ANTENTOP

ANTENTOP 02 2003 # 003

ANTENTOP is *FREE* e-magazine devoted to ANTENnas
Theory,
Operation, and
Practice
Edited by hams for hams

In the Issue:

Practical design of HF and VHF Antennas!

Antennas Theory!

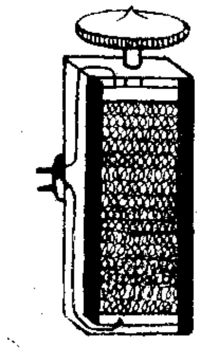
Tesla's Mysteries!

Histories of Early Radio!

And More….

Bottle Antenna

60 GHz in 1890s!



The Spiral-spring Receiver.

Thanks to our authors:

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RN1NZ, RV9CX, RZ3AE
And others…..

EDITORIAL:

Well, my friends, new ANTENTOP – 02 -2003 come in! ANTENTOP is just authors' opinions in the world of amateur radio. I do not correct and re-edit your articles, the articles are printed "as is". A little note, I am not a native English, so, of course, there are some sentence and grammatical mistakes there… Please, be indulgent! (continued on next page)

Now ANTENTOP is sponsored by microHAM, please, visit to microHAM's site at http://www.microham.com/

I believe, you find many interesting there!

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ANTENTOP 02 –2003 contains huge antenna articles, and several historical articles. Hope, you will like it. Our pages opened for all amateurs, so, you are welcome always, or as a reader or as a writer.

73! Igor Grigorov, RK3ZK

ex: UA3-117-386, UA3ZNW, UA3ZNW/UA1N, UZ3ZK
op: UK3ZAM, UK5LAP,
EN1NWB, EN5QRP, EN100GM

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Welcome to ANTENTOP, FREE e - magazine!

ANTENTOP is ***FREE e- magazine***, made in **PDF**, devoted to antennas and amateur radio. Everyone may share his experience with others hams on the pages. Your opinions and articles are published without any changes, as I know, every your word has the mean.

Every issue of ANTENTOP is going to have 100 pages and this one will be paste in whole on the site. Preview's files will be removed in this case. I do not know what a term for one issue will need, may be 2-3 month or so. As I have counted, a whole issue of ANTENTOP will hold nearly 10 - 20 MB .

A little note, I am not a native English, so, of course, there are some sentence and grammatical mistakes there… Please, be indulgent!

Preview: Some articles from "cooking" issue will be pasted for preview on this site, others no. Because, as I think, it must be something mysterious in every issue.

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I have a big collection of pictures, I have got the pictures and stuff in others ways, from ***FREE websites***, from commercial CDs, intended for ***FREE using***, and so on... I use to the pictures (and seldom, some stuff from closed websites) in ANTENTOP. ***If the owners still are alive***, please, contact with me, I immediately remove any Copyright stuff, or, if it is necessary, all needed references will be made there.

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73! ***Igor Grigorov***, RK3ZK

ex: UA3-117-386, UA3ZNW, UA3ZNW/UA1N, UZ3ZK

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History

Feel Yourself a Student!

Dear friends, I would like to give to you an interesting and reliable antenna theory. Hours searching in the web gave me lots theoretical information about antennas. Really, at first I did not know what information to chose for ANTENTOP. Finally, I stopped on lectures “Modern Antennas in Wireless Telecommunications” written by Prof. Natalia K. Nikolova from McMaster University, Hamilton, Canada.

You ask me: Why?

Well, I have read many textbooks on Antennas, both, as in Russian as in English. So, I have the possibility to compare different textbook, and I think, that the lectures give knowledge in antenna field in great way. Here first lecture “Introduction into Antenna Study” is here. Next issues of ANTENTOP will contain some other lectures.

So, feel yourself a student! Go to Antenna Studies!

I.G.

My Friends, the Intro was given at ANTENTOP- 01- 2003 to Antennas Lectures.

Now I know, that the Lecture is one of popular topics of ANTENTOP- 01- 2003. The Lecture was downloaded 1000 times to September, 12! Not bad!

Now I want to present you one more very interesting Lecture - it is a Lecture about practical constructing of all shapes dipoles. I believe, you cannot find such info anywhere for free! Very interesting and very useful info for every ham, for every radio- engineer.

So, feel yourself a student! Go to Antenna Studies!

I.G.

McMaster University
Inspiring Innovation and Discovery

McMaster University Hall

Prof. Natalia K. Nikolova

LECTURE 10: Other Practical Dipole/Monopole Geometries. Matching Techniques for Dipole/Monopole Feeds.

(*The folded dipole antenna. Conical skirt monopoles. Sleeve antennas. Turnstile antenna. Impedance matching techniques. Dipoles with traps.*)

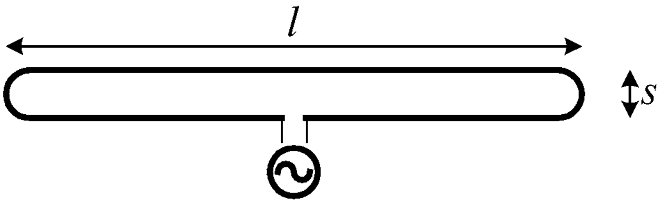
by Prof. Natalia K. Nikolova

All lectures are available at: http://www.ece.mcmaster.ca/faculty/georgieva/antenna_dload/

LECTURE 10: Other Practical Dipole/Monopole Geometries. Matching Techniques for Dipole/Monopole Feeds.

(*The folded dipole antenna. Conical skirt monopoles. Sleeve antennas. Turnstile antenna. Impedance matching techniques. Dipoles with traps.*)

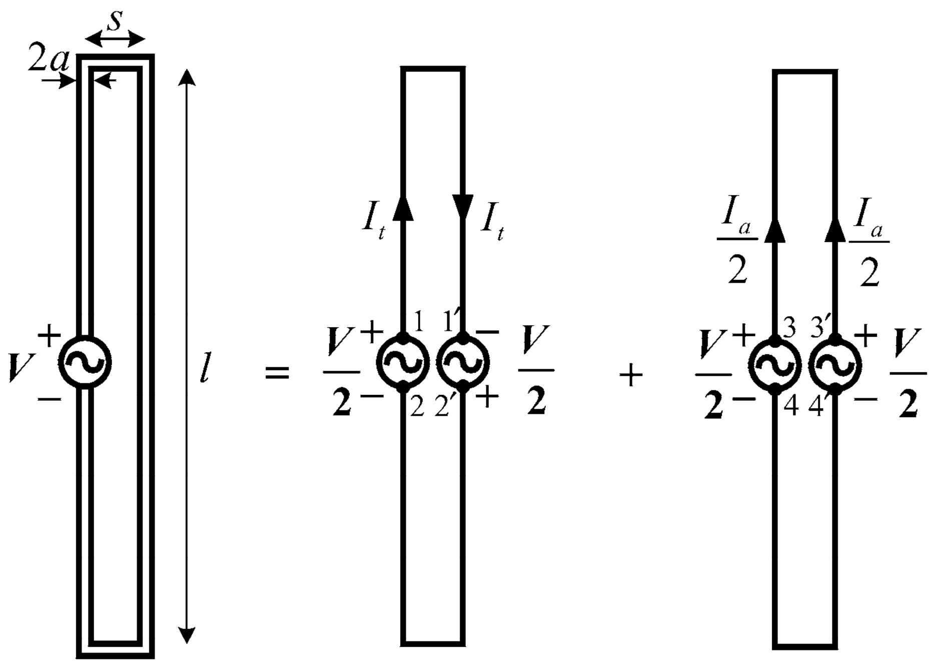
1. Folded dipoles



The folded dipole is a very popular antenna for reception of TV broadcast signals. It has essentially the same pattern as the dipole of the same length l but it provides four times greater input impedance when $l \simeq \lambda/2$. The length of a single-wire dipole is usually $\lambda/4 \le l \le \lambda$ for best directivity with no side lobes. Most often, $l \simeq \lambda/2$. The input resistance then is $R_{in} \simeq 73\ \Omega$. Wire antennas are not fit to coaxial feed lines because of the different field structure. However, they are ideally suited for twin-lead (two-wire) feed lines. These lines (two parallel thin wire lines separated by a distance of about 8-10 mm) have $Z_c \approx 300\ \Omega$. Therefore, an input antenna impedance of $(4\times 73)\ \Omega$ is perfect for matching to 2-wire feed lines. The separation distance between the two wires of the folded dipole should not exceed 0.05λ.

The folded dipole can be analyzed by decomposing its current into two modes: the transmission-line mode and the antenna mode. This analysis, albeit approximate[1], illustrates the four-fold impedance transformation.

[1] G.A. Thiele, E.P. Ekelman, Jr., L.W. Henderson, "On the accuracy of the transmission line model for the folded dipole," *IEEE Trans. on Antennas and Propagation*, vol. AP-28, No. 5, pp. 700-703, Sept. 1980.



Folded dipole (a) Transmission-line mode (b) Antenna mode

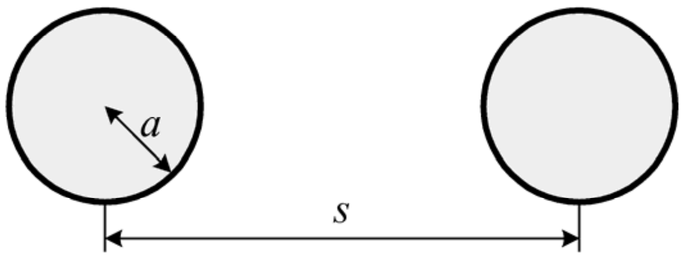
The input impedance at the terminals $1-1'$ and $2-2'$ can be determined as the input impedance of a shorted transmission line of length $l/2$:

$$Z_t = \left[Z_0 \left(\frac{Z_L + jZ_0 \tan(\beta l/2)}{Z_0 + jZ_L \tan(\beta l/2)} \right) \right]_{Z_L=0} \tag{10.1}$$

$$\Rightarrow Z_t = jZ_0 \tan\left(\frac{\beta l}{2}\right) \tag{10.2}$$

Here, Z_0 is the characteristic impedance of a 2-wire transmission line:

$$Z_0 = \frac{\eta}{\pi} \operatorname{arccosh}\left(\frac{s}{2a}\right) = \frac{\eta}{\pi} \ln\left[\frac{s/2 + \sqrt{(s/2)^2 - a^2}}{a}\right] \tag{10.3}$$



Usually, the folded dipole has a length of $l \simeq \lambda/2$. Then,

$$Z_t(\lambda/2) = jZ_0 \tan(\pi/2) \to \infty \qquad (10.4)$$

If $l \neq \lambda/2$, the more general expression (10.2) should be used. The current in the transmission-line mode is:

$$I_t = \frac{V}{2Z_t} \qquad (10.5)$$

Let us consider now the antenna mode. The generators' terminals $3-3'$ (and $4-4'$) are with identical potentials. Therefore, they can be connected without loss of generality. The following assumption is made: an equivalent dipole of effective radius

$$a_e = \sqrt{as} \qquad (10.6)$$

is radiating excited by $V/2$ voltage. Since usually $a \ll \lambda$ and $s \ll \lambda$, the input impedance of the equivalent dipole Z_a is assumed equal to the input impedance of an infinitesimally thin dipole of the respective length l. If $l = \lambda/2$, then $Z_a = 73\ \Omega$. The current in the antenna mode is:

$$I_a = \frac{V}{2Z_a} \qquad (10.7)$$

The current at each leg of the equivalent dipole is obviously

$$\frac{I_a}{2} = \frac{V}{4Z_a} \qquad (10.8)$$

The total current of a folded dipole is obtained by combining both modes. At the input

$$I_{in} = I_t + \frac{I_a}{2} = V\left(\frac{1}{2Z_t} + \frac{1}{4Z_a}\right) \qquad (10.9)$$

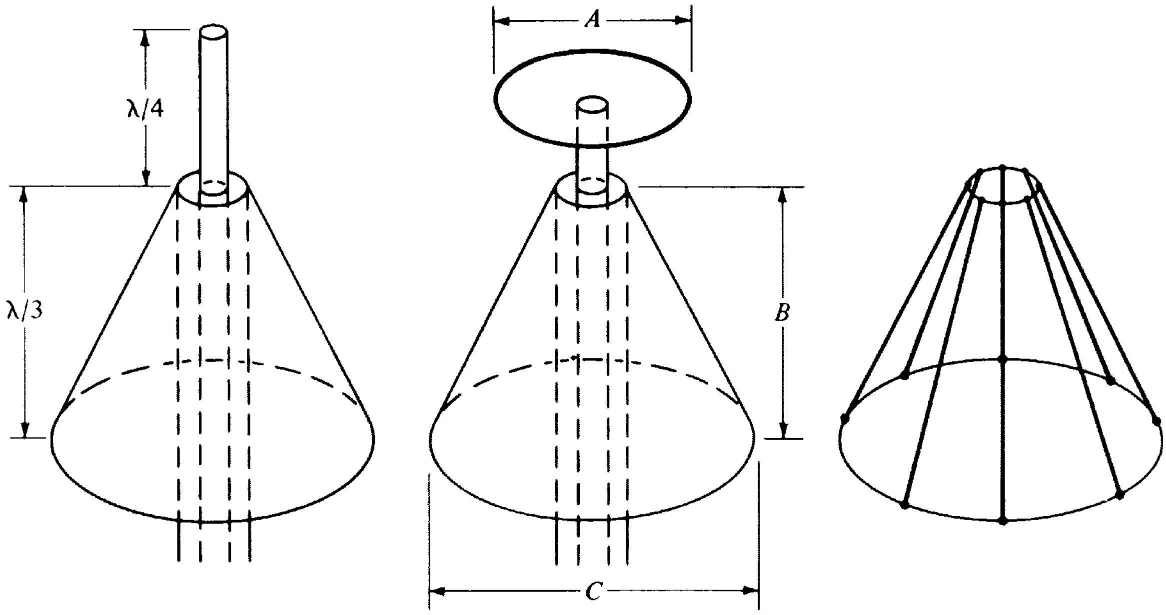
$$\Rightarrow Z_{in} = \frac{4Z_t Z_a}{2Z_a + Z_t} \qquad (10.10)$$

When $l = \lambda/2$ (half-wavelength folded dipole), then $Z_t \to \infty$, and

$$\Rightarrow Z_{in} = 4Z_a\Big|_{l=\frac{\lambda}{2}} \simeq 292\ \Omega \qquad (10.11)$$

Thus, the half-wavelength folded dipole is very well suited for direct connection to a twin-lead line ($Z_c \approx 300\ \Omega$). It is often made in a very simple way: a suitable portion (the end part of the twin-lead cable of length $l = \lambda/2$) is separated into two single wire leads, which are bent to form the folded dipole.

2. Conical (skirt) monopoles and discones



(a) Conical skirt monopole (b) Discone (c) Wire-simulation

These monopoles have much broader frequency band for their impedance variations (a couple of octaves) than the ordinary quarter-wavelength monopoles. They are a combination of the two basic antennas: the monopole/dipole antenna and the biconical antenna. The discone and conical skirt monopoles find wide application in the VHF (30-300 MHz) and the UHF (300 MHz - 3 GHz) spectrum for FM broadcast, television and mobile communications.

There are numerous variations of the dipole/monopole/cone geometries, which aim at broader bandwidth rather than shaping the radiation pattern. All these antennas provide omnidirectional radiation.

The discone (disk-cone) is the most broadband among these types of antennas. This antenna was first designed by Kandoian[2] in 1945. The performance of the discone in frequency is similar to that of a high-pass filter. Below certain effective cutoff frequency, it has a considerable reactance and produces severe standing waves in the feed line. This

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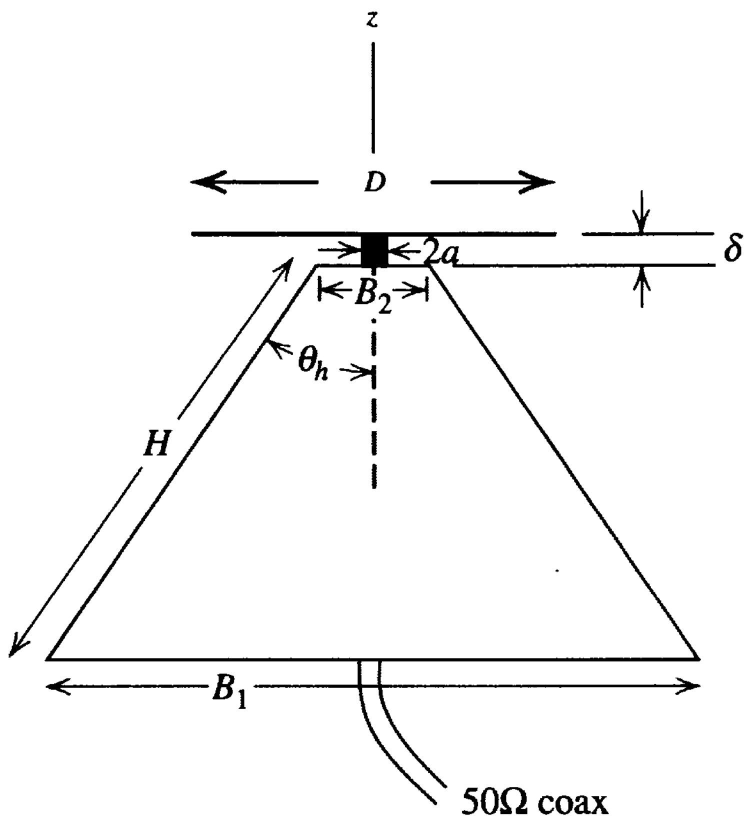
[2] A.G. Kandoian, "Three new antenna types and their application," *Proc. IRE*, vol. 34, pp. 70W-75W, Feb. 1946.

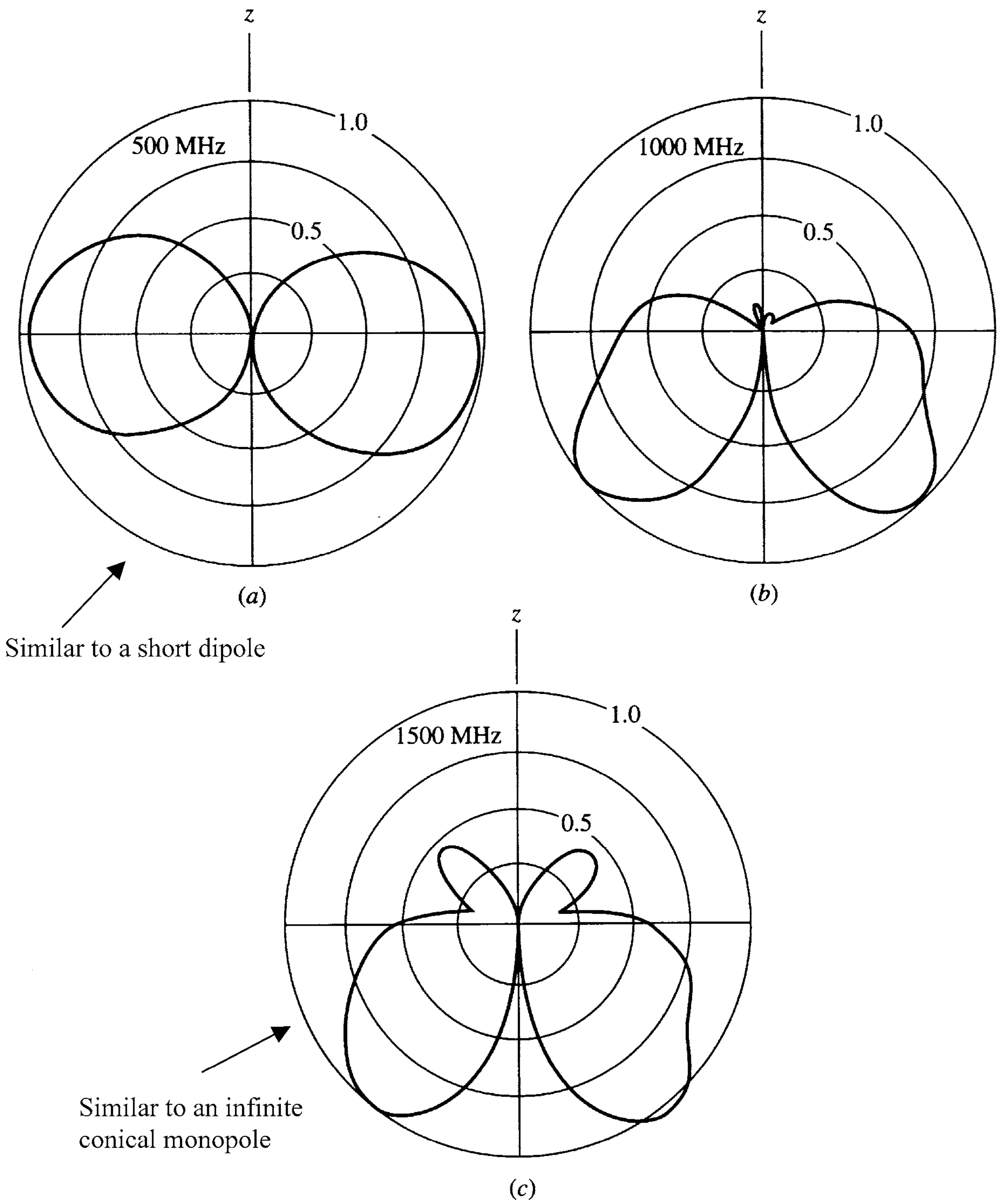
happens approximately at wavelength such that the slant height of the cone is $\approx \lambda/4$.



Typical dimensions of a discone antenna at central frequency are: $D \approx 0.4\lambda$, $B_1 \approx 0.6\lambda$, $H = 0.7\lambda$, $45^\circ \le 2\theta_h \le 75^\circ$ and $\delta \ll \lambda$. The typical input impedance is designed to be 50 Ω. Optimum design formulas are given by Nail[3]: $B_2 \approx \lambda_u / 75$ at the highest operating frequency, $\delta \approx (0.3 \div 0.5)B_2$, and $D \approx 0.7B_1$.

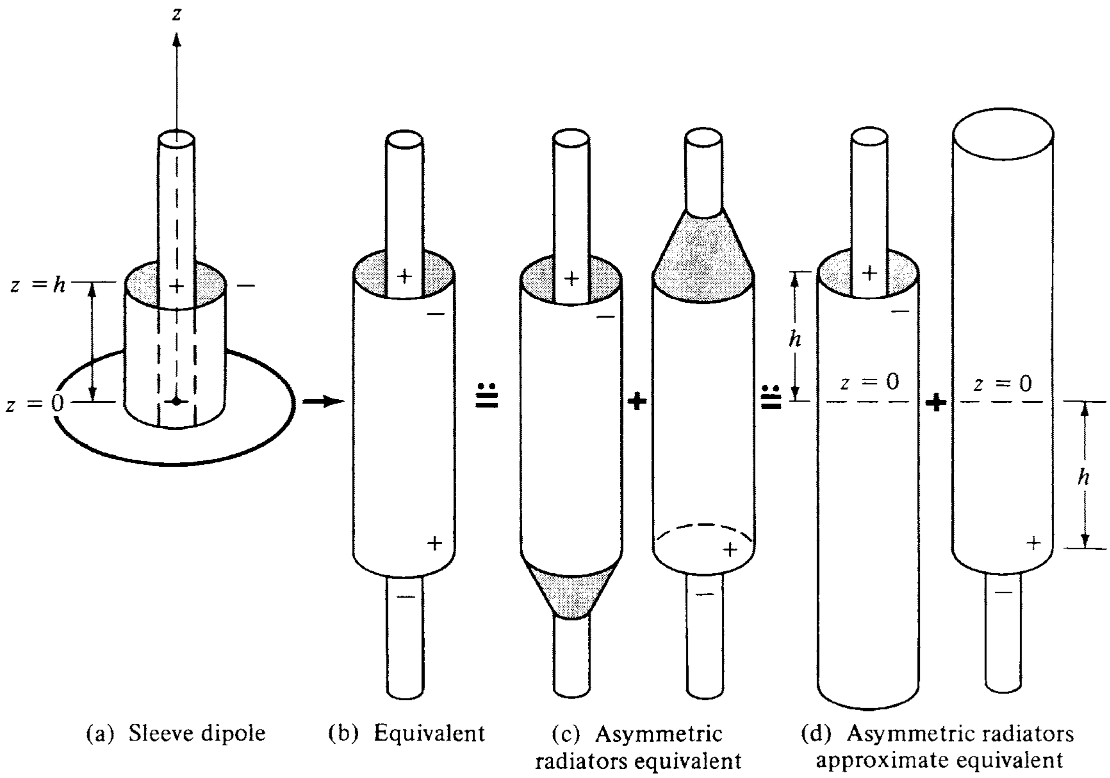
[3] J.J. Nail, "Designing discone antennas," *Electronics*, vol. 26, pp. 167-169, Aug. 1953.

Measured patterns for a discone: $H = 21.3$ cm, $B = 19.3$ cm, $\theta_h = 25^\circ$:



3. Sleeve (coaxial) dipoles and monopoles

The impedance of dipole/monopole antennas is very frequency sensitive. The addition of a sleeve to a dipole or a monopole can increase the bandwidth up to more than an octave.



Sleeve dipole and its equivalents. (SOURCE: W. L. Weeks, *Antenna Engineering*, McGraw-Hill, New York, 1968)

This type of antenna closely resembles an asymmetric dipole, and can be analyzed using the approximation in (d). The outer shield of the coaxial line is connected to the ground plane, but it also extends above it a distance h, in order to provide mechanical strength, impedance tuning and impedance broadband characteristics. The equivalent in (d) consists of two dipoles, which are asymmetrically driven at $z' = +h$ or $z' - h$. When analyzing the field of the two asymmetrically driven dipoles, one can ignore the change in diameter occurring at the feed point.

The input impedance of an asymmetric dipole can be related to its self-impedance approximately as:

$$Z_{as} = \frac{Z_m}{\sin^2\left[\beta\left(\frac{l}{2} - h\right)\right]} \quad (10.12)$$

where h is the off-center displacement. The relation (10.12) was already derived when the centered-feed impedance of a dipole of arbitrary length was analyzed in Lecture 7. A symmetrically driven dipole would have an input impedance of:

$$Z_s = \frac{Z_m}{\sin^2\left(\beta\frac{l}{2}\right)} \quad (10.13)$$

For a half-wavelength dipole ($l = \lambda/2$), it is easy to show that the relation between the input impedance of the asymmetric dipole Z_{as} and the center-fed symmetric dipole Z_s is:

$$Z_{as} \simeq \frac{Z_s}{\cos^2(\beta h)} \quad (10.14)$$

The general expression is:

$$Z_{as}(h) \simeq Z_s \frac{\sin^2\left(\beta\frac{l}{2}\right)}{\sin^2\left[\beta\left(\frac{l}{2} - h\right)\right]} \quad (10.15)$$

From (10.15) or from (10.12) it is obvious that one can control the input impedance by shortening or extending the sleeve along the stub.

The equivalent antenna structure in (d) actually consists of two asymmetrically driven dipoles. The total input current is:

$$I_{in} = I_{as}(z' = +h) + I_{as}(z' = -h) \quad (10.16)$$

The input admittance is:

$$Y_{in} = \frac{I_{in}}{V_{in}} = \frac{I_{as}(z' = +h) + I_{as}(z' = -h)}{V_{in}} = \frac{I_{as}(z = h)}{V_{in}}\left[1 + \frac{I_{as}(z = -h)}{I_{as}(z = +h)}\right] \quad (10.17)$$

$$\Rightarrow Y_{in} = Y_{as}\left[1 + \frac{I_{as}(z' = -h)}{I_{as}(z' = +h)}\right] \quad (10.18)$$

Here, $Y_{as} = 1/Z_{as}$ can be calculated from (10.15). The assumption for a sinusoidal current distribution dictates that the currents in (10.18) should be calculated from the formula:

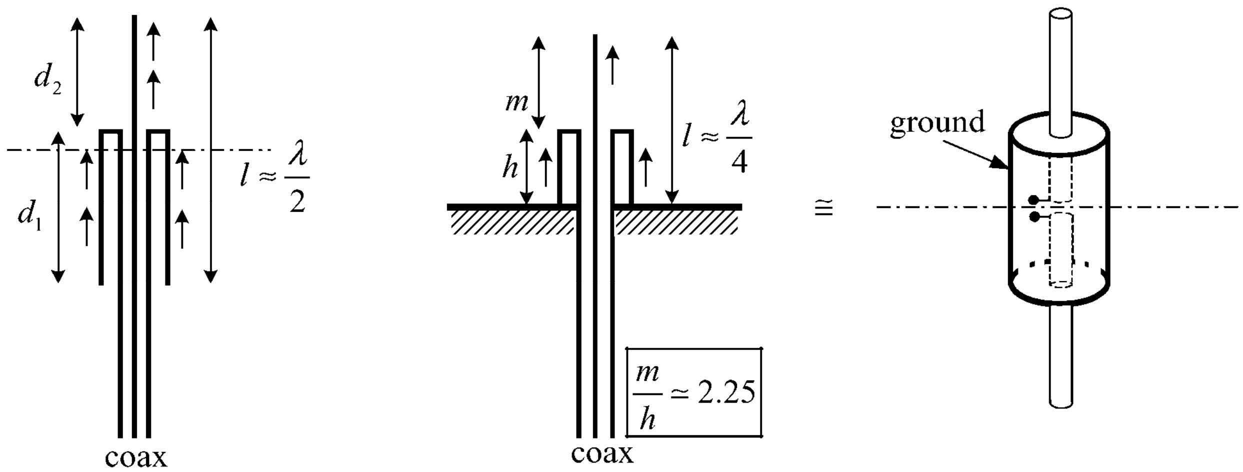
$$I(z') = I_m \sin\left[\beta\left(\frac{l}{2} - |z'|\right)\right] \quad (10.19)$$

Since the two dipoles in (d) are geometrically identical, it follows from (10.18) that:

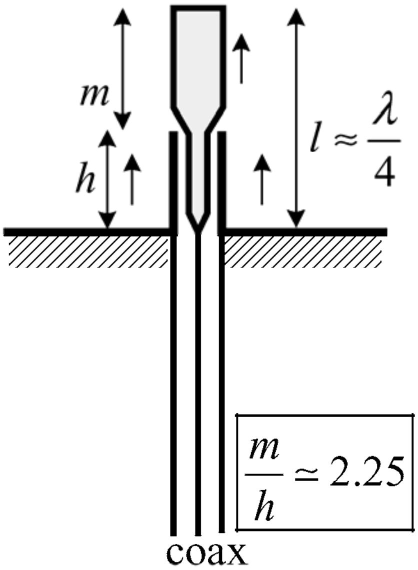
$$Y_{in} \simeq 2Y_{as} \quad (10.20)$$

The first sleeve monopole resonance will occur at a length of approximately $l \simeq \lambda/4$. The other important design variable is the monopole-to-sleeve ratio $\eta = (l-h)/h$. It has been experimentally established that $\eta = 2.25$ yields optimum (nearly constant with frequency) radiation patterns over a 4:1 band. The value of $\eta = (l-h)/h$ has little effect on the radiation pattern if $l \le \lambda/2$, since the current on the outside of the sleeve will have approximately the same phase as that on the top potion of the monopole itself. However, for longer lengths, the ration η has marked effect on the radiation patterns since the current on the outside of the sleeve will not necessarily be in-phase with that on the top portion of the monopole.

Some practical geometries:



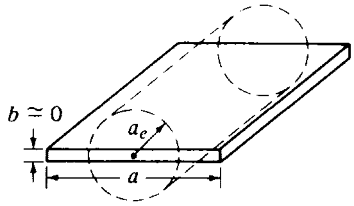
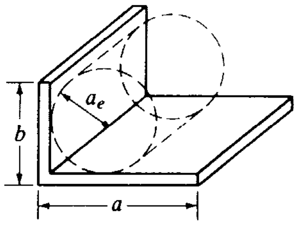
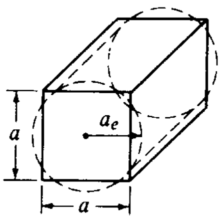
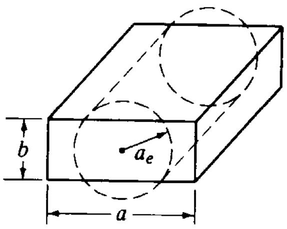
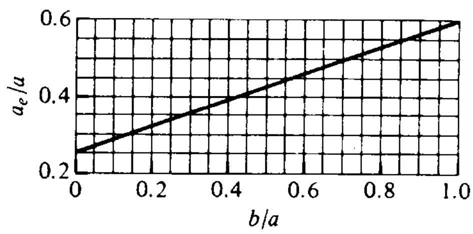
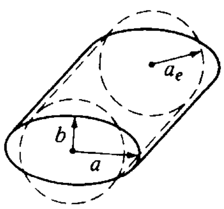
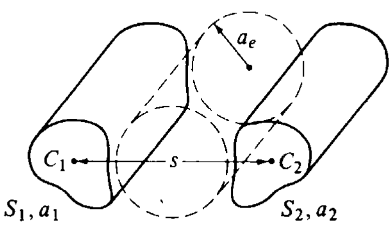
(a) assymertically-fed sleeve dipole (b) sleeve monopole (c) sleeve dipole



(d) another sleeve monopole

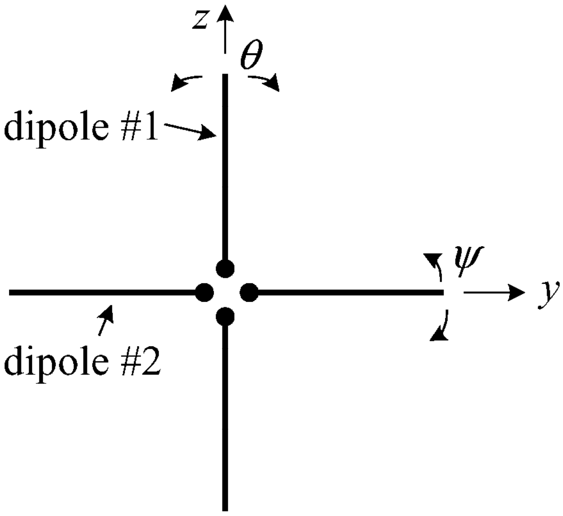
Up to now, it was always assumed that the cross-section of the wire is circular of radius a, when deriving the expressions for the input impedance. An electrical equivalent radius can be obtained for some uniform wires of non-circular cross-section. This is very helpful when calculating the impedance of dipoles made of non-circular cross-section wires. The equivalent radii for certain wires are given below.

Table 9.3 CONDUCTOR GEOMETRICAL SHAPES AND THEIR EQUIVALENT CIRCULAR CYLINDER RADII

Geometrical Shape	Electrical Equivalent Radius
	$a_e = 0.25a$
	$a_e \simeq 0.2(a + b)$
	$a_e = 0.59a$
	
	$a_e = \frac{1}{2}(a + b)$
	$\ln a_e \simeq \frac{1}{(S_1 + S_2)^2}$ $\times [S_1^2 \ln a_1 + S_2^2 \ln a_2 + 2S_1S_2 \ln s]$ S_1, S_2 = peripheries of conductors C_1, C_2 a_1, a_2 = equivalent radii of conductors C_1, C_2

4. Turnstile antenna

The turnstile antenna is a combination of two orthogonal in space dipoles fed in phase-quadrature. This antenna is capable of producing circularly polarized field in the direction, which is normal to the dipoles' plane. It produces an isotropic pattern in the dipoles' plane (the θ-plane) of linearly (along $\hat{\theta}$) polarized wave. In all other directions, the wave is elliptically polarized.



In the $\varphi = 90^\circ$- plane (the $y - z$ plane in which the dipoles lie), the field is a superposition of the fields whose patterns are:

$$\bar{E}_\theta^{(1)}(t) = \sin\theta\cos\omega t \quad (10.21)$$

$$\bar{E}_\psi^{(2)}(t) = \sin\psi\cos(\omega t \pm \pi/2) = \pm\sin\omega t \cdot \sqrt{1-\sin^2\theta\sin^2\varphi} =$$
$$= \pm\cos\theta\cdot\sin\omega t$$
$$(10.22)$$

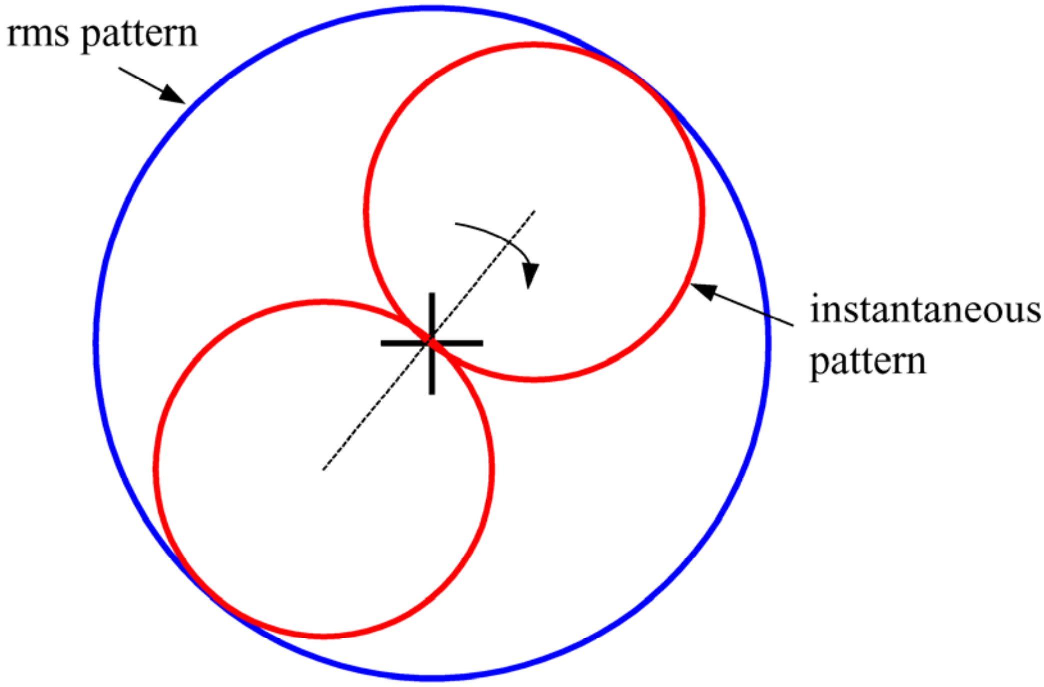
In the $\varphi = 90^\circ$- plane, the ψ-component of a vector is actually a θ-component. Equations (10.21) and (10.22) define a total field of:

$$\bar{E}_\theta(t,\theta) = \sin\theta\cos\omega t \pm \cos\theta\sin\omega t \quad (10.23)$$

which reduces to

$$\bar{E}_\theta(t,\theta) = \sin(\theta \pm \omega t) \quad (10.24)$$

The rms pattern is circular, although the instantaneous pattern rotates.



5. Matching techniques for wire antennas

There two major issues when constructing the feed circuit: impedance matching and balanced-unbalanced matching.

5.1. Impedance matching

$$\mathrm{VSWR} = \frac{1+|\Gamma|}{1-|\Gamma|} \tag{10.25}$$

Reflected power in terms of VSWR:

$$|\Gamma|^2 = \left(\frac{\mathrm{VSWR}-1}{\mathrm{VSWR}+1}\right)^2 \tag{10.26}$$

Transmitted power:

$$|T|^2 = 1 - |\Gamma|^2 \tag{10.27}$$

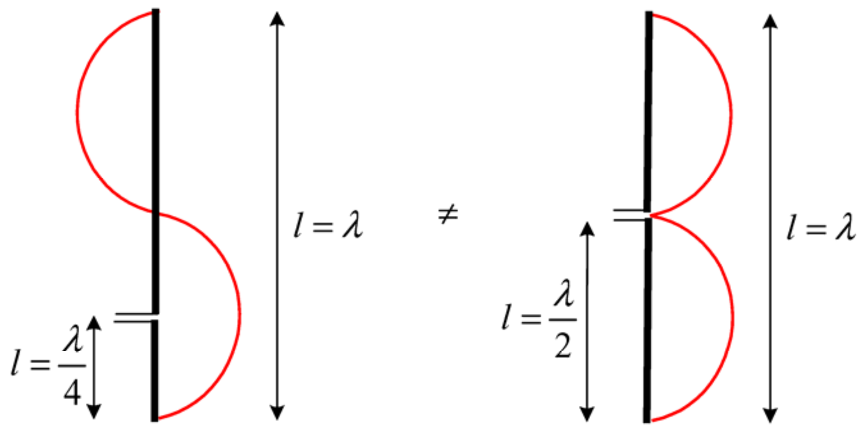
Impedance mismatch is undesirable not only because of the inefficient power transfer. In high-power transmitting systems, high VSWR leads to maxima of the standing wave, which can cause arcing. Sometimes, the frequency of the transmitter can be affected by severe impedance mismatch (“frequency pulling”).

