Grounded and Underground Antennas

Chapter from the book: Alpert, Bulatov, Runge: Antennas of the Third Reich: Published by Ministry of Defense of the USSR, Moscow, 1948. (Circulation: 300 copies). Credit line: http://www.radioscanner.ru/files/antennas/file10355/

Figure 131 shows that the closer a horizontal antenna to the ground the more horizontal component at Electro- Magnetic Radiation of the antenna. However the closer an antenna is to the ground the less efficiency of the antenna.

Efficiency is lowered because of the losses in the ground and in the antenna wire. The losses rise dramatically with increasing of the working frequency of the antenna.

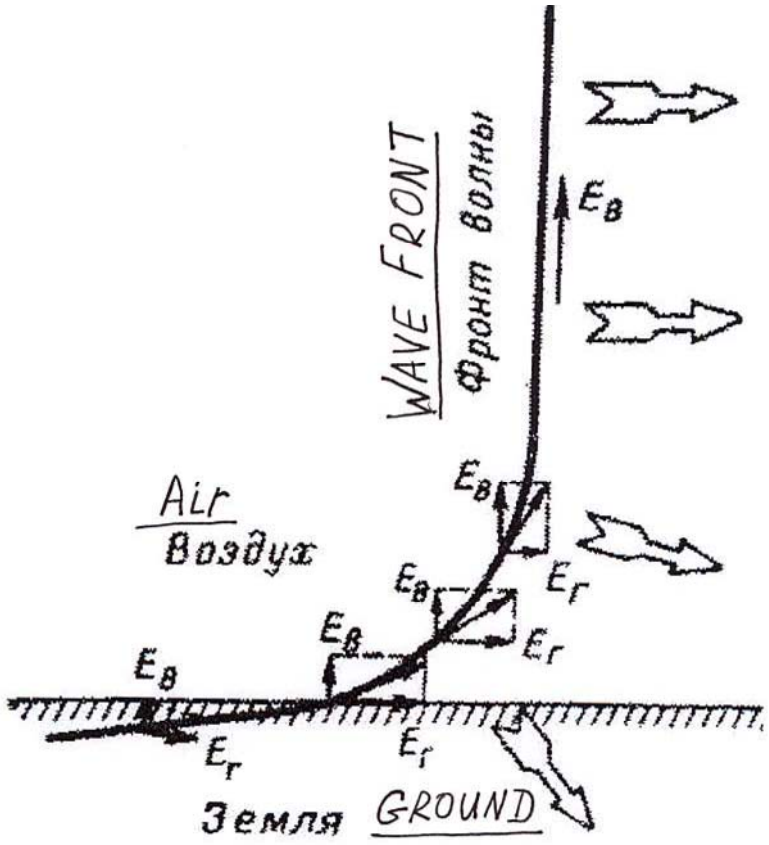


Рис. 131. Изменение наклона волны у поверхности земли

Figure 131 Changing the Front of a Radio-wave near the Ground

Figure 145 shows experimental data of the (antenna) gain by the ground wave for TWA of the 150 meter length of wire hanged at 2.8-meteres above the ground and Grounded Antenna - Insulated Wire in 150- meter length sitting on the ground. If the Grounded Antenna would be made from a naked wire the antenna dramatically decreased (compare to grounded antenna from the **Figure 145**).

Installation of the ground antenna is much easer the TWA. However, a ground antenna is much easer to damage compare to TWA. It is happened by moving vehicles. TWA is usually hang up at a height 2.8- 3 meter to avoid the damage by the vehicles.

Sometimes for grounded antennas is used a usual horizontal dipole antenna located straight over the ground.

