Title: ELECTRODELESS LOW PRESSURE LAMP WITH MULTIPLE FERRITE CORES AND INDUCTION COILS

Abstract: An electrodeless low pressure discharge lamp has an elongated envelope and at least one cavity extending into the envelope. The cavity accommodates a plurality of hollow ferrite cores separated from each other with a few mm distance. Each ferrite core has an induction coil winding around the core. The cavity has a cooling copper tube or rod located inside the ferrite core that removes heat from the cores and dumps the heat into a heat sink welded to the cooling tube/rod thereby keep the temperature of the ferrite cores below their Curie point. The induction coils are electrically connected respectively to matching networks that are connected in parallel with each other to the high frequency power source. Inductively coupled plasmas generated in the envelope respectively by the core/coil assemblies produce UV and visible radiation that are uniform along a lengthwise axis of the envelope.
For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.
DESCRIPTION

ELECTRODELESS LOW PRESSURE LAMP WITH MULTIPLE FERRITE CORES AND INDUCTION COILS

TECHNICAL FIELD

This invention relates to electric lamps and, more specifically, to low pressure lamps (e.g. fluorescent lamps) operated at low and intermediate pressures at frequencies from 50 kHz to 3 MHz.

BACKGROUND ART

Electrodeless fluorescent lamps utilizing an inductively coupled plasma have been widely used for indoor and outdoor applications. These lamps have longer life than conventional fluorescent lamps employing heating filaments. Presently, however, only a few electrodeless lamps have been brought to market. Most of them have a bulbous envelope, as seen in the lamps available under the trade names of "Genura" from General Electric Company, "QL" from Phillips, and "Everlight" from Matsushita Electric Works, Ltd. Few are used for general lighting. They are not suitable for applications where long lamps with axially uniform light output are required (e.g. tunnel lighting).

A closed-loop electrodeless fluorescent lamp operated at a frequency of 250 kHz was recently introduced on the market by Osram/Sylvania and described in U.S. Patent 5,834,905 by Godyak et al. This lamp has uniform light output along the envelope of 400 mm length and can be used in tunnel lighting. However, the width of that lamp is a rather large (140 mm) to fit in many reflectors used in tunnel lighting fixtures.

U.S. Patent 5,382,879 to Council et al. described a long tubular fluorescent lamp operated at RF frequency from 30 MHz and higher. UV and visible radiations are produced by capacitive discharge plasmas generated inside the tube with the help of inner or outer RF electrodes positioned on the tube walls. However, the plasma efficiency of a capacitive discharge operated without magnetic field at RF frequencies of f < 400 MHz is relatively low since most of the RF power goes for the ion acceleration at the sheath. Also, the cost of the lamp driver at such high frequencies is high.

U.S. Patent 5,760,547 to Borowiec described the electrodeless lamp with a bulbous envelope and a cavity that employs two independently powered
induction coils. Such an arrangement causes spreading of the plasma along the axis of the envelope and results in a more axially uniform light output. However, this lamp is best used for operation at a high frequency (MHz range) where the induction coil of few turns can be used. For efficient operation at lower frequency, f<400 kHz, an electrodeless lamp requires low loss ferrite cores. Again, a lamp with a bulbous envelope does not have an axially uniform plasma and, hence, axially uniform radiation as required by the tunnel lighting.

DISCLOSURE OF THE INVENTION

According to the present invention, we have found an efficient electrodeless fluorescent lamp that is suitable for tunnel lighting and is operated at frequencies from 20 kHz to 3 MHz. The lamp comprises a glass, tubular, evacuated envelope having a length between about 50 mm and 2000 mm and a diameter between about 10 mm and 500 mm. The lamp further comprises one or more cavities with ferrite cores disposed in the cavities and a coil wound on each core. The axis of each core is coaxial with the cavity or coplanar with the axis of the envelope. The cavities have lengths between about 10 mm and 1950 mm. A thermally conductive cooling rod or tube is disposed in each core and is attached to an external heat sink to draw heat from the cores. When using the tube, the outer diameter of the tube is between about 4 mm and 50 mm and the inner diameter is between about 2 mm and 48 mm. With the rod, the outer diameter is between about 4 mm and 50 mm.

