By calculations, this wa[s] approximately the same effect as that of extendin[g] the 17-foot portions of the antenna by the sam[e] amount as the dangling lengths, so it would seem

Table I — Characteristics of various loading techniques, 66-foot 80-m dipole.

Loading	*Approx. feed-point resistance, resonance*	*SWR at resonance*	*3:1-SWR bandwidth, % of resonant freq.*
40-μH coils only	26 ohms	1.92:1	1.69
36.5-μH coils, 18" dangling ends	26	1.90:1	1.79
36" hats outside 32.5-μH coils	23	2.15:1	1.68
30-μH coils, 36" hats at ends	25	1.98:1	2.05
None (λ/2 dipole)	43.5	1.15	Greater than 3.6

Coil positions for each loaded antenna were 16 feet from antenna center. All antennas were constructed of No. 12 wire and installed at a height of 50 feet.

to make little difference whether short sections of extra length are added inside the supporting insulators or are at the ends, suspended at right angles to the main antenna wire.

The inductors were reduced from 40 to 36.5 μH (25-turn coils replaced the original 27-turn coils), and resonance occurred at about 3575 kHz. At this frequency the resistance was 26 ohms and the SWR 1.90:1. The 3:1-SWR bandwidth, 64 kHz, is 1.79% of the frequency of resonance. The impedance plot for this arrangement is shown as Curve A in Fig. 6. The resistance at resonance for this antenna is identical to that with the coils alone, and the bandwidth is only 4 kHz greater, 64 kHz vs. 60. From these results, one would conclude that the main advantage offered by the "danglers" is a small saving of space over a flat-top antenna.

Capacitance Hats Near Loading Coils:

Next the dangling end sections were removed and a pair of capacitance hats was formed, each from two 36-inch lengths of No. 12 solid wire. The two wires for a single hat were attached at their centers to the antenna wire at a point just outside one of the loading coils. The hat wires were then bent radially to form an X at right angles to the antenna wire, like four spokes of a wheel with the main antenna wire at the hub. The diameter of the X-shaped hat was thus 36 inches. The second hat was placed in a like manner just outside the second coil. Burndy connectors were used to affix the hat wires. The resonant frequency of this configuration with the original 40-μH loading coils was found to be 3290 kHz. The effect of adding the hats was about the same as that of extending the 17-foot lengths to 19 feet.

When the inductors were replaced with 23-turn coils (32.5 μH), the antenna resonated at about 3.575 MHz, the resistance being 23 ohms. The SWR at resonance is 2.15:1, and the 3:1-SWR bandwidth for this configuration is 60 kHz, 1.68% of the resonant frequency. The impedance of this arrangement versus frequency is shown by Curve B of Fig. 6.

It is surprising to note that, by the standards of most amateurs, the characteristics of this antenna are not as good as those of the same length antenna with loading coils alone. The SWR at resonance for

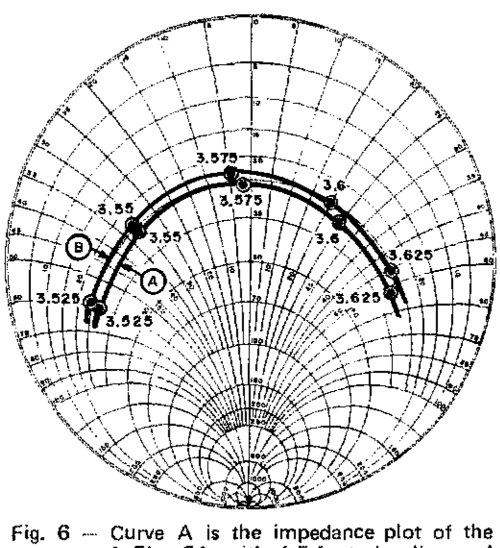


Fig. 6 — Curve A is the impedance plot of the antenna of Fig. 5A with 1.5-foot dangling end sections added and the coil trimmed to restore resonance near the original frequency. Curve B is a plot of the same antenna with X-shaped capacitance hats added at a point just outside the loading coils (dangling sections removed and coils trimmed to reestablish resonance).

the antenna with combination capacitive and inductive loading is higher (2.15 vs. 1.92), and the 3:1-SWR bandwidths are the same, 60 kHz. Perhaps a significant factor here, though, is that the diameter of the capacitance hats used for these measurements was small, only .011 wavelength. Supporting much larger hats presents mechanical problems with wire antennas, however, as even these were a bit flimsy and would require reshaping after gusty weather.