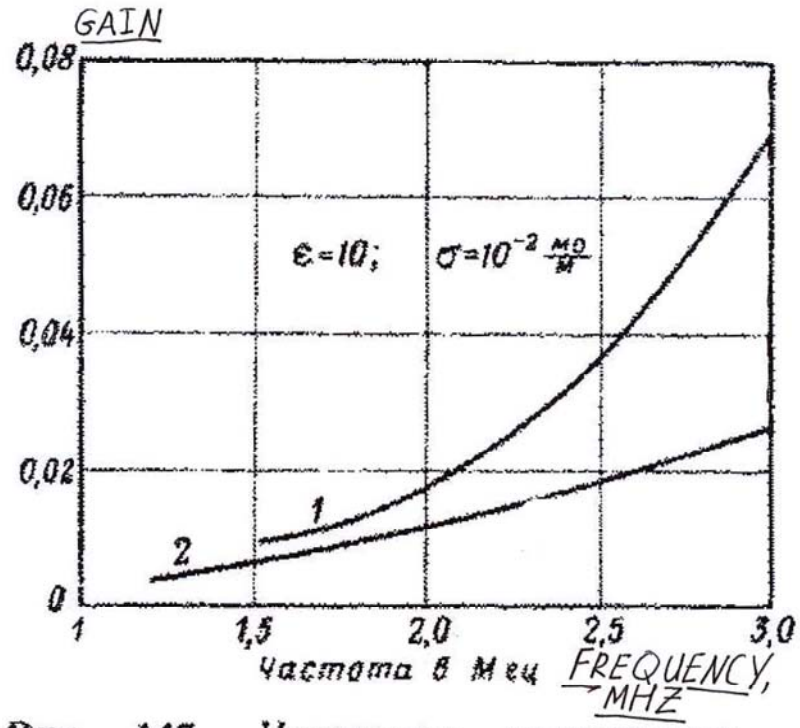


Рис. 145. Частотная зависимость коэффициента усиления по земной волне:

1 — для АБВ $\frac{150}{2,8}$; 2 — для 150-метрового изолированного провода, лежащего на поверхности земли

Figure 145 Experimental data of the (antenna) gain Vs frequency by the ground wave:

1. Travelled Wave Antenna - 150 meter length of wire hanged at 2.8-meteres above the ground
2. Grounded (sitting on the ground) Insulated Wire in 150- meter length

Underground antennas are more long life compare to TWA and Ground Antennas. Underground antennas can work because horizontal component of the EMF (Electromagnetic Field) can penetrate into the ground (**Figure 131**). So, as a rule a horizontal wires used for underground antennas.

Efficiency of the underground antennas is depended onto parameters of the soil. Antennas placed into wet soil have gain less compare to antennas placed into dry soil.

The decreasing of the antenna gain of the underground antenna in the wet soil can be explained by increasing of the attenuation of the radio- wave in the antenna wire (but not the attenuation of the radio-wave in the wet ground).

To increase the gain of the underground antenna it needs that a low- losses dielectric would be placed around the antenna wire and the soil. To this effect the wire of the underground antenna concludes in a rather thick plastic shield (Cable Underground Antenna)

(*Note from I.G.:I had several pieces of the antenna wire from the underground antennas. It was copper wire inside the round (16-mm OD) white thick plastic shield. A strong black plastic (thickness near 1-mm) was above the white plastic shield*) or installed the antenna in the underground cavities or trench (Trench Antenna).

Often an usual coaxial cable is used for installing the Cable Underground Antenna. **Figure 146** shows real design of the Cable Underground Antenna.

The antenna is made from a length of 15-meters of a Russian coaxial cable **RK-3** (or **RK-6**). Table 1 shows data for some old- age Russian Coaxial Cables. Copper braid is removed at the length of 10 meters (part 1 of the antenna). Antenna is dug in a trench onto depth of 0.2- 0.5- meters.

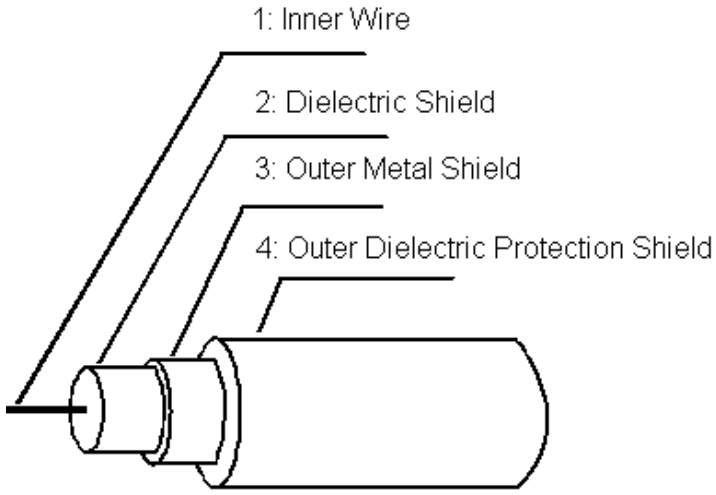
Antenna is located to the needed direction. Part 2 of the antenna is the feeder. The feeder is going to bunker 3 where a transmitter is installed. Part 4 shows terminal for connection with a transmitter.