TABLE: VSWR and Transmitted Power

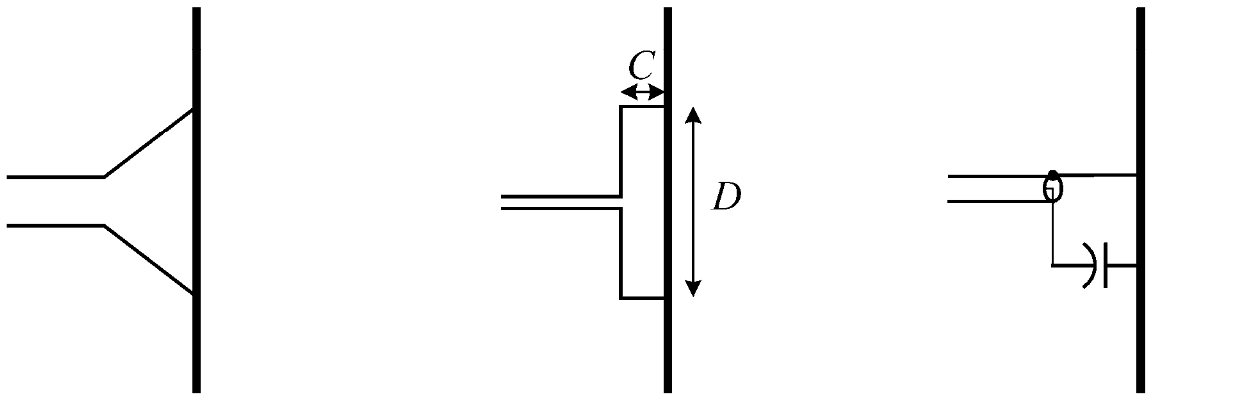
VSWR	$\|\Gamma\|^2 \times 100\%$	$\|T\|^2 \times 100\%$
1.0	0.0	100.0
1.1	0.2	99.8
1.2	0.8	99.2
1.5	4.0	96.0
2.0	11.1	88.9
3.0	25.0	75.0
4.0	36.0	64.0
5.0	44.4	55.6
5.83	50.0	50.0
10.0	66.9	33.1

A common way to find the proper feed location along a dipole or monopole is to feed off-center, which provides increase of the input impedance with respect to the center-feed impedance according to equation (10.14). The input resistance of a half-wavelength dipole is approximately 73 Ω, which is well suited for standard coaxial lines. The quarter-wavelength monopole has an input resistance of approx. 37 Ω, and, usually the sleeve-type of feed is used to achieve greater values of the antenna input impedance. The folded dipole is excellent to feed with 300 Ω twin-lead line.

However, the off-center feed is unsymmetrical and can lead to undesirable phase reversal in the antenna if $l > \lambda/2$. This will profoundly change the radiation pattern. To avoid such cases, symmetrical feeds for increased impedance are used.



A few forms of shunt matching (or shunt feed) are shown below:



(a) Delta match (b) Tee match (c) Gamma match

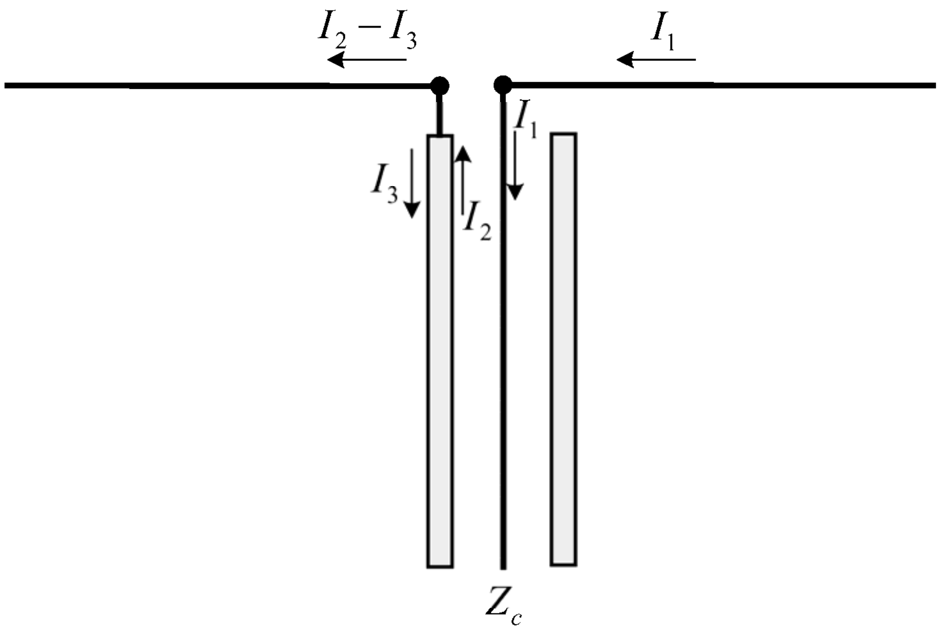
We shall explain the principles of operation of the T-match only, which is the simplest of all to design and which gives the basic idea for all shunt feeds. The T-match interconnection can be viewed as two shorted transmission lines and a very-wide-gap dipole in parallel with respect to the twin-lead cable. The shorted transmission lines are less than quarter-wavelength long, and, therefore they have an inductive reactance. This reactance is usually greater than the capacitive reactance of the wide-gap dipole, and an additional tuning lumped capacitor might be used to achieve better match. As the distance D increases, the input impedance increases, too. It has a maximum at about $D = l/2$ (half the dipole's length). Then, it starts decreasing again, and when $D = l$, it equals the folded-dipole input impedance. In practice, sliding contacts are made between the shunt arms and the dipole for impedance adjustments and tuning. Note that shunt matches may radiate, which is very undesirable at the operating frequency band.

The Gamma-match is essentially the same as the T-match, only that it is designed for unbalanced-balanced connection.

Additional matching devices are sometimes used such as quarter-wavelength impedance transformers, reactive stubs for compensating antenna reactance, etc. These devices are well studied and described in courses in Microwave Engineering.

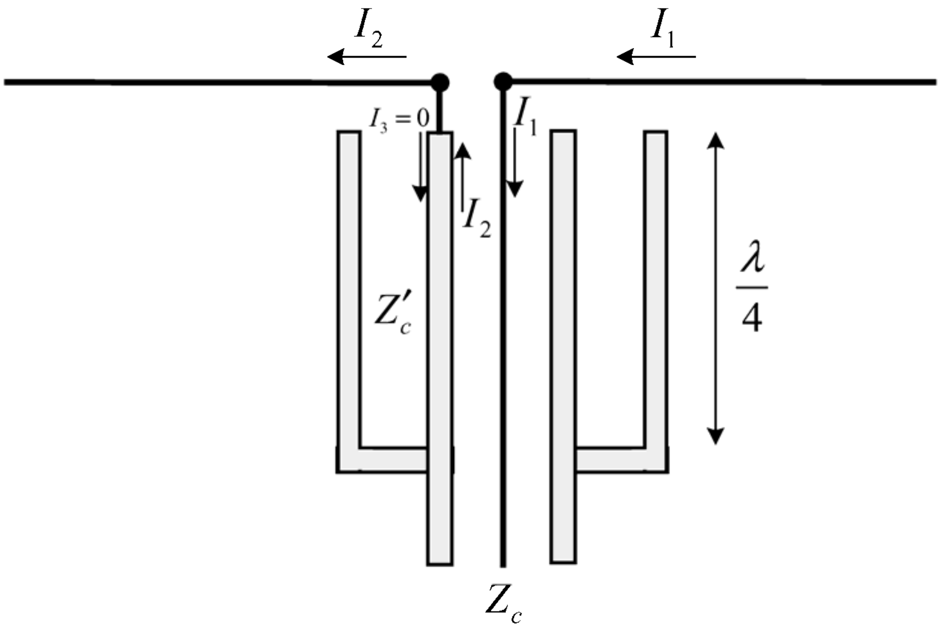
5.2. Balanced-to-unbalanced feed

Sometimes when high-frequency devices are connected, their impedances (in a quasi-static sense) might be well matched, and still one might observe significant reflections. This is sometimes referred to as "field mismatch". A typical example in antenna technology is the interconnect between a coaxial line of $Z_c = 75\ \Omega$ and a half-wavelength dipole of $Z_{in} = 73\ \Omega$. The reflections are much more severe than one would predict using equation (10.26). This is because the field and the current distributions in the coaxial line and at the input of the wire dipole are very different.



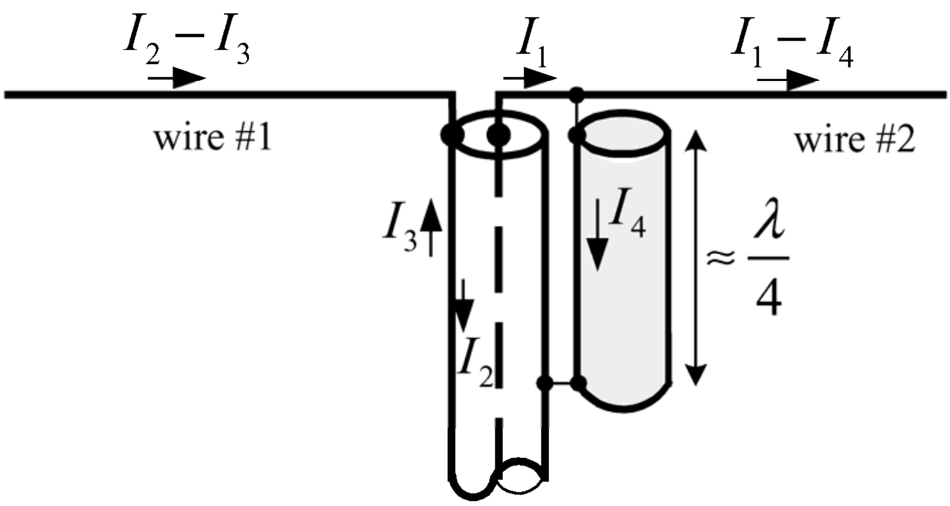
The unequal currents at the dipole's legs unbalance the antenna and the coax. To balance the currents, various devices are used, called baluns (balanced-to-unbalanced transformer).

1) <u>Sleeve (bazooka) balun 1:1</u>
The sleeve and the outer conductor of the coax form another coax line, which has a characteristic impedance of Z_c'. This line is shorted quarter-wavelength away from the antenna input terminals.



This is a narrowband balun, which does not have impedance-transformer capability (1:1 balun). It is not very easy to construct.

2) <u>Folded balun 1:1</u> (split-coax balun, $\lambda/4$-coax balun)
This 1:1 balun is easier to make. It is also narrowband.

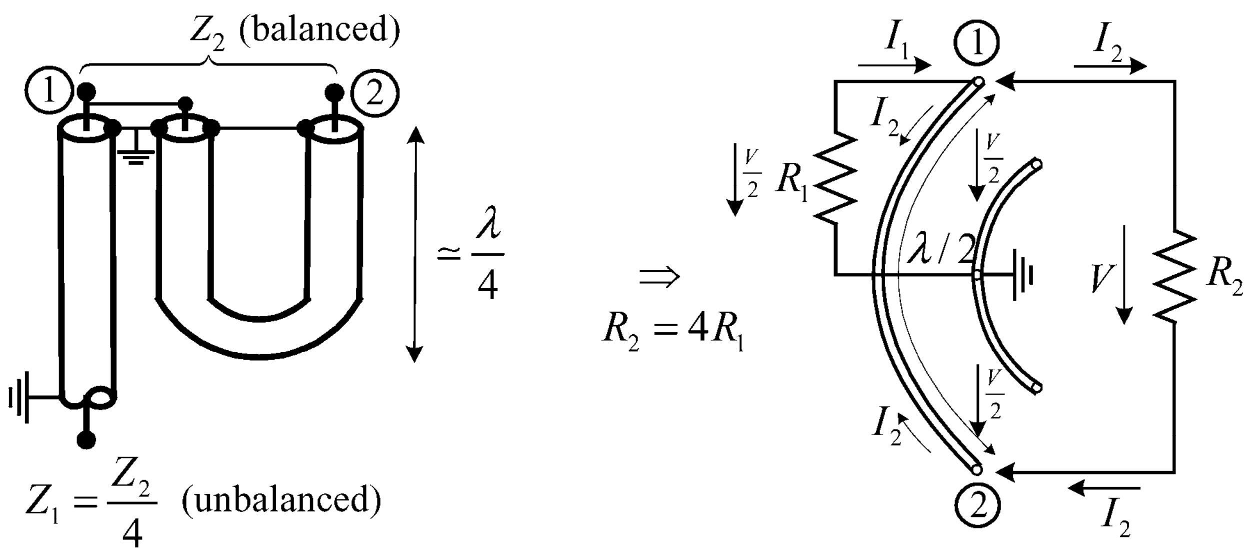


The outer shield of the feeding coax line and the additional coax-line section form a two-lead transmission line, shorted a distance $\approx \lambda/4$ away from the antenna input. This line is in parallel with the antenna but does not affect the overall impedance because it has infinite impedance at the antenna terminals. The additional coax line redirects a portion of the I_1 current, which induces the two-lead current I_4. The currents I_3 and I_4 are well balanced $(I_3 = I_4)$ because the current of wire #1 $(I_2 - I_3)$ would induce as much current at the outer coax shield I_3, as the current of wire #2 $(I_1 - I_4)$ would induce in the outer shield of the auxiliary coax I_4 (note the geometry similarity of the interconnects), i.e.

$$\frac{I_3}{I_2 - I_3} = \frac{I_4}{I_1 - I_4}$$

Since $I_1 = I_2$ in the feeding coax, it is also true that $I_3 = I_4$. Thus, the current at the outer coax shield is effectively canceled from a certain point on ($\approx \lambda/4$).

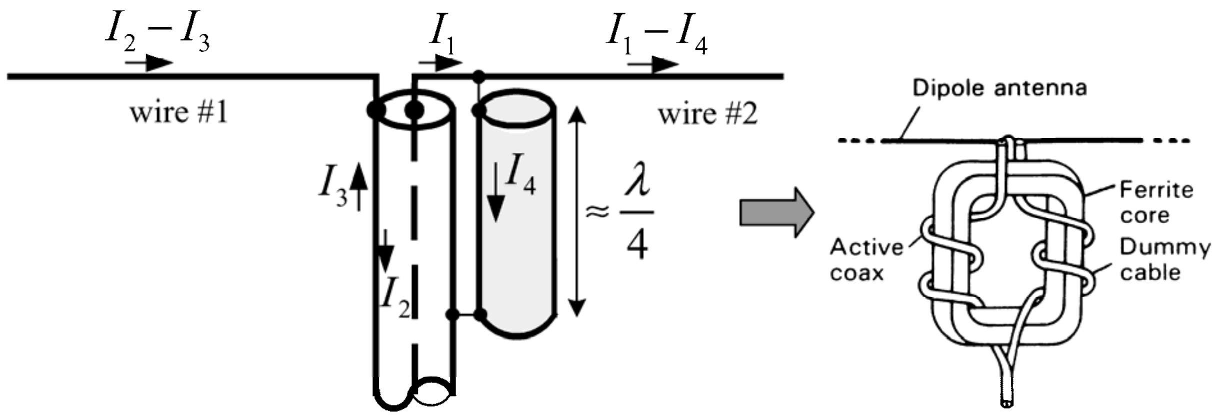
3) Half-wavelength coaxial balun 1:4



Typically, a coax feed of $Z_c = 75\ \Omega$ would be connected with such a balun to a folded dipole of $Z_A \simeq 292\ \Omega$ (see equation (10.11)).

All baluns described above are narrowband because of the critical dependence on the wavelength of the aixiliary transmission-line sections. Broadband baluns for high-frequency applications can be constructed by tapering a balanced transmission line to an unbalanced one very gradually, over a distance of at least several wavelengths (microstrip-to-twin-lead, coax-to-twin-lead).

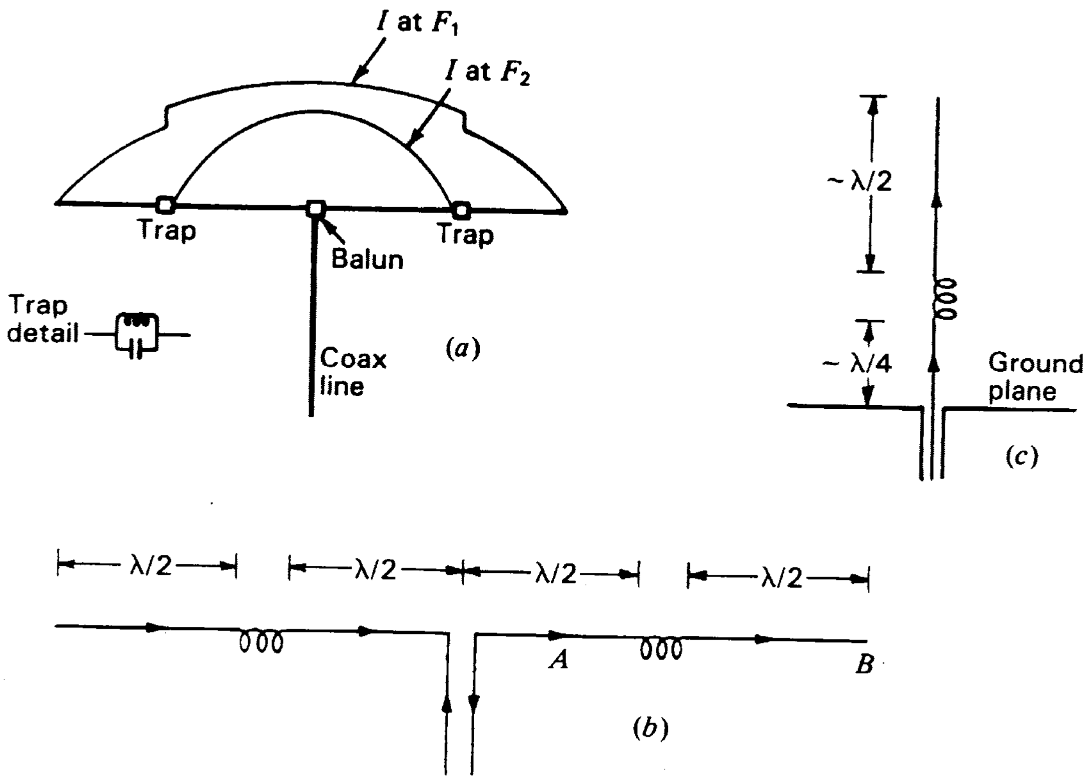
At lower frequencies (below UHF) tapered baluns are impractical, and transformers are used for impedance adjustment and balancing the feed. Often ferrite core bifilar wound wire baluns are preferred for their small dimensions and broadband characteristics (bandwidths of 10:1 are achievable). A ferrite-core transformer 1:1, which is equivalent to the folded balun 1:1, but is much more broadband, is shown below.



The transmission line formed by the outer shields of the two coaxial lines is now a very high-impedance line because of the high relative permeability of the ferrite core. Thus, its length does not depend critically on λ, in order not to disturb the antenna input impedance.

6. Dipoles with traps

In many wideband applications, it is not necessary to have frequency-independent antennas (which are more expensive and difficult to manufacture) but rather an antenna that can operate at two (or more) different bands. Typical example is the dual-band antennas in PCS and cellular communication systems. A dual-band antenna can be constructed from a single center-fed dipole (or its respective monopole) by means of tuned traps. Each trap represents a tuned parallel *LC* circuit. At frequency f_1, for which the whole dipole is $\simeq \lambda/2$ long, the trap is typically an inductor. This reduces slightly the resonant length of the dipole, and has to be taken into account in the antenna design. At another frequency $f_2 > f_1$, the traps become resonant and effectively cut the outer portions of the dipole, making the dipole much shorter and resonant at this new frequency. If the traps, for example, are in the middle of the dipole's legs, then $f_2 = 2f_1$ and the antenna can operate equally well at two frequencies separated by an octave. It should be noted that the isolation of the outer portions of the dipole depends not only on the high impedance of the trap but also on the impedance of this outer portion. When the outer portions are about $\lambda/4$ long, they have very low impedance compared to the trap's impedance and are effectively mismatched, i.e. their currents are negligible. However, this is not the case if the outer portions were $\lambda/2$ each.



When the outer portions of the dipole are about $\lambda/2$ each they represent very high impedance themselves in series with the trap. They are no longer isolated. A coil only can form a trap at certain (very high) frequencies because of its own distributed capacitance. This trap would now act as a 180° phase shifter. Figure (b) shows how one can construct an array of 4 in-phase $\lambda/2$-elements with a single feed and achieve a gain of 6.4 dBi. Figure (c) shows the $3\lambda/4$ monopole, which is obtained from the dipole in (b) by cutting the dipole at point A, and mounting it above a ground plane. This is a common antenna for cellular telephony and PCS handsets. Its gain in 8.3 dBi and it has an input resistance of $\approx 150\ \Omega$.

The Wireless Power Transmission System of Nicola Tesla

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Historical Problems

Tesla described his wireless power transmission method by three characteristics: 1) the reduction or elimination of electromagnetic radiations, 2) that it operated through the earth, and 3) that the mechanism of transmission is an electric current - as contrasted with radiations. Modern analysts, on the other hand, model Tesla's transmission system on present day broadcast radio technology. This model assumes an antenna propagating electromagnetic waves into the air where these radiations either will not or will, depending on the presuppositions of the writer, bring about the effects claimed by the inventor.

Anachronistic interpretation - applying the assumptions of today's electrical theories to Tesla's original turn of the century researches - is only half the problem of understanding the inventor's wireless method. The situation is further complicated by the similar sounding descriptions Tesla gave to his earlier and later transmission techniques.

In his early work Tesla attempted electronic transmission by modifying the atmosphere. This is the case in his patent entitled Method of Intensifying and Utilizing Effects Transmitted Through Natural Media, #685,953, applied for in June 1899. In this patent he proposes a very powerful signal generator to ionize atmospheric gases and, by that, create a conductive path between the transmitter and receiver through which a current could be sent. Later, when Tesla disclosed what he described as through-the-earth (or water) transmission with essentially the same type of apparatus and operating at ELF frequencies, it has been assumed by modern authorities that Tesla was mistaken about his method of propagation and was really witnessing earth-ionosphere cavity resonance at Schuman frequencies [1,2].

Tesla, though, was more than an engineer of conventional methods. He was an electrical researcher who investigated fundamental issues of the science. It will be shown that the three characteristics of Tesla's wireless transmission system describe an electrostatic wireless method that used the earth as a conductor and transmitted displacement currents. At moderate power levels the system could be used for communication. At greater levels, power could be sent by wireless.

Non-Hertzian Transmission

During 1899 - 1900 Tesla set up a laboratory in Colorado Springs to investigate wireless signal transmission. It was during this period he discovered that a properly configured receiver could detect waves, initiated by lightning strikes, propagating through the earth. When he incorporated this discovery into a patent he differentiated the earlier technology dealing with "effects transmitted through natural media" from the new form of signaling that involved the transmission of energy. This is seen in his patent Art of Transmitting Electrical Energy Through the Natural Mediums, #787,412, applied for 11 months after the previous patent, in May 1900.

A great deal of detail about the apparatus for generating and receiving electrical signals (tuned resonant circuits that were recognized in 1943 by the Supreme Court as the basis of commercial radio designs) is given in **the patent** but it **assumes, or more likely, avoids revealing, the physics behind the mode of propagation**. Tesla does point toward his novel transmission technique when he notes in the patent that the "globe may ... behave ... as a conductor of limited size;"[3] and that low frequency oscillations keep the "radiation of energy into space in the form of hertzian or electromagnetic waves... very small."[4] These two claims, alone, indicate a technology different from today's.

The illustration (see **Figure 1** on the next page)for the patent is of a transmitter consisting of an elevated capacitance, a coil, a signal generator, and a single electrode in the earth. The receiver is pictured as having a mechanism to oscillate at the same period as the transmitter, a capacitor, a detector, and two earthed plates.

To understand Tesla's wireless transmission system it is necessary to look at his technical writings on the physics behind his engineering. One of his lectures on evacuated tube illumination provides a good example.

The published version of the talk illustrates a setup for illuminating the bulbs closely resembling the transmission configuration. (See **Figure 2**)

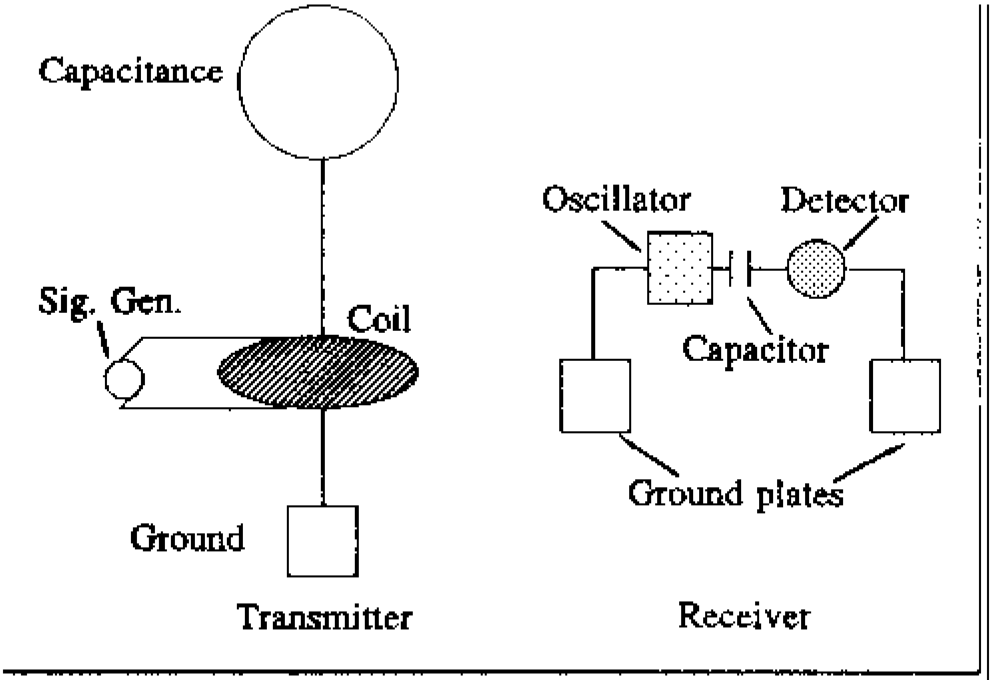


Figure 1 Tesla #787,412

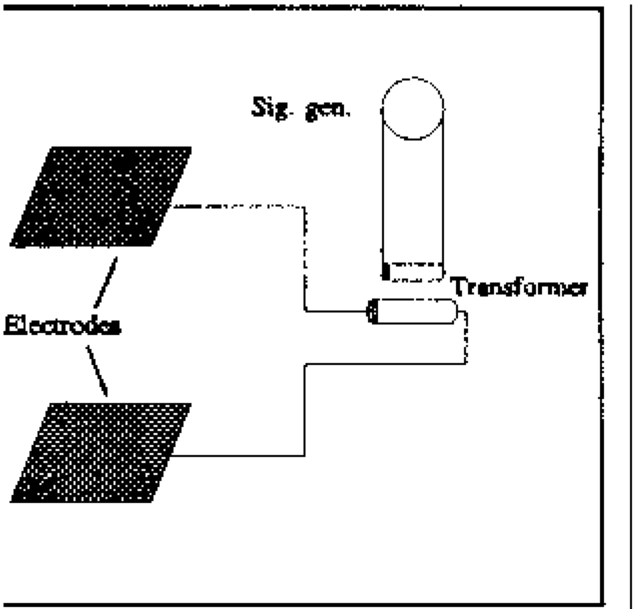


Figure 2 Illumination system

As he described it the evacuated bulbs were place between the electrodes:

... when we excite luminosity in exhausted tubes the effect is due to the rapidly alternating electrostatic potential;

… the medium is harmonically strained and released.[5]

He also noted:

…It might be thought that electrostatic effects are unsuited for such action at a distance. It is true that electrostatic effects diminish nearly with the cube of distance from the coil, whereas electromagnetic inductive effects diminish simply with distance. But when we establish an electro- static field of force, the condition is very different, for then, instead of the differential effect of both the terminals, we get their conjoint effect.[6]

To make sure that the difference between the type of fields he intended and those of Hertz was understood he explained:

…As the term electrostatic might imply a steady electric condition, it should be remarked, that in these experiments the force is not constant, but varies. When two conducting bodies are insulated and electrified, we say that an electrostatic force is acting between them.[7]

Tesla's emphasis on the non-Hertzian nature of his signaling process, particularly when taken within the context of his work with electrostatics, indicates the mode of propagation assumed by the patent involves setting up an electrostatic field of force between the transmitter and receiver.

As he often insisted, this mode of transmission differs significantly from that of Hertzian waves in that this one is a form of conduction:

…So far, I have considered principally effects produced by a varying electrostatic force in an insulating medium, such as air. When such a force is acting upon a conducting body of measurable dimensions, it causes within the same, or on its surface, ***displacements of the electricity, and gives rise to electric currents*** ...[8]

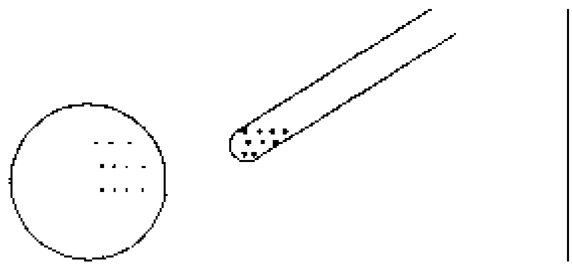
He advocated such a form of signaling long before submitting his design for patenting:

…Some enthusiasts have expressed their belief that telephony to any distance by induction through the air is possible. I cannot stretch my imagination so far, but I do firmly believe that it is practi- cable to disturb by means of powerful machines the electrostatic condition of the earth and thus transmit intelligible signals and perhaps power.[9]

The physics of Tesla's wireless transmission system is, in its basic form, is electrostatic induction. . (See **Figure 3**)

Instead of a charged body inducing an opposite charge on an uncharged body, as in the standard text book illustration, both the transmitter and receiver contain charge that establishes a field of force between the two. By oscillating these two bodies of bound charge at the same frequency, it is possible to signal between two points

Figure 3



In order to differentiate Tesla's wireless method from contemporary understanding of the technique, and from the misunderstandings arising from the chronology of Tesla's research into the nature of electrical communication, his method is contrasted with modern patents for electrostatic submarine communication and the inventor's earlier work in this field.

Contemporary Patents

L. Gilstrap's patent for an Electrostatic Communication System (see **Figure 4**), #3,964,051, issued June 15, 1976, describes a device

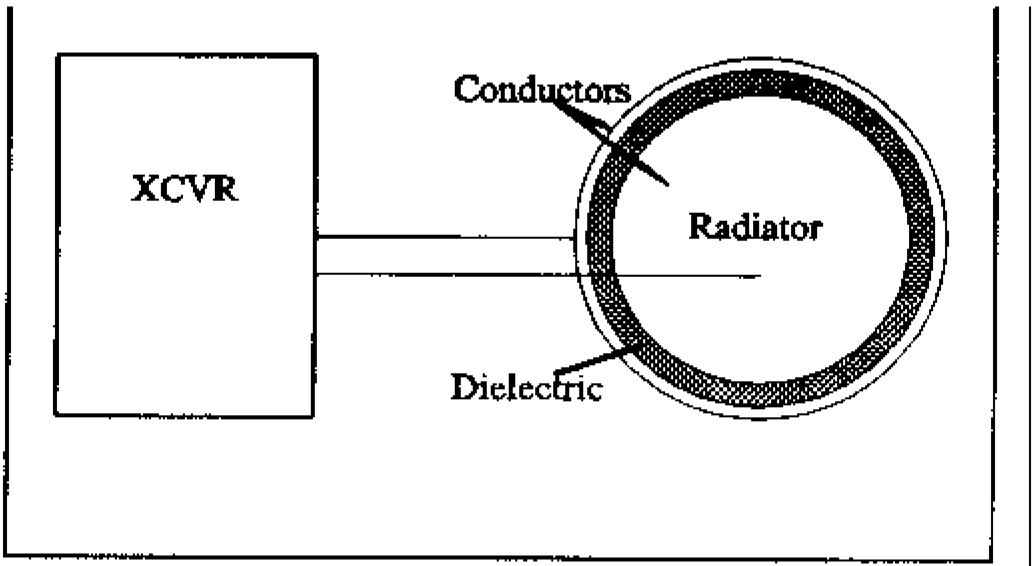


Figure 4 Gilstrap, #3,964,051

consisting of two concentric conducting spheres separated by a dielectric layer to form a monopole radiator for electrostatic waves.

The patent does not give details how "longitudinal electrostatic or capacitive waves, also called scalar or polarization waves because of their relationship to the Maxwell wave equations" differ in their method of propagation from conventional forms of electromagnetic radiation. It simply states that as the spheres are subject to voltages of opposite polarity the "outer sphere then appears as an ideal monopole radiator to the external dielectric medium, in this case water."[10]

That this design was not effective, according to a report, is due to the configuration of the radiator. The electric field is confined to the region between the two conducting spheres. Little energy, if any, is available to stress the external dielectric medium, the water.

P. Curry's patent for an Underwater *Electric Field Communication System*, #3,265,972, issued August 9, 1966 proposes a radiator of a different configuration and discusses communications by electrostatic induction. (See **Figure 5**)

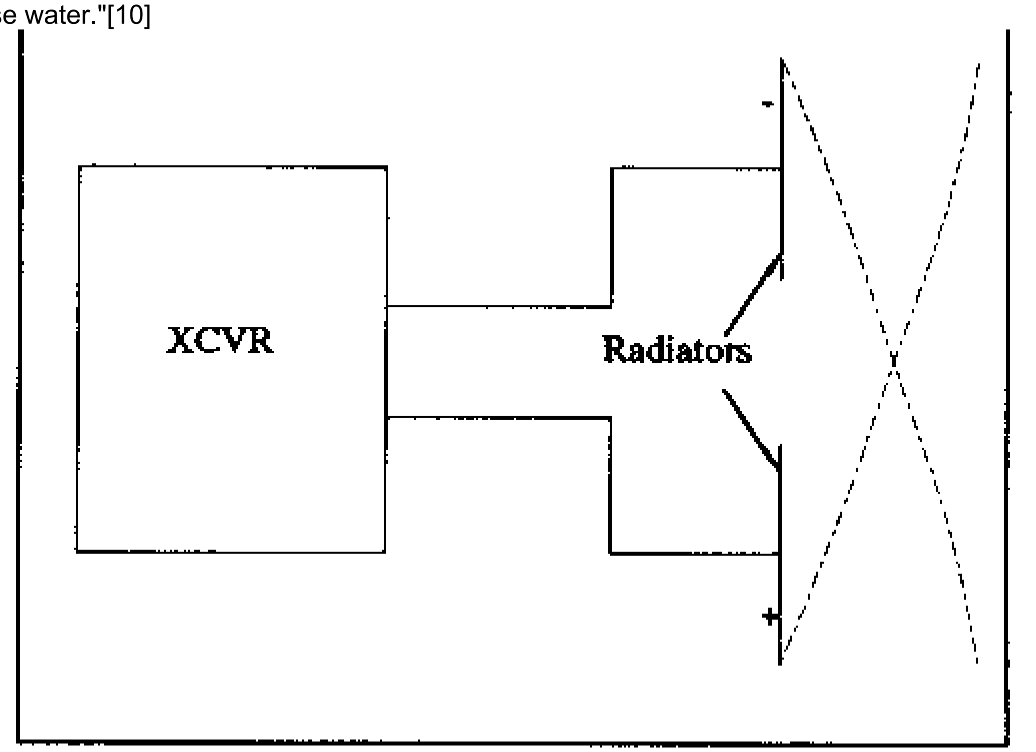


Figure 5 Curry #3,265,972

Curry states:

…The antenna system for an electromagnetic emission into space circulates energy in accordance with the laws governing electrical current in motion. Since the field strength produced by an antenna is proportional to the alternating currents circulating in it, its optimum structural relationships are directed to a reduction of the total antenna resistance, thus to increase the total current for a given power input to a radiator.[11]

Further on he adds:

…While a radiator for electromagnetic emission produces its field strength by the effect of changing currents; the radiator for electrostatic emission of the type here to be described produces its field strength by the effect of changing potentials.[12]

By applying a varying potential to the plates of the radiator, charge of opposite polarity accumulates on the two plates such that a charge gradient exists in the region between the radiators. The patent explains:

... a phase displacement of 90 degrees exists the wave of charge potentials induced by an alternating current signal upon the water ... and the resulting wave of charge displacements occurring in the water body between the segments.[13]

The method of propagation, then, is to cause electrical changes in the two plates resulting in the launching into the medium of sinusoidal carrier waves - as illustrated by the dotted lines in **Figure 5**.

In a detailed analysis of forces involved Curry shows that radiators with a capacitance of .0053 microfarads operating at 100 KHz with signal generator output of 200 volts coupled with a biasing potential of 1000 volts will produce a force from its charge displacement of 26,500 dynes.[14]

On the receiving side Curry states that the charge gradient can be expected to attenuate substantially at even moderate distance from the point of transmission. As an example he notes that if a signal intensity of 10,600 dynes at the point of transmission is reduced one billion times the "standing wave of the signal energy will therefore be charged with a force differential of 1.06 x 10-5 dynes. Each dipole having a capacitance of .0053 microfarads produces a system capacitance of .00265 microfarads. The voltage developed in the receiving network is given by

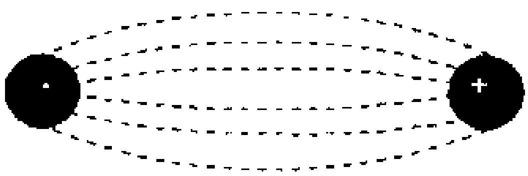
$$\boldsymbol{e}=\text{square root } (F/(C \times 10^{7})$$

which in this case equals .02 volts. As noted "this is substantially above the minimum requirements of signal intensity for the detection of electrical signal energies."[15]

With such a great amount of operational detail it would seem that this design should perform as claimed. The device, however, is not in widespread use 25 years after the issuing of the patent. This forces the conclusion that the device did not successfully propagate signals through the water. Why it would not will be made clear by examining the Tesla design for wireless communication. It will be shown that the dipole nature of the radiator and the inability to state the amount of attenuation over a given distance (it was simply given as a billion times weaker than the transmitted signal) point to a fundamental misunderstanding of the nature of electrostatic induction.

The shortcoming of the Curry design for an electrostatic communication system can be seen in the basic nature relationship existing between two points of charge.(See **Figure 6**)

Figure 6



Because lines of flux exist between two opposite charges a dipole transmitting antenna is not needed. Curry proposed a dipole in order to create a wave of the proper length to be propagated through the medium. However, in electrostatics it is not necessary for flux lines to detach and close upon themselves to propagate an electric field. The field is established by the flux lines between the two points of charge. Curry misunderstood the nature of the electrostatic field. Once the field is established, a change in pressure on the charge will cause a variation in charge at the other end of the field - a displacement current.

Also, Tesla points out that a dipole is not needed to receive even low frequency signals in an electrostatic system. Tesla pictured his receivers with electrodes spaced a quarter wavelength apart but this was to charge an unpowered receiver as rapidly as possible. The receiver's capacitor would see maximum voltage changes, and, thus, would gain sufficient charge to power a device, if the ground electrodes had such a spacing. If, though, "the impulses are... are alternating, but sufficiently long in duration" they can be received by a single electrode that is turned on and off with the same period as the transmitter. Because the field's flux lines do not radiate but start at the transmitter and terminate on the receiver, the receiving structure does not have to be a specific shape or length.

His patent, then, also describes a through-the-earth, compact ELF communication system. Today's ELF antenna arrays, by contrast, require hundreds of square miles for their deployment.

Proof of Principle Test

This method of electrostatic communication can be tested by using a grounded, resonant electrostatic detector coupled to a standard communications receiver, encased in RF shielding to receive a signal. For demonstration purposes a commercial station transmitting on 1.16 MHz at 50KW, 40 miles away from the receiver could be used as the test source.

If the transmitter's antenna is feed at 50ohms impedance, the antenna current is:

The quarter wavelength period for 1.16 MHz is:

$$P = 1/4f$$

$$P = 1/(4)1.16\times10^{6}$$

$$P = 2.16\times10^{-7} \text{ sec.}$$

The amount of charge in the antenna during the quarter period is:

$$i = q/s \text{ and } q = is$$

$$q = 31.6 amps \times 2.16 \times 10^{-7} s$$

$$q = 6.8 \times 10^{-6} coulombs$$

If 100 watts is assumed for the detector circuit, the current at 50 ohms is:

$$I = \text{square root } (100/50) = 1.4 \ amps$$

and the charge:

$$q = 1.4 \ amps \times 2.16 \times 10^{-7} = 3 \times 10^{-7} \ coulombs$$

Using Coulomb's law to calculate the force on each charge separated by the given distance:

$$F=(q_1q_2)/(4p \ e_0 r^2)$$

$$F=(3\times10^{-7})(6.8\times10^{-6})/(4p \ (8.9 \times 10^{-12})(6.4\times10^{4})^2)$$

$$F = 4.5\times10^{-12} \ nt. = 4.5\times10^{-7} \ dynes$$

Assuming, finally, that the detector circuit uses a 100 microfarad capacitor, the force of the field will result in a voltage as such:

$$\mathbf{e} = \text{square root } (F/(C \times 10^{7}))$$

$$\mathbf{e} = \text{square root } ((4.5 \times 10^{-7})/(100\times10^{-6}\times10^{7}))$$

$$\mathbf{e} = 21 \times 10^{-6}$$

A change of 21 microvolts would be well above the 5 microvolt level required for a radio receiver to capture a signal from the electrostatic detector circuit. It should be remembered, too, that Tesia worked at higher energy levels than used in this example. He used hundreds of amps at lower frequencies(more charge) and potentials of millions of volts.

This analysis of Tesla's wireless transmission method is preliminary, but does indicate the type of field of force and distance calculations that have to be made in order to have a successful electrostatic communication system. Issues dealing with the optimum frequencies, the earth as a dielectric, and the function of the earth's charge in power transmission have to be investigated. This is in addition to the questions yet to be discovered. However, it is clear that 100 years ago Nikola Tesia began a branch of communication technology that differs significantly from that in use today.

If you have questions to the author, please, do not shame email to:

onichelson@post.harvard.edu

Notes

1. Wait, James R., "Propagation of ELF Electromagnetic Waves and Project Sanguine/Seafarer," *IEEE Journal of Oceanic Engineering,* vol. OE-2, no. 2, April 1977, pgs. 161-172.

2. Corum, James F., and Corum, Kenneth L., "Disclosures Concerning the Operation of an ELF Oscillator," *Tesla '84: Proceedings of the Tesla Centennial Symposium,* Dr. Elizabeth Rauscher and Mr. Toby Grotz, editors, International Tesla Society, Inc.. Colorado Springs, 1985, pgs. 41-49.

3. Tesla #787,412: page 1, lines 53 - 56.

4. *Ibid.,* page 3, lines 35 -41.

5. Tesla, Nikola, "Experiments With Alternate Currents of Very High Frequency and Their Application to Methods of Artificial Illumination" (1891), reproduced in *Nikola Tesia: Lectures * Patents* Articles.* published by the Nikola Tesla Museum, Nolit, Beograd, 1956, pg. L-42.