The envelope is configured to have an outer wall and an inner wall defining therebetween a closed space. It is within this closed space that a filling of an inert gas and a vaporous metal such as mercury, cadmium, sodium or the like is placed. The cavity 2 is confined or surrounded by the inner wall to define an open space for accommodating at least one assembly composed of the ferrite core and the induction coil. A protective coating is deposited on the interior surfaces of the outer wall as well as the inner wall of the envelop. A conventional phosphor coating is deposited on the protective coating. A reflective coating (alumina or the like) is deposited on the inner wall surrounding the cavity between the protective and phosphor coatings, to reflect the UV and visible light back to the envelope walls.

The ferrite core is made from a low loss ferrite material (such as
ferrous-based MnZn or the like) into a cylindrical shape and is positioned inside of the cavity. Each ferrite core is wrapped with an induction coil which is electrically connected to a conventional matching network. All matching networks are connected in parallel and are powered by a high frequency power source, a driver. The driver generates a voltage at a high frequency of 20 kHz-3,000 kHz, and is connected electrically to a power supply.

An object of the present invention is to provide an efficient electrodeless fluorescent lamp suitable for tunnel lighting and operated at a frequency from 20 kHz to 3 MHz and power from 5 W to 1,000 W.

Another object of the present invention is to provide the lamp having an envelope which is designed to include cavities of the proper position, shape, and size so as to assure a sufficient volume inside the envelope for several plasmas needed for the efficient production of the axially uniform visible and UV radiations.

Yet another object of the present invention is to provide the lamp having an assembly that comprises the ferrite core and the induction coil that have very low power losses.

A further object of the present invention is to provide the lamp in which the coil/core assemblies are located in an envelope to avoid the mutual interference of magnetic fields generated by each assembly.

Many other objects, features, and advantages of the present invention will become apparent to those skilled in the art upon reading the following specifications when taken in conjunction with the drawing and claims.

BRIEF DESCRIPTION OF THE DRAWINGS
FIG. 1 is a cross sectional view of an electrodeless lamp shown with a schematic driver circuit diagram in accordance with a first embodiment of the present invention.
FIG. 2 is a cross sectional view of an electrodeless lamp shown with a schematic driver circuit diagram in accordance with a second embodiment of the present invention.
FIG. 3 is a cross sectional view of an electrodeless lamp shown with a schematic driver circuit diagram in accordance with a third embodiment of the present invention.
FIG. 4 is a cross sectional view of an electrodeless lamp shown with a schematic driver circuit diagram in accordance with a fourth embodiment of
the present invention.

FIG. 5 is a graph showing lamp efficacy, ε, as a function of lamp power, \( P_{\text{lamp}} \), for the lamp built according to the first embodiment of the present invention and another according to the prior art, at a driving frequency \( f \) of 320 kHz, and an argon pressure is 120 mtorr.

MODE FOR CARRYING OUT THE INVENTION

Referring to FIG. 1, a lamp includes a glass-made envelope 1 of elongated configuration having a lengthwise axis. The length of the envelope \( H_{\text{env}} \) is substantially larger than the tube diameter, \( D_{\text{env}} \). In the preferred embodiment, the length of the envelope 1, \( H_{\text{env}} = 300 \) mm, and the diameter of the envelop, \( D_{\text{env}} = 70 \) mm. The envelope 1 has an outer wall 20 and an inner wall 30 defining therebetween a closed space. Also, the envelope 1 is formed with a straight cylindrical cavity 2 which extends in such a manner as to be confined by the inner wall 30 and which is aligned with an axis A-A of the envelop 1. Cavity diameter, \( D_{\text{cav}} \), and length, \( H_{\text{cav}} \), are smaller than those of the envelope. The diameter of the cavity can be between about 5 mm and 100 mm. In the preferred embodiment, the cavity diameter, \( D_{\text{cav}} = 25 \) mm, and the length, \( H_{\text{cav}} = 290 \) mm. The bottom 3 of the envelope 1 is sealed to the open end 4 of the cavity 2. A small space 5 separates the top 6a of the envelope and the top 6b of the cavity. In this embodiment, the length of the space 5, \( H_{\text{cav}} = 10 \) mm.