Central conductor is connected to “antenna” terminal. Screen of the coaxial cable is connected to the “ground” terminal of the transmitter.

Figure 147 shows Diagram of Directivity in the horizon plane of the Cable Underground Antenna.

Table 1 Old Russian Coaxial Cables RK1, RK3 and RK6

Type	Zw, Ohm	Diameter 1, mm	Diameter 2, mm	Diameter 3, mm	Diameter 4, mm
RK1	77	1x0.68	4.6	5.2	7.3
RK3	68	1x1.37	9.0	9.6	13.0
RK6	52	7x0.85	9.2	9.8	12.4



Coaxial Cable

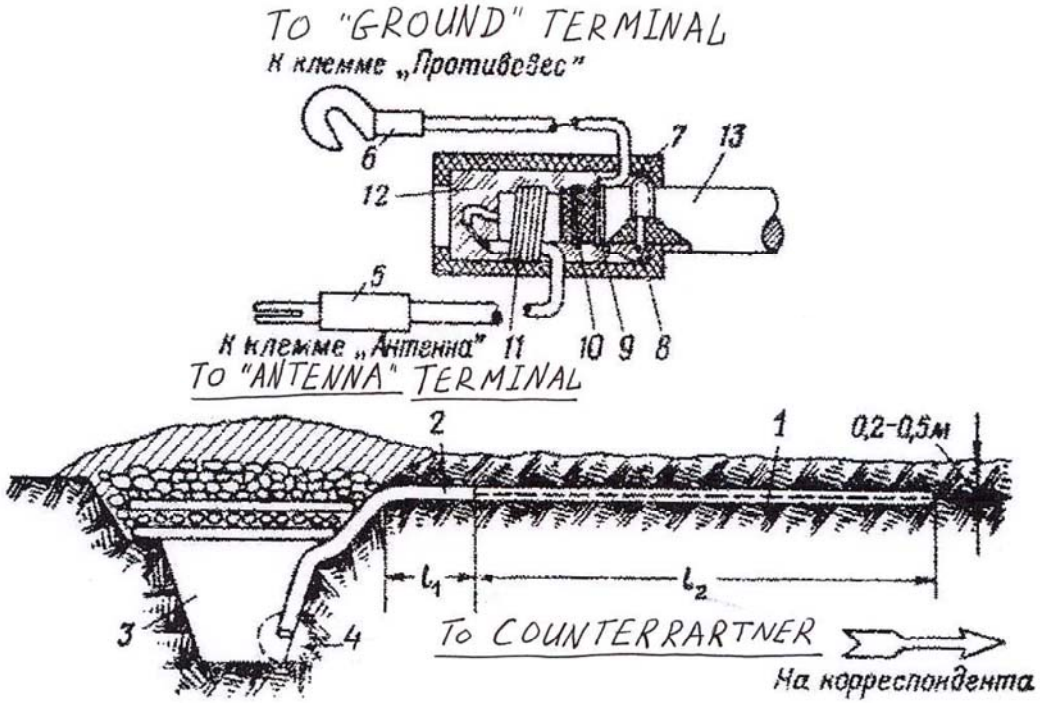


Рис. 148. Кабельная подземная антенна

Figure 146 Cable Underground Antenna

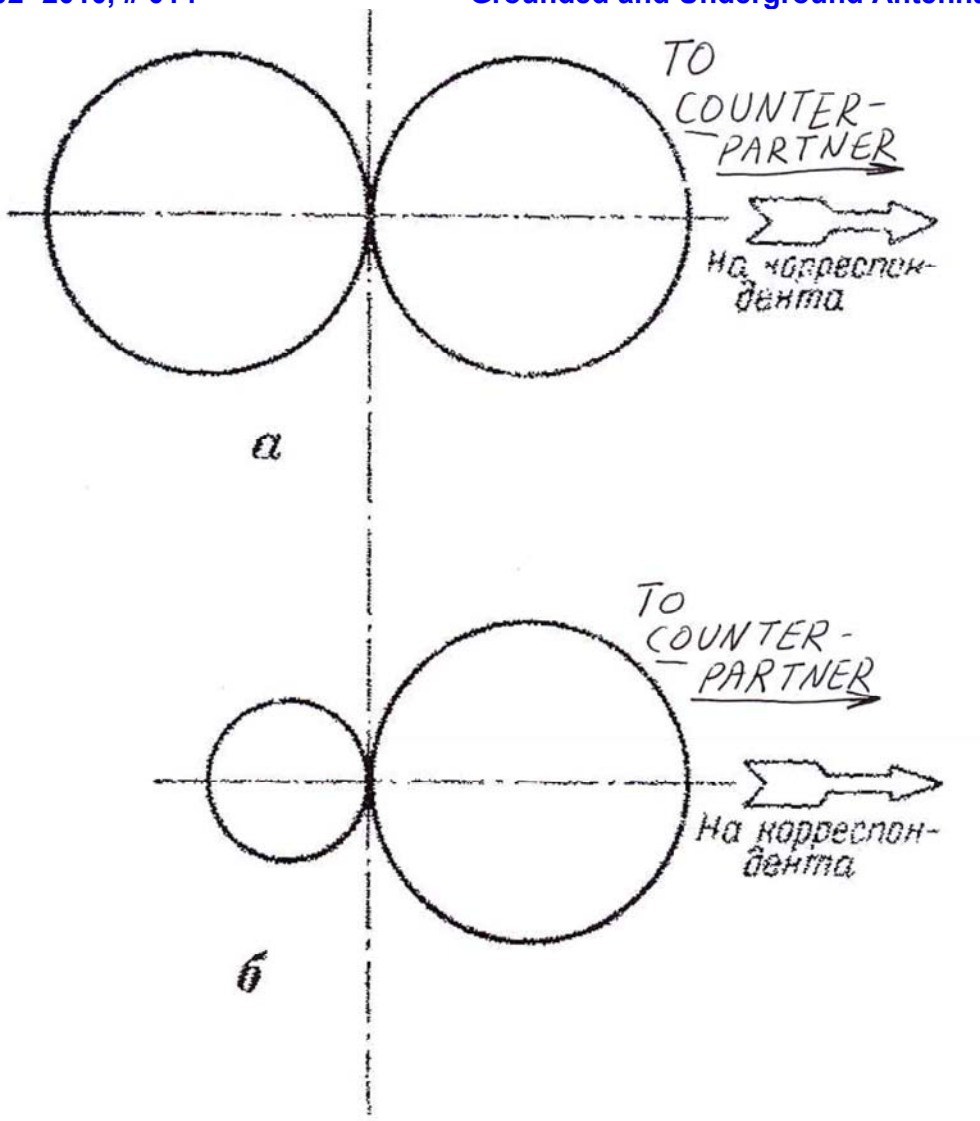


Рис. 147. Горизонтальные диаграммы направленности кабельной подземной антенны:
а — при работе на низких частотах; *б* — при работе на высоких частотах

Figure 147 Diagram of Directivity in the horizon plane of the Cable Underground Antenna

A For "Low" frequencies
B For "High" frequencies

(***Note I.G.:*** At the article no explaining the "Low" and "High" frequencies)

Two Cable Underground Antennas may make a Zenith Underground Antenna. The antenna made similar to symmetrical spreading antenna shown on **Figure 133 A**.
Note I.G.: Zenith Antenna is common known as NVIS (Near Vertical Incidence Skywave) Antenna.

Underground Cable Antenna has length of the radiation part (L2 at **Figure 146**) approximately 10 meters. The length was found by practice. There is no sense to use radiation part with length more the 10 meters because far parts of the Underground Cable Antenna do not radiate efficiently.

To increase efficiency of the Underground Cable Antenna (**Figure 146**) the radiation parts L2 placed into the trench above dry sticks or straw. Then the same dry sticks or straw put on above the parts L2. So, antenna wire is placed inside dielectric sleeve. Ground is placed above the dielectric sleeve. Such design allows easy remove the Underground Cable Antenna from the trench.