6. *Ibid.,pg.* L-43.

7. ________, "On Light and Other High Frequency Phenomena (1893), *ibid.,* pg. L-121.

8. *Ibid.* L-127, emphasis added.

9. *Ibid., pg.* L-138.

10. Gilstrap: Column 2, lines 34-48.

11. Curry: Column 1, lines 21-28.

12. Curry: Column 1, lines 44-48.

13. Curry: Column 4, lines 8 - 38.

14. Curry: Columns 5-6.

15. Curry: Column 7, Imes 35 - 75 to column 8 line 2.

Nicola Tesla

Interferences from Old Power Amplifiers

By Igor Grigorov, RK3ZK

One of the possible causes of interferences to reception of the radio and television from Power Amplifiers (PA) is degradation of an output tube or an output transistor of the Power Amplifier (PA).

Let's put the basic signs directing this cause.

At first, there are stable heavy interferences to radio equipment when the PA (or transceiver, in which one the PA is) works even on low - frequency amateur ranges 160- and 80 meters, where, as usual, such interferences are absent.

At second, it is very possible that the PA is "excited" at some restricted segments of amateur ranges, or at an amateur range, or when this one is operated at a definite mode – CW, SSB or RTTY. For example, a PA is excited by operation on SSB, but ensures stable running on CW. One more version, a PA is excited when it works in the beginning of an amateur range, but this one works good in the middle or in the upper end of this range.

At third, usually the invalid PAs consume a large d.c. current but give a small RF power. When the Pas consume a large d.c. current they, as usual, give a large level of interferences. When the Pas work at a small consumed d.c. current, they do not give interferences at all!

To improve this situation can only changing the degraded tube or transistor for a new one. Or, to reduce output power helps to remove the interferences.

Tubes…

It is quite possible to detect the degraded tube with metal anode in visually way. An anode of a new tube has evenly color, usually grey. An anode of a degraded tube has unnaturally color often the anode has an undulating spots. Joints of the degraded anode quite often have distortions.

Pins of some output tubes after a long-period operation are covered with oxides, especially if a power amplifier was maintained in a wet location, ever on open air, or in a location, where aggressive gases are in air. Sometimes, a non- hermetic lead-acid or alkaline accumulator placed near a PA causes to cover the pins by a layer of oxides. The cleaning of pins of tube socket often gives only short-term effect. Only soldering the oxidation pins of tube to pins of tube socket improves the situation.

Transistor…

Power transistors do more harm then tubes. All modern RF bipolar transistors have a structure consisting of many independent emitters. When only one emitter is degraded the whole transistor is degraded, too. The degraded emitter can produce harmonicses of the base signal that causes RFI and TVI.

The degradation is quite possible at a current overload or just long-lived operation of a transistorized PA. The overload can be as on the input signal - overflow of a base current, so on the output signal - overflow of a collector current. Even a short-term overload can damage a power transistor. Very often when the degraded transistor is checked at d.c., it behaves as operable. Only changing of a degraded transistor for a good one allows to find the true source of the interferences.

Cool soldering…

Cool soldering represents especially unpleasant phenomenon for both, as transistor as tube PA. It can reduce to appearance of heavy radio interferences. All suspicious soldered places are knocked by wooden or plastic stick and monitoring at thus for interferences. After that the fond cool soldering is thoroughly soldered.

Remember, a long term service of any PA is possible only when all modes of operation of output transistor or output tube are at right conditions.

Trap in the Main

By Igor Grigorov, RK3ZK

Back to 90th, it happened, that my power PA begun to produce TVI and very heavy TVI were appeared only on 40 meters. A low frequency filter that was installed on the PA had not given any effect. My researches showed me, that neighbours' TV-sets were overloaded by power signals leaking from my PA to wire of the main. Most power leaking was only on 40 meters. I did not know the reason for the damage till now, but I needed to remove the TVI. What could I do?

Well, usual rejection circuits (trap) were switched on in main wires, as shown in **Figure 1**. And that is all, the TVI were disappeared.

For good rejection the traps should be made as possible best. In my design, L1 and L2 coils, intended for suppression of frequencies of range of 40 meters, contained 30 turn of copper wire of 1-mm diameter (#18 AWG), ID for the coils was 2.5 cm, length was 4 cm. LED was connected to seventh turn of the coil. Air dielectric variable capacitor of 10-100-pF is used for each trap. **Figure 2** shows the design of the traps. Please, Note, **Figure 2** is not in scale.

The traps were placed in a box made from PC board material. The box was disposed directly on the back panel of my PA. The trap box should be connected to main transformer of the PA by short, as it is possible,

Rejection circuits in main wires

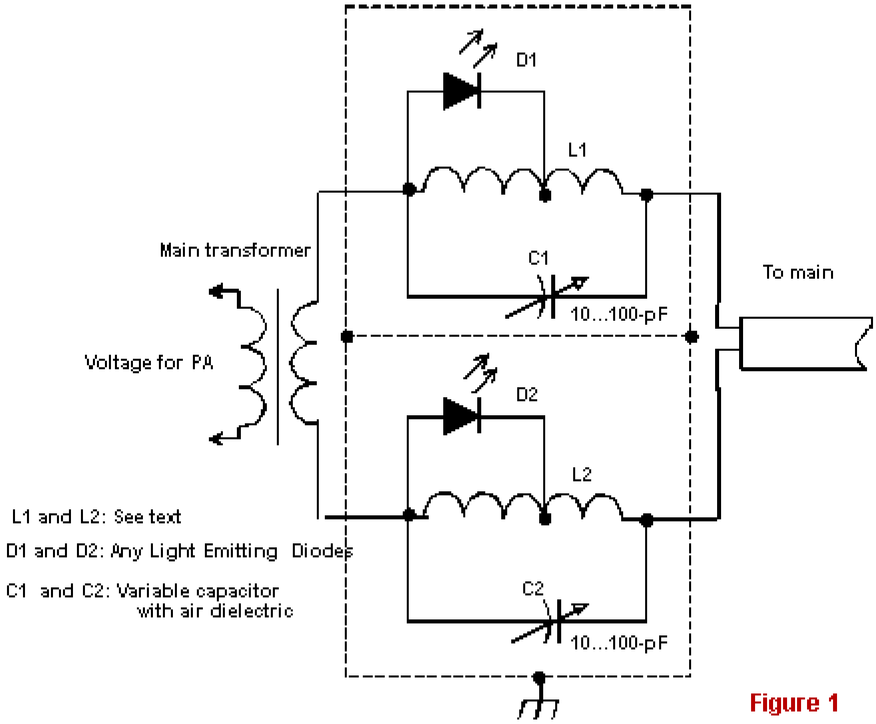


Figure 1

wires. If a free place is near a main transformer inside a PA the trap box can be placed at this place. The PA case was grounded by 3 cm width copper tape.

Tuning: Trap must be tuned to the middle of the amateur frequency band. **Figure 3** shows how to do this. Each trap is connected to a PA, loaded at a dummy load, through a capacitor of 10-pF. Out power in 10-W is enough for tuning the trap. By variable capacitors C1 and C2 do maximum glow from LEDs D1 and D2.

Having installed the trap box in the PA, switch the PA to transmission mode and once again tune fine the traps by C1 and C2. If the LEDs too shine out, decrease tap number from the coils. When traps are tuned, it is possible ***not*** disconnected the LED from coil.

On my view, set-up the trap by a PA is very conveniently. However, the way is not sole. For example, a GDO gives good result also. At this method the trap is tuned to needed resonance frequency. Other method is to use a RF-voltmeter

Trap design

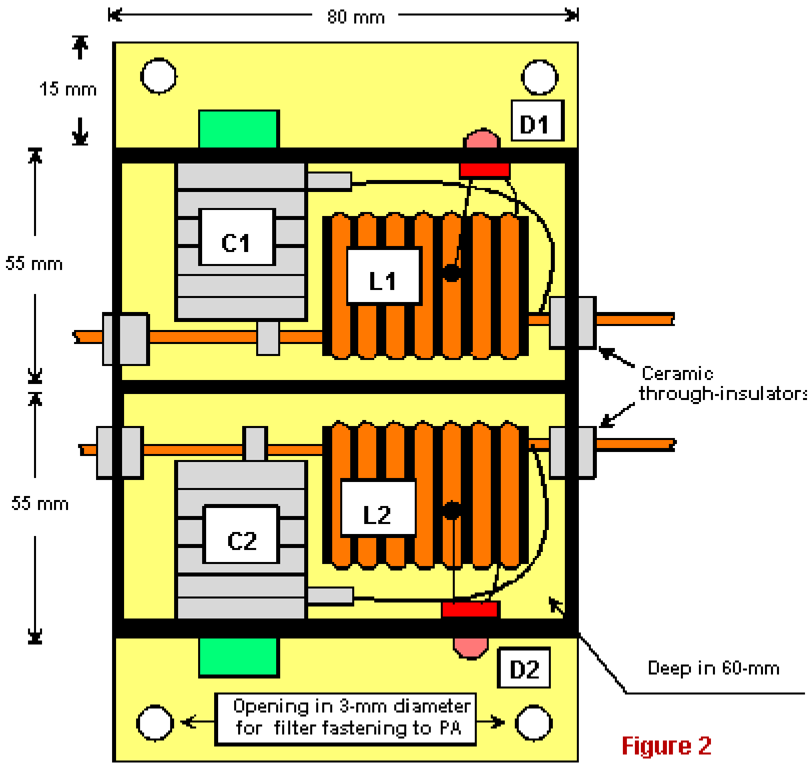


Figure 2

Trap tuning

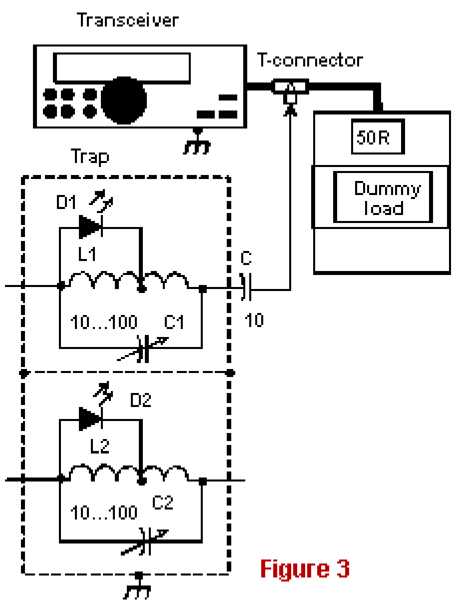


Figure 3

and to do tuning to the maximum of RF-voltage across the trap.

If RF –voltage is leaking to the main at other amateur ranges, traps in main's wire must be installed for each of these ranges. The basic requests for the traps are the traps must have as possible high Q-factor and the traps must be shielded from each other. Distance between a screen and coils should be not less half of diameter of the coil. **Table 1** shows data for trap intended for amateur ranges from 160 up to 10 meters. Air dielectric variable capacitor of 10 -100-pF is used for tuning the traps.

Figure 4 shows schematic and construction for symmetrical retuning main filter. You may try to do the filter if you have leaking of RF energy to the main at several amateur bands. Data for coils takes from **Table 1**. The filter is tuned or by a LED (see **Figure 1**) or by a RF- voltmeter.

http://www.antentop.bel.ru/

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Table 1 Data for coils of trap design

Band, MHz	Coil diameter, mm	Length of winding, mm	Quantity of turns, n	Wire diameter, mm/AWG
1.9	20	20	100	0.15/34
3.5	20	20	50	0.3/29
7	25	40	30	1.0/18
10	25	30	15	1.0/18
14	25	25	12	1.0/18
18	25	30	10	1.0/18
21-24	20	15	8	1.0/18
26-30	20	20	8	1.0/18

Retuning symmetrical RF filter

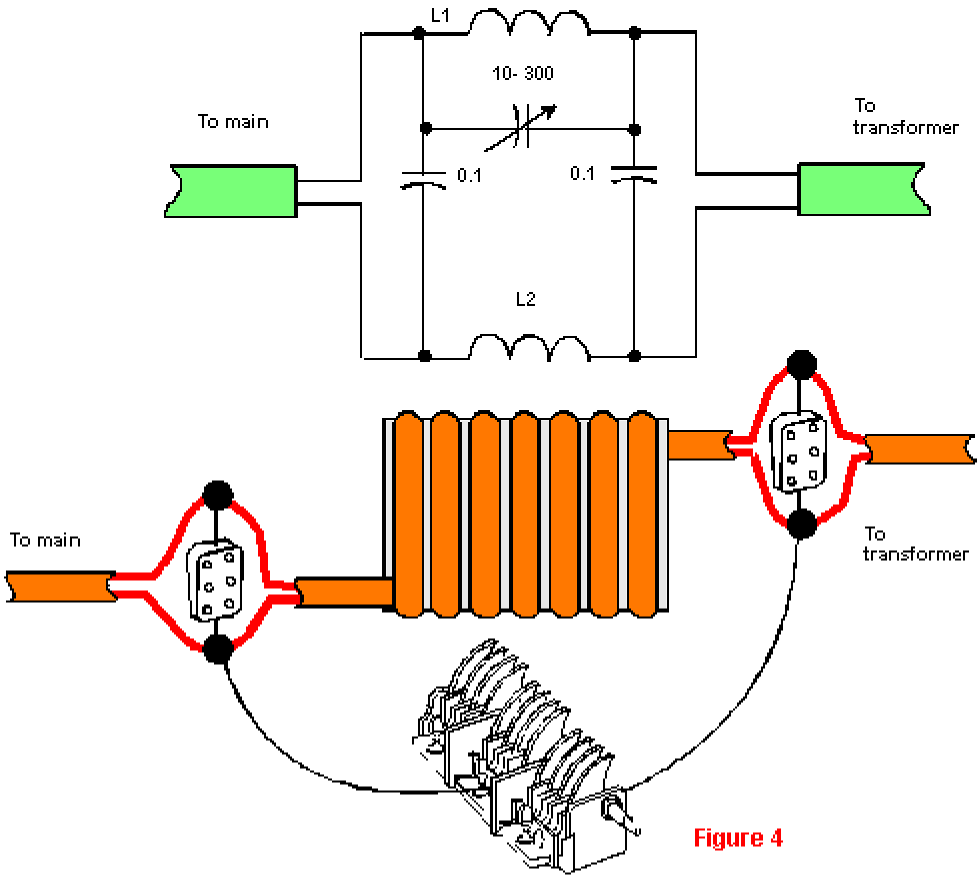
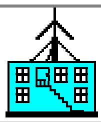
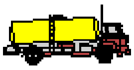
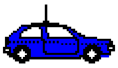
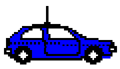
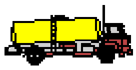
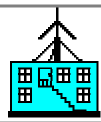
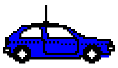
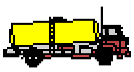
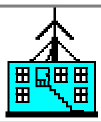
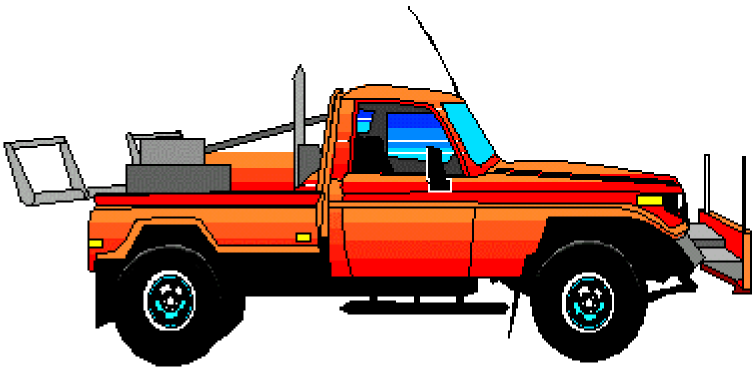


Figure 4

http://www.cqham.ru/

HAND-HELD/CAR/TRUCK/HOUSE 27 AND 145 MHZ COMMUNICATION

CB- 27-MHz (distance in kilometers)				
				40-50
			15-25	20-30
		8-15	10-20	15-25
	2.5-6	4-10	5-12	8-16
				
	5-12	7-15	8-16	10-18
		12-25	15-30	25-40
			20-35	35-50
				60-80
VHF- 145-MHz (distance in kilometers)				



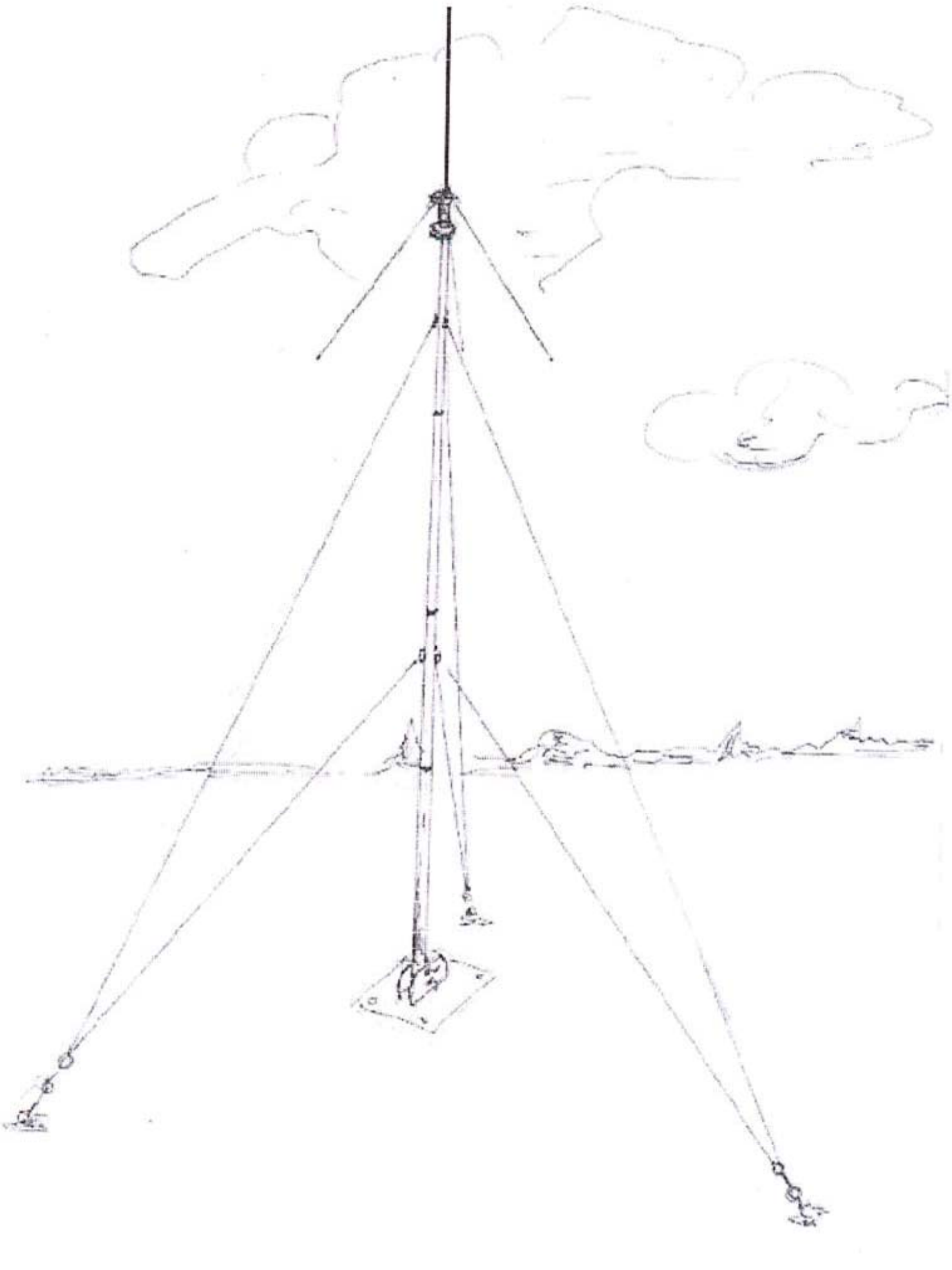
ANTENNA TOWER

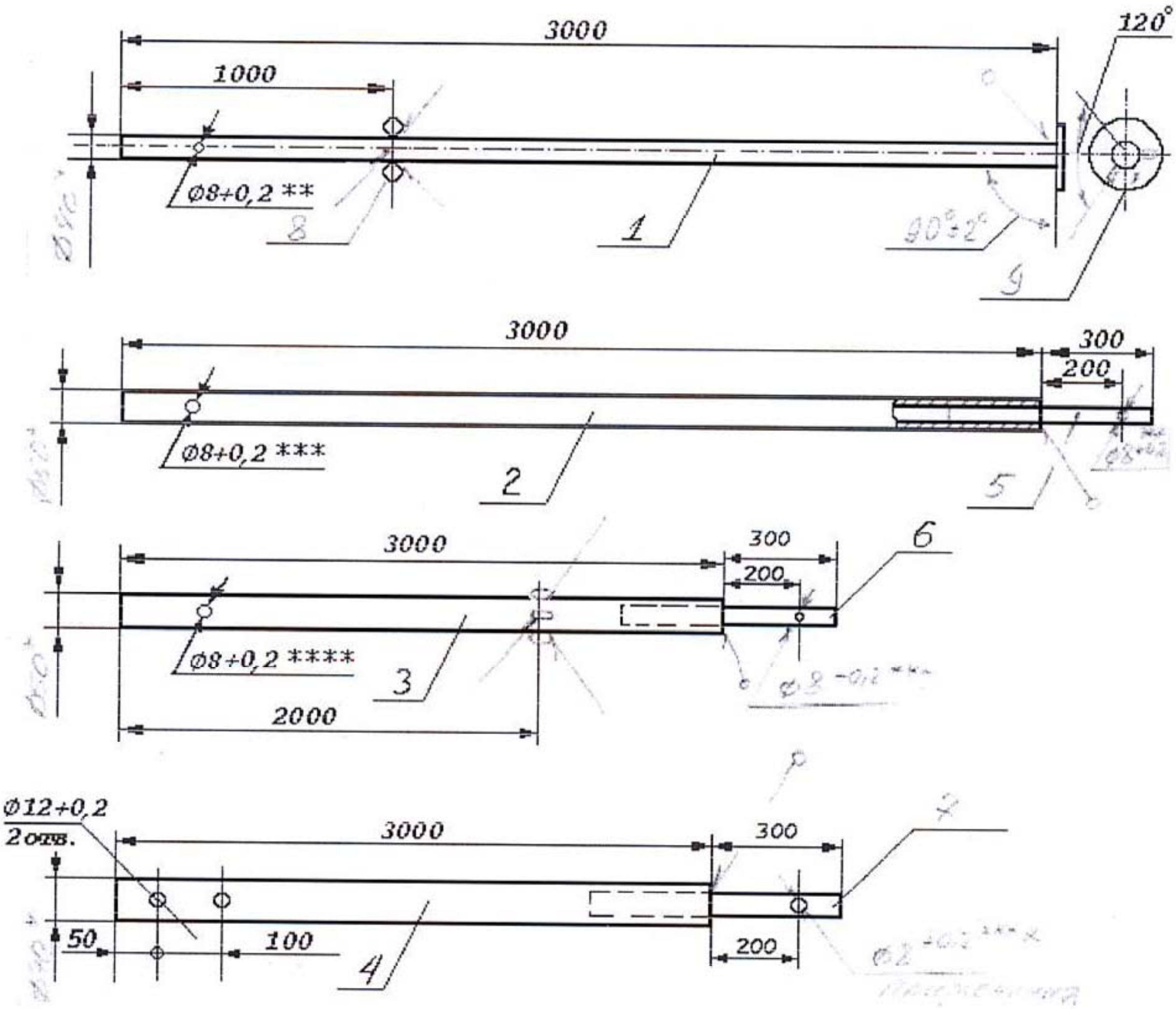
Credit Line: **http://www.allo.bel.ru/**

As usual, such towers are used for erecting VHF antennas of a service radio station, and Russia commercial firms widely make such Antenna Towers.

I think, hams also can use some ideas from construction of the tower for their operation.

73! Igor Grigorov, RK3ZK

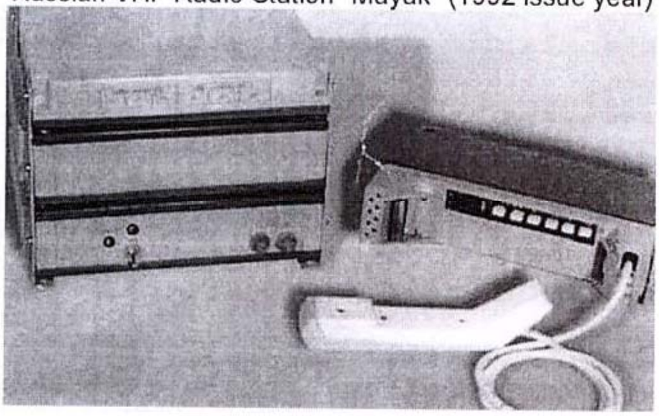




1. Upper Part. Tube 40-mm OD
2. Middle Part. Tube 50-mm OD
3. Middle Part-2. Tube 60-mm OD
4. Bottom Part. Tube 70-mm OD
5. Tube, OD = ID of Item 1
6. Tube, OD = ID of Item 2
7. Tube, OD = ID of Item 3
8. Nut, M24, 6 Pieces
9. Flange of Antenna

* Sizes for Notes
** Drill Hole 8-mm together on Item 1 and Item 2
*** Drill Hole 8-mm together on Item 2 and Item 3
**** Drill Hole 8-mm together on Item 3 and Item 4

Russian VHF Radio Station "Mayak" (1992 issue year)



Russian VHF Radio Station "Mayak" (2002 issue year)

"Bottle" Antenna for 145 MHz

By Sergey Mironov, RA1TW

Any amateur can do the antenna during one hour. To do the antenna takes a half of hour and to tune the antenna also takes a half of hour. So, do not waste time and go to make the Bottle Antenna!

At first take a look at schematic of the Bottle Antenna (**Figure 1**).

Specification:

1. Dielectric plate, approximately of 80x250-mm.
2. Vibrator, (5/8)λ
3. Matching spool
4. Tinned plate, approximately of 25x35-mm.
5. Counterpoises, (1/4)λ
6. Stud, washers, screw-nuts
7. Coaxial cable

How to do it

1. Take Dielectric plate (1) and install Vibrator (2) on the plate. Use clamps or hard wire for this.

145 MHz the vibrator takes the length 1270-mm at the diameter of the vibrator 4…5-mm, and 1200 m at the diameter of the vibrator 10…14-mm.

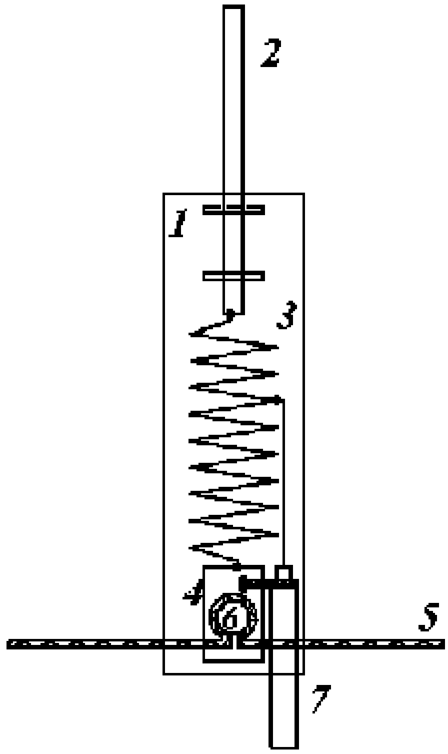
2. Install Tinned plate (4) on the Dielectric plate. Use Stud, washers, screw - nuts (6).

3. Do Matching spool (3). The spool has 9 turns of 1.5…2.5-mm diameter (# 14- 10 AWG) copper or silvered plate wire. ID of the spool is 15…18-mm, RA1TW use to old markers as a form for the spools. Length of the spool is 34-mm.

4. Install the Matching spool on the Dielectric plate. For doing this, the upper end of the spool is fixed to the Vibrator and the down end of the spool is fixed to the Tinned plate. Use solder or fix the ends with the help of screws.

5. Do counterpoises. Two 105-cm lengths of copper or aluminum wire of 4…6-mm (# 2…6 AWG) are bended as a Greek letter OMEGA looks (see **Figure 2**).

Bottle Antenna
Side view



Top view

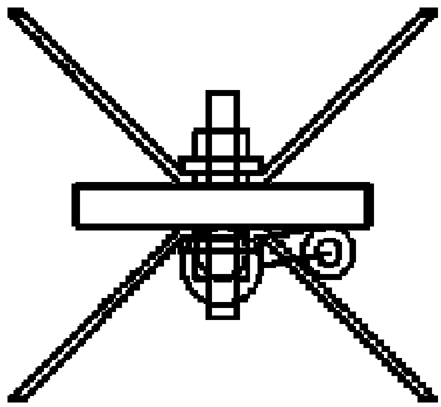


Figure 1

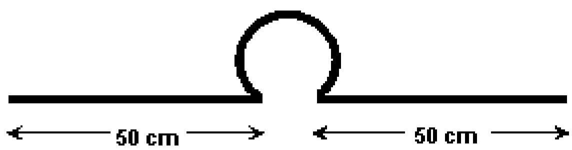


Figure 2. Counterpoises

6. Fix the OMEGA- counterpoises to the Stud with the help of the Screw-nuts. The counterpoises should be at 90 degree to the Vibrator and to each other.

7. Fix the OMEGA- counterpoises to the Stud with the help of the Screw-nuts. The counterpoises should be at 90 degree to the Vibrator and to each other.

8. Install Coax (7). Central core is soldered to 3-1/3 tap from the Vibrator, the braid is soldered to the Tinned plate (4).

9. Take a Bottle from dry drink. (I know, RA1TW always prefers a bottle from beer!. I.G.) Do a hole in the screw - top of the Bottle, cut the bottom of the Bottle, cut four slots for counterpoises, and then, install the Bottle (see photo) on the Antenna.

That is all the Bottle Antenna is ready!

Tuning:

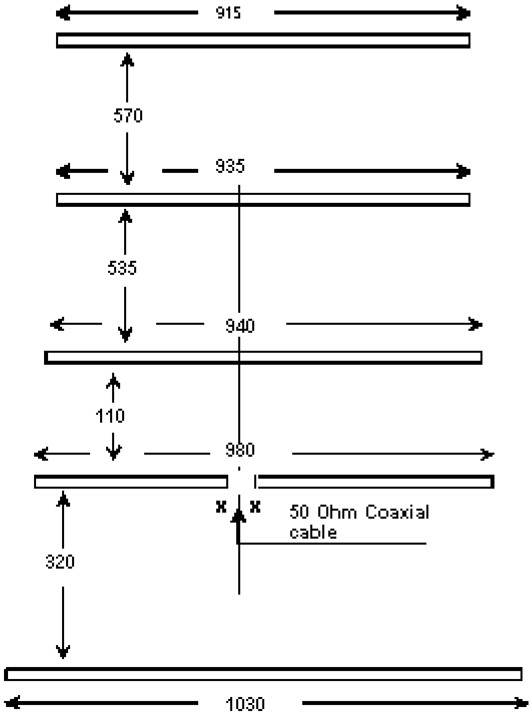
The best way to adjust the Bottle Antenna is to use Meter of Amplitude vs Frequency Response characteristics. The device is switched to the Bottle Antenna and we see the frequency characteristic of the antenna. Stretch out the Matching spool or cut lengths of the Vibrator and Counterpoises if the resonance frequency of the antenna is below then 145 MHz. Gripe the Matching spool if the resonance frequency of the antenna is higher then 145 MHz Then select the tap for the best SWR. It is possible to match with the antenna a coaxial cable with any characteristic impedance –50 or 75 Ohms.

RA1TW

Of course, you can adjust the antenna with the help of only SWR – meter or VHF - bridge.There are 8 such home - made Bottle Antennas at Novgorod. All antennas work very well. They provide good communication as inside city as from city to a country for a distance more of 100 kilometers.

Credit line: http://hamnv.boom.ru

Five Elements VHF Antenna RN1NZ For 145 MHz



Gain: 8.5 dBi

SWR: Less then 1.5:1 at 144...146 MHz

Front/Back Ratio: more then 18 dB

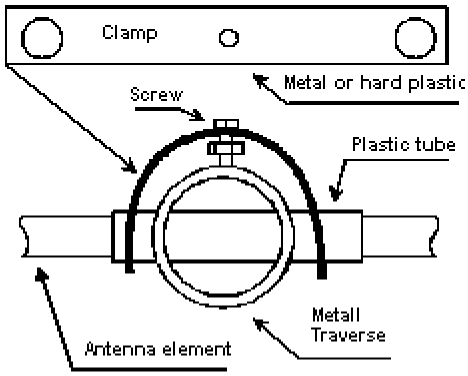
Input Impedance: 50 Ohm

All elements have diameter of 4-mm (or # 6 AWG)

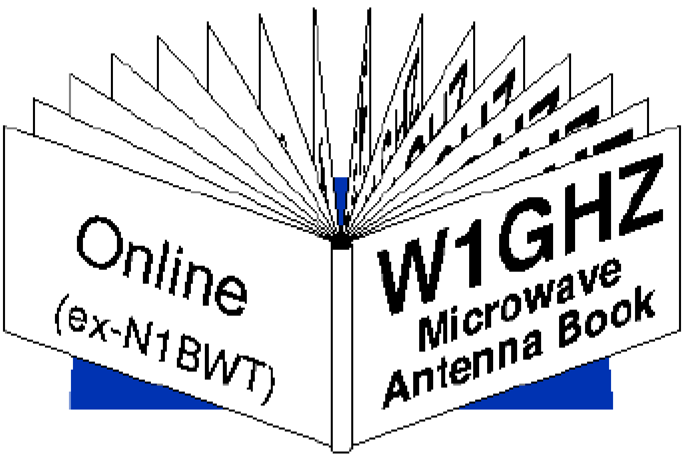
Traverse has diameter of 15-mm and lenfth of 1600-m

Antenna elements are electrically insulated from the traverse

Antenna Construction



Visit and take for FREE the great
Microwave Antenna Book
By Paul Wade W1GHZ (ex N1BWT)



http://www.qsl.net/n1bwt/contents.htm

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Part-I: Practical Antennas (8 Chapters!)

Part-II: Antenna Measurement (2 Chapters!)

Part-III: Computer Analysis of Antennas (2 Chapters!)

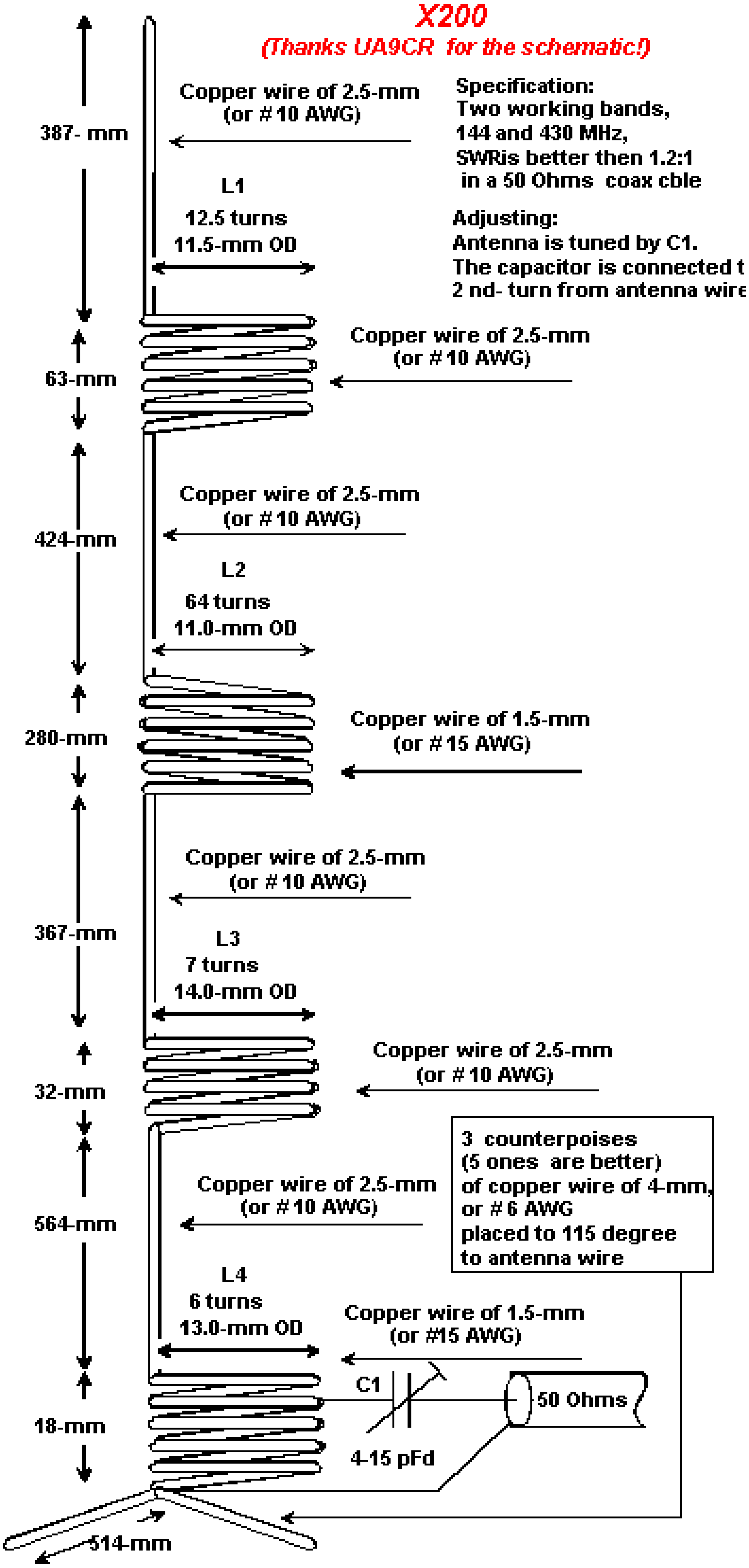
RN1NZ
rn1nz@onego.ru

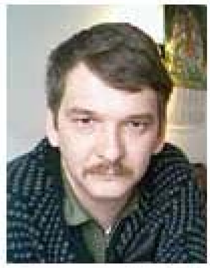
Credit Line: RN1NZ @ Radio #4, 2002, p.65
For more info see:
www.radio.ru/

Antenna X200

X200

(Thanks UA9CR for the schematic!)





Александр UA9CR

Dear Friends,

Most of us are heard about VHF antenna X200. It is very interesting and very reliable two bands antenna.

RV9CX made some modifications for the antenna, so, the new RV9CX-X200 is more suitable for doing at amateur conditions. Go to the next page for the new antenna!

