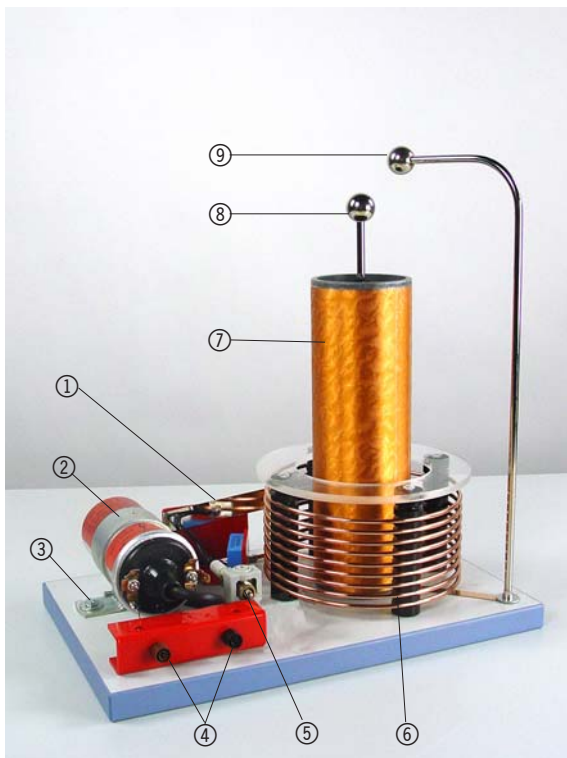


Tesla-Transformer 8496250

Instruction Sheet

4/9/05 LW/ALF



- ① Coil tap
- ② Ignition coil
- ③ Base plate
- ④ 4-mm safety sockets
- ⑤ Spark gap (spark plug)
- ⑥ Primary coil
- ⑦ Secondary coil
- ⑧ Spherical electrode, short
- ⑨ Spherical electrode, long

The Tesla transformer is for demonstration and study of physical laws relating to high-frequency electromagnetic waves.

In detail, the ELWE Tesla transformer allows the following phenomena to be demonstrated:

- Generation of high-frequency electromagnetic oscillations in a resonant circuit with low inductance and capacitance
- Shielding for high-frequency electromagnetic oscillations
- Illumination of a fluorescent lamp in a high-frequency field with no electrical contact
- Corona discharge
- Spark discharge
- Wireless energy transmission via Hertz waves

- Penetration and absorption of Hertz waves
- Standing waves in a Tesla coil

1. Safety instructions

- Caution! It is essential that experiments be performed with care by trained technical staff. The experiment is to be performed by teachers.
- Only to be operated indoors
- The Tesla transformer may only be operated exclusively as described in this manual using the supplied accessories.
- The Tesla transformer produces high-frequency electromagnetic waves. Due to its large bandwidth the transformer can interfere with or damage sensitive electronic equipment in close proximity to

it. Such equipment should therefore be placed at least 5 meters away from the transformer.

- The frequencies emitted by the Tesla transformer cover many radio frequency bands. The equipment may therefore be used only for brief periods for educational demonstration purposes.
- If there are people with cardiac pacemakers or other electronic control units close to the Tesla transformer, the transformer may not be put into operation. This could result in death.
- The equipment may not be used by persons to whom electrical shocks pose a serious danger (people who are ill).
- The Tesla transformer may not be used for experiments on animals or any other living creatures.
- The Tesla transformer may not come into contact with any fluid or become damp in any way.
- Do not try to repair any faults or damage to the Tesla transformer yourself.
- The Tesla transformer may not come into contact with any metal or other conductors. A safe distance of 20 cm from the high-voltage coil must be maintained at all times in order to prevent the crossing of sparks.
- Do not use in the proximity of flammable materials or volatile liquids, gases or vapours. The equipment generates sparks.
- The design of the Tesla transformer involved the best compromise between performance and universality of use whilst maintaining the required safety.
- Safety equipment to prevent any contact with the high-voltage components has been deliberately omitted so that students can see the design and operation of the device in full detail.
- The safety of those performing the experiments is thoroughly guaranteed if changes to the Tesla transformer (modifications to the number of windings in the primary coil) and the experiment set-up are only made when the equipment is switched off.

There is no need to touch parts of the transformer or the experiment set-up while voltage is being applied during any of the experiments.

- The input voltage for the Tesla transformer (20V) can be handled with no risk to safety at all. The primary current (3 A) is also safe.
- This is also true of the output voltage. The secondary voltage has a frequency between 200 kHz and 1200 kHz at a voltage of approximately 100 000 V. The maximum current is about 0.08 mA.

2. Design

The secondary coil is inserted concentrically into the primary coil. The Tesla transformer is connected to an AC supply via the connection sockets (4).