The mercury vapor pressure in the envelope 1 is maintained by the temperature of a mercury drop (or an amalgam) disposed in the exhaust tubulation 7. The pressure of the inert gas (argon, krypton or the like) is between 0.01 torr and 10 torr. A protective coating 8 is deposited on the interior surface of the envelope at portions forming the outer wall 20 and the inner wall 30 surrounding the cavity, respectively. A phosphor coating 9 is deposited on the protective coating 8. A reflective coating 10 (alumina and the like) is deposited on the inner wall the surrounding the cavity between the protective coating 8 and phosphor coating 9. Although these coatings are shown in FIG. 1 as being deposited only partially, it should be noted that the combination of the coatings 8, 9 and 10 are deposited on substantially the entire portion surrounding the cavity and that the combination of the coatings 8 and 9 are deposited on substantially the entire portion of the envelop except for the portion surrounding the cavity and for the tabulation 7.
A plasma production means comprising several induction assemblies which include several hollow ferrite cores each having an induction coil. In the preferred embodiment, there are three assemblies with ferrite cores, 11a, 11b and 11c, and coils 12a, 12b and 12c. All assemblies are positioned on the axis of the envelope 1 inside the cavity 2. In the preferred embodiment, all three ferrite cores have the same diameter and the same length. In other modifications, the ferrite cores may have different lengths.

The induction coil can have from 2 to 200 turns and the pitch between the turns is from 0.2 mm to 50 mm. The cores are cylindrical and can have a length between about 4 mm and 200 mm, an outer diameter between about 4 mm and 98 mm and an inner diameter between about 2 mm and 50 mm. In the preferred embodiment, all three coils have the same number of turns, N = 40, and the same pitch of 6.0 mm. The coil can be made from copper wire of gauge from #10 to #52, each coated with a thin silver layer. In preferred embodiment, the coil wire is made from multi-stranded Litz wire having from 250 copper-made strands each of gauge #40. In other modifications, the number of strands can be from 20 to 600 and the gauge from #30 to #44.

Each coil is connected to a matching network. All matching networks 13a, 13b, 13c are connected in parallel to the power source (driver) 14 and individually tuned so to minimize the reflected power from each induction assembly. The ferrite cores 11a, 11b and 11c are separated a few millimeters from each other to minimize mutual interference of alternating magnetic fields generated by high frequency voltages applied from matching networks 12a, 13b, 13c on the coils 12a, 12b, 12c, respectively.

Alternating magnetic fields induce azimuthal alternating voltages in the envelope that ignite and maintain in the envelope the inductively coupled plasmas 15a, 15b and 15c. Each plasma has a toroidal shape and has the maximum plasma density, \( N(z) = N_{\text{max}} \), approximately in the midplane of the correspondent ferrite core. Three toroidal plasmas 15a, 15b and 15c, excited and maintained in the envelope 1, occupy the volume that is substantially larger than that occupied by a single plasma generated by the single core and coil assembly. This results in the higher UV and visible radiations generated by the three plasmas, 15a, 15b, 15c, than that generated by a single plasma. Also, the axial distribution of visible radiation is more uniform in the lamp with three core/coil assemblies than in the lamp.
employing a single induction assembly.

Each of the ferrite cores, 11a, 11b and 11c is heated mainly by the correspondent plasma by convection via the cavity walls. To remove the heat from the ferrite cores and keep their temperatures below the Curie point (<200°C), a solid rod 16 made from copper or other material having high thermal conductivity, such as aluminum, is inserted in hollow ferrite cores, 11a, 11b, 11c and welded to a heat sink 17 located below the envelope bottom 3.