Comments about the antenna please send to Dmitriy, RV9CX: rscs@rosteck-msi.ru

Also, you can visit to

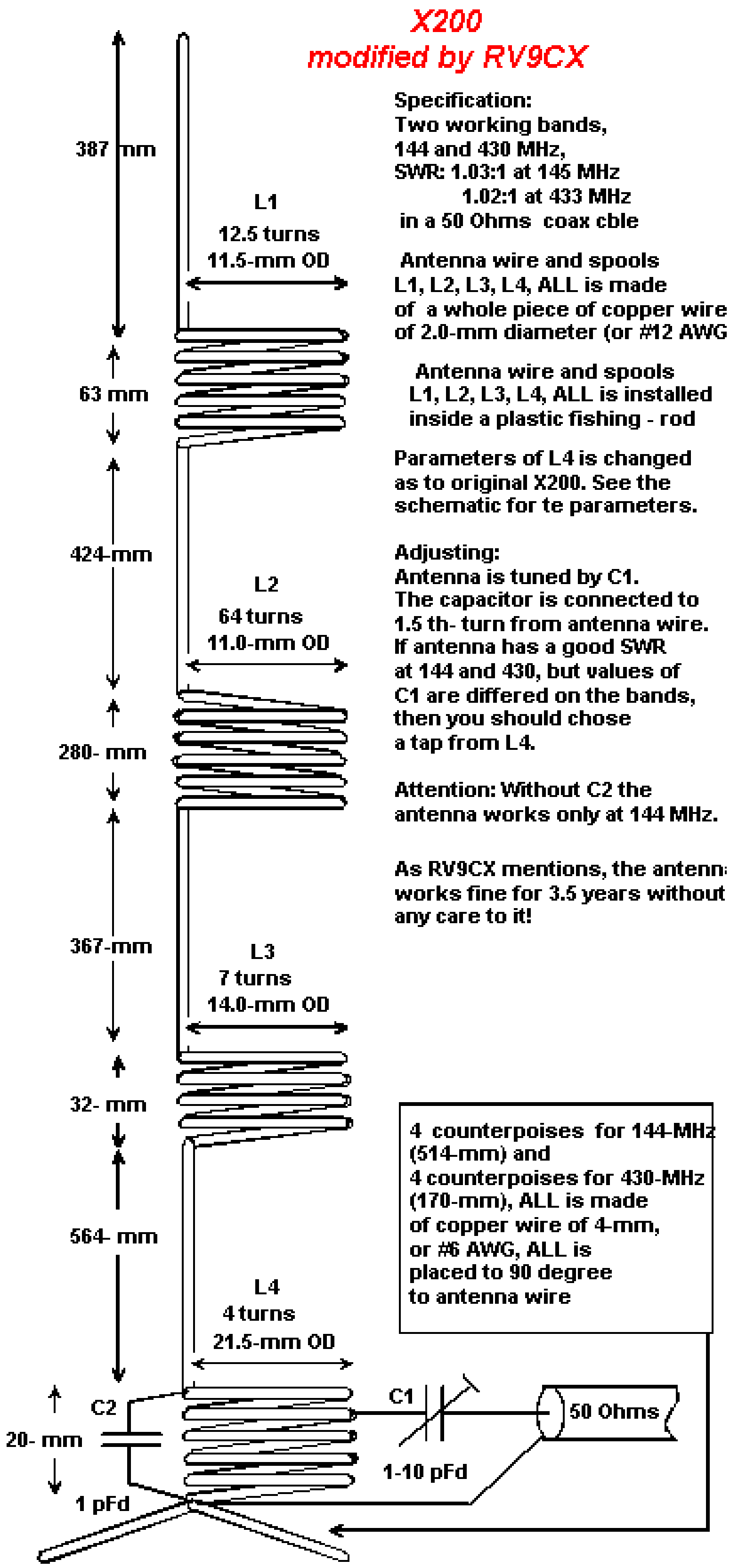
www.znuki.ru

CLUB-X

X = Ь = та ти ти та

The site, where are Dmitriy and his friends

DX X-HAMRADIO ИКС
KENWOOD TS-950SDX XXX-VIDEO
X-РАДИОСПОРТ X-CALL


X200
modified by RV9CX
Specification:
Two working bands,
144 and 430 MHz,
SWR: 1.03:1 at 145 MHz
1.02:1 at 433 MHz
in a 50 Ohms coax cble
Antenna wire and spools
L1, L2, L3, L4, ALL is made
of a whole piece of copper wire
of 2.0-mm diameter (or #12 AWG
Antenna wire and spools
L1, L2, L3, L4, ALL is installed
inside a plastic fishing - rod
Parameters of L4 is changed
as to original X200. See the
schematic for te parameters.
Adjusting:
Antenna is tuned by C1.
The capacitor is connected to
1.5 th- turn from antenna wire.
If antenna has a good SWR
at 144 and 430, but values of
C1 are differed on the bands,
then you should chose
a tap from L4.
Attention: Without C2 the
antenna works only at 144 MHz.
As RV9CX mentions, the antenn
works fine for 3.5 years without
any care to it!
387 mm
L1
12.5 turns
11.5-mm OD
63 mm
424-mm
L2
64 turns
11.0-mm OD
280- mm
367-mm
L3
7 turns
14.0-mm OD
32- mm
564- mm
L4
4 turns
21.5-mm OD
C2
20- mm
1 pFd
C1
1-10 pFd
50 Ohms
4 counterpoises for 144-MHz
(514-mm) and
4 counterpoises for 430-MHz
(170-mm), ALL is made
of copper wire of 4-mm,
or #6 AWG, ALL is
placed to 90 degree
to antenna wire


RV9CX

J- Antenna for 160, 15 and 10(FM) meters
Unusual Look to Usual Things

by Valentin Gvozdev , RU3AEP, http://www.vgvozdev.narod.ru/
gvozdev@excite.com

Introduction

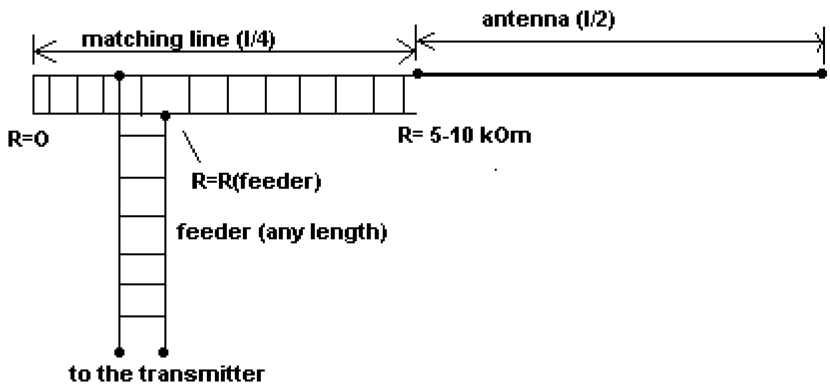
After getting my first amateur license I had to think, what antenna to build for a top-band (160 m), I realized, that conditions are too bad for it. I live in a 7-floor house, which has a roof with a high slope (about 35-40 degrees), which is very dangerous to operate on it. Also, the house is almost completely surrounded by wide streets and electrical wires going along them. After long thinking, I concluded, that there is only one possibility to make an antenna - to hang up a long wire from my roof to the roof of another house. Unfortunately, any dipole-type antenna was unacceptable, because in this case my apartment would have been too far away from the feed point of the antenna, and the condition of right angle (90°) between feeder and antenna itself could not be satisfied. Fortunately, in that time I have read about one very old, but not frequently used antenna - so called Zeppelin-antenna with a matched feeding.

Classical design with an opened line

Actually, this is shortly described in well-known book ("Antennenbuch"), written by DM2ABK (Karl Rothammel), but has been recently developed by Sergey Makarkin (RX3AKT), a radioamateur from Moscow, who has published a good article in "Radio-Design" journal (N2, 1998).

Classical design is presented below (**Figure 1**). As it can be seen, there is feeder with rather high impedance (~300-600 Ohm), and 1/4-wavelength matching line. From one end, this line is shortened, and here its impedance is just a zero (current is high, but voltage is almost zero). Another end of this line is connected to the long wire, which has length exactly 1/2 wavelength. At this point, the impedance is very high (several kiloohms). That is why, a big voltage exists here during a transmission. This is quite suitable for a wire feeding, because a 1/2-wavelength has high impedance when fed from the end.

Figure 1. Classical Zeppelin-antenna design



The feeder from the transmitter with a specific impedance R_f is connected to the matching line in the point, where impedance of the latter is equal to that of the feeder. Such point is usually located not so far from the shortened end. If everything is done properly, feeder may have any length and SWR is closed to 1:1 in rather narrow band, central frequency of which is determined by the geometrical size of matching line and antenna.

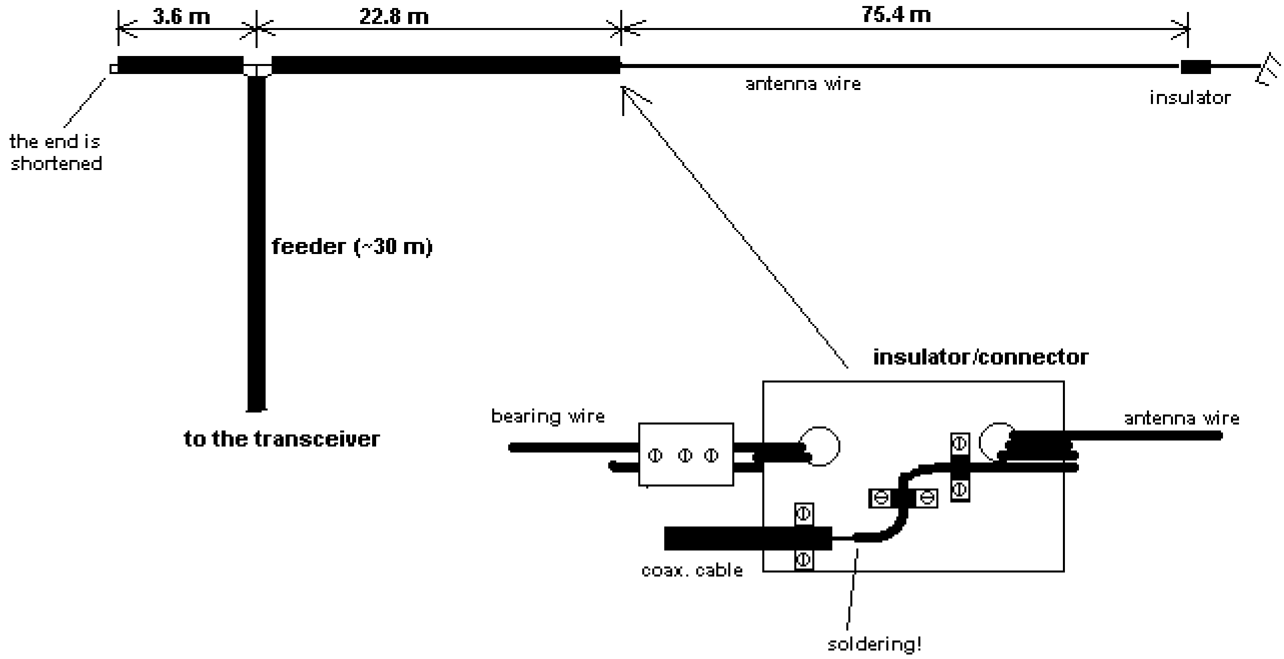
Classical design with a coaxial cable for 160 meters

This design can be used almost without change, but instead of symmetrical feeder a coaxial cable can be used to connect the whole system to the unsymmetrical output of the transmitter (**Figure 2**). Using of a coaxial cable instead of an open line has one big advantage – in contrast with the symmetrical transmission line it is almost insensitive to the environment, weather conditions and can be placed really everywhere.

Such antenna with feeding 'from the end' is much more easy to make, that a simple dipole. Here, antenna wire bears only itself, and this reduces the mechanical strength and thickness of the wire to be used. Also, you may use your window as one the point of antenna fixing. In this case, all the cable will be inside your shack and antenna could be tuned precisely in comfortable conditions. If the beginning of antenna is outside the apartment, most part of matching line can be used as the continuation of the feeding cable.

On **Figure 2** there is a design, that I implemented for using on 160 m amateur band, and which, to my mind, is a perfect solution for the people, who cannot mount a classical dipole.

Figure 2. Long wire antenna for 160 m with a coaxial matching line.



In my case, all coaxial cables have 75 Ohm impedance, the antenna wire, as well as two bearing wires are made from very hard bimetallic insulated cable (outer diameter is about 3 mm). The trickiest part - the connector between cable and antenna - is shown on **Figure 2**.. It should be noted, that voltage on it is quite high, and so everything should be well insulated from each other. It is good idea to place this connector somewhere indoors, otherwise rains and snow may cause decreasing of insulation efficiency and antenna performance. This antenna uses a tuned line made from the coaxial cable, and for proper operation of the whole system the antenna wire should have the length equal to the $\lambda*0.95/2$, and the coaxial line must resonate on the working frequency.

It is a good idea, to connect the shortened end of the matching line to the ground (cold water pipe, heating system, building elements etc.) to provide adequate safety and to reduce possible TV/RF interferences while transmitting.

Tuning and adjusting of the antenna

To achieve what was declared in the previous paragraph, first of all the precise length of the matching line should be determined. Theoretically, it should be closed to $\lambda/(4*sqrt(d))$ (sqrt - Square Root, d - dielectric constant of the insulator used in the coaxial cable). SQRT(d) value is typically about 1.52 for most cables with polyethylene-based dielectric, that is why, 'shortening coefficient' is about 0.66. But the practical value will be a little different from that.

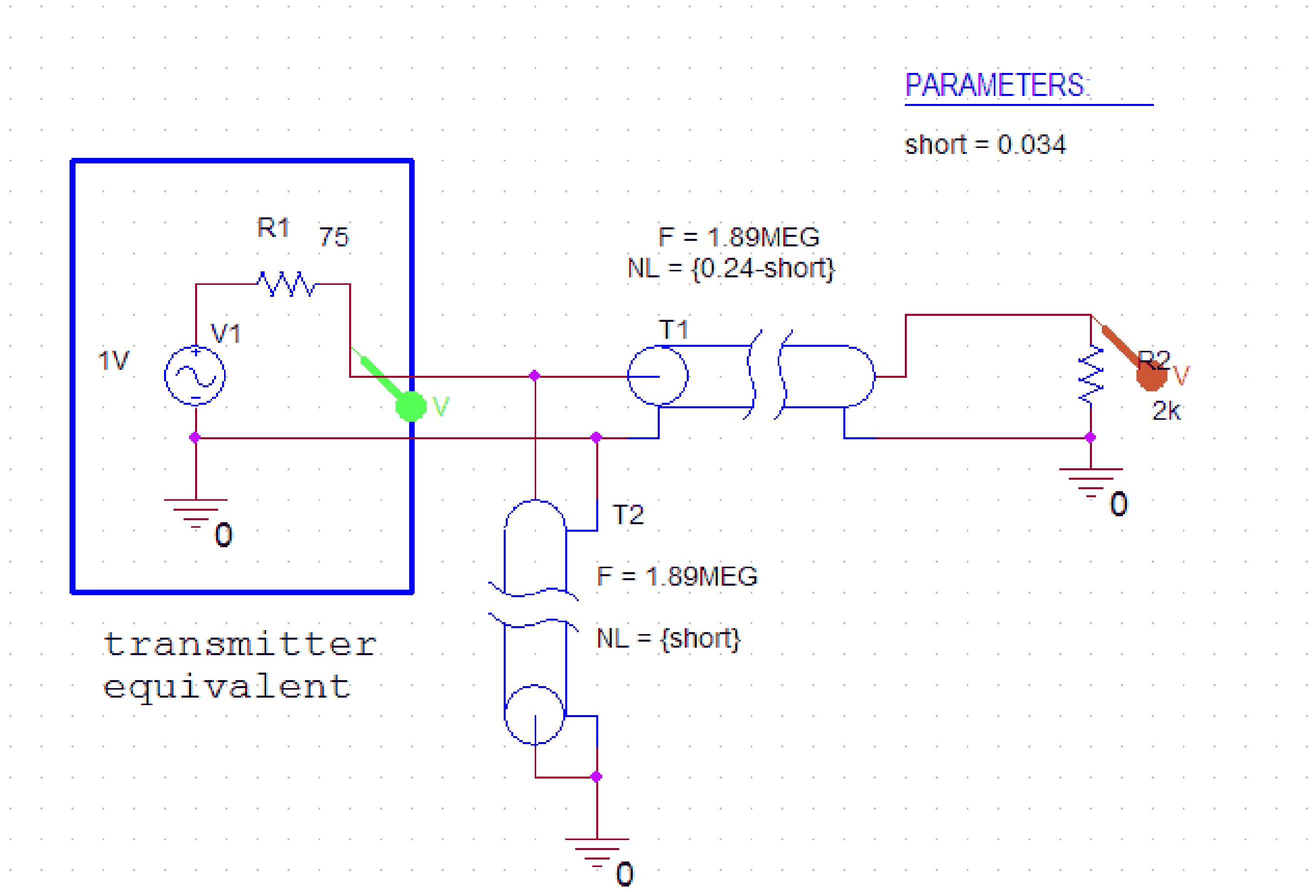
The lengths indicated on **Figure 2** are mine values, and they can be used as the approximate reference. Exact numbers depends on the antenna environment and should be determined experimentally. It should be noted, that in 'ideal' case it is not a simple task, because in such system three values have to be varied (one is antenna length, and another two are lengths of the parts of the matching line). But as it appeared from my experience, for practical purposes the most important thing is to choose correct total length of the matching line, which must resonate on the desired frequency.

To do this, I suggest to use the following technique. To make your line resonate on the middle of the band (1890 kHz), you first have to make the line about 1 m longer, that estimated length of the tuned line (for example, 24 m), making shortened segment about 3.6 m. Then, connect the 2-3 kiloohms resistor to the "open' end of the line, and the transceiver through SWR meter - to the feeder. The resistor here serves as a loading instead of the antenna wire.

After assembling of the system, put RF power (1-2 W or even less is enough) on some frequency inside 160 m band into line and watch the SWR. If the line is completely out of resonance, SWR will be closed to infinity, and no power will be dissipated on the resistor. Then, the frequency should be found, which gives the sharp minimum of the SWR. It has to be around 1800 KHz. Here, the SWR is usually less than 1.5:1, and the full power of the transceiver is dissipated on the resistor, which means, that the matching line works well. When touching the 'hot' end of the loading, it may be seemed, that is really very hot – this is due to the high HF voltage, which causes skin burning (be careful to do it, even by low power of RF source!).

For better understanding of these processes is useful to look to the results of simulation of this system using Pspice simulation software. The equivalent schematics (**Figure 3**) includes voltage source V1 in series with 75 Ohm resistor (which emulates output resistance of the transmitter), two coaxial lines T1 and T2 and loading R2. Since Pspice does not allow to set lengths of the transmission lines directly in length units, they are set in wavelengths (NL) on the specified frequency (in our case, F=1.89 MHz).

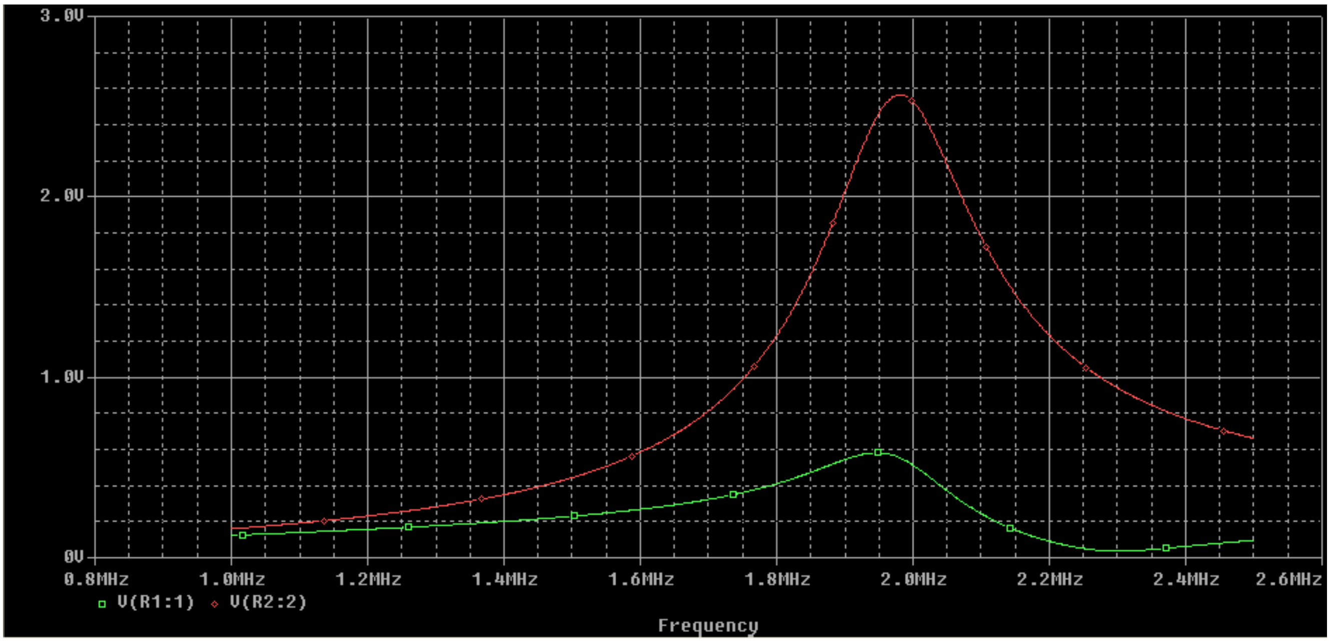
Figure 3. Equivalent schematics for matching line, used for simulation.



Calculated frequency response is presented on the **Figure 4**. Here, the colors of the traces correspond with the colors of the voltage markers on the schematic. As it can be seen, on the resonant frequency about 1.95 MHz there is sharp voltage maximum on R2 (red trace), which reaches 2.6V – it is about 5 times more, than the voltage on the transmitter's output (green trace). Also it should be noted, that on the resonant frequency voltage on R1 (green trace) is closed to one half of source voltage (in our case, 1V). Practically, it means, that there is good matching between transmitter and the "antenna" and most of generated power is dissipated on the loading.

After the resonance has been found, it should be shifted up to the desired frequency. To do this, the end of the cable should be cut carefully in several steps, watching the resonance frequency each time, which must increase with each cut. After you achieve the desired frequency, the matching line is almost ready, and you can mount the whole antenna system in the chosen place. It should be noted, that the minimum of the SWR in mounted antenna is usually 20-30 kHz down, compared to the value achieved by the tuning on the resistor.

Figure 4. Frequency response of the matching line in range 1 – 2.5 MHz



In my case, the antenna for 160 m band had a minimum of SWR at 1875 kHz (about 1.3:1), on the edges of the band SWR increased to 2.0…2.5:1, since the design is a narrow-band one. Compared to my previous dipole, which hanged on the low height (about 5 meters over the ground) along the building, this antenna exhibited much better transmission efficiency and higher signal to noise ratio while receiving.

The same design for 10 meters - cheap and simple.

About 2 years after getting my first amateur license I upgraded it to the higher license class, which allowed me to operate on 10 meters SSB. In that year, there was a perfect propagation on 10 meters band during the daylight time, and I needed an efficient antenna to work on it. Probably, in some time I will have something like rotable multielement Yagi on my roof, but now it seems to me inaccessible as the Moon due to many factors. After some time I decided to repeat what I built for 160 meters for 10 meters, proportionally reducing all geometrical sizes of the antenna wire and matching line.

Since the wavelength on 28500 KHz is just 10.52 m, a half-wavelength dipole should be about 5 meters, and the total length of the coaxial matching line will be 10.52/(4*1.52) = 1.73 m. The feeder is connected to the line 23 cm away from the shortened end. These sizes are relative small and the whole antenna system may be placed without being mounted on the roof, for example just from your window to the neighboring tree.

I made the antenna from a 2 mm copper wire with a plastic insulators at the ends, using 75 Ohm coaxial cable for feeder and matching line. There was nothing difficult to tune the system - I hanged the antenna across my apartment and adjusted the length of the matching line as described above for 160m design using 1.80 m as the starting value. The only thing that should be noted is that the actual resonance of the line is very sensitive to the length variations, so on the final steps the cable should be cut in 1 cm (!) portions or even less to not miss the desired resonance position. After I hanged the antenna on the designated position, SWR was less then 1.5 on all frequencies ranging from 28200 to 29000 KHz.

This antenna is really very simple and cheap, but nevertheless, I allowed me to establish many connections with Europe and even Far East using just about 10 Watts of power. I really enjoyed working on 10 meters ether in local communications and transnational QSOs, and this was made possible just by several hours of time, dedicated to the antenna building and tuning.

About working on other bands – some facts and theory.

Though LW antennas with a feeding through coaxial transformer, which were described above, seem to be monoband, this appeared not completely true. As I found out, the whole system has many resonant frequencies, and some of them, are inside or near amateur bands and can be used for working on these bands.

As it could be expected, operation on the frequencies, which are twice more that 'native' ones, is impossible. When using an antenna for 160 m, on 80 m band observed SWR is closed to infinity and the transmission efficiency is not more that by using a random wire with length of several meters... Simply it can be understood, that on doubling the working frequency the matching line is completely out of resonance, and works as a "short" for the transmitter. But everything has advantages, and this fact means not only impossibility to work on 80 m, which is definitely bad, but also deep suppression of 2- nd harmonic by working on 160 m, which is really well.

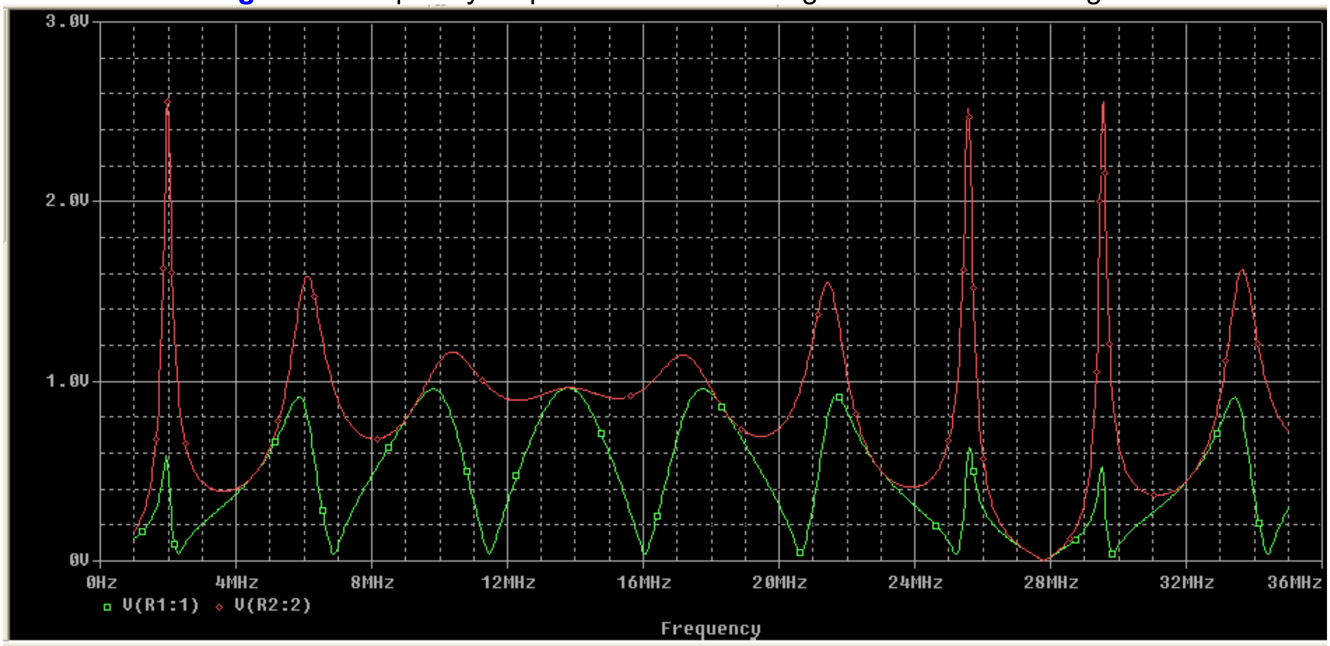
Almost the same situation is on 40 m band. Here the active component of input impedance of the antenna (measured by noise bridge) is also quite low (several Ohms), and no resonance exists inside or near amateur frequencies.

But if you try to work on this antenna on 15 and 10 meters bands, the situation is more optimistic. In my case, on 21430 KHz the SWR was about 1.3:1 and increases to 2.5:1 when moving down to 21000 KHz. Measured impedance was about 55 Ohm with a low capacitive reactance. From first sight, it is quite strange, but nevertheless, antenna behaved well on this band, and using just 10 W of power, I was able to make long-distance QSO's even with North America. The most interesting fact was, that this was "true" resonance of the antenna, without any participation of the feeder (SWR did not change significally when the feeder length was alternated).

In contrast to this, on 10 meters band the antenna behaves very poor – the air seems to be "empty", and even common industrial noise is received with a level comparable to internal noise of the receiver. Compared to the special 10 meters antenna (see above), the signal of distant correspondents were weaker by 10-20 dB (!), and on transmission even my neighbors gave me reports like 53-54. However, when frequency was moved up to 29 MHz and higher, the efficiency improved dramatically.

To understand this phenomenon, some calculations were performed. First of all, it was found, that frequency response of the matching line with a resistive loading (see **Figure 3**) in range 1.5 – 32 MHz has many maxima, and one of them is inside 15-m amateur band (**Figure 5**, red trace). Another maxima is near 29.5 MHz – in the upper part of 10-m band.

Figure 5. Frequency response of the matching line in whole HF range



I guess, that these results may be assumed at least as a qualitative explanation of the antenna behavior. I say "qualitative" because the whole system can not be adequately represented by a matching line with a resistor at the end – impedance of the antenna wire also should be taken into account. However it is clear, why besides 'native' band, antenna works well on 21 MHz, and why on frequencies about 28500 there is a minimum of performance, which rapidly increases when moving up to 29 MHz.

Conclusion

As a conclusion is can be said, that LW antenna with a coaxial matching line (J-antenna), which is designed for 160 m band, can do perfect job on 15 meters and on a part of 10 meters band also without any switching and tuning devices. Of course, the efficiency on 'upper' bands is be substantially lower, that on 'native' one due to RF losses in the matching line (which actually works with a very high SWR). But to my mind it is still acceptable, especially in the case, when there are no conditions to mount huge and efficient antennas.

Three Band Universal RZ3AE Antenna

Evgeniy, RZ3AE

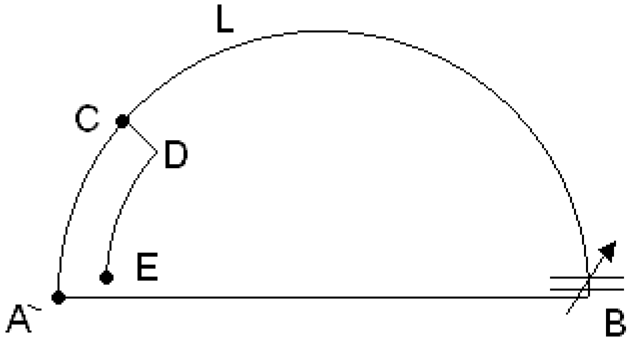
bort3@narod.ru

For several years I use to a simple and rather effective home – made antenna for a work from my balcony, a hotel window, from the ground in a radio- expedition and from my car. I with my friends have made a dozen such antennas and all the antennas work very well. One antenna, in depend of its dimension, works at three old amateur ranges- 10, 15,20 or 15, 20,40, or 20,40, 80.

Antenna description:

Figure 1 shows the antenna. Antenna wire is a tube or copper or bimetal rod of 5-12-mm diameter (#0000—5 AWG). D-E wire is thinner then a-c-b wire in 2-5 times. Antenna is tuned by air (a vacuum capacitor is better!) variable capacitor with air-gap in 2-mm. The capacity is 5- 750-pF.

Figure 1 RZ3AE Antenna



Antenna ratio:

L = 1.57AB

CD = 5-8 centimeters

AC ≈ 0.2L

Most high frequency for the antenna is: 4 (AB+L).

Antenna adjustment

To run a QRP power at most high frequency for the antenna. Move a crosspiece CD to find the minimum SWR. Check position of the crosspiece. To run a QRP power for next working band of the antenna. Move a crosspiece CD to find the minimum SWR. Check position of the crosspiece. And so on.

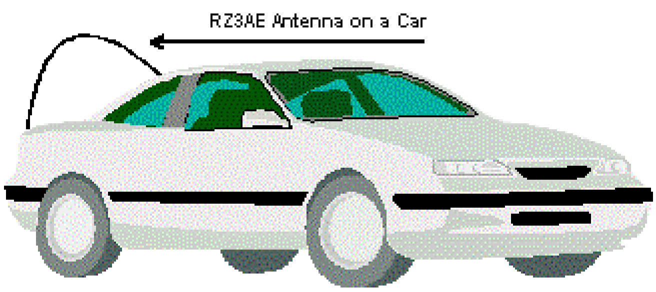
Antenna operation

To stand the crosspiece by manually or by RF-relays for choosing band. The antenna has very high directivity, so, choose needed position for the antenna. Switch your transceiver and enjoy!

Antenna results

I tried the antenna at different conditions and everywhere the antenna works well, from my house, from my car (the antenna is placed at boot of my car), from a field. I use to the antenna with IC-706 MK2G.

I wish all good luck! 73!



Fast Made a Half - Wave Antenna for 80 Meters

By Igor Grigorov, RK3ZK

G-QRP-C
6363

The antenna was made by me in one of the hot summer days near five years back. I was going for weekend to my bungalow and I decided to take my home- brew 80 – meters transceiver with myself. I had no antenna for the transceiver. So, I needed to do any antenna, but I had no time as no quality stuff for doing this one. I opened my box with old tips… and… Thirty minutes while I have had a new antenna that served me several years!

Figure 1 shows the all antenna system. I have done a half wave antenna with "bottle" matching device. As you can see a wire in long of 40 meters (a half wave antenna) is matched with 50-Ohm output of my transceiver with help of a parallel circuit ("bottle" matching device) – it is L1C1 in **Figure 1**. Spool L2 has not electrical connection with antenna circuit. RF energy is transferred from antenna to the spool only by magnetic field, that reduces the level of static interferences at receiving mode. The counterpoise has length of 20 meters of a naked copper wire in diameter of 1,5 millimeters (#14 AWG). I used a wire from an old burned down electrical transformer 220-V/12-V. The counterpoise serves as electrotechnical both as radio ground for the antenna. At operation time of the antenna the counterpoise is placed on the ground in any position (straight or bending). To short static electrical charge from antenna wire to ground is main task of the counterpoise. Not wise to use a long antenna in field without an electrotechnical ground, because in the first it is unsafe, and in the second, the antenna is very rustle on reception without an electrotechnical ground.

Figure 2 shows the construction of the matching device. I used a half - liter plastic bottle in diameter 60 millimeters from mineral water. C1 is attached at a side of the bottle with help of a strong copper wire in diameter of 1 millimeter (#18 AWG). L1 has 15 turns of copper wire in diameter of 1,5 millimeters (# 14 AWG), length of winding is 70 millimeters.

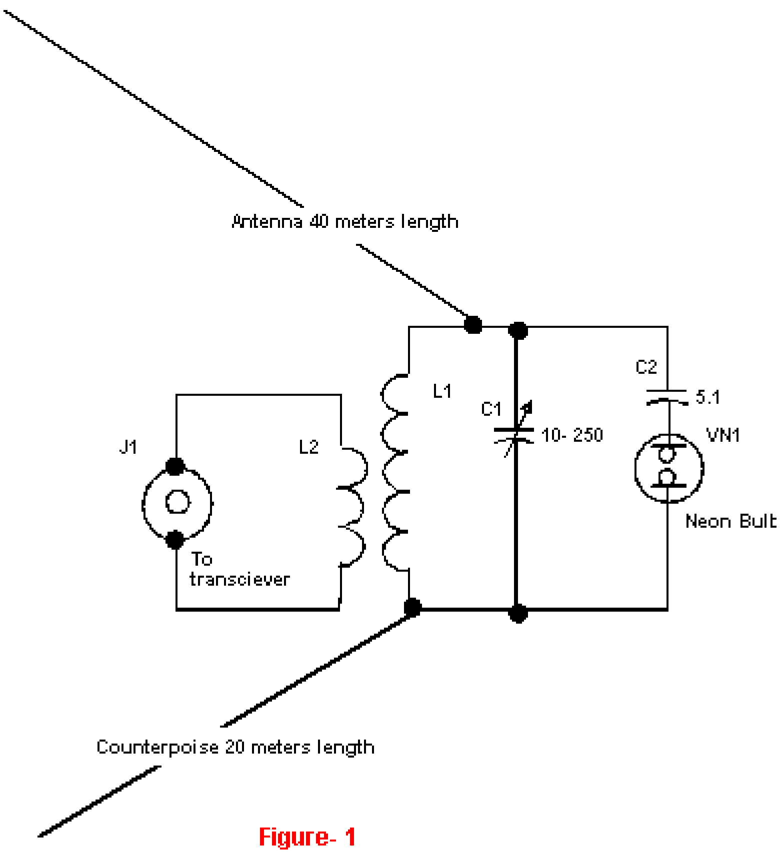


Figure- 1

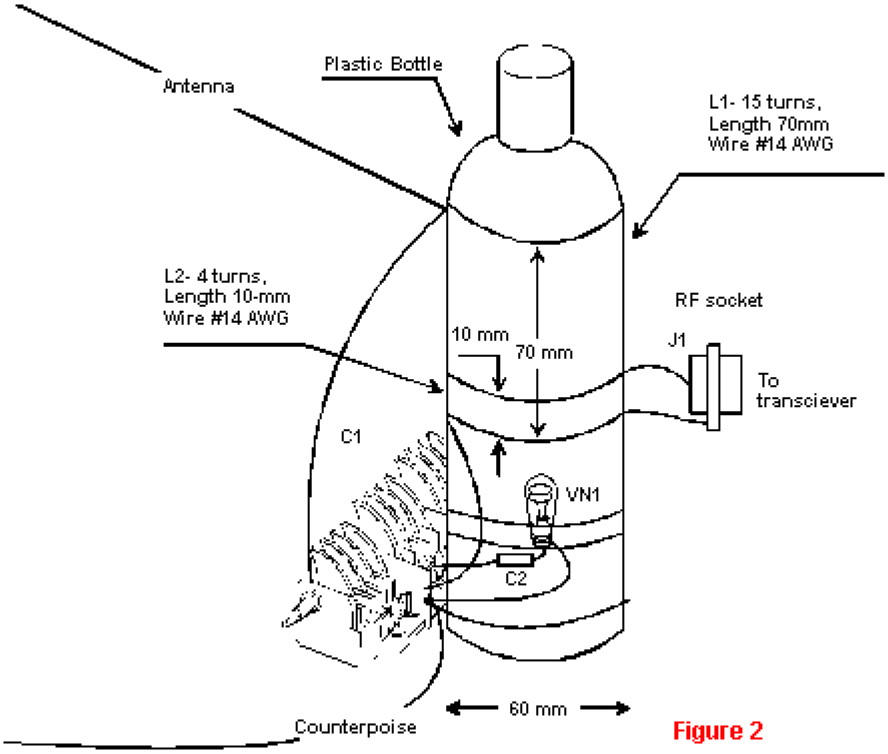


Figure 2

L2 is placed at the bottom of L1. L2 contains 4 turns of copper wire in diameter of 1,5 millimeters (# 14 AWG), length of winding is 10 millimeters. Ends of L2 are directly soldered to J1 RF – socket. VN1 is attached by a piece of Scotch to the bottle. Antenna is tuned by max glow of VN1.

The antenna works very effectively when the upper end of the antenna at lengths of five or more meters above the ground. I don't use an end antenna insulator. A long synthetic rope can simply be attached to the upper end of the antenna. The down end of the antenna could be just near the ground. A coaxial cable having any reasonable length can be between "bottle" ATU and a ham transceiver. **Figure 3** shows the antenna at field operation. Of course, it is very possible to use the antenna for stationary work from a ham shack.

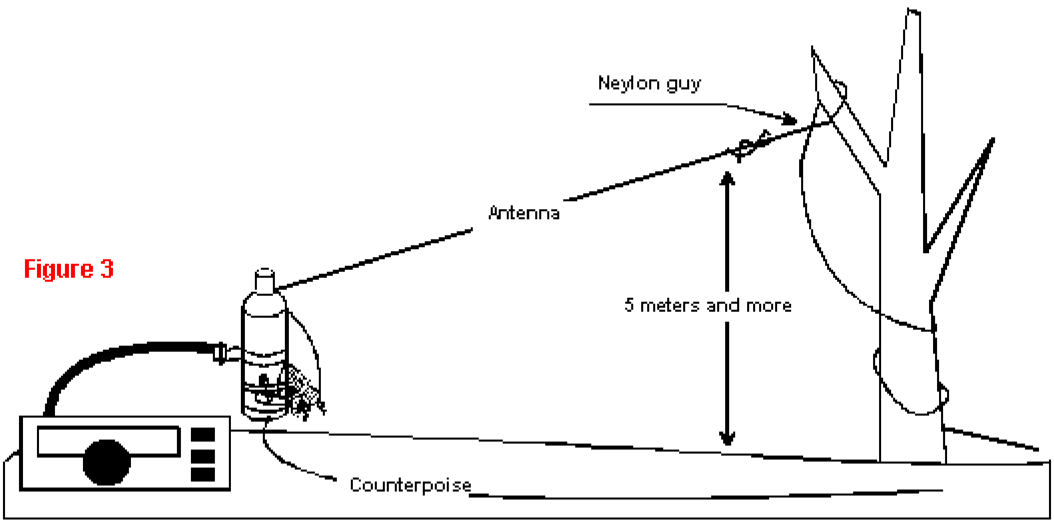
The antenna works very well, and I recommend try it!

73/72!

One more a website devoted QRP!

US1RCH Page
www.qsl.net/us1rch
http://www.qsl.net/us1rch/

Figure 3



Field Strength Meter for the 137 kHz Band

By Dick Rollema, PA0SE
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http://www.veron.nl/tech/lf/fsm/pa0se.htm

Introduction

The power radiated by an antenna is equal to the radiation resistance multiplied by the antenna current squared. Measurement of antenna current can be done in the 137 kHz band by for instance a thermocouple ammeter or other means. The unknown factor is the radiation resistance. Computer programmes for antenna simulation can produce a value for the radiation resistance but proper modelling the antenna is not always easy. Another problem is the influence of the earth. The ground constants are seldom known and even if they are it is not certain that the computer program applies them in the correct way.

A more reliable way of determining radiated power in the 137 kHz band is by measuring the field strength near the station but outside the near field region. A distance of 1 km is probably sufficient to reduce the influence of the near field on the measurement sufficiently and 2 km is definitely safe.

At such a distance we are in the far field of the antenna but near enough so that the field strength does not depend on the type of ground. When a strength of the electric field of E mV/M is measured the radiated power follows from a simple equation:

$P=0.0111(E*d)^3$ in which; (1)

P in watt

E in mV/m

d in kilometers

* means multiplication

The equation produces the power really radiated by the antenna, in other words the power "dissipated" in the radiation resistance.

Note that this is not the same as ERP. By definition ERP is the fictitious power to be fed to a **half wave dipole in free space** that produces the measured field strength. As Rik, ON7YD, has pointed out in his e-mail of June 25 a short vertical (and our 137 kHz antennas are always short) has a theoretical gain of a factor 1.83 (2.62 dB) over a half wave dipole in free space.

So if you want to know your ERP multiply the power given by equation (1) by 1.83 (or add 2.62 dB). But apart from a regulations point of view I see no advantage in using ERP. The actual power radiated by the antenna is what counts.

I have a feeling that some amateurs talk about their "ERP" when they mean "radiated power". Maybe I'm wrong; I hope so.

Most field strength meters do not measure the electric but the magnetic component of the electromagnetic field. But this is no problem because in the far field of the antenna (where we measure) there is a fixed relation between the electric and the magnetic field components:

$E/H=120*pi$ ohm=377 ohm (2) in which:

E in V/m and H in A/m.

The portable field strength meter to be described is a direct conversion receiver with two audio output signals. One is fed to headphones for tuning the meter to the signal to be measured. The other output feeds a digital multimeter.

The voltage indicated by the DVM has a linear relation to the field strength. The meter is calibrated so that a field strength of 5 mV/m produces a reading of 1 V on the DVM.

The instrument can be tuned over the range 135.530 to 139.296 kHz. This includes DCF39 on 138.82 kHz which is useful for comparison purposes.