Capacitance Hats at Antenna Ends:

Finally, the X-shaped capacitance hats were moved to the outside ends of the antenna, just inside the end insulators. With the original 40-μH coils, resonance appeared at 3215 kHz. From calculations, it was as if the 17-foot end sections were actually 21 feet long. With 30-μH coils (22 turns) in place, the resonant frequency was 3560 kHz. At this frequency the resistance was 25 ohms and the SWR 1.98:1. The 3:1-SWR bandwidth is 73 kHz, or 2.05% of the resonant frequency. The impedance plot of this antenna is given in Fig. 7.

It is interesting to note that the position and shape of the plot for this antenna on Smith Chart coordinates is nearly identical to that for the same length antenna with loading coils only, the solid curve of Fig. 5B. For this antenna, however, the plot points for 25-kHz frequency increments appear closer together, which accounts for the increased bandwidth.

Conclusions:

The measured characteristics of these various configurations of loading for the 80-meter antennas are tabulated in Table I. Remember that the overall "flat-top" length of each antenna arrangement is 66 feet, and that the loading coils are always positioned 16 feet each side of the center of the antenna, being pruned for resonance at approximately 3550 kHz. For comparison, information for a half-wave dipole is also included.

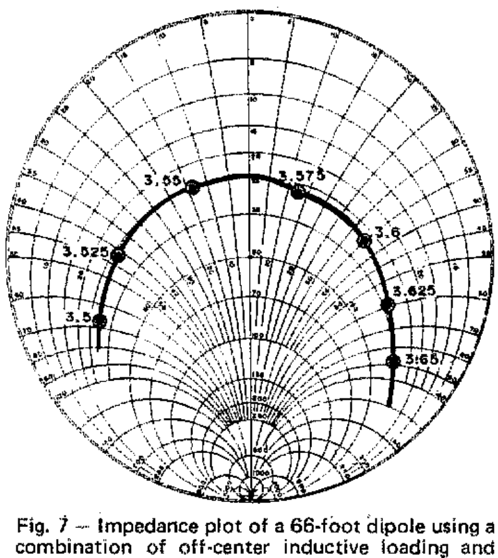


Fig. 7 – Impedance plot of a 66-foot dipole using a combination of off-center inductive loading and capacitive end loading. Of all the shortened configurations tried, this arrangement offered the greatest bandwidth.

Of the various arrangements, capacitive end loading decidedly provides the greatest bandwidth, excepting the full-size half-wave antenna, of course. Although there are slight differences in the resistance value at resonance, all are of the same order of magnitude. These values, as well as those for the 160-m antenna discussed earlier, tend to confirm a *broad* rule of thumb that the writer has formulated for this type of antenna: The feed-point impedance value at resonance is roughly proportional to the length of the antenna. That is, a loaded antenna which is half the size of a half-wave dipole will have approximately half the radiation resistance of the full-sized antenna.

Eq. 1 given earlier or the chart of Fig. 2 allows one to calculate loading-coil values for antennas with loading coils only. Additional capacitive loading is not taken into account. Calculating the effects of various capacitive loading arrangements appears to be difficult, and work remains to be done in this area.

Multiband Antennas with Loading Coils

All of the foregoing material has been devoted to the loading of an antenna for resonance at a single frequency. Resonated as described, the antenna is electrically a half wave in length. It will, however, operate well on higher frequencies – frequencies at which it is an odd multiple of half waves in *electrical* length . . . three half waves, five half waves, etc. Because of the lumped loading of the shortened antenna, these higher frequencies will likely not be closely related to odd-order harmonics of the fundamental frequency, as the case would be for a nonloaded radiator. (For example, it is a well-known fact that a 7-MHz half-wave dipole operates well on its third harmonic, 21 MHz.)