The second embodiment of the present invention is shown schematically in FIG. 2. The envelope 101 is shaped into a straight annular cylinder of uniform diameter which is opened at opposite longitudinal ends. The envelope has an annular closed space which is elongated along a lengthwise axis B-B of the envelope and is defined between an outer wall 120 and an inner wall 130 of the envelope. With this result, a straight cavity 102 of uniform diameter is defined as being surrounded by the inner wall 130 to extend along the axis of the envelope in a coaxial relation thereto, i.e., penetrate through the center of the envelope. The diameter, Denv of the envelope is substantially smaller than the envelope length, Henv. The length of the cavity 102, Henv is essentially equal to the length of the envelope 102, that is Hcav = Henv. Two open ends, 103a and 103b, of the cavity 102 are sealed to two open ends, 104a and 104b, of the envelope 101 thereby making envelope 101 of a hollow shape.

The envelope 101 is filled with an inert gas such as argon, krypton or the like at pressure between 0.01 torr and 10 torr. The vapor pressure of metal such as mercury, sodium or the like is controlled by the temperature of the mercury drop (or an amalgam) located in the exhaust tubulation 107.

Protective coating 108 and phosphor coating 109 are deposited on the interior surface of the envelope at portions forming the outer wall 120 of the envelope and the inner wall 130 surrounding the cavity, respectively. The reflective coating 110 is deposited on the inner wall 130 surrounding the cavity 102 between the protective and phosphor coatings 108 and 109, respectively. The combination of the coatings 108, 109 and 110 are deposited on substantially the entire portion surrounding the cavity and that the combination of the coatings 108 and 109 are deposited on substantially the entire portion of the envelop except for the portion surrounding the cavity and for the tabulation 107.

Several induction assemblies, each comprising a ferrite core 111 and an
induction coil 112 are inserted in the cavity 102 along the envelope axis. In the preferred embodiment, three assemblies with three cores 111a, 111b and 111c and three coils, 112a, 112b, 112c are employed.

Each induction coil is electrically connected to a matching network. Three matching networks 113a, 113b, 113c are connected in parallel to a power source (driver) 114. When the sufficiently high alternating voltage is applied to the induction coil, an inductively coupled toroidal plasma 115 is generated near the ferrite core. The maximum plasma density is located near the midplane of the ferrite core. The volume occupied by the three plasmas, 115a, 115b, 115c is substantially larger than the volume occupied by a single plasma generated by a single core/coil assembly. As the result, the UV and visible radiation produced by the three plasmas are higher than one produced by a single plasma. Also, the axial uniformity of the visible radiation is better in the case of three plasmas.

To keep the temperature of each ferrite core below the Curie point, two metal (copper, aluminum or the like) rods or tubes 116a and 116b are inserted in the cavity 102 along the envelope axis. Both rods (tubes) 116a and 116b, are thermally connected (welded or brazed) to two heat sinks 117a and 117b. A very tiny space 118 separates two rods in the center of the cavity. The length of the space 118 \( H_{sp} \) is between 0.5 mm and 10 mm. In the preferred embodiment, \( H_{sp} = 1 \) mm.