Description of the instrument

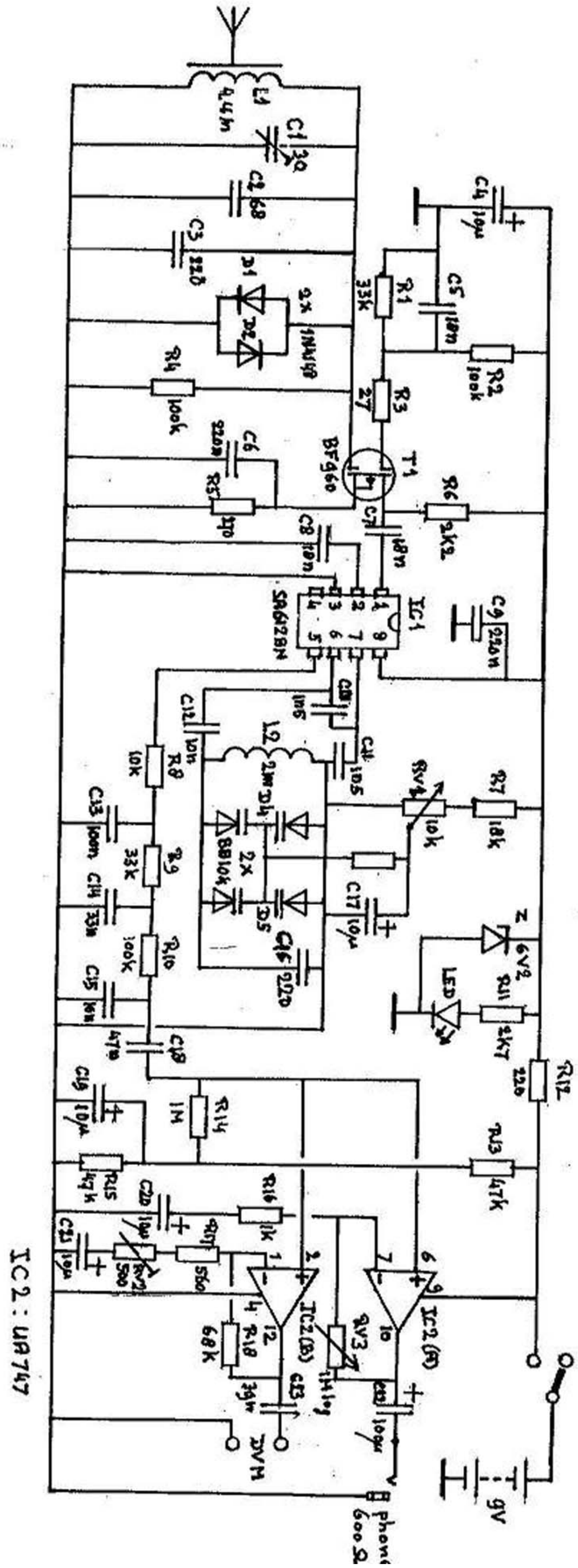
The antenna is a ferrite rod from a broadcast receiver with the original long wave coil in place. The rod is centered in an aluminum tube of 32 mm internal diameter and 145 mm length. I made a slot in the tube to prevent it becoming a short circuited turn. One of the photographs show how the rod is kept in place by two discs of perspex that are glued to the rod.

The electronic circuitry is inside a diecast aluminum box of 120 x 95 x 61 mm. The antenna is tuned by capacitors C1, C2 and C3. C2 and C3 were selected so that C1 can tune the antenna to the centre of the band. It then happened to be at its minimum capacitance as one of the photographs shows. R4 was added to widen the frequency response so that it is sufficiently flat over the range of interest. D1 and D2 protect the meter when used near a live transmitter. T1 amplifies the signal without loading the antenna circuit. It is important in a direct conversion receiver that the signal from the local oscillator cannot reach the antenna circuit. The rf amplifier, including C7, is therefore mounted on a separate piece of copper clad circuit board (not etched, I never use PCB's). Where insulated tie points are required I add small pieces of the same material to the board with instant glue.

RRATA Field Strength meter PA0SE

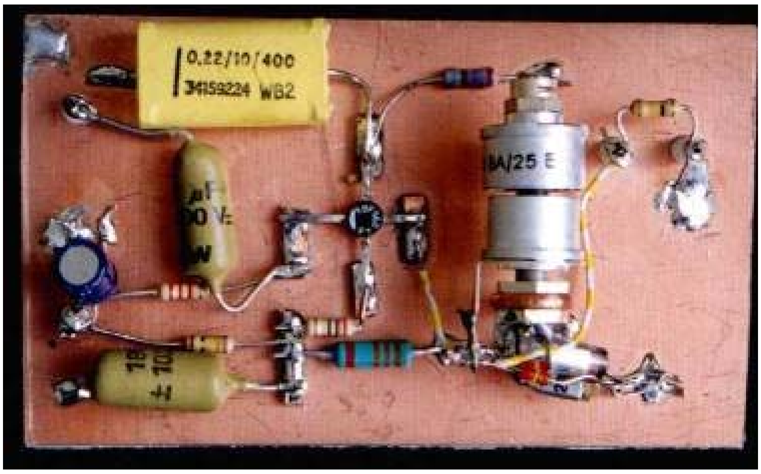
=================================

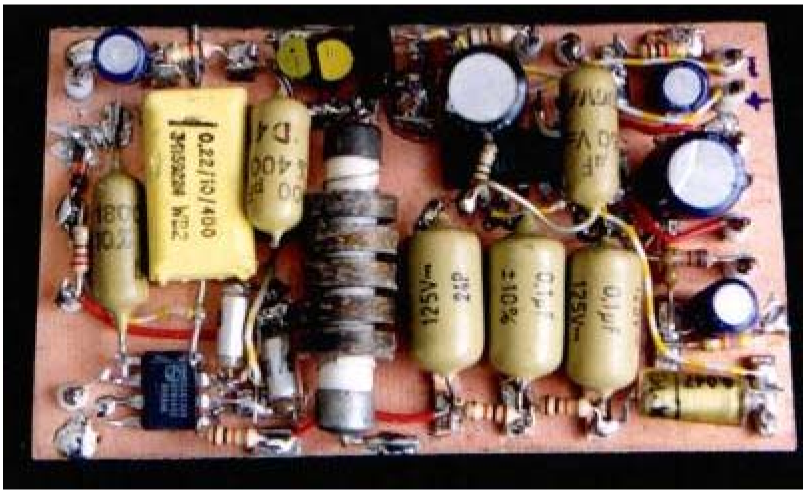
Schematic is on the next page. The values of both L1 and L2 should be mH and not uH.
C15 should be 220 pF not nF.
The LED is shown upside down.
. The resistor feeding bias to the BB104:s has no value. However 100k is a good choice which I have used in some other projects



IC2: UA747
SA612BN
BF960
LED
DVM
9V

The remaining part of the circuitry is on a second board. Here we find the mixer, an IC type SA612BN, incorporating the oscillator circuit. The ubiquitous NE612 can be used as well.





The values of C10, C11 and C16 were dictated by the choice of coil L2. I used a 2 mH hf choke from my junkbox, as shown in one of the photographs. C10 and C11 are the usual capacitors found in a Colpitts oscillator. C12 isolates L2 from the DC on pin 6 of the mixer. I found the BB104 type dual varicaps in my junk box. Two in parallel were necessary to obtain the required tuning range. The lower frequency was set by selecting C16. The upper limit was found to be a bit high and this was corrected by adding R7. RV1 is the tuning control. (The unmarked resistor between the wiper of RV1 and the varicaps is 120 kohm.)

Selectivity of a direct conversion receiver is determined by a low pass filter in the audio path. A high degree of selectivity is required here because of the extremely strong station DCF39 at 138.82 kHz, only 1020 Hz above the upper limit of the band. I use a RC-filter with three sections, each having a time constant RC=1 mS. At first resistors and capacitors of the same value were used in the three sections and this is the situation seen in one of the photographs.

Later I realised that a better response is obtained when the loading of a section on its preceding one is decreased and this resulted in the values seen in the circuit diagram. The lower limit of the frequency response is set by the time constant RC=(R17 + RV2)*C21 respectively RC=R16*C20. The response of the metering circuit shows a maximum at about 36 Hz and is 3 dB down at 16 and 88 Hz.

The output of the low pass filter is fed to the two sections of a dual opamp type UA747. The upper opamp feeds the headphones. Volume is controlled by RV3 in the feedback path.

The lower opamp feeds a digital multimeter that must be capable of measuring AC in the millivolt range up to about 2 V. Preset resistor RV2 is adjusted when calibrating the instrument. I choose to make the audio output, as indicated by the DVM, 1000 mV when the instrument is placed in a field of 5 mV/m. The reading is linear up to about 10 mV/m maximum (2 V on the meter).

The instrument is fed by a 9 V battery. The LED is a small one that gives a clear indication of the instrument being switched on when drawing a current of only 2 mA.

To make the gain of the RF amplifier and mixer independent of battery voltage the supply for these stages is stabilized at 6.2 V by a zener diode. R12 was selected so that the zener keeps control for battery voltages down to 7 V. There is no need to stabilize the supply for the opamps because their gain is controlled by negative feedback and therefore hardly depending on the supply voltage. The instrument draws about 17 mA from a new battery.

Calibration

To calibrate the field strength meter the instrument must be placed in a magnetic field of known strength. This can be produced by a pair of so called "Helmholtz coils".

German scientist Helmholtz already in the 19th century found by computation that a homogeneous magnetic field can be produced by placing two circular one-turn coils of radius r metres parallel to each other at a distance of r metres and with their axes coaxial. When a current I is made to flow through each of the coils in the same direction a homogeneous field of H=1/(1.40*r) (3) is generated in a considerable volume between the coils. H in A/m; I in amps; r in m.

I constructed a pair of Helmholtz coils with r=0.292 m as shown in one of the photographs. The coils are connected in parallel and in series with a 50 ohm resistor.

At 137 kHz the reactance of the coils is so low that it can be neglected against the 50 ohm resistor. Therefore when the coil pair in series with 50 ohm is connected to a signal generator with U volt output the current I through the coils in parallel is

I=U/50. (I in amps).

Note that each of the coils carries half of that current.

To check my set-up I made a single turn coil of 10 cm diameter and connected it via a coaxial cable to a selective level meter. I had calculated that with 1 volt applied to the Helmholtz coils in series with 50 ohm a voltage of 208 microvolt should be induced in the 10 cm coil when held between the Helmholtz coil pair. I measured 210 microvolt! Almost too good to be true. But upon checking everything again I found nothing wrong.

As I wanted the field strength meter to produce a reading of 1000 mV in a field strength of 5 mV meter I applied equation (2) and found that the corresponding magnetic field component is H=13.3*10-6 A/m. Using equation (3) the generator output voltage was found that would result in the wanted field between the Helmholtz coils. The field strength meter was put between the coils and RV2 adjusted for a voltage of 1000 mV on the digital multimeter. That completed calibration.

Measuring field strength

Try to find an open space at least 1 kilometre from the transmitter. Keep the antenna of the meter horizontal and tune the signal to zero beat. Now slowly increase or decrease the tuning slightly for a maximum reading on the DVM. Whether or not you can hear the beat note of about 36 Hz depends on the quality of your headphones. Turn around slowly to find the position for maximum signal. Now walk around a bit. If the reading varies the field is distorted by for instance a metallic fence, a lamppost or underground cables or pipelines. (On 137 kHz the waves penetrate tens of metres into the earth!) When a constant indication is found, multiply the reading in volt by five to obtain the field strength in mV/m.

Find the distance to the transmitter on a map or by other means (GPS!). Apply equation (1) to find radiated power. Multiply by 1.83 if ERP is required.

Good luck!

73, Dick, PA0SE

Download the article (Word2) and pictures as a zip file (223k)

http://www.veron.nl/tech/lf/fsm/pa0se.zip

PHOTOS FROM THE SECOND RUSSIAN LF-DXPEDITION. ASIA, VILLAGE DOVOLNOE. MEMBERS: UA9OC AND RU6LA

Mart, 2003

Ed Lesnichy ed@dx.ru

A New one DX –LF QSO!

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The tube PA worked at opened air at minus 3 up to minus 25 Celsius! 100 watts output is not bad at the very sever conditions…

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QRP - projects from UR- QRP- C

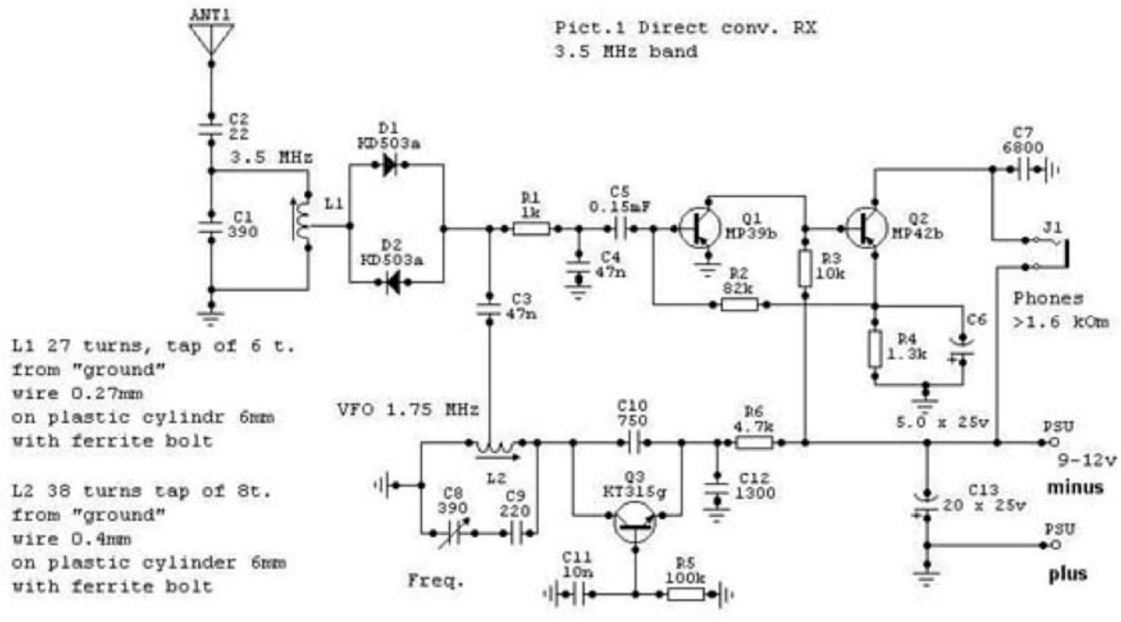
RU-QRP- C presented for you several QRP- projects of their members.

My First QRP-Station

Three transceivers from Oleg Borodin, RV3GM/QRP E-mail master72@lipetsk.ru

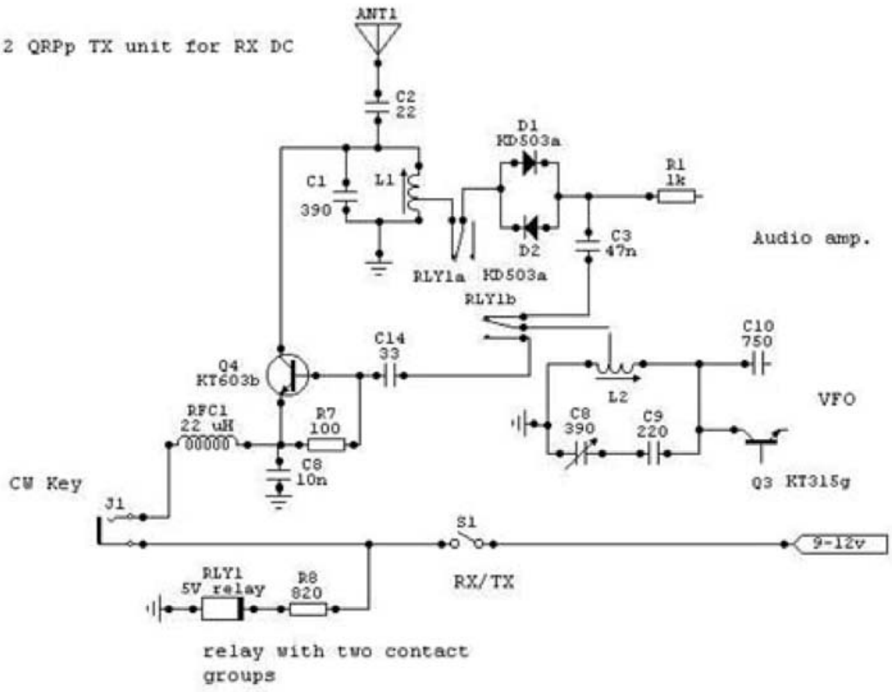
*Remember, '70-th when I was a young SWL, I has build my first direct conversional receiver (**pict. 1**) It was too wonderful for me because he is very simple, just a three transistors are in receiver's circuit and a few any details. I powered this RX by 9 volts battery of pocket broadcast receiver. I has not a good antenna and I used a piece of wire in my room. For the first testing construction I did not made a PCB and build this RX as "space" style on a piece of printed board. It was a 80m band version. Results was shocked me at once!*

Before I used for SWL old broadcast receiver by 6 valves with home-made local oscillator. Having heard an ether on my new DC RX and at once forgot about the old lamp receiver. The sound was clear, sensitivity very high and I has heard a lot of DXs during some evenings and nights. After my first fun I has developed PCB and rebuild the RX for the box of printed boards also.



Alongside to this 80m variant receivers under the similar circuit on 40 and 20 m bands are also were constructed. The results were obtained also excellent.

My next step with Direct Convertional was when I get a HAM license. I began to experiment the receiver in hope to transform it into the transceiver. First of all I have decided to submit a VFO signal to the antenna through a keyed amplifier stage (**pict.2**). It worked well. There was even a frequency shift by transmission about 1 kHz that enabled to hear stations without additional RIT. But, taking into account, that VFO works on frequency twice below, than the received frequency, power of a transmitting signal in the antenna was rather small, just few decimals of milliwatts. I has just a few nearest QSOs with this QRPp on 80m band only. It is impossible to use this circuit on 40 or 20m bands because the friequency shift is too large (5 to 10 kHz) and your signals will be outside from a signals of your correspondents.



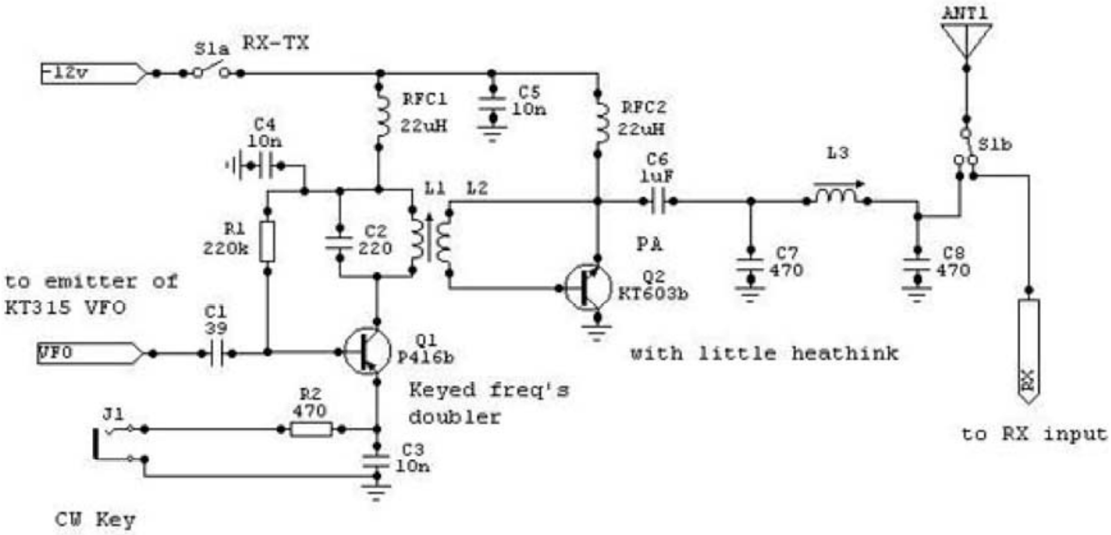
Pict.2 QRPp TX unit for RX DC

The following version of the transceiver based on receiver (**fig. 3**) consist in addition keyed freq's doubler and stage of an amplifier. It gives me a good 0.75 watt output at 80 and 40 m bands and 0.3 watt at 20m. I only needed to add the RIT and sidetone.

I has a many pleasure days with this transceivers. I build a three tcvrs for any bands. I did not made a multi-band trcvr because the complicating of commutation bands chains would necessarily be mirrored in quality of the transceiver in the worse side. The frequency stability would worsen, be sure. Well also it is not necessary to forget that the main advantage of direct conversion equipment is a simplicity.

The kits of parts and PCB of these receivers or transceivers are available at me, send me your orders by e-mail or post.

72! from RV3GM/QRP



Pict.3 Transceiver's unit for RX DC

GNOMIK - 80-M QRP transceiver

Introduction

The goal of this project is to provide to Amateur Radio beginners with a working QRPp CW transceiver that they build and learning the knowledge of transmitting and receiving equipment on the most of popular HF band 80 m.

This "Gnomik " transceiver contains two separate units: direct conversion receiver (RX) based on modified DC receiver designed by Vlad Polyakov RA3AAE and transmission unit (PA) based on standard scheme frequency-doubler and amplifier. The RX's heterodyne operate on a half of receiving frequency.

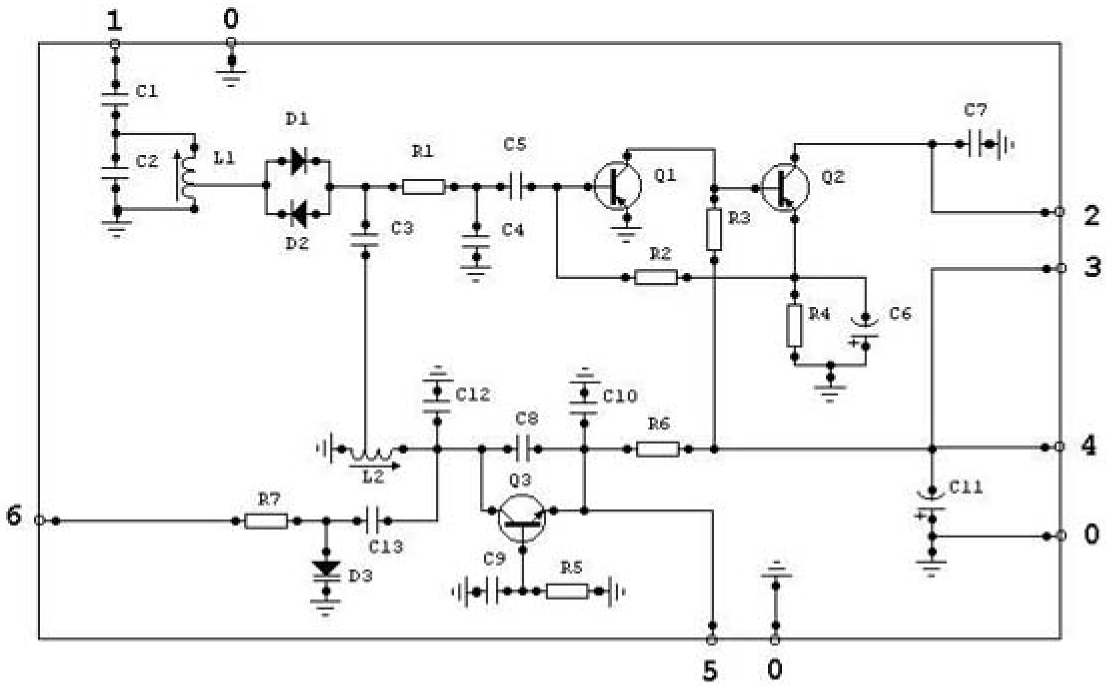
Schemes (example)

History

For the first time "Gnomik" was designed at 1986 year by Oleg RV3GM after he has experimented with RA3AAE DC receiver. Oleg updated receiver with transmission unit and after some modifications "Gnomik "was ready. There are some QSO's from Oleg's Log Book he has operated with "Gnomik":

Band - 80 m Mode - CW Antenna - VS1AA (15 m up)

Date	GMT	CALL	My RST	Report
07 Apr. 1986	20.35	RB5GFX	549	Kherson (Ukraine)
07 Apr. 1986	21.42	UA3QIX	559	Voronezh, Victor
11 Apr. 1986	18.30	UA4CPX	579	Saratov (on Volga)
18 Apr. 1986	00.27	UA6PCQ	569	Grozny (Caucasus)
20 Apr. 1986	19.03	UA1OB	569	nr Arkhangelsk
26 May 1986	20.37	UM8PGA	579	Naryn (Kirgiz Rep.)
31 May 1986	20.10	LZ2ZA	559	Vama
10 July 1986	19.54	HA6OJ	579	Mohora
etc... etc...				



Parameters

Output power of transceiver is 500 mW approximately. Sensitivity of receiver is about 2 uV. Antenna's impedance 50 Ohm. "Gnomik" powered by stabilized DC power supply unit 12:13,8 V @ 150 mA max. current (positive to "ground").

Upgrade

Optionally, you may insert to "Gnomik" some modifications: RIT, side-tone, digital frequency meter,

output RF meter, S-meter, Antenna Tuning Unit. That's fine! How you like! But don't forget, that the major advantage of direct conversion QRPp equipment is it's simplicity! 72 and good luck!

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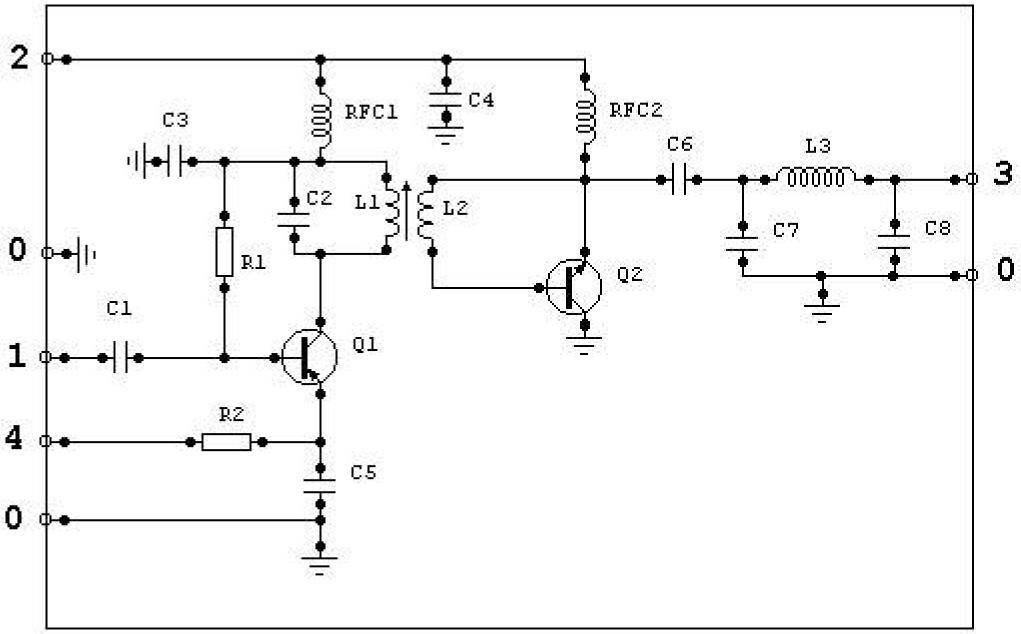
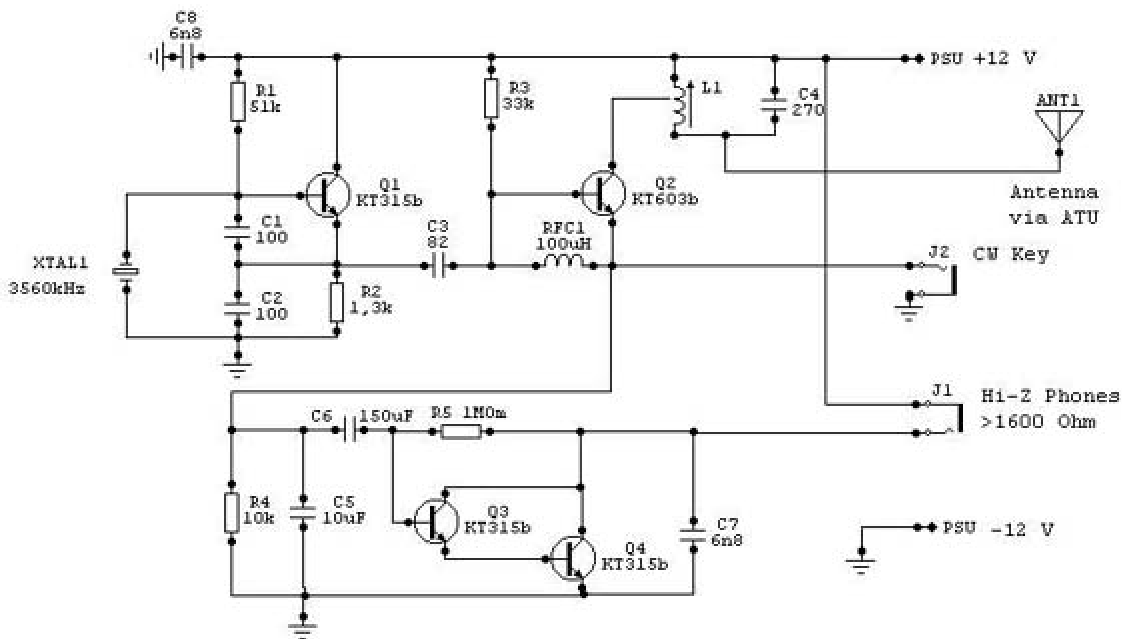


[Kit is available at RV3GM]()

MICRO-80 - 80-M XTAL QRPp transcei

Pict.1 Microtransceiver Micro-80



"Micro-80" is the first smallest and the simplest transceiver in the World. This is a prototype of some next wellknow kits "PIXIE", "Tiny Tornado".

This transceiver's kit contains all the components (without xtal only), PCB and assembly manual. Just 4 n-p-n transistors, 5 resistors, 2 inductors and 7 capacitors are mount on 35 x 50 mm PCB.

There are some QSO's from RV3GM Log Book operated with "Micro-80":

[Kit is available at RV3GM]()

Antenna - Long Wire (36 m up)
Band - 80 m 300 mW output

Date	GMT	CALL	My RST	Report
02 Mar. 1989	19.05	UA1ARA	569	nr Leningrad
17 Mar. 1989	19.25	UV9CAI	559	Ural
31 Mar. 1989	17.45	YU3CN	559	op. Bojan, QRP 3 w
10 Jul. 1989	20.55	UA1NBW	589	Karelia, Sergey
02 Feb. 1991	21.23	DK0HSC	559	HSC HQ
17 Feb. 1991	19.33	UB5WDQ	569	Lvov, QRP 5 w
19 Feb. 1991	16.35	SM6CGG	549	Boras, op. Arne, QRP 5 w
20 Feb. 1991	19.40	RO4OZ	559	Moldova

etc... etc...

Credit Line: **My first Station**: SPRAT, The journal of the G- QRP-C, #112, pp.: 4-7.

GNOMIC and **MICRO-80**: http://ruqrp.narod.ru

And some info about RU-QRP-C

RU- QRP- C

RU-QRP Club has organized 1'st August 2002 under the initiative Oleg V. Borodin RV3GM/QRP. By the purpose of creation of Club is the association the Radio Amateurs interested by communications on the small power equipment; propagation of operation on QRP in the purposes of reduction of mutual interferences, study of propagation radio waves, boosting of skill operations in a drain ether; the help initial to the Radio Amateurs in study the RX & TX equipment and antennas, rules of operation in a drain ether; an exchange by experience and hardening friendly between the Radio Amateurs of World Wide.

The member of Club can become any Amateur interested QRP having the license. For this purpose it is necessary to send to address Club or on to E-mail announcement the any shape with the indicating first name, middle initial, last name, callsign, address E-mails, post address. Briefly to tell about achievement in QRP. It is desirable to point age, experience of operation in drain ether and whenever possible to affix in aspect of files of a format *.jpg interesting photos for a photoalbum. At an entrance to Club necessarily it is required to give datas on the achievements on QRP. Such datas is statistics on wkd/cfm QRP DXCC and 2-way QRP DXCC (separately on sorts of CW, SSB, Digital and per Bands). See special blank on the link "Join to the Club" at the site. Each member of Club receives unique Member's number.

Club have a good cooperations with QRP-Clubs of other countries: QRP-ARCI, G-QRP, QRPp-I, Hawaii-QRP, Maryland Milliwatt, UR-QRP, OK-QRP etc.

http://ruqrp.narod.ru

Russian Amateur RU-QRP Radio Club

In Club is present library with a collection technical literature on to different aspects QRP. And also the subscription to journals of International QRP of Clubs: QRP Quaterly, SPRAT, OK-QRP etc. Club is submitted on constantly International Internet - Forums QRP-L, QRPp-I, G-QRP, OK-QRP. RU-QRP Club is an associative member of World QRP Federation (W.Q.F.)

On all questions, coupled with activity of Club, with by the offers on improvement Club operations, with the interesting projects welcome to the address: P.O. Box 229, Lipetsk, 398043, Russia (for the answer apply the SASE) or by E-mail master72@lipetsk.ru
RU-QRP Club's Chairman Oleg V. Borodin
72! de RV3GM

QRP Amateur Radio WEBRING

QRP- TALES

By Alexei Rusakov, UA4ARL/qrp (RU-QRP # 005) ua4arl@vistcom.ru

September 13, 2002.

The day before yesterday I decided to hang my ZL-antenna for 20m in another direction - and so sad it was for me, fixing the last point I broke director wire. My antenna made of D6mm antenna-rope had been already used for 2 years and I had no any desire to prolong it's term

Yesterday I switched to two alternative dipoles instead.

Today in the morning I started tuning my new 2-el Beam of D3mm bi-metall directed North-South strictly. On 20m SWR that's 1point2. And just after it I tried SWR on other high bands. On 10m band the SWR was 1point4. And on 15m band [CW] SWR surprised me with 1point1. I'd just only checked SWR not changing tuning from the middle of [CW] on 15m and switched on my soldering iron on in order to changeall temporary contacts for cable [SO-239]s. Frequency, once established, was the same.

Early morning. The band's not opened yet. The sweet noise sound pouring from speaker-phone. I've switched off one of the dipoles and the other was still wired to transceiver. Still soldering. And just that time I'm hearing on that frequency someone asks for "QRL?" and in a half a minuteI hear "CQ CQ de 9U0X".

I switch to another antenna - that was [Delta for 40m] and lost him, and while immediately returning to the dipole I have RST 539. I'm hurring to cacth my

luck, trying to repair my hand-made connections, but wires were already cut for soldering and so it's a great deal to screw them all once again. I have two bulks of wire under my legs, and on my knees, so hard to screw because the coax-cable is so thick and hard. So I connect the antenna cables together manually using the newspaper as isolator!!

When the second dipole added the signal up tp 559. I ask him at QRP, he doesn't reply, and QRO I don't use [interestingy].

Three minutes after other HAM's came and one Italian station invites me SKED 18.085 kHz. My [delta-loop] hear nothing and Beam SWR - unlimited. I used my 20m Beam and received RST 559 in answer!!!! And that pal from Italy asked SKED 24 MHz once more. I follow them. Delta-loop is empty and Beam SWR the same as on 18MHz. I call and have 559 in answer!!!! QSO at 08.35z и 08.38z.

9U - Burundi - my new country reached on QRP (204).

Credit Line: : http://ruqrp.narod.ru

International QRP frequencies:

Band	Frequency, kHz
160	CW - 1843
80	CW - 3560 SSB - 3690
40	CW - 7030 SSB - 7090
30	CW - 10106
20	CW - 14060 SSB - 14285
17	CW - 18096
15	CW - 21060 SSB - 21285
12	CW – 24906
10	CW - 28060 SSB - 28360

http://www.antentop.bel.ru/

FREE e-RADIO magazine ANTENTOP www.antentop.bel.ru

Old computer's PSU gives useful parts for antennas

Igor Grigorov, RK3ZK

Continue from ANTENTOP 01- 2003, #002

An autotransformer

AT-33T transformer works satisfactorily in connection shown in **Fig. 1**. It is ***an autotransformer connection***. Mind, the secondary winding must be connected to the primary one at the right phase (**A** or **B** to **C**).

The experiment shows the right connection. Data for the RF autotransformer are shown in **Tab. 1- 3**. **Tab. 1** shows data for the RF autotransformer while this one is loaded to 300 Ohms. **Tab. 2** shows data for the RF autotransformer while this one is loaded to 450 Ohms. **Tab. 3** shows data for the RF autotransformer while this one is loaded to 600 Ohms. The autotransformer has rather big input resistance on ranges of 160 and 80 meters therefore values of a VSWR relative to 75 Ohms are shown in these tables.

An autotransformer

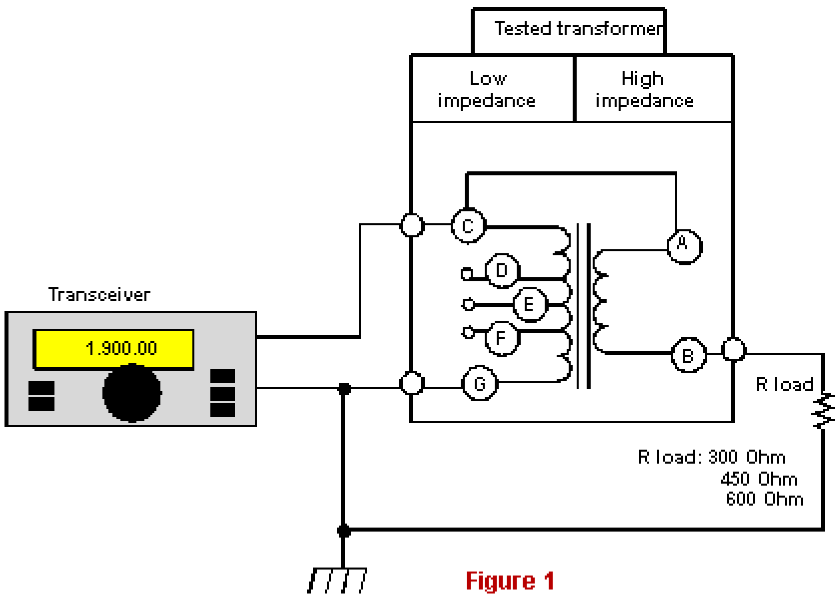


Figure 1

Table 1 RF - autotransformer loaded to 300 Ohms

Frequency, MHz	1.9	3.7	7.1	10.1	14.2
Input resistance, Ohms	80	60	45	40	35
VSWR relative to 50 Ohms	1:1.53	1:1.15	1:1.16	1:1.31	1:1.49
VSWR relative to 75 Ohms	1:1.07	1:1.25	1:1.67	1:1.88	1:2.15
Efficiency, %	76	62	46	28	8

Table 2 RF - autotransformer loaded to 450 Ohms

Frequency, MHz	1.9	3.7	7.1	10.1	14.2
Input resistance, Ohms	100	65	30	25	20
VSWR relative to 50 Ohms	1:1.92	1:1.25	1:1.74	1:2	1:2.61
VSWR relative to 75 Ohms	1:1.33	1:1.16	1:2.51	1:3.01	1:3.76
Efficiency, %	67	69	60	45	12

Table 3 RF - autotransformer loaded to 600 Ohms

Frequency, MHz	1.9	3.7	7.1	10.1	14.2
Input resistance, Ohms	110	70	18	15	8
VSWR relative to 50 Ohms	1:2.11	1:1.34	1:2.9	1:3.48	1:6.53
VSWR relative to 75 Ohms	1:1.46	1:1.08	1:4.18	1:5.01	1:9.4
Efficiency, %	61	87	65	52	12

Using data from **Tab. 1- 3**, I made diagrams for three transformer's loads – 300, 450 and 600 Ohms. The diagrams show:

- An input resistance vs. frequency (**Fig. 2**),
- A VSWR relative to 50 Ohms vs. frequency (**Fig. 3**),
- A VSWR relative to 75 Ohms vs. frequency (**Fig. 4**),
- The efficiency vs. frequency (**Fig. 5**).

As it was mentioned above, the efficiency is the most important parameter of any RF transformer. The RF autotransformer has a high efficiency (87 percent) only on a range of 160 meters while this one is loaded to 600 Ohms. The efficiency falls sharply on other amateur HF ranges.

As for a range of 40 meters the RF autotransformer has the efficiency of 65-35 percent (it depends on the transformer's load). As for a range of 30 meters the RF autotransformer has the efficiency of 52 and 45 percent while this one is accordingly loaded to 600 and 450 Ohms. The efficiency is more in comparison with RF- transformers shown in **Fig. 3** and **7, Part- I**. Alas, while the autotransformer has a high efficiency, it has a low input resistance and accordingly, a high VSWR! Therefore it is impossible to use a 50 or 75-Ohm coaxial cable together with the autotransformer.