A loaded dipole will become an electrical 3/2-λ antenna at some frequency *below* that which is three times the fundamental resonant frequency. Depending upon the overall antenna length, coil value, and coil position, it is possible for an 80-meter loaded dipole to become a 3/2-λ performer on 40 meters. With such an arrangement, one would have a dual-band antenna without requiring the use of traps. The idea can be expanded upon to arrive at a loaded antenna without traps which will operate on more than two bands. This scheme offers considerable constructional simplification as compared with trap arrangements.

The multiband loading-coil concept has been recognized for better than half a century, but little use of the technique has been made by amateurs. Some years ago a very good article on the subject was published by William Lattin, W4JRW.† That article is recommended reading for anyone inter-

(Continued on page 58)

proposal before October's deadline – and the League's General Counsel in his formal filing – pointed out that Class E problems potentially are international as well as national, and that the request for the reallocation (from the Electronics Industries Association) was based on a number of unjustified assumptions. At this time, I cannot comment any further on the Class E matter – except to say that any rumors that the Commission has prejudged the issues (rumors to which the League's 1973 annual report alludes) are speculative indeed.

Citizens band operation also exists in Class D, of course, and we at the Commission are aware of continuing amateur concerns over this service. Without in any way detracting from your position as a largely self-disciplined and indeed highly professional force of radio operators, I feel I must repeat that the Commission is required to look to the overall public interest in each and every one of the services it regulates. Because we recognize the need for strict enforcement of justifiable rules, the Commission during fiscal year 1974:

Created three specially trained and equipped teams to devote themselves entirely to Class D enforcement, with a fourth team being added this summer;

Initiated approximately 1,000 actions involving monetary forfeitures, some 700 revocation proceedings and 100 cease and desist proceedings;

Obtained with the aid of the Justice Department some 20 criminal convictions, including the well known Bennett case tried in Detroit; and

This past June, in conjunction with local police authorities, operated 40 special inspection stations in 21 states for two days for the purpose of checking licenses in CB use by truckers. Of the 36,000 trucks passing through the stations, nearly 20 per cent were found to be equipped with Class D equipment, and more than half of these units were found to be unlicensed.

These figures leave no doubt of the magnitude of the CB enforcement problem. On the other hand, we are also aware of the growing interest in the Citizens Radio Service, in which, in 1973-74, the Commission received some 342,000 applications – a nearly 50 per cent increase over the previous year. As in any popular activity, where the numbers engaged far outman those who monitor the activity, a regulatory body must strike some public-interest balance between too many regulations, which it cannot enforce, and too few regulations, which may result in harm to other users of radio-frequency equipment and to the public generally. I can assure that we are working hard at the Commission to achieve such a proper balance and also a program which will make the Citizens Radio Service a useful one to those American citizens who desire to utilize it.

The theme of cooperation between the FCC and the League, as well as amateurs generally, has been sounded several times during my remarks – and it is fitting one on which to conclude. Of the 75 petitions from radio amateurs and their organizations now on file at the Commission, 44 deal in some way with changes in the present system of operator privileges and requirements. The Commission now refers to its study of this area as the "restructuring of the Amateur Service," although that phrase is not necessarily intended to signal wholesale revisions. It appears wise to make some changes in licensing structure, but these will not be sprung upon you by surprise. Instead, we will continue to brief amateur groups and their media to try to get early reactions to our proposed regulatory actions. Later, the formal process of rule making will take place with an opportunity for written comments.

Because we particularly value the comments of the League – whose 90,000 members represent about a third of the amateurs licensed in the United States and Canada – let me stress that they are helpful not only in ultimate rule making but also in the earlier petition stage. To the extent that your hard-working staff can manage it, we at the FCC would welcome ARRL's reactions to petitions that may affect the Amateur Service – which I guess is another way of saying that if you want a job done right, give it to a busy group.

Thank you, and congratulations on your 60th Anniversary. May you have many more! QST

Dipole Antennas *(Continued from page 34)*

ested in more details on the concept. Supplemental information has been published by Buchanan.† Attempts by this writer to calculate antenna sizes and coil values for dual-band antennas have met with some success. From calculations and experiments to date, it appears that with only two loading coils (one each side of center), the antenna must always be greater than a half wave in physical length for the higher of the two frequency bands. In other words, any 80/40 meter arrangement, for example, apparently would need to be longer than 66 feet from tip to tip. However, much work also remains to be done in this area.

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