The third embodiment of the present invention is shown in FIG. 3. The envelope 201 is shaped into an straight annular cylinder of uniform diameter which is opened at opposite longitudinal ends. The envelope has an annular closed space which is elongated along a lengthwise axis C-C of the envelope and is defined between an outer wall 220 and an inner wall 230 of the envelope. A center web 206 is formed in the envelope to communicate the annular closed space at the longitudinal center of the envelope. With this result, two cavities 202a and 202b of the same diameter are defined as being surrounded by the inner wall 230 as well as the web 206 to extend coaxially along the axis of the envelope in such a manner that each cavity is closed at its one end by the web. Each cavity has one open end 203a and 203b that are sealed to envelope's bottoms 204a and 204b. Two cavity tops 205a and 205b are separated from each other with the web 206. In the preferred embodiment, the length of the web 206, \( H_{1-2} \), can be from 2 mm to 50 mm.
Protective and phosphor coatings 208 and 209 are deposited on the interior surface of the envelope 201 at portions forming the outer wall 220 and the inner wall 230 surrounding cavities 202a and 202b. Reflective coating 210 is deposited on the inner wall 230 between protective and phosphor coatings 208 and 209. Mercury vapor pressure is controlled by the temperature of the mercury drop (or an amalgam) positioned in the exhaust tubulation 207. The inert gas (argon, krypton, or the like) pressure is between 0.01 torr and 10 torr. In the preferred embodiment, argon pressure is about 0.120 torr. The combination of the coatings 208, 209 and 210 are deposited on substantially the entire portion surrounding the cavity and that the combination of the coatings 208 and 209 are deposited on substantially the entire portion of the envelop except for the portion surrounding the cavity and for the tubulation.

The induction means comprises several induction assemblies positioned on the axis of both reentrant cavities. Each assembly comprises a ferrite core and an induction coil wound on the ferrite core. Each assembly is separated from neighboring assembly with a space, $H_{c1}$, of which length can vary from 2 mm to 200 mm. In the preferred embodiment, where four induction assemblies were employed with two assemblies in each cavity the space $H_{c1}$ between each assembly was 10 mm. In other modifications, each cavity can have different number of induction assemblies.

Ferrite cores 211a, 211b and induction coils 212a, 212b are inserted in the cavity 202a. Ferrite cores 211c, 211d, and induction coils 212c, 212d are inserted in the cavity 202b. In the preferred embodiment, all coils have the same number of turns, 40, and the same pitch, 1 mm. In other modifications, coils can have different number of turns, from 2 to 200, and different height of the pitch, from 0.2 to 40 mm.

Two metal rods (tubes) 216a and 216b are used to keep temperatures of the ferrite cores below Curie point. Two ends of rods stick out from the cavities 202a and 202b and are thermally connected (welded or brazed) to the two heat sinks 217a and 217b respectively.

All four coils 203a, 203b, 203c and 203d are connected to four matching networks 212a, 212b, 212c and 212d respectively. Each matching network is tuned so to minimize the reflected power from the corresponding core/coil assembly. All matching networks are connected in parallel to the common power source (driver) 213.
An inductively coupled plasma generated by each core/coil has a toroidal shape with the maximum in plasma density near the core's midplane. A plasma resulting from the combination of four individual plasmas has much better axial uniformity than that of each individual plasma. Consequently, the UV and visible radiations produced by the four inductively coupled plasmas are also axially very uniform.

The fourth embodiment of the present invention is shown in FIG. 4. The envelope 301 is made from the straight glass tube of 70 mm diameter and has a length of 440 mm. The envelope 310 is elongated along its longitudinal axis D-D, and is recessed at two longitudinally spaced portions to form tubular inner walls 330. The inner walls 330 extend in a direction perpendicular to the axis D-D of the envelope to define cavities 302a and 302b of uniform diameter. Each cavity thus surrounded by the inner wall 330 is closed at its one end, leaving a closed space in the envelope as confined by an outer wall 320 of the envelope and the inner walls 330. In the preferred embodiment presented in FIG. 4, two cavities 302a and 302b are sealed with their open ends to the envelope. The axes E - E and F - F of cavities 302a and 302b are perpendicular to the axis D - D of the envelope 301 and are parallel to each other. In other modifications, axes of cavities are not parallel to each other but lie in the parallel planes and are perpendicular to axis D - D.