An input resistance vs. frequency

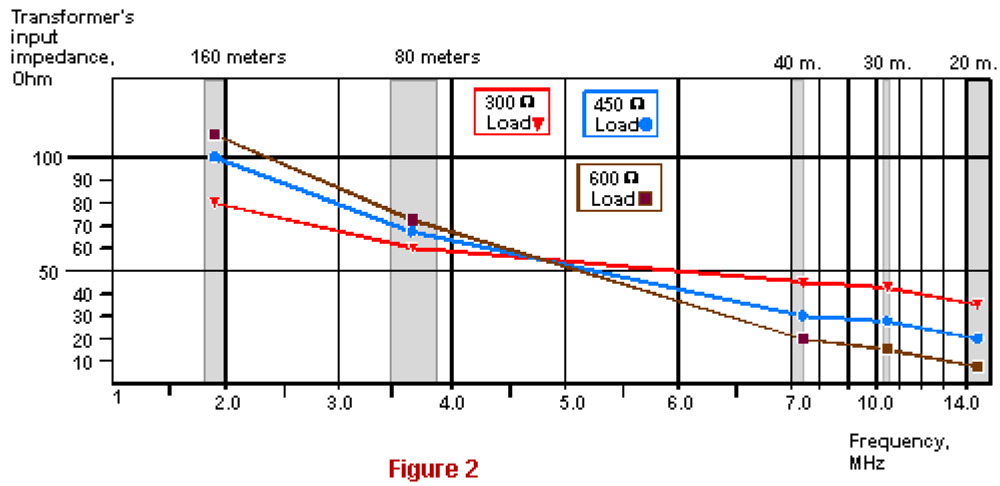


Figure 2

VSWR relative to 50 Ohms vs. frequency

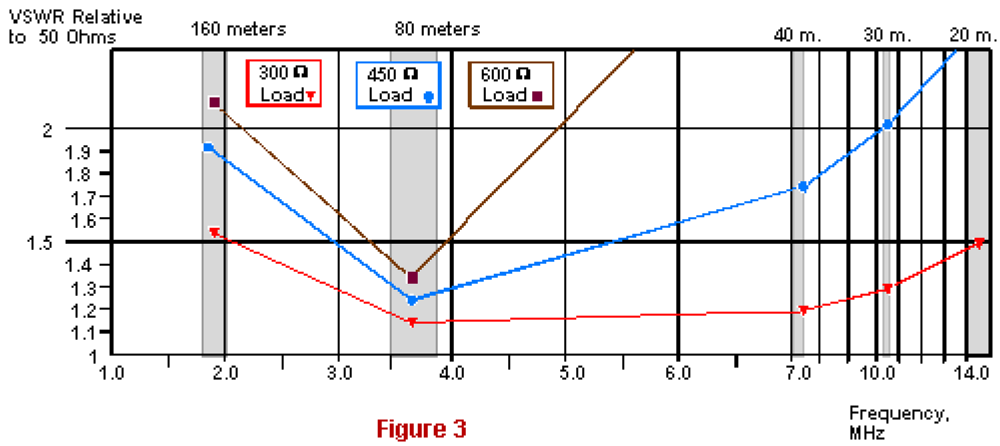


Figure 3

VSWR relative to 75 Ohms vs. frequency

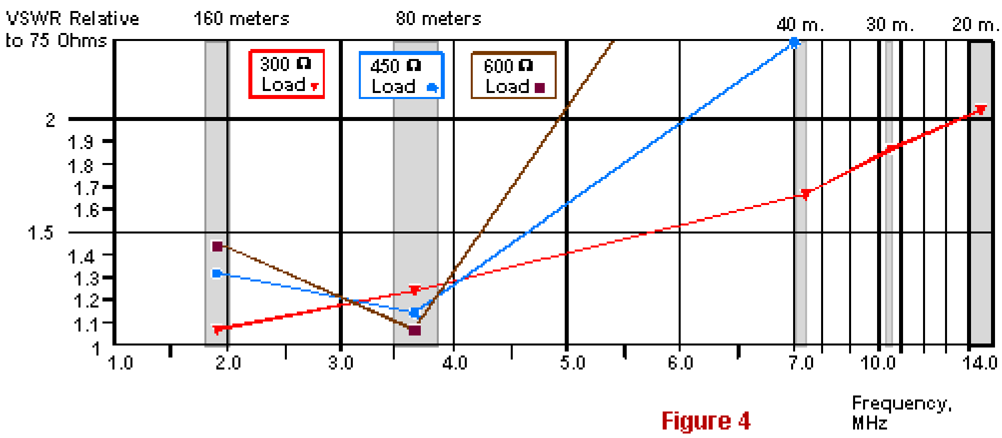


Figure 4

Conclusion for the connection shown in Fig. 1: The autotransformer can be used in a transmission and reception mode on a range of 80 meters while this one loaded to 600 Ohms. (An antenna Beverage or T2FD can be such a load.) The autotransformer should be used with a 75-Ohm coaxial cable. The maximum of the RF power going to the transformer must be limited to 50 watts.

The efficiency vs. frequency

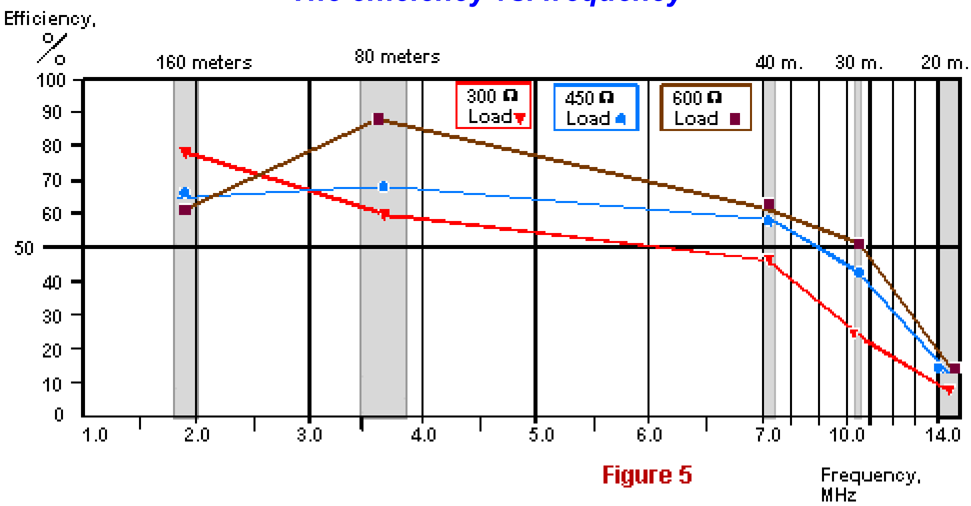


Figure 5

On ranges of 160 -80 meters it is possible to use the autotransformer only for a reception mode with the transformer loaded to 450 or 600 Ohms and its primary winding is connected to a 75-Ohm coaxial cable. On ranges of 160 -40 meters it is possible to use the autotransformer only for a reception mode with the transformer loaded to 300 Ohms and its primary winding is connected to a 50-Ohm coaxial cable.

Note: Do not use the transformer without a load! It causes a high VSWR and damage to the transformer. If the transformer is used outside it should be protected against atmospheric influences. It is possible to use an egg from a sweet – surprise “Chupa - Chups” for such a protection.

One more application - An RF ammeter

I found one more useful application for AT-33T transformer. This one was turned to **a current transform for an RF ammeter.** You need to add only a current loop to AT-33T transformer and this one will be a current transformer for an RF ammeter. The current loop (or a current winding) contains only one turn of a wire placed on a cheek of transformer's core (see **Fig. 6**). There was used a copper wire of 0.8 mm in diameter/# 20 AWG.

I found that the 24 volt winding (**Fig. 7A**) as well as the inverter's winding (**Fig. 7B**) works as well as the meter's winding. A germanium diode was used in an RF detector at the meter's winding. A d.c. meter had a 1mA full scale deflection and 140-Ohm resistance. To verify the work of the RF ammeter made on the base of AT-33T transformer I connected it in serial with a control ammeter. **Fig. 8** shows the circuit. **Note:** A control ammeter was a home brew RF ammeter designed by the reference **[1]**. The RF ammeter was calibrated with the help of a standard measuring equipment.

Tab. 4 contains testing data for the RF ammeter shown in **Fig. 8.** Using data from **Tab. 4** I made diagrams “meter reading vs. frequency” to the 24 volt winding and to the inverter's winding (see **Fig. 9**). The curve shows that the inverter's winding (**A- B**) is the optimal winding for application in the RF ammeter made on the base of AT-33T transformer.

Current loop on the transformer side

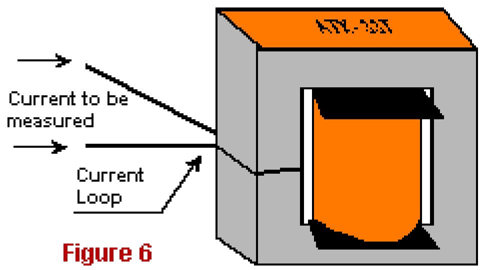
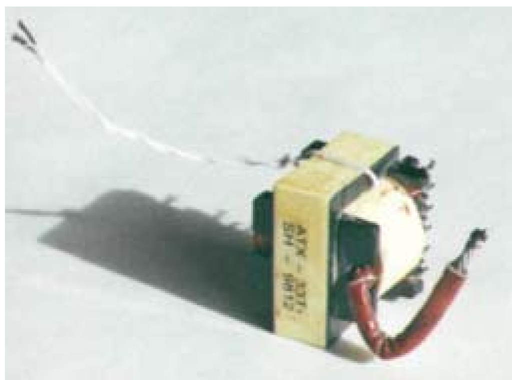
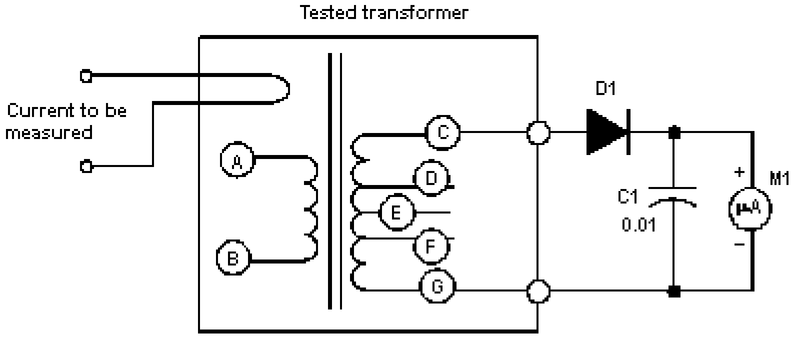


Figure 6

Current loop on the transformer side

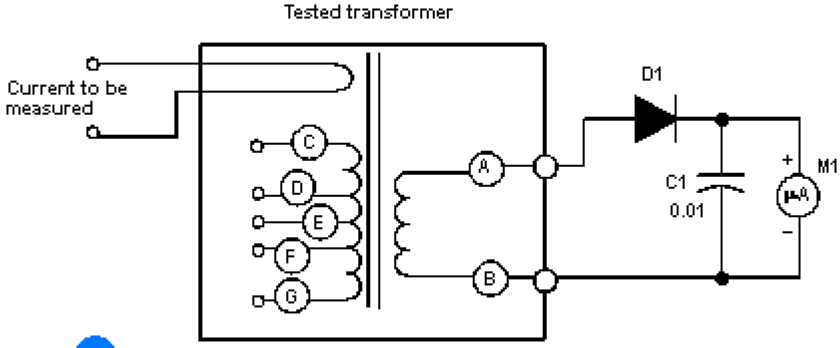


Schematic diagram of the current transformer



A Figure 7

D1- RF - diode, germanium, 1N34A, 1N82A
M1- DC - μ ammeter, 0-1000 μA



B Figure 7

D1- RF - diode, germanium, 1N34A, 1N82A
M1- DC - μ ammeter, 0-1000 μA

Circuit for testing of the RF ammeter

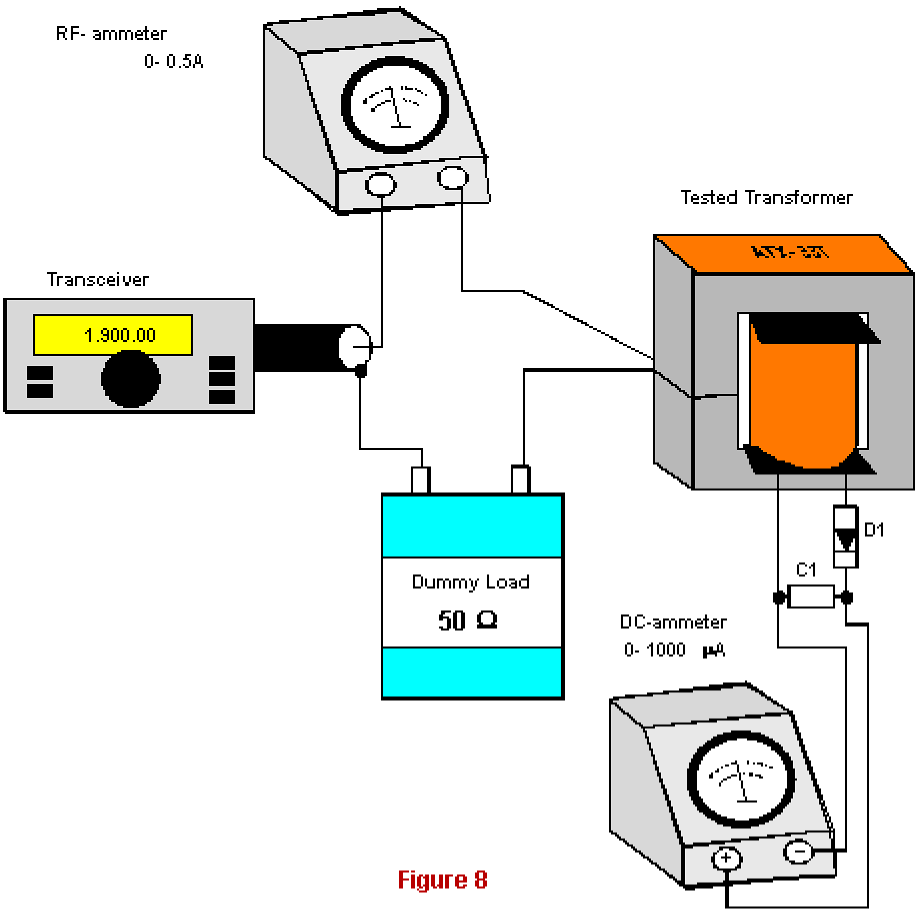


Figure 8

Table 4 Data for the 24 volts winding and for inverter's winding

Frequency, MHz	1.9	2.0	2.3	2.5	2.8	3.0	3.4	3.7	4.2	5.0	6.2	7.1	10.0	14.2
24-V winding, Meter reading, µA	1000	900	750	700	660	580	500	410	250	160	80	80	60	15
Inverter's winding, Meter reading, µA	700	680	660	650	630	600	550	520	500	420	380	380	280	120

Note: The RF current through a current loop is constant on all frequencies and equals to 0.26A

Meter reading vs. frequency

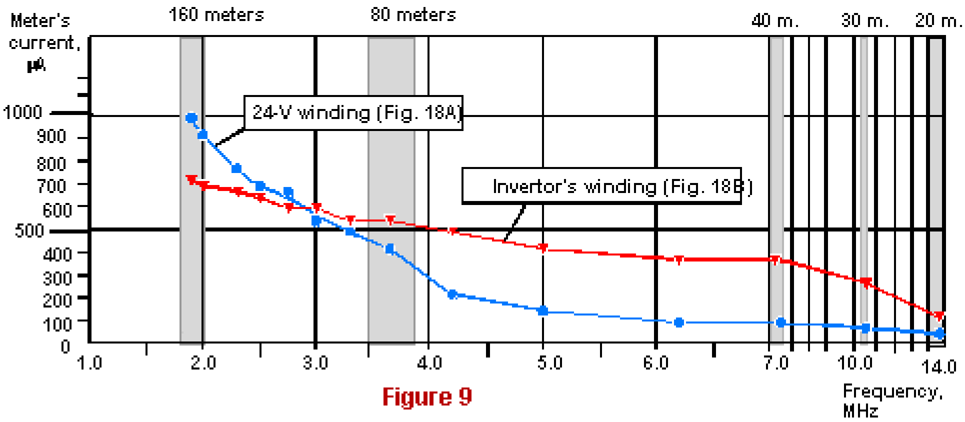


Figure 9

Linear RF ammeter

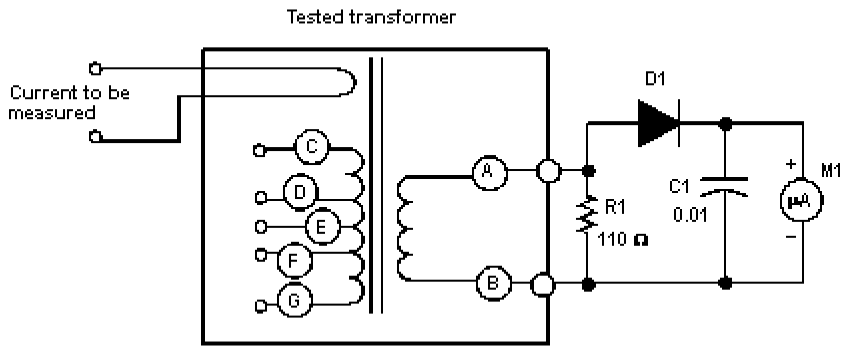


Figure 10

D1- RF - diode, germanium, 1N34A, 1N82A
M1- DC - µ ammeter, 0-100 µA

The RF ammeter has two drawbacks. Firstly, it works on a limited frequency range, to 7 MHz for my test. Secondly, the RF ammeter is too frequency dependent. I eliminated these defects to a certain extent. A low- resistance resistor R1 bridged to the meter's winding reduces the frequency dependence and extends the frequency range. Fig. 10 shows the circuit for the "linear" RF ammeter. A germanium diode was used in the RF detector of the "linear" RF ammeter. A d.c. meter had a 100μA full scale deflection and 320-Ohm resistance.

I picked up a value of the R1 that while at 1.5 MHz the control RF ammeter showed the RF current of 0.1A the detector's meter had a full-scale deflection of 100μA. R1 had 110 Ohms in this case. All other measurements were made at RF current of 0.1A and R1 of 110 Ohms. Data for the measurements are shown in Tab. 5. Using data from this table I constructed diagrams "meter reading vs. frequency" (see Fig. 11).

Table 5 Linear RF ammeter

Frequency, MHz	1.5	3.0	3.6	7.0	10.0	14.2
Meter reading, μA	100	95	93	90	90	50

Note: The RF current through a current loop is constant on all frequencies and equals to 0.1A

Fig. 11 shows that the RF ammeter (Fig. 10) provides almost linear measurement of the RF current on ranges of 160- 30 meters. It is possible to expand the measuring range of the RF ammeter with the help of a variable resistor connected in serial with the d.c. meter. Fig. 12 shows such a RF ammeter with an expanded scale.

Meter reading vs. frequency

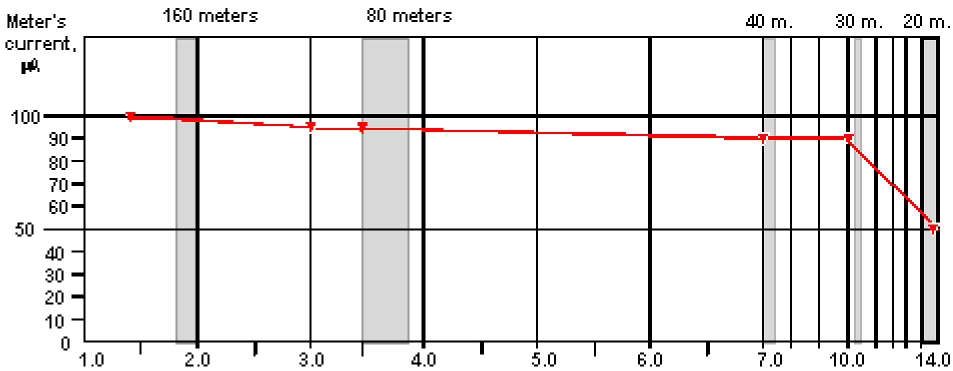


Figure 11

RF ammeter with an expanded scale

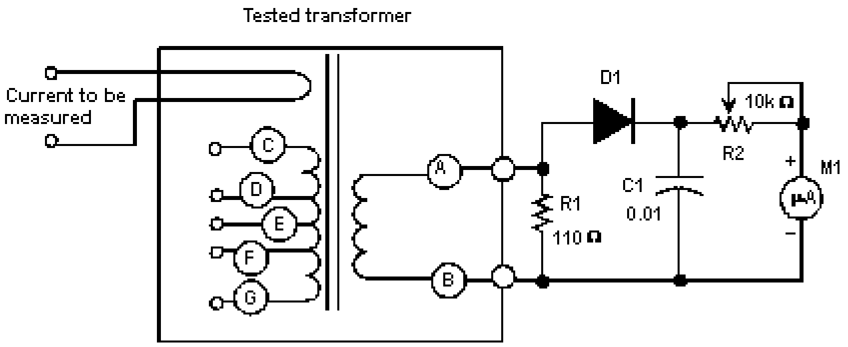


Figure 12

D1- RF - diode, germanium, 1N34A, 1N82A
M1- DC - μ ammeter, 0-100 μA

Conclusion: It is possible to use AT-33T transformer in design of an RF ammeter. However, large dimensions of AT-33T transformer and the limited frequency range of an RF ammeter made on its base are the drawbacks of its application.

If you want the RF ammeter to work linearly on 160 - 30 meters use circuits given in **Fig. 11 –12.** The drawback of these circuits is that an expensive d.c. micro - ammeter of a 100μA full- scale deflection is used there.

If you need an RF ammeter for only one amateur range of 160, 80 or 40 meters, or you do not need linearity from your RF ammeter while this one is working on these ranges, use the circuit given in **Fig. 7.** In this case an inexpensive micro-ammeter with a 1000μA full- scale deflection will do well.

SUPPLEMENTARY,

….or several words about my researches of the AT-33T- transformer….

Researches the opportunity

Fig. 13 3 shows the measurement circuit for researches the opportunity. The primary winding (**A - B** in **Fig. 3**) was loaded to 300, 450, 600 Ohms. Using different ways the secondary winding (**C- G** in **Fig. 13)** was connected to my home brew RF-bridge (this one was described in the reference **[1]**). My transceiver K-116 fed the RF-bridge. I made a lot of experiments and a lot of data for using of the ATX-33T by way of an RF transformer were obtained. Most interesting data will show below.

Measurement circuit

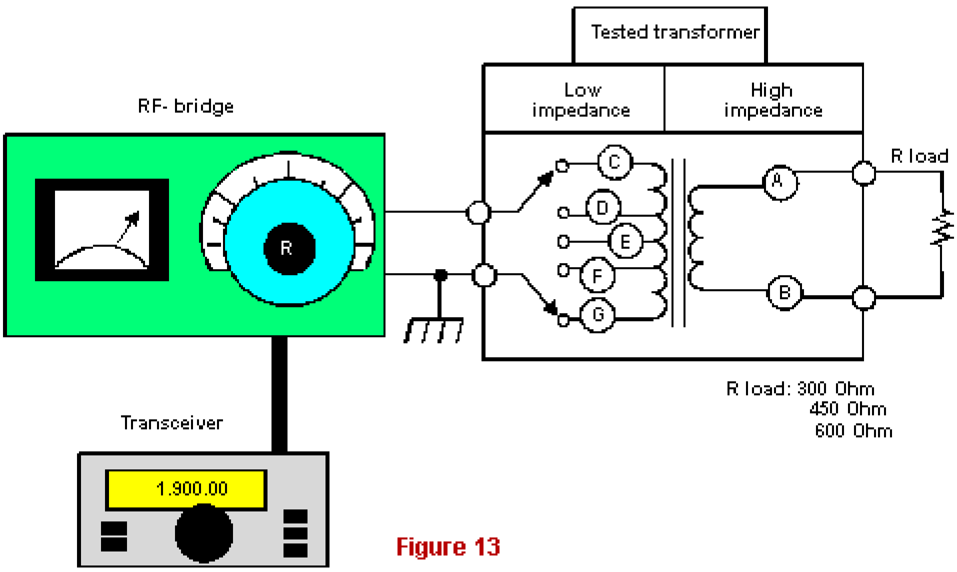


Figure 13

Efficiency is the first

However, what about an RF transformer has own input resistance close to 50 Ohms, when it loaded to 300-600 Ohms? It cannot serve as a final confirmation about its suitability for transfer an RF energy. Any RF transformer should have a good ***efficiency***. Efficiency (Eff) is relation of a power, which transformer's load is dissipated (P_1), to a power going from a transmitter to the transformer (P_2). We can write the formula as:

$$Eff = P_1/P_2,$$

Thus I took an important attention to measuring of the efficiency. I used only one circuit (see **Fig. 13**) for measurement of an input resistance, but I used three different circuits for metering of the efficiency! Each of the circuits gave own metering error, and demanded specific measuring devices. I want to write about all of the three circuits, because, they can be useful to hams who wants to do own experiments with other types of PSU transformers.

Fixing of the efficiency with the help of RF-ammeters

Fig. 14 shows very obvious and simple circuit for "current" method of measurement of the efficiency. Both RF currents, going to the transformer and to the load, were metered. I metered the RF currents by self-made RF ammeters (the RF ammeters were described in reference **[1]**, pp. 21-22, 27- 31). When the RF currents are fixed, it is possible to find the efficiency of the RF transformer. The efficiency (Eff) is equal:

$Eff = P_1/P_2,$

Where:

P_1- a dissipated power by the load,
P_2 - a consumed power by the transformer.

P1 and P2 are equal:

$$P_1 = I^2R,$$

$$P_2 = It^2Rt,$$

Where:
I - a current going to transformer load,
It - a current going to the transformer from a transmitter,
R – the transformer's load resistance,
Rt – an input resistance of the transformer.
Here **P** is in watts, **V**, **I**, **R** are in volts, amperes and ohms.

Finding the efficiency by means of metering of RF currents

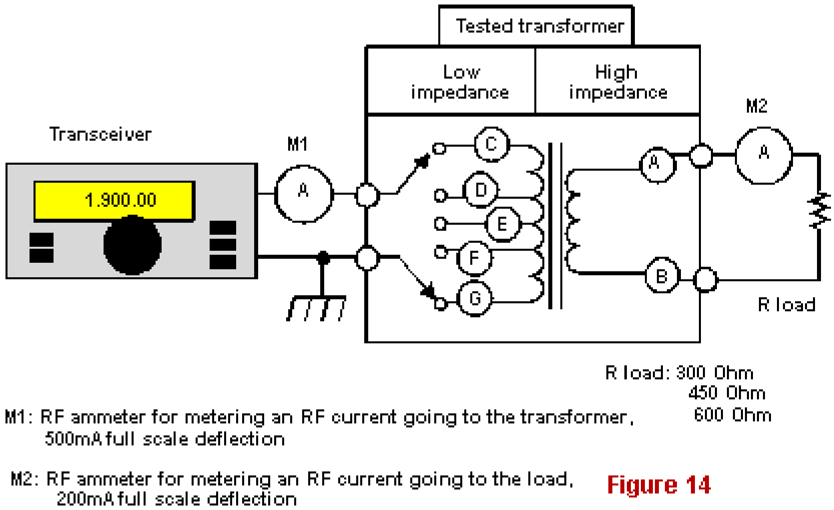


Figure 14

A transformer load resistance is known. Transformer's input resistance was early obtained by the circuit shown in **Fig. 13**. Thereby it is easy to find the efficiency. **Note:** The efficiency of the transformer was defined when a RF power of 10 watts gone to the transformer.

Instead of this it is possible to use another method.

Fixing of the efficiency with the help of RF-voltmeters

It is very easy to find the efficiency using the circuit shown on **Fig. 14.** However, RF ammeters are not widely used in a ham practice, on other hand RF voltmeters are common used devices. As result of this many hams would prefer to find the efficiency using only RF voltmeters. The "voltage" method is shown in **Fig. 15**. I used several RF voltmeters for my experimenters. One RF voltmeter was a commercial made Russian RF voltmeter, model VC-7 -4. Others voltmeters were home made, the reference **[1]** shows its circuits. I used a commercial made Russian oscilloscope model N-3015 like an RF voltmeter for several experimenters. Remember an oscilloscope shows a peak – to peak (p-p) value of RF voltage, the RF Vrms (root – mean – square) is root square from V p-p. Certainly, usually an oscilloscope has much more metering error then a good RF voltmeter.

It is possible to find the efficiency of the RF transformer when both RF voltages, one at a transformer load another at the primary winding, are fixed. The efficiency (Eff) is equal:

$$Eff = P_1/P_2,$$

Where:

P_1- a dissipated power by the load,
P_2 - a consumed power by the transformer.

P_1 and P_2 are equal:

$$P_1 = V_1^2/R;$$

$$P_2 = V_2^2/Rt,$$

Where:

V_1 – an RF voltage across a transformer load,
V_2 - an RF voltage across the primary winding of an RF transformer,
Rt – an input resistance of an RF transformer,
R – a resistance of a transformer load.

Where:

P_1- a dissipated power by the load,
P_2 - a consumed power by the transformer.

P1 and P2 are equal:

$$P_1 = I^2R,$$

$$P_2 = It^2Rt,$$

Where:
I - a current going to transformer load,
It - a current going to the transformer from a transmitter,
R – the transformer's load resistance,
Rt – an input resistance of the transformer.
Here **P** is in watts, **V**, **I**, **R** are in volts, amperes and ohms.

Finding the efficiency by means of metering of RF currents

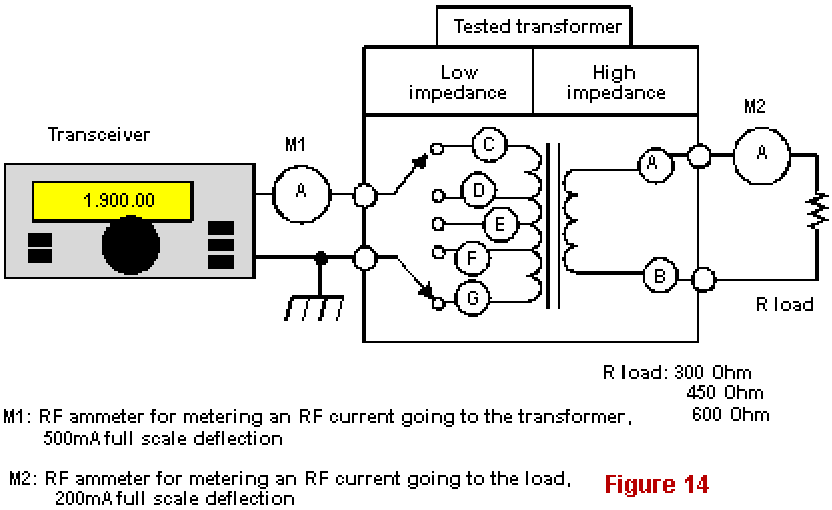


Figure 14

A transformer load resistance is known. Transformer's input resistance was early obtained by the circuit shown in **Fig. 13**. Thereby it is easy to find the efficiency. **Note:** The efficiency of the transformer was defined when a RF power of 10 watts gone to the transformer.

Instead of this it is possible to use another method.

Fixing of the efficiency with the help of RF-voltmeters

It is very easy to find the efficiency using the circuit shown on **Fig. 14.** However, RF ammeters are not widely used in a ham practice, on other hand RF voltmeters are common used devices. As result of this many hams would prefer to find the efficiency using only RF voltmeters. The "voltage" method is shown in **Fig. 15**. I used several RF voltmeters for my experimenters. One RF voltmeter was a commercial made Russian RF voltmeter, model VC-7 -4. Others voltmeters were home made, the reference **[1]** shows its circuits. I used a commercial made Russian oscilloscope model N-3015 like an RF voltmeter for several experimenters. Remember an oscilloscope shows a peak – to peak (p-p) value of RF voltage, the RF Vrms (root – mean – square) is root square from V p-p. Certainly, usually an oscilloscope has much more metering error then a good RF voltmeter.

It is possible to find the efficiency of the RF transformer when both RF voltages, one at a transformer load another at the primary winding, are fixed. The efficiency (Eff) is equal:

$$Eff = P_1/P_2,$$

Where:

P_1- a dissipated power by the load,
P_2 - a consumed power by the transformer.

P_1 and P_2 are equal:

$$P_1 = V_1^2/R;$$

$$P_2 = V_2^2/Rt,$$

Where:

V_1 – an RF voltage across a transformer load,
V_2 - an RF voltage across the primary winding of an RF transformer,
Rt – an input resistance of an RF transformer,
R – a resistance of a transformer load.

Finding the efficiency by RF voltages

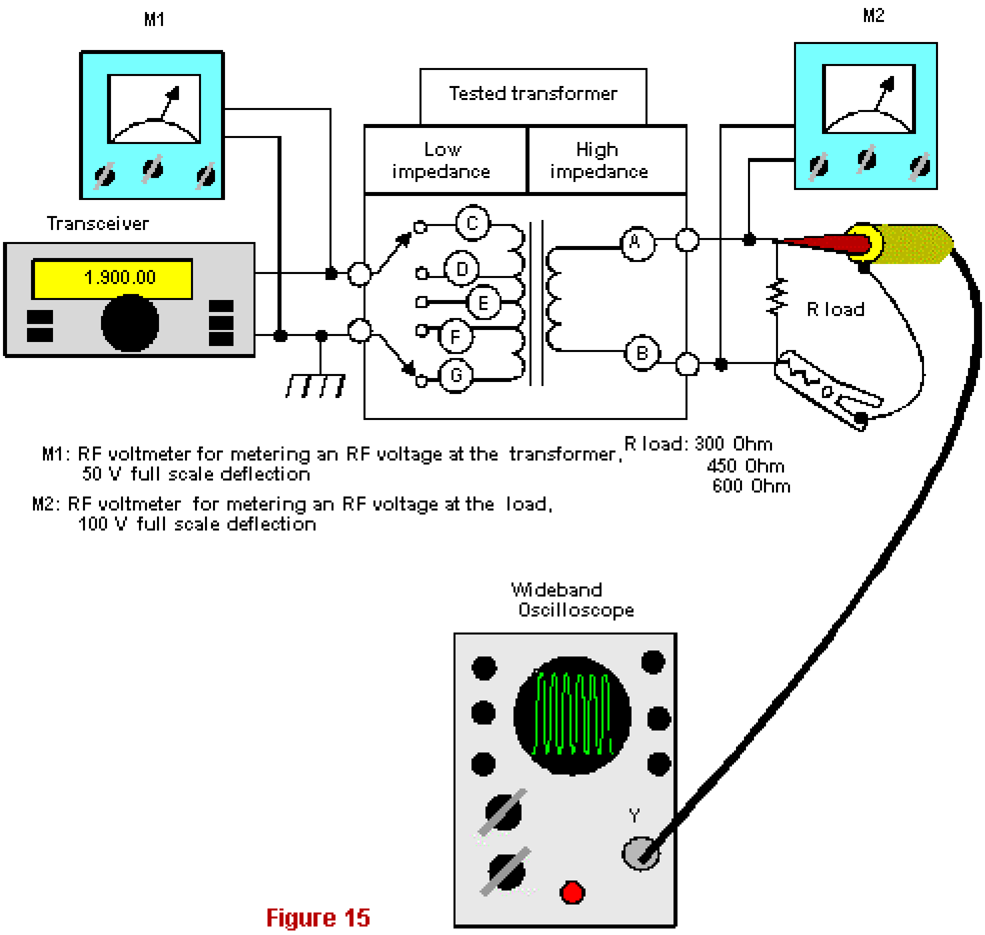


Figure 15

Here **P** is in watts, **V**, **I**, **R** are in volts, amperes and ohms. A transformer load resistance is known. Transformer's input resistance was early obtained by the circuit shown in **Fig. 13**. Thereby it is easy to find the efficiency. **Note:** The efficiency of the transformer was defined when a RF power of 10 watts gone to the transformer.

Both above described methods gave almost identical values of the efficiency for my RF transformer. However all the methods demanded special measuring RF equipment, such as an RF ammeter, an RF voltmeter or an RF oscilloscope. Not each of hams has the equipment. So I used one more method for finding of the efficiency. The method is named "a method of a poor ham", because it does not demand any RF measuring equipment!

"A method of a poor ham"

If a ham has not any special measuring RF equipment, he can use an indirect method for definition of the efficiency. **Fig. 16** shows the measuring scheme for the indirect method. The RF transformer is connected to a transmitter having a variable power. An incandescent bulb is bridged to the primary winding of the RF transformer. Other incandescent bulb is connected in serial with a load resistor at the load side. The bulb and the resistor form a load for the RF transformer.

I used incandescent bulbs of 26-V/0.12-A both at the primary winding side and at the load side. The common resistance (a serial resistor + a bulb) should provide one of standard load resistances - 300, 450 or 600 Ohms. **Tab. 6** shows needed values of the serial resistor for forming the standard load resistances. Columns of **Tab. 6** contain two values of the serial resistor. The upper value is a calculated value. The down value (in brackets) is the closest value of a standard resistance to the calculated value.

Note: The serial resistor was calculated under the hypothesis, that the incandescent bulb has 216 Ohms when 26 volts of RF is across this one (26 volts/0.12 amperes = 216.6 Ohms). Certainly, a bulb has a different resistance at the same value of direct or RF current through it, so, the bulb gives not the same shining at the same value of direct or RF current through it, but for our case the difference in the shining is very small.

Poor ham method of measuring of the efficiency

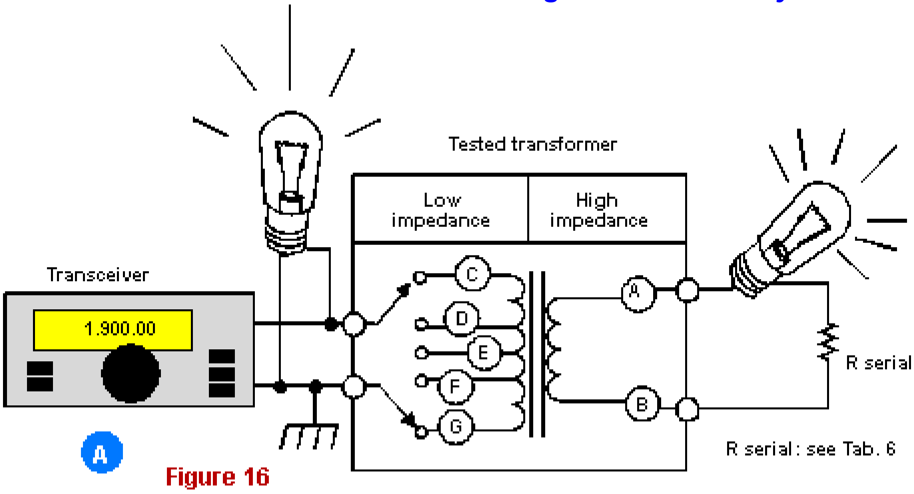


Figure 16

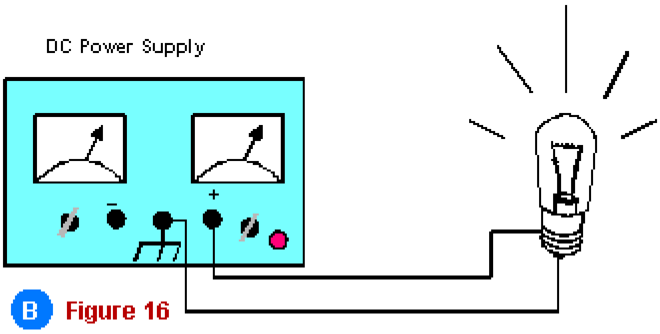


Figure 16

Table 6 Serial resistor and dissipated power at transformer's load

Load resistance, Ohms	300	450	600
Resistance of the serial resistor, Ohms	84 (75)	234 (220)	384 (390)
Dissipated power at transformer's load (the serial resistor plus the bulb), Watts	4.3	6.55	8.46

How to find the efficiency:

- A transmitter stands at a minimal RF power.
- Smoothly to increase the RF power of the transmitter.
- The load bulb should have the same glow like this one has at 26 volts d.c.
- In this case we make a decision, that, an RF voltage of 26 volts is acting across the bulb and an RF current of 0.12 amperes is going through the bulb.

Hence it is possible to calculate a power, which is dissipated at transformer's load (the bulb plus the resistor). Use **Tab. 6** for this. The table shows a full power, which is dissipated at transformer's load at a full glow the incandescent bulb.

The first stage in definition of the efficiency of the RF transformer is completed. Go to the second stage. We should find going an RF power to the transformer.

- Take attention to the incandescent bulb, which is bridged to the input winding, and fix (at your memory) its glow.

- Then do this bulb connected to a variable d.c. PSU (see **Fig. 16B**).

- Smoothly to increase the d.c voltage up to the level, when the bulb has the same glow that this one has had at the RF current.
- Fix the d.c voltage on PSU's meter.
- In this case we make a decision, the d.c voltage has the same level like that RF voltage across the bulb.
- Hence it is possible to calculate going from the transmitter into the RF transformer power. The power is:

$$P = V^2/R,$$

Where: P- a power, going to the transformer,
V – an RF voltage across input winding,
R – a resistance of input winding.

We know both the dissipated power at the load and the power going into the input winding. So, it is possible to find the efficiency. Certainly, the indirect method gives us a big error. However it is a very simple method, and even a beginner radio amateur can do it.

Note: When the incandescent bulb at the input winding is glowing to its full brightness, the RF power, going to the RF transformer, is close to 10-15 watts. When the incandescent bulb at transformer's load is glowing to a full brightness, the dissipated RF power (in the load) is of 4-9 watts (see **Tab. 6**). Hence, using the indirect method, and at a full luminescence of load's bulb of 26V/0.12A, it is possible to find values of the efficiency in limits of 40-90 percents. To increase the limits, it need connect a resistor (either the same bulb) in serial together with the bulb at the input winding.

Reference:

1. Grigorov I.N.: Antenna. Matching and tuning.- Moscow, RadioSoft, 2002.
ISBN: 5- 93037- 087- 7

Good Bye Buran and Station "MIR" Good Fly in our Memory!

Tesla Wireless and the Tunguska Explosion

Tesla's writings have many references to the use of his wireless power transmission technology as a directed energy weapon. These references are examined in their relationship to the Tunguska explosion of 1908 which may have been a test firing of Tesla's energy weapon.

This article was first published in a different form in 1990. The idea of a Tesla directed energy weapon causing the Tunguska explosion was incorporated in a fictional biography (1994), by another writer, and was the subject of a *Sightings* television program segment.