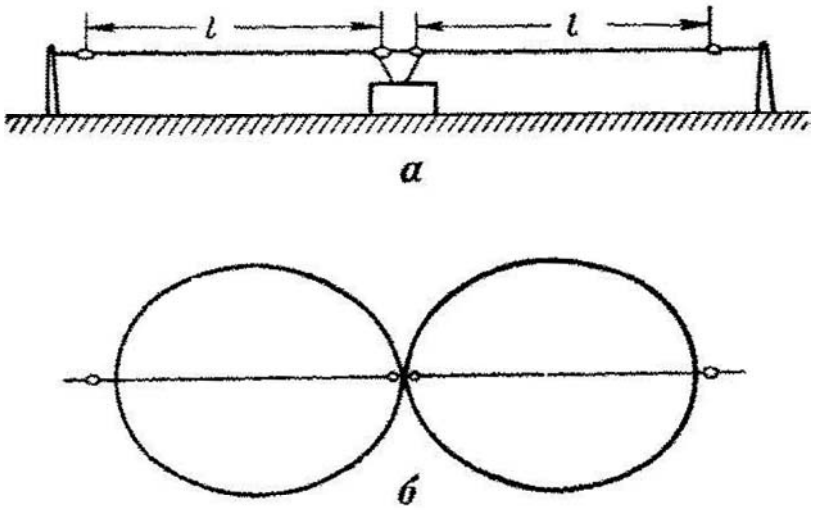


Рис. 133. Низкорасположенный горизонтальный вибратор (*а*) и его горизонтальная диаграмма направленности (*б*)

Figure 133 Spreading (Low-Height) Dipole Antenna (**A**) and its Diagram Directivity in the horizon plane (**B**)

Figure 148 shows design of the Trench Antenna. Trench Antenna consists of the three major parts. Part 1- radiation wire, part 2- feeder (as usual a coaxial cable), part 3- grounding system.

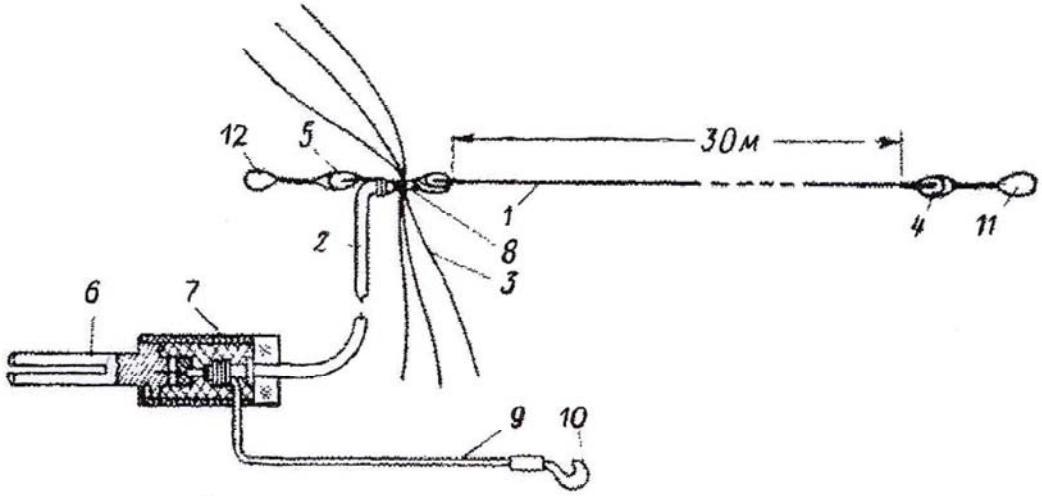


Рис. 148. Конструкция траншейной антенны

Figure 148 Design of the Trench Antenna

Radiation part (item 1) made of insulated wire in 30 meter length and diameter near 1-mm. Insulators (item 5 and 6) are placed at ends of the wire. Feeder (item 2) is length of coaxial cable in 10 meters. If antenna is used with low power transmitter it is possible fed it through thin coaxial cable RK-1. If antenna is used with middle or high power transmitter it is possible fed it through thick coaxial cable RK- 3 or RK-6. Central wire of the coaxial cable from the one side is soldered to Radiation part (item 1), from other side is soldered to plug (item 6) that is mounted inside insulated box (item 7).

Bandage (item 8) fastened the ground of the coaxial to additional bare wire between insulators (item 5).