2.1 Scope of delivery

1 Tesla transformer	8496252
1 Spherical electrode, short	8496258
1 Spherical electrode, long	8496260
1 Needle electrode with spin electrode	8496262
1 Hand coil	8496254
1 Secondary coil	8496258
1 Fluorescent lamp with holder	8496264
1 Reflector	8496266

2.2 Recommended accessories:

Secondary coil with holder	8496255
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2.3 Technical data

Transformer dimensions:	330 mm x 200 mm x 120 mm
Secondary coil dimensions:	240 mm x 75 mm Ø
Transformer weight:	3 kg approx.
No. of windings in primary coil:	9
No. of windings in secondary coil:	1150
Primary coil voltage:	20 V AC
Secondary coil voltage:	100 kV approx.

3. How it works

A capacitor is charged by means of a half-wave of the power supply voltage via the ignition coil. The capacitor discharges via the spark gap/spark plug and the primary coil of the Tesla transformer.

A damped oscillation starts in the primary winding and this transfers energy to the secondary coil where an electromagnetic oscillation is induced at a frequency between 200 and 1200 kHz.

A high-frequency voltage of more than 100 kV is generated in the secondary coil. The secondary coil oscillates at the frequency of the resonant circuit.

4. Operation

- For all the experiments described in the following, a power supply with an AC voltage adjustable between 15 and 24 V (max. 4 A) is required (e.g. 8521153). To start up the equipment the power supply voltage is increased until sparks begin to discharge periodically across the spark plug.
- The equipment is not suitable for continuous operation. After 5 minutes of operation the equipment requires a cooling period of at least 15 minutes.

5. Experiments

5.1 Shielding for electromagnetic oscillations

- The Tesla transformer is operated without its secondary coil. The hand coil 8496254 is placed over the plastic ring of the secondary coil.

- The tap for the primary coil should be placed at its highest position. After starting the Tesla transformer, a voltage is induced in the hand coil (and the fluorescent lamp illuminates).
- Next the reflector 8496266 is inserted between the primary coil and the hand coil. The aluminium foil forms a shield that the electromagnetic oscillations cannot penetrate and the lamp connected to the hand coil no longer illuminates.

5.2 Thomson's equation for the oscillation

- The Tesla transformer is run with secondary coil 8496256. Needle electrode 8496262 is inserted into the socket at the top.
- When the voltage is applied, a corona discharge ensues from the point of the needle. Varying the position of the tap (modifying the inductance of the primary coil) the equipment is configured so that the discharge is at its maximum level (increase in voltage at the resonant frequency).
- Next the two secondary coils are inserted one above the other and the needle electrode is inserted into the upper coil.
- Resonance now occurs with a higher number of turns in the primary coil since the pair of secondary coils now has twice the number of turns. This means the resonant frequency is lower.
- Increasing the number of windings in the resonant circuit reduces the resonant frequency.

5.3 Corona discharge

- The Tesla transformer is operated with two secondary coils and the needle electrode inserted.
- The number of turns for the coil in the resonant circuit is set to seven. There now ensues a corona discharge from the tip of the needle due to the high voltage.

5.4 Electrical wind

- The transformer is operated with one secondary coil and 4 windings in the primary coil. The needle electrode is inserted into the secondary coil and the tinsel wheel 8496262 placed on it.
- The ends of the S-shaped spin electrode come to a point. Due to the strong electric field electrons are emitted and attach themselves to molecules of air. These are then repelled. The motion of the air molecules results in a force of reaction, which causes the electrode to spin.

5.5 Spark discharge

- The transformer is operated with just one secondary coil and 4 windings on the primary coil. The needle electrode is placed on the secondary coil.
- The long spherical electrode 8496260 is plugged into the second earth socket and the sphere is directed towards the tip of the needle.
- Now sparks several centimeters long start to leap between the tip of the needle and the sphere.

5.6 Wireless transmission of energy

- The transformer is operated with one secondary coil and the spherical electrode 8496258 attached.
- A second secondary coil attached to the base 8496257 with its holder for fluorescent lamp 8496264 is set up about 1 m away from the Tesla transformer.
- The earth sockets of the coil base and the Tesla transformer should be connected together via a laboratory cable.
- When the Tesla transformer is switched on with the light in the room partially dipped, it can be seen that the fluorescent tube illuminates. Wireless energy transfer is taking place between the coils.
- With reflector 8496266 inserted between the coils, the shielding effect of the metal foil can be demonstrated.

5.7 Standing waves in a Tesla coil

- The Tesla transformer is operated with two coils connected together. The small spherical electrode is placed at the upper end. The number of primary coil windings is set to 8.
- Move the hand coil from above down over the pair of coils. The lower it gets, the brighter the lamp lights. The secondary coil oscillates as a $\lambda/4$ dipole. At the top end a current node appears and at the bottom, an antinode.
- Reduce the number of primary coil windings to three and slowly lower the hand coil from the upper end of the Tesla coil again. A current node appears at the top end and the lamp does not illuminate or only very weakly.
- Moving further down, it is possible to detect two more antinodes and one more node in the oscillation. The Tesla coil is oscillating in the nature of a $3/4\text{-}\lambda$ dipole.