Tesla's Wireless Power Transmitter and the Tunguska Explosion of 1908

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The French ship *Iena* blew up in 1907. Electrical experts were sought by the press for an explanation. Many thought the explosion was caused by an electrical spark and the discussion was about the origin of the ignition. Lee De Forest, inventor of the Audion vacuum tube adopted by many radio broadcasters, pointed out that Nikola Tesla had experimented with a "dirigible torpedo" capable of delivering such destructive power to a ship through remote control. He noted, though, Tesla also claimed that the same technology used for remotely controlling vehicles also could project an electrical wave of "sufficient intensity to cause a spark in a ship's magazine and explode it." (1)

In the summer of 1913, Signor Giulio Ulivi, blew up a gas meter with his "F-Ray" device and destroyed his laboratory. Then, in August of that year, exploded three mines in the port of Trouville for a number of high ranking French naval officers. The following November, he travelled to Splezzia, Italy to repeat the experiments on several old ships and torpedo boats for that country's navy.(2)

In the Spring of 1924 newspapers carried several stories about "death rays" inventions in different parts of the world. The work of Harry Grindell-Matthews, London, was the first reported. The *New York Times* of May 21st had this one:

> Paris, May 20 - If confidence of Grindell Matthews, inventor of the so-called ' diabolical ray,' in his discovery is justified it may become possible to put the whole of an enemy army out of action, destroy any force of airplanes attacking a city or paralyze any fleet venturing within a certain distance of the coast by invisible rays. So much the inventor consented to tell The New York Times correspondent today while continuing to refuse to divulge the exact nature of the rays beyond that they are used to direct an electric current able to perform the program just mentioned.[(3)]

Grindell-Matthews stated that his destructive rays would operate over a distance of four miles and that the maximum distance for this type of weapon would be seven or eight miles. Asked if it would be possible to destroy an approaching enemy fleet, the inventor said it would not, because "Ships, like land, are in continual contact with the earth, but what I can do is to put the ships out of action by the destruction of vital parts of the machinery, and also by putting the crews temporarily out of action through shock."[(4)] Airplanes, on the other hand, could be completely destroyed. As soon as his ray touched the plane it would burst into flames and fall to earth.

Grindell-Matthews asserted, "I am convinced the Germans possess the ray." He believed, though, they were carrying out their experiments with high frequencies and at high power, around 200 kilowatts, and could not control the weapon to hit a specific target. So far, said Grindell-Matthews, he had tried tests at 500 watts in his laboratory over a distance of sixty-four feet.

A French company, the Great Rhone Engineering Works of Lyon, had offered Grindell-Matthews extensive financial backing that would allow him to test his device at much higher power levels. He replied that would not undertake such tests "except under conditions of absolute safety on a wide tract of uninhabited land," such was the destructive power of his rays.

Details of the "diabolical rays'" destructive power surfaced that August. "Tests have been reported where the ray has been used to stop the operation of automobiles by arresting the action of the magnetos, and an quantity of gunpowder is said to have been exploded by playing the beams on it from a distance of thirty-six feet."[(5)] Grindell-Matthews was able, also, to electrocute mice, shrivel plants, and light the wick of an oil lamp from the same distance away.[(6)]

His own laboratory assistants were themselves became unintentional victims of the ray. When crossing its path during tests they were either knocked unconscious by violent electrical shocks or received intense burns. The inventor stated that though it would be possible to kill enemy infantry with the ray, "it would be quite easy to graduate the electric power used so that hostile troops would only be knocked out long enough to effect their capture."[(7)]

On May 25th, a second death ray was announced in England. Doctor T.F. Wall, a "lecturer in electrical research in Sheffield University, "applied for a patent for means of transmitting electrical energy in any direction without the use of wires. According to one report. even though he has not made tests on a large scale yet "Dr. Wall expressed the belief that his invention would be capable of destroying life, stopping airplanes in flight and bringing motor cars to a standstill." On a more positive note, he added that his invention would have beneficial applications in surgical and medical operations.[(8)]

Germany joined the technology race on May 25th when it announced its electrical weapon. As the *Chicago Tribune* reported:

> Berlin - That the German Government has an invention of death rays that will bring down airplanes, halt tanks on the battlefields, ruin automobile motors, and spread a curtain of death like the gas clouds of the recent war was the information given to Reichstag members by Herr Wulle, chief of the militarists in that body. It is learned that three inventions have been perfected in Germany for the same purpose and have been patented.

Sensing something of importance the *New York Times* copyrighted its story of May 28th on a ray weapon developed by the Soviets. The story opened: "News has leaked out from the Communist circles in Moscow that behind Trotsky's recent war-like utterance lies an electromagnetic invention, by a Russian engineer named Grammachikoff for destroying airplanes."[(9)]

Tests of the destructive ray, the *Times* continued, had began the previous August with the aid of German technical experts. A large scale demonstration at Podosinsky Aerodome near Moscow was so successful that the revolutionary Military Council and the Political Bureau decided to fund enough electronic anti-aircraft stations to protect sensitive areas of Russia. Similar, but more powerful, stations were to be constructed to disable the electrical mechanisms of warships. The Commander of the Soviet Air Services, Rosenholtz, was so overwhelmed by the ray weapon demonstration that he proposed "to curtail the activity of the air fleet, because the invention rendered a large air fleet unnecessary for the purpose of defense."

An English engineer, J.H. Hamil, offered the American army plans for producing " an invisible ray capable of stopping airplanes and automobiles in midflight," invented by a German scientist. The ray device was said to have been used the previous summer to bring down French planes over Bavaria. Hamil noted, however, that "the fundamental work was done by Nikola Tesla in Colorado Springs about 30 years ago. He built a powerful electrical coil. It was found that the dynamos and other electrical apparatus of a Colorado fuel company within a 100 yards or so were all put out of business.[10]

Hamil believed the Tesla coil scattered rays which short- circuited electrical machinery at close range. Laboratories all over the world, he added, were testing methods of stepping up the Tesla coil to produce its effects at greater distances. "Working on an entirely different principle," Hamil said, "the German scientist has succeeded in projecting and directing electrical power."

Those Colorado Springs tests carried out by Tesla were well remembered by local residents. With a 200 foot pole topped by a large copper sphere rising above his laboratory he generated potentials that discharged lightning bolts up to 135 feet long. Thunder from the released energy could be heard 15 miles away in Cripple Creek. People walking along the streets were amazed to see sparks jumping between their feet and the ground, and flames of electricity would spring from a tap when anyone turned them on for a drink of water. Light bulbs within 100 feet of the experimental tower glowed when they were turned off. Horses at the livery stable received shocks through their metal shoes and bolted from the stalls. Even insects were affected: Butterflies became electrified and "helplessly swirled in circles - their wings spouting blue halos of 'St. Elmo's Fire.'"[11]

The effect that captured the attention of foreign death ray inventors occurred at the Colorado Springs Electric Company powerhouse. One day while Tesla was conducting a high power test, the crackling from inside the laboratory suddenly stopped. Bursting into the lab Tesla demanded to know why his assistant had disconnected the coil. The assistant protested that had not done anything. The power from the city's generator, the assistant said, must have quit. When the angry Tesla telephoned the power company he received an equally angry reply that the power company had not cut the power, but that Tesla's experiment had destroyed the generator!

The inventor explained to *The Electrical Experimenter*, in August of 1917 what had happened.

> As an example of what has been done with several hundred kilowatts of high frequency energy liberated, it was found that the dynamos in a power house six miles away were repeatedly burned out, due to the powerful high frequency currents set up in them, and which caused heavy sparks to jump thru the windings and destroy the insulation! The lightning arresters in the power house showed a stream of blue-white sparks passing between the metal plates to the earth connection.[12]

When questioned about the Ulivi ray that created so much comment a few years earlier, Tesla asserted, in the same interview, that "it was transplanted from this country to Italy." He saw it as simply a modification of his ultra-powerful high frequency coil tested in Colorado. With thousands of horsepower[13] of energy "it would become readily possible to detonate powder and munition magazines by means of the high frequency currents induced in every bit of metal, even when located five to six miles away or more."

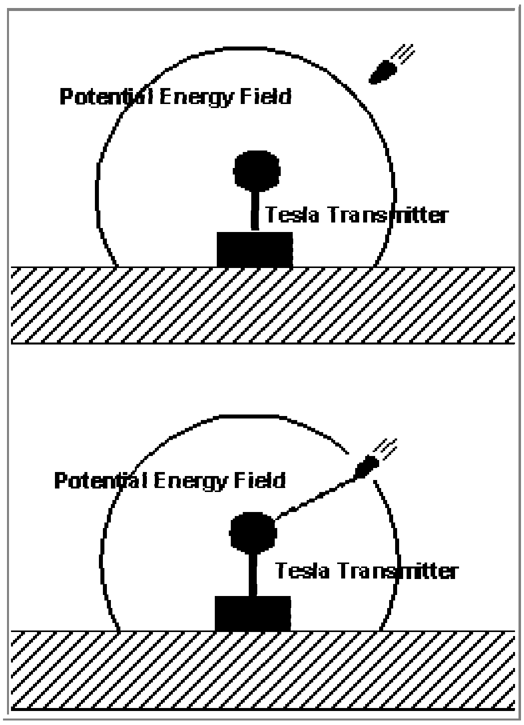
With others attributing an energy weapons technology to Tesla's wireless power transmission research, his comments on the destructive capabilities of his system take on a great deal of importance. Writing tersely for *Liberty* magazine of February 1935 he stated:

> My invention requires a large plant, but once it is established it will be possible to destroy anything, men or machines, approaching within a radius of 200 miles. It will, so to speak, provide a wall of power offering an insuperable obstacle against any effective aggression.[14]

He went on to make a distinction between his invention and those brought forward by others. He claimed that his device did not use any so-called "death rays" because such radiation cannot be produced in large amounts and rapidly become weaker over distance. He likely was making reference to a Grindell-Matthews type of device that, according to contemporary reports, used a powerful ultra-violet beam to make the air conducting so that high energy current could be directed to the target. The range of an ultra-violet searchlight would be much less than what Tesla was claiming. As he put it: "all the energy of New York City (approximately two million horsepower [1.5 billion watts]) transformed into rays and projected twenty miles, would not kill a human being."

Not wanting to give away a potentially valuable creation in an interview, he was intentionally opaque concerning the details of his design. He did clarify how his design differed from the ray type of devices.

My apparatus projects particles which may be relatively large or of microscopic dimensions, enabling us to convey to a small area at a great distance trillions of times more energy than is possible with rays of any kind. Many thousands of horsepower can be thus transmitted by a stream thinner than a hair, so that nothing can resist.



Tesla particle beam system - possible configuration

If Tesla's energy weapon cannot be called a "ray" device, but as one projecting microscopic particles, it would seem that it had to differ from the other designs in one of two ways. Either he was making the distinction between a beam of radiant energy, like a beam from a flashlight that has billions of energy carrying photons, and his own with all of its energy concentrated into a stream a single particle wide, or he was making a distinction about the size of the beam and the method it is used to reach the target.

In a Grindell-Matthews type of beam, the flashlight model, a huge number of high energy particles or photons would have to be sent out from the system so that a large enough area on the target would be covered to disable it. What Tesla seems to have intended was that his energy transmitter would set up a field of force around itself which, when penetrated, would release its energy directly to the target. The effect would be like sending a current of particles through a wire directly to the target. A large area on the target would not have to be "painted" by a beam, so the current reaching the intruder could be very thin and deliver a great deal of energy to a small area.

The Colorado tests that gave rise to the variety of "death ray" inventions in the U.S. and Europe may have lead to the development of a much more powerful weapon.

When Tesla realized that economic forces would not allow the development of a new type of electrical generator that would supply power without burning fuel he "was led to recognize [that] the transmission of electrical energy to any distance through the media as by far the best solution of the great problem of harnessing the sun's energy for the use of man."[(15),(16)] His idea was that a relatively few generating plants located near waterfalls would supply his very high energy transmitters which, in turn, would send power through the earth to be picked up wherever it was needed.

Receiving energy from this high pressure reservoir only would require a person to put a rod into the ground and connect it to a receiver operating in resonance with the electrical motion in the earth. As Tesla described in 1911, "The entire apparatus for lighting the average country dwelling will contain no moving parts whatever, and could be readily carried about in a small valise."[(17)]

The difference between a current used to "light the average country dwelling" and a current used as a method of destruction, however, is a matter of timing. If the amount of electricity used to run a television for an hour is released in a millionth of a second, it would have a very different, and negative, effect on the television.

Tesla said his transmitter could produce 100 million volts of pressure and currents up to 1000 amperes, with experimental power levels of billion or tens of billions of watts.[18] If that amount of power were released in "an incomparably small interval of time,"[19] the energy would be equal to the explosion of millions of tons of TNT, that is, a multi-megaton explosion. Such a transmitter would be capable of projecting the force of a nuclear warhead by radio. Any location in the world could be vaporized at the speed of light.

Not unexpectedly, many scientists doubted the technical feasibility of Tesla's wireless power transmission scheme whether for commercial or military purposes. Modern authorities in electronics, even those who express admiration for the Tesla's genius, believe he was mistaken in the interpretation of his experiments when it came to electrical transmission through the earth.[20],[21],[22]

On the other hand, statements from authoritative witnesses who saw Tesla's equipment in operation support his claim about transmission with something other than the radio waves known today. During the Chicago World's Fair of 1893, the Westinghouse exhibit set up by Tesla was visited by the Herman von Helmholtz, the first director of the Physico-Technical Institute of Berlin and one of the leading scientists of his time. When Tesla "asked the celebrated physicist for an expression of opinion on the feasibility of the [transmission] scheme. He stated unhesitatingly that it was practicable."[23] In 1897, Lord Kelvin visited New York and stopped at the Tesla laboratory where Tesla "entertained him with demonstrations in support of my wireless theory."

> Suddenly [Kelvin] remarked with evident astonishment: 'Then you are not making use of Hertz waves?' 'Certainly not', I replied, '*these are radiations*.' ... I can never forget the magic change that came over the illustrious philosopher the moment he freed himself from that erroneous impression. The skeptic who would not believe was suddenly transformed into the warmest of supporters. He parted from me not only thoroly convinced of the scientific soundness of the idea but strongly exprest his confidence in its success.[24]

A recent analysis of Tesla's wireless transmission method shows that he used an electrostatic transmission technique that did not radiate radio waves as we know them and could sent waves through the earth with little loss of power.[25] The question remains of whether Tesla demonstrated the weapons application of his power transmission system. Circumstantial evidence found in the chronology of Tesla's work and financial fortunes between 1900 and 1908 points to there having been a test of this weapon.

1900: Tesla returned to New York from Colorado Springs after completing the tests of wireless power transmission that destroyed the power company's generator. He received $150,000 from J.P. Morgan to build a transmitter to signal Europe. With the first portion of the money he obtained 200 acres of land at Shoreham, Long Island and built an 187 foot tall tower with a steel shaft running 120 feet into the ground. This tower was topped with a 55 ton, 68 foot diameter metal dome. He called the research site "Wardenclyffe" and envisioned 2000 people eventually working at his global communications center.

A stock offering is made by the Marconi company. Supporters of the Marconi Company include his old adversary Edison and one-time associate Michael Pupin. Investors rushed to buy the Marconi shares. On December 12th, Marconi sent the first transatlantic signal, the letter "S," from Cornwall, England to Newfoundland, Canada. He did this with, as the financiers noted, equipment much less costly than that being built by Tesla.

1902: The Wardenclyffe transmitter nears completion. Marconi is hailed as a hero around the world while Tesla is seen as a shirker by the public for ignoring a call to jury duty in a murder case (he was excused from duty because of his opposition to the death penalty).

1903: When Morgan sent the balance of the $150,000, it would not cover the outstanding balance Tesla owed on the Wardenclyffe construction. To encourage a larger investment in the face of Marconi's success, Tesla revealed to Morgan his real purpose was not to just send radio signals but the wireless transmission of power to any point on the planet. Morgan was uninterested and declined to provide further funding.

A financial panic that Fall put an end to Tesla's hopes for financing by Morgan or other wealthy industrialists. This left Tesla without money even to buy the coal to fire the transmitter's electrical generators.

1904 - 1906: Tesla writes for the *Electrical World*, "The Transmission of Electrical Energy Without Wires," noting that the globe, even with its great size, responds to electrical currents like a small metal ball.
Tesla declares to the press the completion of Wardenclyffe. Marconi is hailed as a world hero.

Tesla subject to multiple law suits over unpaid Colorado Springs expenses. George Westinghouse, who bought Tesla's patents for alternating current motors and generators in the 1880's, turns down the inventor's power transmission business proposal. Workers gradually stop coming to the Wardenclyffe laboratory when there are no funds to pay them. In an article, Tesla comments on Peary's expedition to the North Pole and tells of his, Tesla's, plans for energy transmission to any central point on the ground.

1907: When commenting on the destruction of the French ship *Iena,* Tesla noted in a letter to the *New York Times* that he has built and tested dirigible torpedoes (remotely controlled torpedoes), but that electrical waves would be more destructive. "As to projecting wave energy to any particular region of the globe ... this can be done by my devices," he wrote. Further, he claimed that "the spot at which the desired effect is to be produced can be calculated very closely, assuming the accepted terrestrial measurements to be correct."[26]

1908: Tesla repeated the idea of destruction by electrical waves to the newspaper on April 21st. His letter to the editor stated, "When I spoke of future warfare I meant that it should be conducted by direct application of electrical waves without the use of aerial engines or other implements of destruction." He added: "This is not a dream. Even now wireless power plants could be constructed by which any region of the globe might be rendered uninhabitable without subjecting the population of other parts to serious danger or inconvenience."[27]

In the period from 1900 to 1910 Tesla's creative thrust was to establish his plan for wireless transmission of energy. Undercut by Marconi's accomplishment, beset by financial problems, and spurned by the scientific establishment, Tesla was in a desperate situation by mid-decade. The strain became too great by 1906-1907 and, according to Tesla biographers, he suffered an emotional collapse.[28],[29] In order to make a final effort to have his grand scheme recognized, he may have tried one high power test of his transmitter to show off its destructive potential. This would have been in 1908.

The Tunguska event took place on the morning of June 30th, 1908. An explosion estimated to be equivalent to 10-15 megatons of TNT flattened 500,000 acres of pine forest near the Stony Tunguska River in central Siberia. Whole herds of reindeer were destroyed. Several nomadic villages were reported to have vanished. The explosion was heard over a radius of 620 miles. When an expedition was made to the area in 1927 to find evidence of the meteorite presumed to have caused the blast, no impact crater was found. When the ground was drilled for pieces of nickel, iron, or stone, the main constituents of meteorites, none were found down to a depth of 118 feet.

Several explanations have been given for the Tunguska event. The officially accepted version is that a 100,000 ton fragment of Encke's Comet, composed mainly of dust and ice, entered the atmosphere at 62,000 mph, heated up, and exploded over the earth's surface creating a fireball and shock wave but no crater. Alternative explanations of the disaster include a renegade mini-black hole or an alien space ship crashing into the earth with the resulting release of energy.

Associating Tesla with the Tunguska event comes close to putting the inventor's power transmission idea in the same speculative category as ancient astronauts. However, historical facts point to the possibility that this event was caused by a test firing of Tesla's energy weapon.

In 1907 and 1908, Tesla wrote about the destructive effects of his energy transmitter. His Wardenclyffe facility was much larger than the Colorado Springs device that destroyed the power station's generator. Then, in 1915, he stated bluntly:

> It is perfectly practical to transmit electrical energy without wires and produce destructive effects at a distance. I have already constructed a wireless transmitter which makes this possible. ... But when unavoidable [it] may be used to destroy property and life. The art is already so far developed that the great destructive effects can be produced at any point on the globe, defined beforehand with great accuracy (emphasis added).[30]

He seems to confess to such a test having taken place before 1915, and, though the evidence is circumstantial, Tesla had the motive and the means to cause the Tunguska event. His transmitter could generate energy levels and frequencies capable of releasing the destructive force of 10 megatons, or more, of TNT. And the overlooked genius was desperate.

The nature of the Tunguska event, also, is consistent with what would happen during the sudden release of wireless power. No fiery object was reported in the skies at that time by professional or amateur astronomers as would be expected when a 200,000,000 pound object enters the atmosphere at tens of thousands miles an hour. Also, the first reporters, from the town of Tomsk, to reach the area judged the stories about a body falling from the sky was the result of the imagination of an impressionable people. He noted there was considerable noise coming from the explosion, but no stones fell. The absence of an impact crater can be explained by there having been no material body to impact. An explosion caused by broadcast power would not leave a crater.

In contrast to the ice comet collision theory, reports of upper atmosphere and magnetic disturbances coming from other parts of the world at the time of and just after the Tunguska event point to massive changes in earth's electrical condition. Baxter and Atkins cite in their study of the explosion, *The Fire Came By*, that the *Times* of London editorialized about "slight, but plainly marked, disturbances of ... magnets," which the writer, not knowing then of the explosion, associated with solar prominences.[31]

In Berlin, the New York *Times* of July 3rd reported unusual colors in the evening skies thought to be Northern Lights: "Remarkable lights were observed in the northern heavens ... bright diffused white and yellow illumination continuing through the night until it disappears at dawn."[32] Massive glowing "silvery clouds" covered Siberia and northern Europe. A scientist in Holland told of an "undulating mass" moving across the northwest horizon. It seemed to him not to be a cloud, but the "sky itself seemed to undulate." A woman north of London wrote the London *Times* that on midnight of July 1st the sky glowed so brightly it was possible to read large print inside her house. A meteorological observer in England recounted on the nights of June 30th and July 1st:

> A strong orange yellow light became visible in the north and northeast... causing an undue prolongation of twilight lasting to daybreak on July 1st...There was a complete absence of scintillation or flickering, and no tendency for the formation of streamers, or a luminous arch, characteristic of auroral phenomena...Twilight on both of these night was prolonged to daybreak, and there was no real darkness.[33]

The report that most closely ties these strange cosmic happenings with Tesla's power transmission scheme is that while the sky was aglow with this eerie light it was possible to clearly see ships at sea for miles in the middle of the night.[34] Tesla specifically claimed this as one of the effects he could achieve with his high power transmitter. Of particular importance is that none of his claims for lighting the ocean appeared before 1908.[35]

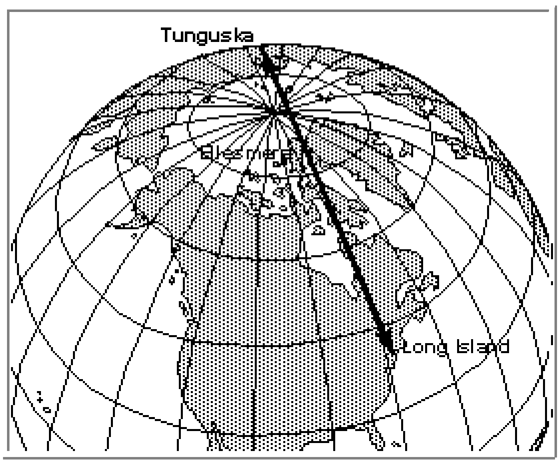
A typical statement about the light induced by his transmitter is this from the New York *American*of December 7th, 1914:

> The lighting of the ocean ... is only one of the less important results to be achieved by the use of this invention [the transmitter]. I have planned many of the details of a plant which might be erected at the Azores and which would be amply sufficient to illuminate the entire ocean so that such a disaster as that of the Titanic would not be repeated. The light would be soft and of very small intensity, but quite adequate to the purpose.[36]

When Tesla used his high power transmitter as a directed energy weapon he drastically altered the normal electrical condition of the earth. By making the electrical charge of the planet vibrate in tune with his transmitter he was able to build up electric fields that effected compasses and caused the upper atmosphere to behave like the gas filled lamps in his laboratory. He had turned the entire globe into a simple electrical component that he could control.

Given Tesla's general pacifistic nature it is hard to understand why he would carry out a test harmful to both animals and the people who herded the animals even when he was in the grip of financial desperation. The answer is that he probably intended no harm, but was aiming for a publicity coup and, literally, missed his target.

At the end of 1908, the whole world was following the daring attempt of Peary to reach the North Pole which he claimed in the Spring of 1909. If Tesla wanted the attention of the international press, few things would have been more impressive than the



Magnifying Transmitter's Test Path

Peary expedition sending out word of a cataclysmic explosion on the ice near or at the North Pole.[37] Tesla, then, if he could not be hailed as the master creator that he was, could be seen as the master of a mysterious new force of destruction.

The test, it seems, was not a complete success. It must have been difficult controlling the vast amount of power in transmitter to the exact spot Tesla intended. The North Pole lies close to a great circle line connecting Shoreham, Long Island and the Tunguska region. That path passes close by Alert on Ellesmere Island where Peary spent the winter.[38] The uninhabited region between Alert and the North Pole might have been the intended target for a test firing of the wireless transmission system. However, "the accepted terrestrial measurements" of that day were not precise enough for the task. The destructive electrical wave overshot its target.

Whoever was privy to Tesla's energy weapon demonstration must have been dismayed either because it missed the intended target and would be a threat to inhabited regions of the planet, or because it worked too well in devastating such a large area at the mere throwing of a switch thousands of miles away. Whatever was the case, Tesla never received the notoriety he sought for his power transmitter.

The evidence is only circumstantial. Perhaps Tesla never did achieve wireless power transmission through the earth. Maybe he made a mistake in interpreting the results of his radio tests in Colorado Springs and really saw a low frequency phenomenon, Schumann oscillations, and not an effect engineers believe a scientific impossibility. Perhaps the mental stress he suffered caused him to retreat into a fantasy world from which he would send out preposterous claims to reporters who gathered for his yearly pronouncements on his birthday. Maybe the atomic bomb size explosion in Siberia near the turn of the century was the result of a meteorite nobody saw fall.

Or, perhaps, Nikola Tesla did shake the world in a way that has been kept secret for over 85 years.

If you have questions to the author, please, do not shame email to:

onichelson@post.harvard.edu

Notes

1. *New York Times*, "Wireless Caused Iena Disaster?", Mar. 19, 1907, p. 4, col. 4.

2. *New York Times*, "Signor Ulivi First Blew Up Gas Meter," Nov. 2, 1913, III, p. 4, col. 5.

3. *New York Times*, "Tells Death Power of 'Diabolical Rays'," May 21, 1924, pg.1.

4. Note 3.

5. *Popular Mechanics*, "'Death Ray' Is Carried by Shafts of Light," Aug. 1924, pgs. 189-192.

6. *Current Opinion*, "A Violet Ray That Kills," June 1924, pgs. 828-829.

7. Note 6.

8. *New York Times*, "Second British Inventor Reveals a Death Ray," May 25, 1924, p. 1, col. 2.

9. *New York Times*, "Suggests Russia Has A 'Ray'," May 28, 1924, pg. 25.

10. *Colorado Springs Gazette*, "Tesla Discovered 'Death Ray' In Experiments Made Here," May 30, 1924, pg. 1.

11. Goldman, Harry L., "Nikola Tesla's Bold Adventure," *The American West*, Mar. 1971, pgs. 4-9; Reprinted by Nick Basura, 3414 Alice St., Los Angeles, Ca. 90065, 1974.

12. Tesla, Nikola, "Famous Scientific Illusions," *Electrical Experimenter*, Feb. 1919, pgs. 692f.

13. One horsepower equals 745.7 watts.

14. Tesla, Nikola, "A Machine to End War," as told to George Sylvester Viereck, *Liberty*, Feb. 1935, p. 5-7.

15. Tesla, Nikola, "The Problem of Increasing Human Energy - Through Use of the Sun's Energy," *The Century Illustrated Magazine*, reprinted in *Lectures, Patents, and Articles*, Nikola Tesla Museum, Belgrade, 1956; reprinted by Health Research (Mokelumme Hill, Calif., 95245), 1973, pg. A-143.

16. Nichelson, Oliver, "Nikola Tesla's Later Energy Generation Designs," IECEC, 1991.

17. *American Examiner*, Copyright 1911, no date, no pg.

18. Tesla, Nikola, *New York Times*, "How to Signal Mars," May 23, 1909, pg. 10. He claims to have sent "a current around the globe " on the order of "15,000,000" horsepower or 11 billion watts.

19. Secor, H. Winfield, "The Tesla High Frequency Oscillator," *The Electrical Experimenter*, March 1916, pg. 615.

20. Wait, James R., "Propagation of ELF Electromagnetic Waves and Project Sanguine/Seafarer," *IEEE Journal of Oceanic Engineering*, vol. OE-2, no. 2, April 1977, pgs. 161-172.

21. Marinic, Aleksandar, *Nikola Tesla, Colorado Springs Notes 1899-1900*, Nikola Tesla Museum, Published by Nolit, Beograd, Yugoslavia, pg.19.

22. Corum, James F., and Corum, Kenneth L., "Disclosures Concerning the Operation of an ELF Oscillator," *Tesla '84: Proceedings of the Tesla Centennial Symposium*, Dr. Elizabeth Rauscher and Mr. Toby Grotz, editors, International Tesla Society, Inc., Colorado Springs, 1985, pgs. 41-49.

23. Tesla, Nikola, "Famous Scientific Illusions," *Electrical Experimenter*, Feb. 1919, pg. 732.

24. Note 22.

25. Nichelson, Oliver, "Tesla's Wireless Transmission Method," 1992.

26. Tesla, Nikola, "Tesla's Wireless Torpedo," *New York Times*, Mar. 20, 1907, pg. 8.

27. Tesla, Nikola, *New York Times*, "Mr. Tesla's Vision," April 21, 1908, pg. 5.

28. Seifer, Marc J., "Nikola Tesla: The Lost Wizard," *Tesla '84: Proceedings of the Tesla Centennial Symposium*, op. cit., pgs. 31-40. Seifer, a psychologist, believes Tesla suffered a nervous breakdown catalyzed by the death of one the partners in the Tesla Electric Company and the shooting of Stanford White, the noted architect, who had designed Wardenclyffe. Seifer places this in 1906 and cites as evidence a letter from George Scherff, Tesla's secretary:

> Wardenclyffe, 4/10/1906
>
> Dear Mr. Tesla:
>
> I have received your letter and am glad to know you are vanquishing your illness. I have scarcely ever seen you so out of sorts as last Sunday; and I was frightened.

29. Cheney, Margaret, *Tesla: Man out of Time*, Dell Publishing Co., N.Y., 1983, pg. 187. Cheney sees a mental change taking place about 1907. Having lost most of his money and many of his friends and seeing less talented people praised for achievements based on his inventions "exerted a corrosive and lasting effect on his personality."

30. Tesla, Nikola, "Tesla's New Device Like Bolts of Thor," *New York Times*, Dec. 8, 1915, pg. 8.

31. Baxter, John and Atkins, Thomas, *The Fire Came By*, Warner Books, N.Y., 1977, pg. 27.

32. Note 30, pg. 26.

33. Spenser Russell quoted in Baxter and Atkins, *The Fire Came By*, page 28, from the *Royal Meteorological Society Quarterly*, 1930.

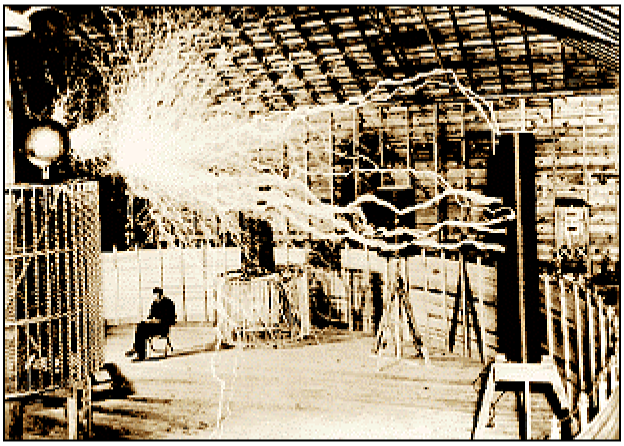
34. Note 30.

35. The earliest mention of lighting the ocean appears to have been in 1911 in a *N.Y. American*article (Sept. 3rd by Marcel Roland). Ratzlaff, John and Anderson, Leland, *Dr. Nikola Tesla Bibliography*, Ragusan Press, 1979, pg. 93.

36. New York *American*, "Tesla Light to Rob Oceans of Every Danger," Dec. 7, 1914, no pg.

37. Tesla suggested a similar test of his power transmission system aimed at the moon where everyone could see "the splash and volitization of matter." See note 19, pg. 255.

38. Bayshore, L.I. is at 40 N 43, 73 W 13; Alert, Canada (Ellesmere Island) 82 N 31, 62 W 05, and Tunguska at 60 N 55, 101 E 57.



HISTORY

At this issue I want to present stuff about Jagadis Chandra Bose, an Indian inventor. "J.C. Bose was at least 60 years ahead of his time", as Sir Neville Mott, Nobel Laureate, remarked in 1977. Let's remembered that great man!

The Work of Jagadis Chandra Bose: 100 Years of MM-Wave Research

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[1] The National Radio Astronomy Observatory is a facility of the National Science Foundation, operated under cooperative agreement by Associated Universities, Inc.

ABSTRACT

Just one hundred years ago, J.C. Bose described to the Royal Institution in London his research carried out in Calcutta at millimeter wavelengths. He used waveguides, horn antennas, dielectric lenses, various polarizers and even semiconductors at frequencies as high as 60 GHz; much of his original equipment is still in existence, now at the Bose Institute in Calcutta. Some concepts from his original 1897 papers have been incorporated into a new 1.3-mm multi-beam receiver now in use on the NRAO 12 Meter Telescope.

INTRODUCTION

James Clerk Maxwell's equations predicting the existence of electromagnetic radiation propagating at the speed of light were made public in 1865; in 1888 Hertz had demonstrated generation of electromagnetic waves, and that their properties were similar to those of light [1]. Before the start of the twentieth century, many of the concepts now familiar in microwaves had been developed [2,3]: the list includes the cylindrical parabolic reflector, dielectric lens, microwave absorbers, the cavity radiator, the radiating iris and the pyramidal electromagnetic horn. Round, square and rectangular waveguides were used, with experimental development anticipating by several years Rayleigh's 1896 theoretical solution [4] for waveguide modes. Many microwave components in use were quasi-optical - a term first introduced by Oliver Lodge [5]. Righi in 1897 published a treatise on microwave optics [6].

Hertz had used a wavelength of 66 cm; other post-Hertzian pre-1900 experimenters used wavelengths well into the short cm-wave region, with Bose in Calcutta [7,8] and Lebedew in Moscow [9] independently performing experiments at wavelengths as short as 5 and 6 mm.

THE RESEARCHES OF J.C. BOSE

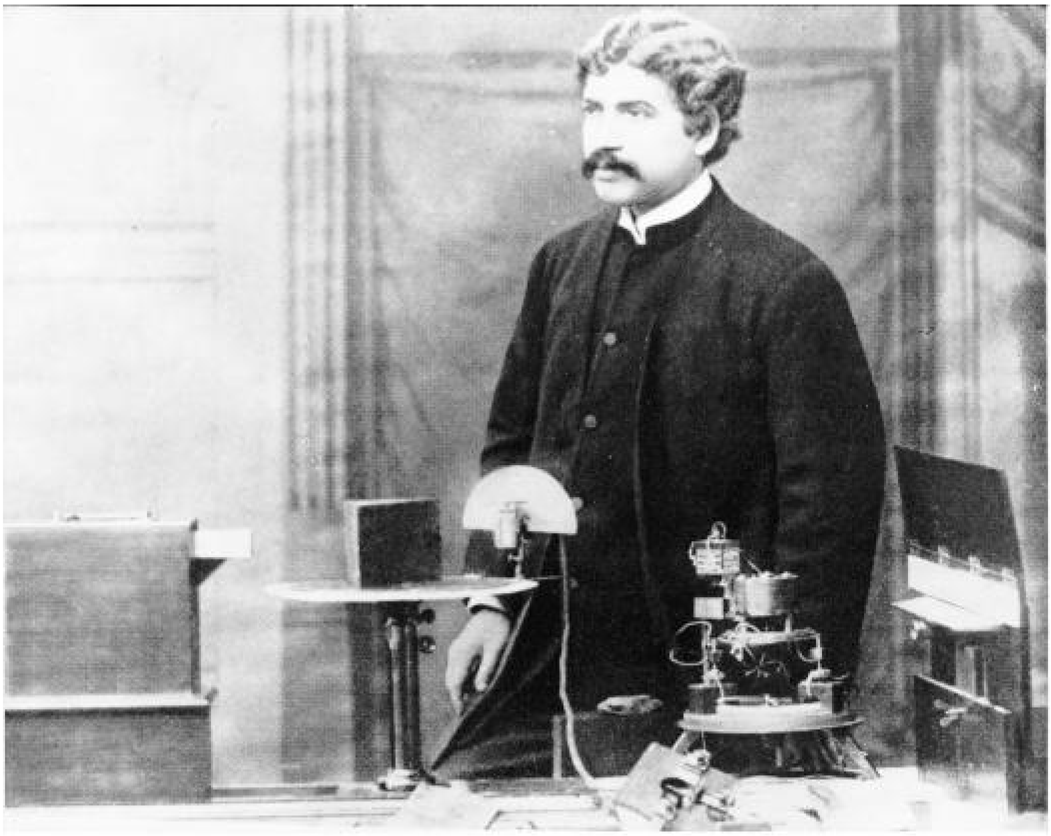
Jagadis Chandra Bose [10,11,12] was born in India in 1858. He received his education first in India, until in 1880 he went to England to study medicine at the University of London. Within a year he moved to Cambridge to take up a scholarship to study Natural Science at Christ's College Cambridge. One of his lecturers at Cambridge was Professor Rayleigh, who clearly had a profound influence on his later work. In 1884 Bose was awarded a B.A. from Cambridge, but also a B.Sc. from London University. Bose then returned to India, taking up a post initially as officiating professor of physics at the Presidency College in

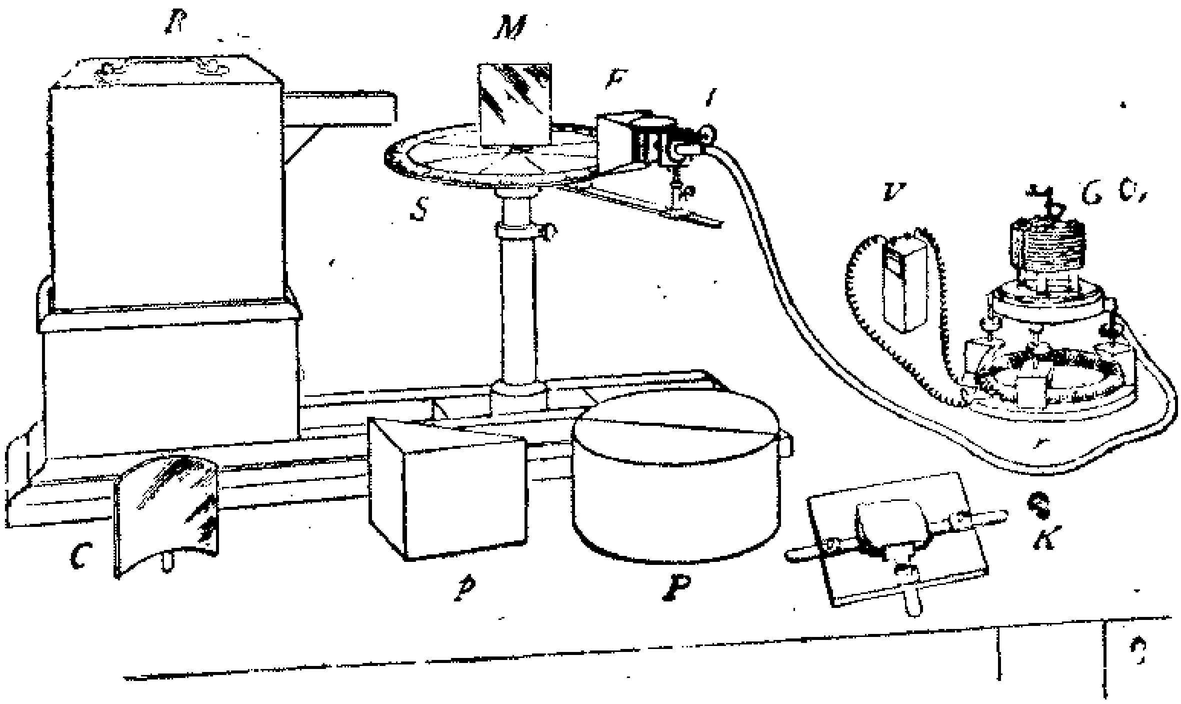
Calcutta. Following the example of Lord Rayleigh, Jagadis Bose made extensive use of scientific demonstrations in class; he is reported as being extraordinarily popular and effective as a teacher. Many of his students at the Presidency College were destined to become famous in their own right - for example S.N. Bose, later to become well known for the Bose-Einstein statistics.

A book by Sir Oliver Lodge, "Heinrich Hertz and His Successors," impressed Bose. In 1894, J.C. Bose converted a small enclosure adjoining a bathroom in the Presidency College into a laboratory. He carried out experiments involving refraction, diffraction and polarization. To receive the radiation, he used a variety of different junctions connected to a highly sensitive galvanometer. He plotted in detail the voltage-current characteristics of his junctions, noting their non-linear characteristics. He developed the use of galena crystals for making receivers, both for short wavelength radio waves and for white and ultraviolet light. Patent rights for their use in detecting electromagnetic radiation were granted to him in 1904. In 1954 Pearson and Brattain [14] gave priority to Bose for the use of a semi-conducting crystal as a detector of radio waves. Sir Neville Mott, Nobel Laureate in 1977 for his own contributions to solid- state electronics, remarked [12] that "J.C. Bose was at least 60 years ahead of his time" and "In fact, he had anticipated the existence of P-type and N-type semiconductors."

In 1895 Bose gave his first public demonstration of electromagnetic waves, using them to ring a bell remotely and to explode some gunpowder. In 1896 the Daily Chronicle of England reported: "The inventor (J.C. Bose) has transmitted signals to a distance of nearly a mile and herein lies the first and obvious and exceedingly valuable application of this new theoretical marvel." Popov in Russia was doing similar experiments, but had written in December 1895 that he was still entertaining the hope of remote signalling with radio waves. The first successful wireless signalling experiment by Marconi on Salisbury Plain in England was not until May 1897. The 1895 public demonstration by Bose in Calcutta predates all these experiments. Invited by Lord Rayleigh, in 1897 Bose reported on his microwave (millimeter-wave) experiments to the Royal Institution and other societies in England [8]. The wavelengths he used ranged from 2.5 cm to 5 mm. In his presentation to the Royal Institution in January 1897 Bose speculated [see p.88 of ref.8] on the existence of electromagnetic radiation from the sun, suggesting that either the solar or the terrestrial atmosphere might be responsible for the lack of success so far in detecting such radiation - solar emission was not detected until 1942, and the 1.2 cm atmospheric water vapor absorption line was discovered during experimental radar work in 1944. Figure 1 shows J.C. Bose at the Royal Institution in London in January 1897; **Figure 2** shows a matching diagram, with a brief description of the apparatus.