Grounding system (item 3) made of six length of wire in 1.5- meters. Al the wires are soldered to wire between insulators (item 5). At the transmitter the ground of the coaxial through wire (item 9) with plug (item 10) is connected to the transmitter's "Ground."

Ropes (item 11 and 12) are stretched out the antenna inside the trench.
Trench Antenna may be installed in open or closed trenches as well as at low height (less the 100- 50- cm) near the ground. Radiation part is stretched between wooden pegs installed at the opposite sides of the trench.

Trench Antenna installed into closed trench is shown at the **Figure 149**. DD of the antenna is practically similar to DD shown on the **Figure 133 B**. However the back lobe has trend to decrease when the operation frequencies increase.

Keep in mind that efficiency of the Trench Antenna may be significantly decreased when the radiation part of the antenna is touched to the wet ground. Keep the radiation part at least 10- 15-cm out of trench wall. To keep good performance of the Trench Antenna do not place the radiation part more the 50 – cm from the ground level. Small masts with end insulator (or dry sticks) may be used in the design of the Trench Antenna to hold the radiation wire.

Counterpoises placed toward to radiation part of the antenna. Usually counterpoises dug on to small depth into the ground. At the band 1- 6 MHz the antenna (**Figure 149**) is almost equal to vertical antenna in 4-meters height.

In conclusion it is necessary to say that Underground and Trench Antennas are less efficiency in radiation of the ground and sky wave compare to antennas installed above the ground. So the Underground and Trench Antennas cannot provide far communication. However the good masking and survivability of the Underground and Trench Antennas allow use it in the military application.

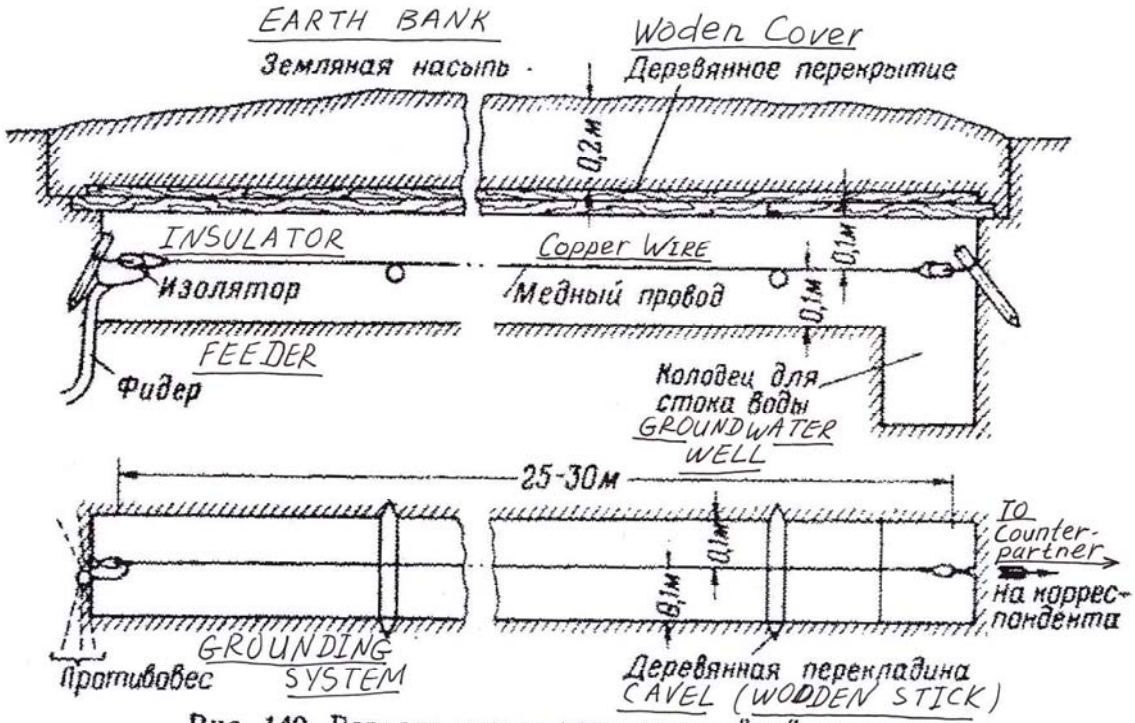


Рис. 149. Вариант размещения траншейной антенны

Figure 149 Trench Antenna installed in the closed trench

73! I. G.