Cavities 302a and 302b are sealed to envelope's walls with their open ends 305a and 305b. In the preferred embodiment, the distance, H_{1,2}, between axes E - E and F - F of cavities 302a and 302b is 220 mm. In other modifications, such as when a multiplicity of cavities, up to 50 for example, (are formed), the distance between each neighboring cavities can vary from 5 mm to 500 mm. The height, H_{cav}, of cavities 302a and 302b is smaller than the diameter of the envelope 301, D_{env} = 70 mm. In the preferred embodiment, H_{cav} = 60 mm, though in other modifications, the height of each cavity can be different and vary from 5 mm to 200 mm. The diameter of each cavity 302a and 302b is 25 mm, though in other modifications, the diameter of each cavity can be different and can vary from 5 mm to 100 mm.

The protective and phosphor coatings 308 and 309 are deposited on the interior surface of the envelope 301 at portions forming the outer wall 320 of the envelope and the inner walls 330 surrounding the cavities 302a and 302b. The reflecting coating 310 is deposited on the inner walls 330.
respectively surrounding the cavities 302a and 302b, between the protective and phosphor coatings, 308 and 309. The mercury pressure is maintained by the temperature of a mercury drop (or an amalgam) located in an exhaust tubulation 307. The combination of the coatings 308, 309 and 310 are deposited on substantially the entire portion surrounding the cavity and that the combination of the coatings 308 and 309 are deposited on substantially the entire portion of the envelop except for the portion surrounding the cavity and for the tubulation.

Two ferrite cores, 311a and 311b are inserted in the cavities 302a and 302b, respectively. In the preferred embodiment, the height of both ferrite cores is the same, \( H_f = 60 \) mm. In other modifications, the height of each ferrite core can vary from 5 mm to 100 mm. The diameter of each ferrite core is 20 mm. In other modifications, the diameter of each ferrite core can vary from 2 mm to 490 mm.

A coil 312a and 312b is wound on each of two ferrite cores 311a and 311b, and connected to one of two matching networks 313a and 313b, respectively. Each of two matching networks is tuned to minimize the reflected power from the correspondent induction assembly. Both matching networks 313a and 313b are connected in parallel to the power source (driver) 314.

Two cooling rods (tubes) 316a and 316b are used to keep the ferrite cores at temperatures below the Curie point. Each cooling rod is inserted into one of the correspondent ferrite cores 311a and 311b and welded (or brazed) to the heat sink 317.

Two toroidal plasmas 315a and 315b are ignited and maintained in the envelope 301 around two cavities 302a and 302b. The resulting UV and visible radiations produced by both plasmas are more uniform along the axis D-D of the envelop than that produced by a single plasma generated by the single induction assembly.

The graph in FIG. 5 shows the luminous efficacy, \( \varepsilon \), of the lamp built in accordance with the first embodiment of the present invention where three ferrite cores and three coils were employed. The data of the lamp efficacy, \( \varepsilon \), measured in the same lamp but with a single ferrite core/coil assembly (prior art) are also presented in FIG. 5. In the lamp, the envelope length, \( H_{env} = 300 \) mm, the envelope diameter, \( D_{env} = 70 \) mm, the cavity height, \( H_{cav} = 290 \) mm, the cavity diameter, \( D_{cav} = 25 \) mm. The driving frequency, \( f = 320 \) kHz,
argon pressure, p = 120 mtorr.

It is seen that in case of three core/coil assembly, the lamp efficacy is much higher than that in case of the single core/coil assembly. Note that the power losses in ferrite cores and coils were essentially the same in both cases (6.5 W). The difference in efficacy is due to the larger envelope volume occupied by the three plasmas generated by the three induction assemblies compared with the volume occupied by the single core/coil plasma.