Figure 1. *J.C. Bose at the Royal Institution, London, 1897. [13]*





R, radiator ; S, spectrometer-circle ; M, plane mirror ; C, cylindrical mirror ; *p*, totally reflecting prism ; P, semi-cylinders ; K, crystal-holder ; F, collecting funnel attached to the spiral spring receiver ; *t*, tangent screw, by which the receiver is rotated ; V, voltaic cell ; *r*, circular rheostat ; G, galvanometer.

Figure 2. *Bose's apparatus demonstrated to the Royal Institution in London in 1897 [8]. Note the waveguide radiator on the transmitter at left, and that the "collecting funnel" (F) is in fact a pyramidal electromagnetic horn antenna, first used by Bose.*

By about the end of the 19th century, the interests of Bose turned away from electromagnetic waves to response phenomena in plants; this included studies of the effects of electromagnetic radiation on plants, a topical field today. He retired from the Presidency College in 1915, but was appointed Professor Emeritus. Two years later the Bose Institute was founded. Bose was elected a Fellow of the Royal Society in 1920. He died in 1937, a week before his 80th birthday; his ashes are in a shrine at the Bose Institute in Calcutta.

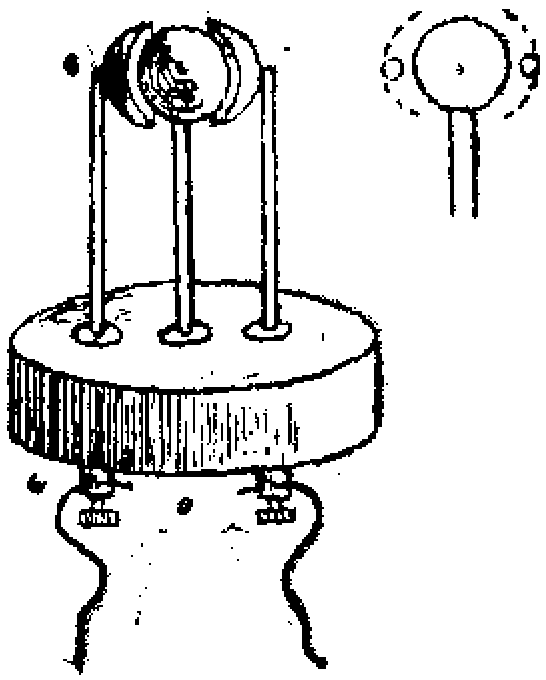
BOSE'S APPARATUS

Bose's experiments were carried out at the Presidency College in Calcutta, although for demonstrations he developed a compact portable version of the equipment, including transmitter, receiver and various microwave components. Some of his original equipment still exists, now at the Bose Institute in Calcutta. In 1985 the author was permitted by the Bose Institute to examine and photograph some of this original apparatus.

Figure 3 (a) shows Bose's diagram of one of his radiators, used for generating 5-mm radiation.

The Radiator

Figure 3(a)



Oscillation is produced by sparking between 2 hollow hemispheres and the interposed sphere. There is a bead of platinum on the inside surface of each hemisphere. For some experiments, a lens of glass or of sulphur was used to collimate the radiation - the first waveguide-lens antenna. The lens was designed according to the refractive index measured by Bose at the wavelength in use. **Figure 3(b)** shows Bose's drawing of such a radiator; the sparks occur between the two outer spheres to the inner sphere, at the focal point of the lens L at the right. Bose was able to measure the wavelength of his radiation with a reflecting diffraction grating made of metal strips [7].

Figure 4(a) is a photograph of one of his radiating antennas; part of the spark oscillations are generated inside the overmoded circular waveguide. A polarizing grid is built into the antenna, clearly visible at the radiating end of the waveguide. Figure 4(b) shows a closeup of the dual spark gaps used for the transmitter; the sparks are generated between the 2 outer spheres and the inner sphere. Figure 4(c) shows both a transmitting antenna (left) and the receiver (right), with a dual prism in between set on the experimental rotating table.

Figure 3(b)

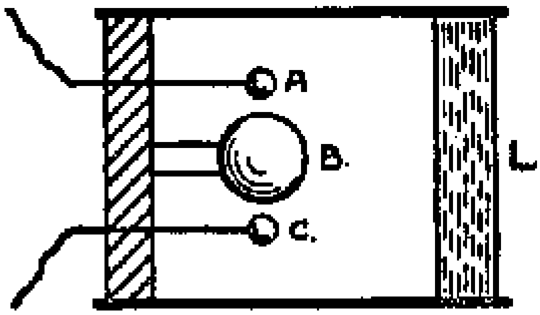


Figure 3 *Bose's diagrams of his radiators. (a) shows the radiator used to generated 5-mm radiation, while (b) shows the arrangement with a lens L at the exit of the waveguide [2]. In some designs the mounting stems for the outer spheres could be inclined to adjust the dimension of the spark gaps.*

Figure 4(a)

One of Bose's transmitter antennas (being held on the right of the picture). Note the polarizing grid; the spark gap is just visible behind the grid. In the background behind this antenna part of the high voltage equipment used to generate the spark can be seen. At the left of the picture is a receiving horn.

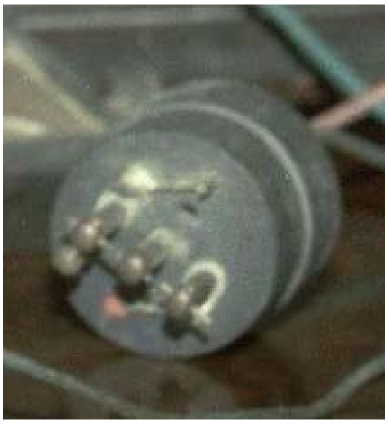


Figure 4(b): A closeup of the spark gaps normally mounted inside the transmitting antenna

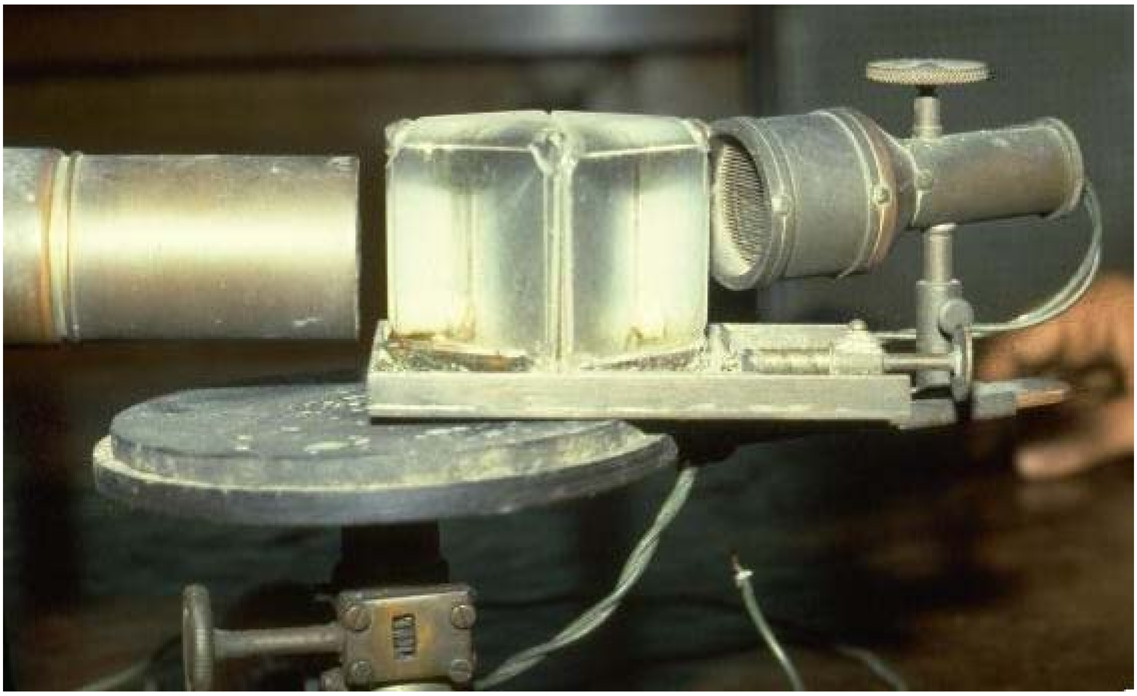


Figure 4(c): A complete setup showing the transmitting antenna at the left, with the receiving antenna at right. Note the adjustment screw on top of the receiving antenna, which is used to adjust the pressure of the point-contact detector (see Fig. 5). In the center is a rotating table (the "spectrometer circle" of Figure 2) on which various microwave components (prisms, lenses, grids, polarizers etc.) may be mounted for study. A dual-prism attenuator (see below) is shown in this photograph. The arrangement as shown is not yet properly aligned.

Figure 5 shows two of Bose's point contact detectors. In use, the detector would be placed inside an overmoded waveguide receiving antenna, very much like the transmitting antenna shown in Figure 4, and with a matching polarizing grid.

Bose measured the I-V characteristics of his junctions; an example characteristic curve of a "Single Point Iron Receiver" is shown in Figure 6. The junction consisted of a sharp point of iron, pressing against an iron surface, with pressure capable of fine adjustment. The different curves in **Figure 6** correspond to different contact pressures. Bose noted that the junction does not obey Ohm's law, and that there is a knee in the curve at approximately 0.45 volts; the junction becomes most effective at detection of short wavelength radiation when the corresponding bias voltage is applied. He made further measurements on a variety of junctions made of different materials, classifying the different materials into positive or negative classes of substance. In one experiment he noted that increasing the applied voltage to the junction actually decreased the resulting current, implying a negative dynamic resistance [15].

Another of Bose's short-wavelength detectors is the spiral-spring receiver. A sketch of a receiver used for 5-mm radiation is shown in **Figure 7**; the spring pressure could be adjusted very finely in order to attain optimum sensitivity. The sensitive surface of the 5-mm receiver was 1 by 2 cm. The device has been described recently [3] as a "space-irradiated multi-contact semiconductor (using the natural oxide of the springs)." A surviving, somewhat larger, spiral spring receiver is shown in the photograph **Figure 8**. The springs are held in place by a sheet of glass, seen to be partly broken in this example.

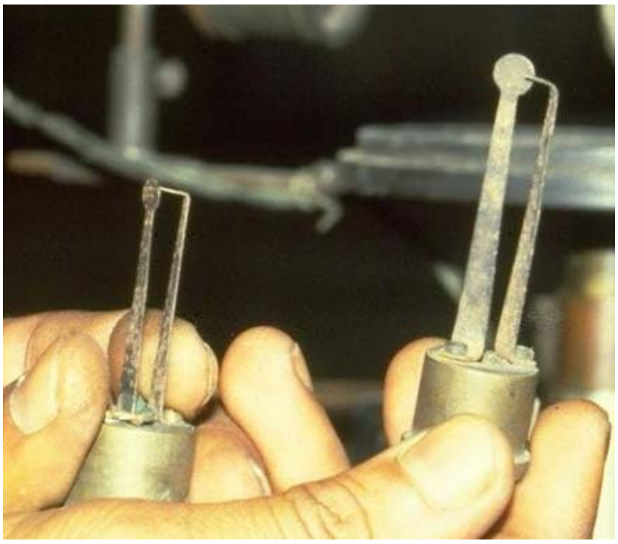


Figure 5. Two of Bose's point contact detectors, removed from the receiving antennas.

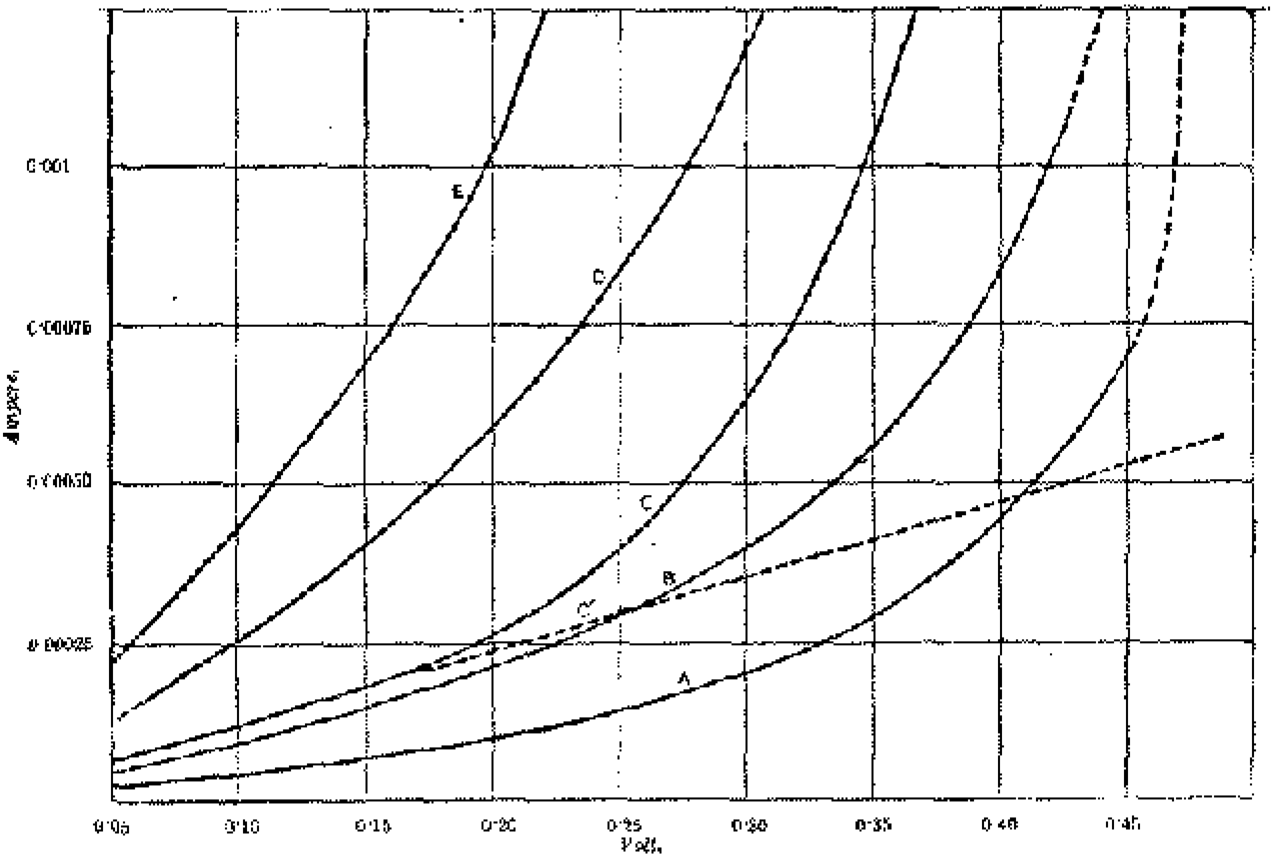


Fig. 52. Characteristic Curves of a Single Point Iron Receiver.
A, B, C, D, E are different curves for different initial currents, C' is the curve for a constant resistance.

Figure 6*. The I-V characteristics measured by Bose for a Single Point Iron Receiver. Note the similarity to modern semiconductor junctions, with a knee voltage of about 0.4 volts.*

Figure 9 is Bose's diagram of his polarization apparatus. The transmitter is the box at left, and a spiral spring receiver ('R') is visible on the right. One of the polarizers used by Bose was a cut-off metal plate grating, consisting of a book (Bradshaw's Railway Timetable, **Figure 10**) with sheets of tinfoil interleaved in the pages. Bose was able to demonstrate that even an ordinary book, without the tinfoil, is able to produce polarization of the transmitted beam. The pages act as parallel dielectric sheets separated by a small air gap.

Bose experimented with samples of jute in polarizing experiments. In one experiment, he made a twisted bundle of jute and showed that it could be used to rotate the plane of polarization. The modern equivalent component may be a twisted dielectric waveguide. He further used this to construct a macroscopic molecular model as an analogy to the rotation of polarization produced by liquids like sugar solutions. **Figure 11** shows Bose's diagram of the jute twisted-fiber polarization rotator, and **Figure 12** is a photograph of a surviving twisted-jute polarizer at the Bose Institute.

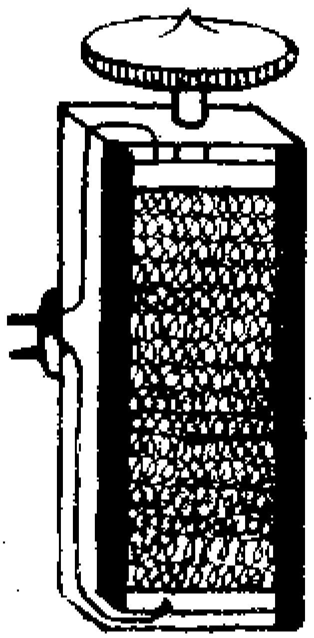


Figure 7*. Bose's diagram of his spiral-spring receiver used for 5-mm radiation.*

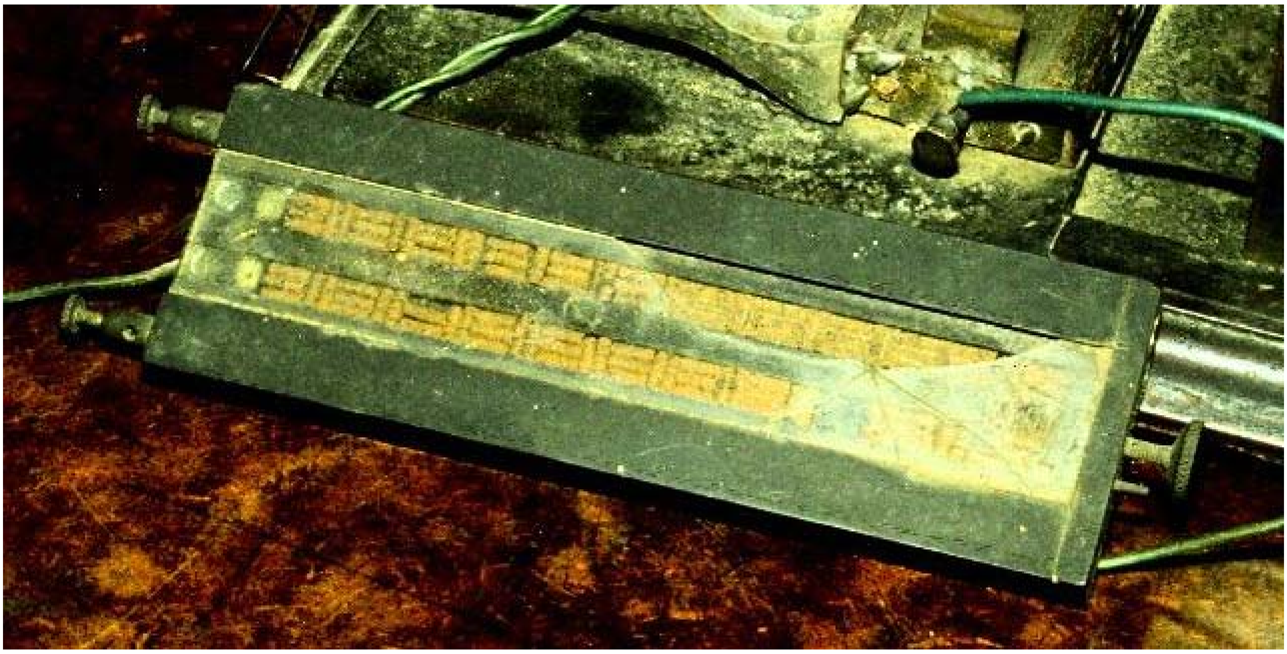
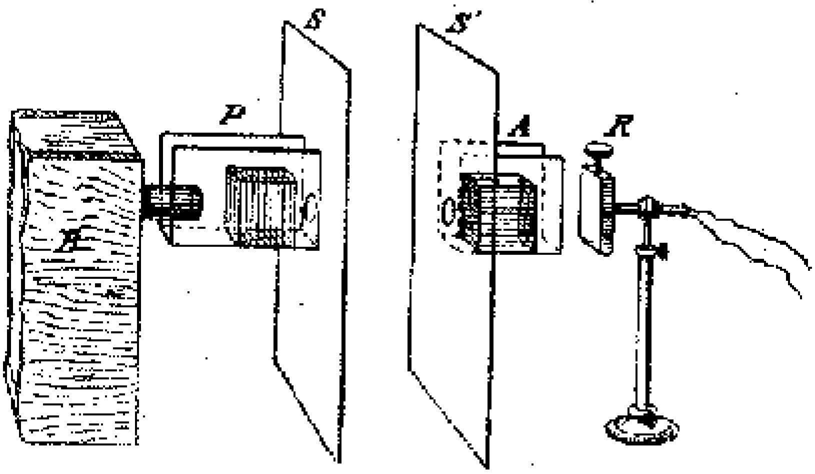


Figure 8. *One of Bose's free-space radiation receivers, recently described [3] as a "space-irradiated multi-contact semiconductor (using the natural oxide of the springs)." The springs are kept in place in their tray by a sheet of glass, seen to be partly broken in this photograph.*



Polarisation apparatus. B, the radiating box; P, the polariser; A, the analyser; S, S', the screens; R, the receiver.

Figure 9. *Bose's diagram of his polarization apparatus. Note the spiral spring receiver 'R' to the right.*

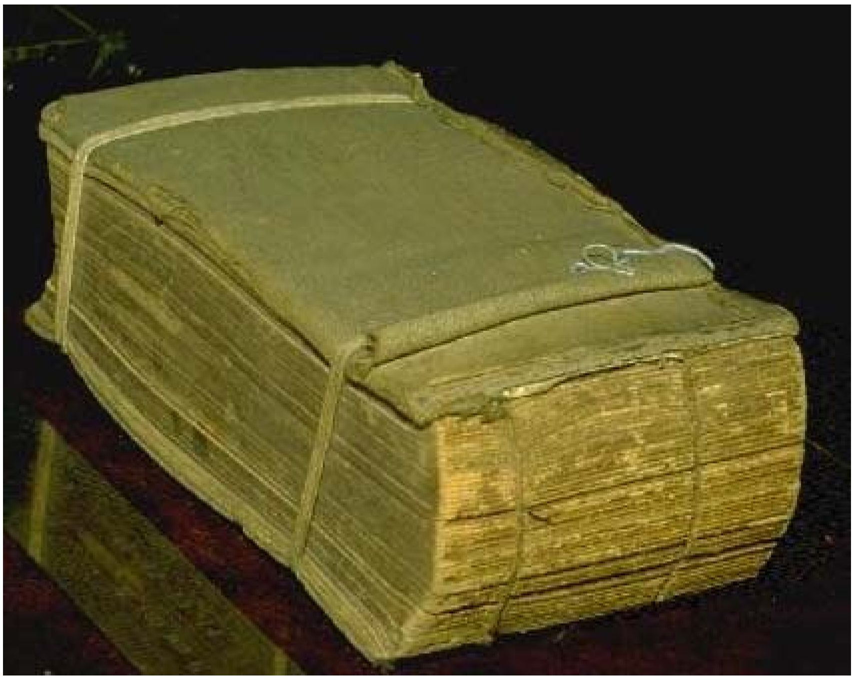


Figure 10. *One of Bose's polarizers was a cut-off metal plate grating, consisting of a book (Bradshaw's Railway Timetable) with sheets of tinfoil interleaved in the pages.*

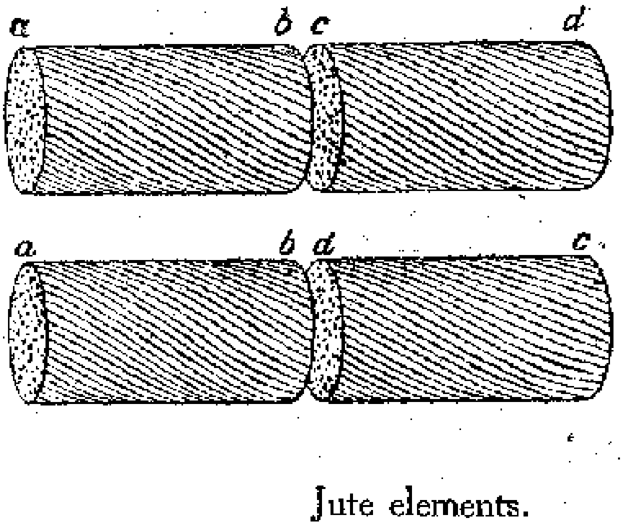


Figure 11. *Bose's diagram of twisted-Jute polarization elements, used to simulate macroscopically the polarization effect of a certain sugar solutions.*

Figure 12. *One of the twisted-jute polarizers used by Bose.*

THE DOUBLE-PRISM ATTENUATOR

Bose's investigations included measurement of refractive index of a variety of substances. He made dielectric lenses and prisms; examples are visible in Figures 1 and 2.

One investigation involved measurement of total internal reflection inside a dielectric prism, and the effect of a small air gap between two identical prisms. When the prisms are widely separated, total internal reflection takes place and the incident radiation is reflected inside the dielectric. When the 2 prisms touch, radiation propagates unhindered through both prisms. By introducing a small air gap, the combination becomes avariable attenuator to incident radiation; this is illustrated in Bose's original diagram, shown in **Figure 13**. Bose investigated this prism attenuator experimentally; his results were published in the Proceedings of the Royal Society in November, 1897 [8]. Schaefer and Gross [16] made a theoretical study of the prism combination in 1910; the device has since been described in standard texts.

At the National Radio Astronomy Observatory in Tucson, Arizona a new multiple-feed receiver, operating at a wavelength of 1.3 mm, has recently been built and installed on the 12 Meter Telescope at Kitt Peak [17].

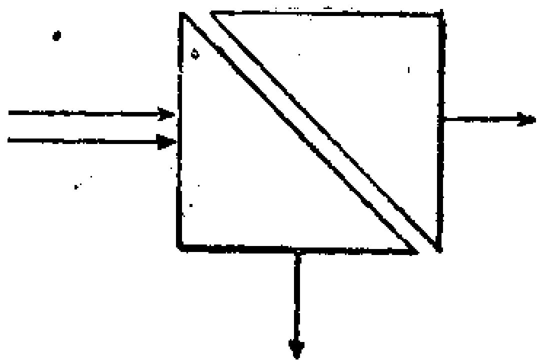


***Figure 13**. Bose's 1897 diagram of the double-prism attenuator.*

***Figure 14**. One of Bose's original double-prism attenuators, with adjustable air gap.*

The system is an 8-feed receiver, where the local oscillator is injected into the superconducting tunnel junction (SIS) mixers optically. With an SIS mixer receiver the power level of the injected local oscillator is critical; each of the 8 mixers requires independent local oscillator power adjustment. This is achieved by adjustable prism attenuators. **Figure 15** shows 4 of these 8 prism attenuators, installed on one side of the 8-feed system; this can be compared with Figure 14, which is a photograph taken at the Bose Institute in Calcutta in 1985, of an original prism system built by Bose.

CONCLUSIONS

Research into the generation and detection of millimeter waves, and the properties of substances at these wavelengths, was being undertaken in some detail one hundred years ago, by J.C. Bose in Calcutta. Many of the microwave components familiar today - waveguide, horn antennas, polarizers, dielectric lenses and

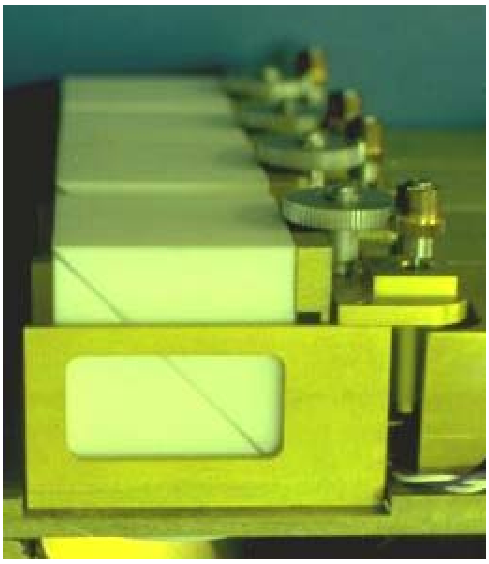


***Figure 15.** Four of the 8 double-prism attenuators used to control local oscillator injection into the NRAO 1.3-mm 8-beam receiver in use at the 12 Meter Telescope at Kitt Peak.*

prisms, and even semiconductor detectors of electromagnetic radiation - were invented and used in the last decade of the nineteenth century. At about the end of the nineteenth century, many of the workers in this area simply became interested in other topics. Attention of the wireless experimenters of the time became focused on much longer wavelengths which eventually, with the help of the then unknown ionosphere, were able to support signalling at very much greater distances.

Although it appears that Bose's demonstration of remote wireless signalling has priority over Marconi, he was the first to use a semiconductor junction to detect radio waves, and he invented various now commonplace microwave components, outside of India he is rarely given the deserved recognition. Further work at millimeter wavelengths was almost nonexistent for nearly 50 years. J.C. Bose was at least this much ahead of his time.

ACKNOWLEDGEMENTS

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I want to present for you some more info about Jagadis Chandra Bose, so, go to the next page.

I.G.

J.C.Bose: The Invertor Who Wouldn't Patent

Prof Rajesh Kochhar

A 100 years after Jagdish Chander Bose, India seems to have come to the painful realization that it is unlikely to make any worthwhile scientific inventions any more. It has therefore decided to invent a J.C. Bose that did not exist before. This Bose cannot be patented internationally but can certainly be put to good use in the domestic and NRI market.

Bose is one of the founding fathers of radio-physics, whose research acted as a bridge between the original discovery by Heinrich Rudolf Hertz and practical use by Guglielmo Marconi.

Marconi shared the 1909 physics Nobel prize. Had Hertz been alive {he died in 1894), then he would probably have been similarly honoured. **Did Marconi cheat Bose?** A story in **The Telegraph** (December 1997) carried the rather sensational title "**Bose invented Marconi's wireless"**. The story was based on a recent report by some US- based Indian engineers that the detecting device (or coherer as it was then called) that Marconi used, the so- called Italian navy coherer, was modified from an instrument invented by Bose two years previously.

The story asserted rather ingeniously that "so far, his (Bose's) reputation has rested on his botanical work." It quoted a scientist associated with the project as saying, " A combination of factors like naivete about patenting, plain misfortune and poli- tics of the contemporary times weighed against Bose."

This assessment is unhistorical and an exercise in time-warp. It presents Bose II a victim of circumstances and conspiracies which he was not. It seeks to assign to Bose and his associates motivations and aspirations that did not exist then, but are an after thought. It attempts to evaluate Bose in a time-frame that came into being later and which Bose could not have anticipated.

It is on record that Europe's encouragement to, support for and recognition of Bose's pioneering research were unstinted and spontaneous. He was offered a professorship at Cambridge University. **He was the first professionally trained mainstream Indian scientist to be elected a fellow of the prestigious Royal Society of London. He was fully aware of the commercial implication of his radio work and conscientiously wanted no part of it. As for Marconi, he was literally on a different wavelength.** From 1894 till about 1900, Bose studied the optical properties of radio waves.

Jagdish Chander Bose

Value of his work lies in his experimental innovations. He modified old detectors and made new ones. In addition, he tested a wide variety of materials for the purpose because metals would get easily oxidized "in the warm and damp climate of Bengal". **As early as 1895, Bose demonstrated to an excited Calcutta audience the wireless Transmission of radio waves over a distance of 75 feet (25 m) through masonry. Bose's waves were microwaves with Lengths in the millimetre range.** For travel through long distances in space one need longer radio waves. Their study was initiated by **A.S. Popoff in Russia and profitably taken up by Marconi**. **For his detectors, he like every body else, made use of Bose's researches which were already published and therefore common property. It would be unfair to grudge Marconi his practical and commercial success**. After all, both he and Bose achieved what they aspired for. Bose presented his first results before the Asiatic Society, Calcutta, in May 1895. According to the pioneering Indian chemist, Prafulla Chandra Ray, who was colleague and close friend of Bose, "It appears that he had not then realised the importance of the new line of research he had hit upon."

Bose sent copies of his research paper to his former teacher Lord Rayleigh and to Lord Kelvin, both of whom immediately saw its worth. Bose went on a lecturing tour of England and Europe during 1896-1897 and then again during 1900-1902 when he visited the US also. After his public lecture in 1897 at the Royal Institution in London, he expressed **"surprise that no secret was at any time made as to its (coherer's) construction, so that it has been open to all the world to adopt it for practical and possibly money-making purposes"**. An early admirer of the Bose coherer was the British navy, which used it to establish effective radio link between a torpedo boat and friendly ships.

In May 1901 he wrote to his friend Rabindranath Tagore: "...the proprietor of a reputed telegraph company...came himself with a Patent form in hand...He proposed to take half of the profit and finance the business in the bargain. This multi-millionaire came to me abegging. My friend, I wish you could see that terrible attachment for gain in this country, that all engaging lucre, that lust for money and more money. Once caught in that trap there would have been no way out for me."

Exasperated by Bose's "quixotic" approach towards money, two of his lady friends, British-born Margaret Noble (better known as Sister Nivedita) and American-born Mrs Sara Bull on their own initiative obtained in 1904 an American patent in Bose's name (for his " galena single contact-point receiver"). Bose, however, remained unmoved and refused to encash the patent. The irony of the situation seems to have gone unnoticed. Here in Nivedita we have a spiritualist advocating the cause of patents and royalties and a physics professor dismissing the idea. The reason must be sought in their backgrounds: Nivedita was a product of industrial Europe while Bose was a child of the orientalised East. There can be no doubt, as P.C. Ray reminded the audiance assembled in 1916 to greet Bose on his knighthood, that **"If he had taken out patents for the apparatus and instruments which he had invented, he could have made millions by their sale"**. **More importantly, he would perhaps have become an Indian role-model for production of wealth through science. As it is, Bose abandoned radio waves altogether, there were no trained students to continue the research; and India's tryst with technical physics came to a premature end.**

Bose's anti-patent position is explained in his authorised 1920 biography written by his close friend **Patrick Geddes**, "Simply stated, it is the position of the old **rishis** of India, of whom he is increasingly recognised by his countrymen as a renewed type, and whose best teaching was ever open to all willing to accept it." Bose carried on his shoulders the full weight of his country's defensiveness. He was the proof, because proof was needed, that Indians could do modern science. As Tagore wrote to him, Bose was God's instrument in the removal of India's shame. Bose did not want want to make hay for himself in the European sunshine.

It is not often realised that the European recognition won by J.C. Bose_and P.C. Ray on the scientific front was the first tangible proof that Indians could be equal to, and command respect from, the Europeans. It thus had a political dimension. Bose illustrates Henry David Thoreau's aphorism: "A man is wise with the wisdom of his time only, and ignorant with its ignorance", with the added proviso that the same calenderic time can denote different cultural times. **For Europe (modern) science was the key to prosperity**. **To India, science was the cause of its misery and humiliation. Industrialisation artisanised the European society. In contrast, in India, since the new middle class was derived from upper castes, science itself was Brahmanised.**

Insistence on the addition of Bose's name as a foot-note in Marconi's biography will be an exercise in historical nitpicking. There may be some solace in the invention of an unhistorical J.C. Bose who would mirror our current economic and technological frustra- tions. But what is needed is the positioning of J.C. Bose in a temporal context and the discovery of a new J.C. Bose who would be active and relevant in the present context.

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A Noble Man Without A "Nobel"

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A NOBLE MAN WITHOUT A 'NOBEL'

Celebrity author Leo Tolstoy has remarked in his short story entitled The Exile: God sees the truth, but waits…. This is exactly what happened, in case of J. C. Bose. Today, the world knows Marconi, an Italian experimentalist, as the inventor of radio waves. But it was Bose, who first invented a device called Mercury Coherer, which could transmit and receive radio waves. It is used in mercury tube and telephone. One of Marconi's close friends, Luigi Solari, a lieutenant in the Italian Navy, drew Marconi's attention towards Bose's invention. He made minor changes in the devices, such as the U–tube was turned into straight tube. A device just a replica of the Bose's instrument was presented for a patent by Marconi, on September 9, 1901. He was credited by the world for sending the radio signals across the Atlantic Ocean, for the first time.

He was invited to deliver a lecture on his invention at the Royal Society of England on June 13, 1902. During the speech, he did not even care to acknowledge the name of J. C. Bose whose pioneering efforts bore him the fruits.

Heinrich Rudolf Hertz was the original propounder of the theory of Radio Physics and Bose and Marconi used his research findings. Hertz died in 1894. Marconi won the Noble Prize in Physics in 1909. If Hertz had been alive then he would probably have shared the honor.

When Marconi was interviewed by the McClure magazine, the interviewer questioned, "What is the difference between these electrical waves, that can penetrate through mountains, buildings etc., and Hertz waves ?" Marconi uttered, "I can't say that, since I am not a scientist. In fact, I doubt whether any scientist knows it at all. But I can have a faint guess, that it may have something to do with waves…" The irony was, the person lacking the knowledge about the radio wave was awarded the Nobel Prize and honored as the father of solid state and microwaves. Moreover, the person, who actually devised the instrument from which the microwaves generated and transmitted for the first time, was left unrecognized and unsung in the history of science. Even one of the assistants and a biographer of Marconi, Mr. Vivian, clearly mentioned that it was nothing but the mercury coherer that Marconi used. In several writings, even Marconi admitted that he had no education or knowledge about radio waves.

During his lifetime Bose never considered all the dark games being played behind him. His belief was : It is the invention, which is of importance for the mankind, not the inventor. He never expressed grief for not receiving the prestigious Nobel Prize.

Bose invented several instruments, which have industrial applications even today. He was offered money and could have made a fortune but never accepted it. He never chased money and permitted anyone to use the fruits of his researches. He was very generous and noble; who never exploited the patents granted for personal and monetary gain. He talked about his inventions as if they were open to the entire world to adopt and accept for practical and money–making purposes. His patriotic zeal is displayed in the following words : "The spirit of our national culture demands that we should for ever be free from the desecration of utilizing knowledge for personal gain".

HIS FRIENDLY NATURE

Besides science, Bose was also interested in literature. Rabindranath Tagore, the Nobel Prize winning Indian poet, was a close friend of J.C. Bose. When Tagore visited Bose for the first time, he was not present. So Tagore put a flower bouquet on his desk, and these flowers came to form a link of friendship between the two great personalities. Bose always enjoyed his company. It was Tagore who encouraged him to spread the message of his scientific breakthrough all over the world. In those days, Rabindranath Tagore was not famous in the West. J. C. Bose helped him in publishing some of his stories. At the fag end of his life, Tagore wrote that his brothers, their families and several servants surrounded him in his huge mansion. Though he felt alone only Jagdishbabu helped him escape loneliness.

Not only Tagore, but also three other renowned personalities – Albert Einstein, Romain Rolland and George Bernard Shaw had intimate friendship with J.C. Bose.

Bose was a simple man bereft of ego and warm at heart. This helped him develop friendships with many a great personalities of his age.

BOSE RESEARCH INSTITUTE

Apart from his scientific inventions, Dr. J. C. Bose laid the foundation of Bose Bigyan Mandir, which is popularly known as Bose Research Institute. It was the first laboratory founded and funded fully by an Indian, in India. He spent about Rs. 5,00,000, the entire savings of his lifetime, to build and equip the Institute. He dedicated the Institute to the nation for the progress of science on November 30, 1917, his 60th birth anniversary. While inaugurating the Institute he said, “This is not a laboratory but a temple”. Bose knew the importance of a well–equipped research center in India and wanted that every Indian should be full of enthusiasm to put India on the fast track of the scientific world.

His main aim behind the foundation of the Institute was to “wring out from nature some of her most jealously guarded secrets”.

Bose worshiped in this Temple for 20 years, till his death. He stuck to the belief derived from his parents : “We should not depend on others to do our work, we ourselves must do our work, but before we can do this we must get over our pride”. The Bose Research Institute, the fulfilled dream of Dr. J.C. Bose, is presently working as a full-fledged research center in Calcutta. Much of the original equipments used by Bose during the research work as well as his ashes are enshrined at the Institute.

ON J. C. BOSE

“J. C. Bose was at least 60 years ahead of his time…. In fact, he had anticipated the existence of P-type and N - type semiconductors.”

- Sir Neville Mott
[Noble Laureate, 1977]

“By your discoveries you have greatly furthered the cause of Science. You must try to revive the grand traditions of your race, which bore aloft the torch light of art and science and was the leader of civilization two thousand years ago. We, in France applaud you.”

- M. Cornu
[President of the Academy of Science, Paris]

“Simply stated, it is the position of the old Rishis of India, of whom he is increasingly recognized by his countrymen as a renewed type, and whose best teaching was ever open to all willing to accept it.”

- Patrick Geddes
[Close friend of J.C. Bose, on Bose’s anti-patent position]

J.C. BOSE: CAN WE CALL HIM THE FATHER OF RADIO?

Nearly 100 years after Guglielmo Marconi's first transatlantic wireless communication, a group of scientists of the US-based Institute of Electronics and Electrical Engineers (IEEE) reported that -"the origin and first major use of the solid state diode detector devices led to the discovery that the first transatlantic wireless signal in Marconi's world famous experiment was received by Marconi using the iron-mercury-iron coherer with a telephone detector invented by Sir J.C.Bose in 1898".

Bose's invention of the **"mercury coherer with a telephone"** which Marconi used was published in the **Proceedings of the Royal Society, London, on April 27, 1899**, over two years before Marconi's first wireless communication on **December 12, 1901, from New Foundland, now in Canada.**

Investigations by the IEE group show that both **Bose and Marconi were in London in 1896-97**. The Italian was conducting wireless experiments for the British post office and Bose was on a lecture tour. **Both the scientists were interviewed by McClure's Magazine (now defunct) in March 1897.**

In the interview, Bose came out with high praise for Marconi, then under attack from established British scientists who doubted his credentials. Marconi never could make it to college because of his poor high school record. Bose also said he was not interested in commercial telegraphy and that others could use his research work

In 1899, Bose unveiled his invention of the mercury coherer with the telephone detector in a paper at the Royal Society.

Brilliant Marconi quickly grasped the commercial importance of Bose's invention and began to explore it secretly. His childhood friend Luigi Solari started experimentally with Bose's invention and presented Marconi with a slightly modified design in the summer of 1901 for use in the upcoming transatlantic experiment.

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