It is apparent that modifications and changes can be made within the scope of the present invention, but it is our intention, however, to be limited only by the scope of the appended claims.
CLAIMS

1. An electrodeless low pressure lamp comprising:
   an evacuated tubular glass envelope, said envelope being elongated to
   have a lengthwise axis, and having an outer wall and an inner wall defining
   therebetween a closed space,
   at least one cavity extending into said envelop, said cavity being
   confined by said inner wall to define an open space;
   at least one vaporous metal filled within said closed space of the
   envelop, the vapor pressure of said metal being controllable by the
   temperature of a cold spot of said envelop,
   an inert gas filled within said envelop at a pressure higher than about 10
   mtorr;
   a plurality of induction assemblies arranged along said lengthwise axis
   of said envelop and disposed within said cavity or cavities, each of said
   induction assemblies comprising a ferrite core and an induction coil wound
   on each of said ferrite cores;
   a cooling means being disposed in said at least one cavity; and
   a plurality of matching networks each connected to each of said
   induction coils, said matching networks being connected in parallel relation
   with each other to a high frequency power source, energizing said induction
   coils to thereby generate plasmas within said closed space of said envelop
   respectively around said induction assemblies.

2. The electrodeless low pressure lamp as defined in claim 1, wherein a
   protective coating is deposited on the interior surfaces of said outer wall and
   said inner wall of said envelop.

3. The electrodeless low pressure lamp as defined in claim 1, wherein a
   phosphor coating is deposited on said protective coating.

4. The electrodeless low pressure lamp as defined in claim 1, wherein a
   reflective coating is deposited on the interior surface of said inner wall of said
   envelop between said protective coating and said phosphor coating.

5. The electrodeless low pressure lamp as defined in claim 1, wherein said
cooling means are disposed in said ferrite cores.

6. The electrodeless low pressure lamp as defined in claim 1, wherein a heat sink is thermally connected to said cooling means.

7. The electrodeless low pressure lamp as defined in claim 1, wherein said envelope is straight and has a length between about 50 mm and 2000 mm.

8. The electrodeless low pressure lamp as defined in claim 7, wherein the diameter of said envelope is between about 10 mm and 500 mm.

9 (Revised). The electrodeless low pressure lamp as defined in claim 1, wherein more than one said cavities are formed in said envelop and arranged along said lengthwise axis

10. The electrodeless low pressure lamp according to claim 9, wherein the diameter of the cavity is between 5 mm and 100 mm.

11. The electrodeless low pressure lamp as defined in claim 10, wherein said cavity accommodates a multiplicity of said ferrite cores having a common axis which coincides with a common axis of said cavities.

12 (Revised). The electrodeless low pressure lamp as defined in claim 11, wherein the distance between adjacent ones of said ferrite cores is from 1 mm to 500 mm along said common axis.

13. The electrodeless low pressure lamp as defined in claim 1, wherein the length of said ferrite core is between 4 mm and 200 mm.

14. The electrodeless low pressure lamp as defined in claim 1 wherein said ferrite core is cylindrical with an outer diameter from 4 to 98 mm and an inner diameter from 2 to 50 mm.

15. The electrodeless low pressure lamp as defined in claim 1, wherein said coil has from 2 to 200 turns and a pitch from 0.2 mm to 50 mm.
16. The electrodeless low pressure lamp as defined in claim 15, wherein said coil is made from multiple strands of Litz Wire.

17. The electrodeless low pressure lamp as defined in claim 16, wherein the number of said strands in said Litz wire is between 20 and 600.

18. The electrodeless low pressure lamp as defined in claim 1, wherein said cooling means is a structure and is formed of a metal of high thermal conductivity and low power losses.

19 (Revised). The electrodeless low pressure lamp as defined in claim 1, wherein said at least one cavity has an axis perpendicular to said lengthwise axis.

20. The electrodeless low pressure lamp as defined in claim 1, wherein said high frequency power source delivers to said matching networks a high frequency power from 5 W to 5000 W at a frequency from 50 kHz to 3 MHz.

21. The electrodeless low pressure lamp as defined in claim 1 wherein said coil is made from copper wire.

22. The electrodeless low pressure lamp as defined in claim 21 wherein said copper wire has a gauge from #10 to #28.

23 The electrodeless low pressure lamp as defined in claim 18 wherein said structure is a rod or tube having diameter from 1 mm to 50 mm.

24. The electrodeless low pressure lamp as defined in claim 1 wherein said ferrite core is of rectangular shape.
FIG. 5