

INDUCTIVE SURFACE ELEMENT

The present invention relates to an inductive surface element that enables propagation conditions of an electromagnetic radiation to be modified. It also relates to a surface wave generation assembly and a surface wave
5 detection assembly, each comprising such an inductive surface element.

A surface wave is an electromagnetic radiation propagation mode which is related to a separation interface between two different media. The two media can differ from one another in their respective values of dielectric permittivity and/or of electrical conductivity. A surface wave has the following
10 characteristics:

- its direction of propagation is parallel to the interface between the two media; and
- it has exponential attenuation in the direction perpendicular to the interface between the two media.

15 In addition, the wave vector which characterizes the propagation parallel to the interface is related to the attenuation coefficient in the perpendicular direction and to the electromagnetic impedance of the interface. Such a surface propagation mode is in contrast to free space propagation mode, which is sometimes called skywave propagation.

20 Surface waves are used in various applications, including radar systems or communication systems where the transmitted waves involved are surface waves. For these systems, the interface used is the boundary between the ground and the air medium above the ground. One advantage of these systems is the reduction in the skyward loss of electromagnetic radiation
25 power, as the transmitted waves are concentrated close to the ground.

Many of the available sources of electromagnetic radiation produce waves that propagate in free space. A surface wave can then be produced using a conversion element which couples some of the waves propagating in

free space, as produced by the source, to surface waves. However, the following difficulties affect the existing conversion elements:

- free space propagation waves persist despite the conversion element, which constitutes a loss of efficiency between the power that is radiated by the source and the power that is actually distributed in the form of surface waves; and
- the surface waves that are produced by the conversion element have dispersed propagation directions parallel to the ground, so that only a portion of the energy carried by these surface waves is transmitted in a desired direction.

Furthermore, when such a conversion element is used in combination with a detector to receive a communication by surface wave transmission, the conversion element also transmits free space propagation waves to the detector, in addition to the surface wave received. The unintentionally transmitted waves propagating in free space then interfere with and disrupt the detection of the signal carried by the surface wave.

Document GB 788 824 discloses an antenna element which is adapted to transmit a wave that is focused perpendicular to a base plate of that element, in free space propagation mode.

Document EP 1 594 186 discloses an antenna which is formed by an open loop above a ground plane. The ground plane is designed to be buried. Two confined waves are formed between the loop and the ground plane, and the peripheral edge of the ground plane produces an outwardly surface wave radiation. However, this system also produces a wave propagating in free space.

Document WO 03/007426 describes an antenna with a small form factor radiating element, which is arranged above a high impedance surface located on a metal ground plane. However, horizontally polarized surface waves of the

electric field appear in the high impedance surface and then transform into waves propagating in free space.

Finally, documents WO 2010/142946 and EP 1 608 037 disclose antennas that have different structures, and which increase the wave emission efficiency for waves where the propagation directions have small elevation angles above the ground. However, these do not concern surface waves whose propagation is actually parallel to the ground and where the power carried remains concentrated close to the ground.

Under these conditions, a first object of the present invention is to generate surface waves where a minimum amount of power is radiated in the form of waves propagating in free space.

A second object of the invention is to generate surface waves that are concentrated in azimuth about a desired propagation direction, parallel to the surface of the ground.

A third object of the invention is to provide a system for generating surface waves, which can use the available radiation sources to produce waves propagating in free space, particularly wire antennas.

A fourth object of the invention is to provide a surface wave generation system which is compact, inexpensive, and easy to implement.

Finally, a fifth object of the invention is to provide a surface wave generation system which is adapted to operate in a frequency range between 0.2 MHz (megahertz) and 3000 MHz, and in particular in the high frequency band known as the HF band, between about 3 MHz and 30 MHz.

To achieve these and other objects, the present invention proposes an inductive surface element for an electromagnetic radiation, said element comprising:

- an electrically conductive base plate which extends in a plane not parallel to the electric field component of the electromagnetic radiation; and

- a series of electrically conductive secondary plates which extend perpendicularly to the base plate, in a same half-space on one side of the base plate, and symmetrically with respect to a plane perpendicular to the base plate in a direction referred to as the sensitive direction.

According to a first feature of the invention, the secondary plates have a same height to within $\pm 10\%$, this height being between $0.035 \times \lambda$ and $0.35 \times \lambda$, where λ is a dimension parameter of the inductive surface element.

According to a second feature of the invention, the distance between the base plate and the facing edges of the secondary plates is between zero and half the height of the relevant secondary plates.

According to a third feature of the invention, the secondary plates are arranged parallel to each other with a period such that the product of the height of the secondary plates times the period is between $0.001 \times \lambda^2$ and $0.15 \times \lambda^2$ to within $\pm 10\%$.

According to a fourth aspect of the invention, the secondary plates each extend for a total length of at least $0.0003 \times \lambda$ perpendicularly to the sensitive direction.

Such an inductive surface element is then able to modify propagation conditions, in the half-space, of a projection of the electric field component which is perpendicular to the base plate, when a wavelength of the electromagnetic radiation is between $\lambda - 10\%$ and $\lambda + 10\%$. The wavelength of the electromagnetic radiation which is considered is the wavelength associated with the propagation in the medium where the inductive surface element is located, and which is equal to the speed of light in this medium divided by the frequency of the radiation. In this manner, the inductive surface element allows generating or detecting surface waves concentrated in azimuth about a direction of propagation parallel to a ground surface, when this element is placed on the ground or is partially buried near the ground surface, the base

plate being parallel to an average boundary surface between the ground and the air half-space.

The inductive surface element of the invention is therefore an electromagnetic conversion element which enables coupling free space
5 propagation modes with surface waves. This coupling is particularly effective due to the element geometry and dimensions introduced by the invention. In other words, the element allows efficient transfer of a portion of the radiated power of free space propagation waves which reach the element, to surface waves. It can therefore be used with available sources of electromagnetic
10 radiation, including wire sources which are inexpensive and easy to use to generate skywaves. These free space propagation waves are then at least partially transformed into surface waves by the inductive surface element of the invention.

In particular, the inductive surface element of the invention is effective in
15 the electromagnetic radiation frequency range that is between 0.2 MHz and 3000 MHz, and in particular in the HF band between 3 MHz and 30 MHz.

Conversely, the inductive surface element of the invention also allows efficient coupling of the surface waves that reach this element, with waves propagating in free space which can then be detected.

20 In addition, the surface waves generated by the inductive surface element of the invention have directions of propagation which are concentrated in azimuth about the sensitive direction of the element. In this respect, the secondary plates are not necessarily planar. They can be adapted to change the azimuthal directivity of the inductive surface element. For example, while
25 remaining perpendicular to the base plate, they may have a circular curvature on either side of the sensitive direction.

Finally, the inductive surface element of the invention is simple, inexpensive, and easy to implement. In particular, it can be manufactured separately from the electromagnetic radiation source or detector with which it
30 is to be used, which simplifies its manufacturing process.

In preferred embodiments of the invention, some of the following improvements may be used separately or in combination:

- each series of secondary plates may comprise at least six secondary plates;
- 5 – a width of at least one of the secondary plates may be between $\lambda/2$ and λ , measured parallel to the base plate and perpendicularly to the sensitive direction;
- the height of the secondary plates may be between $\lambda/20$ and $\lambda/5$, measured perpendicularly to the base plate and therefrom;
- 10 – the inductive surface element may comprise a series of secondary plates in which each secondary plate consists of a pair of ternary plates. In this case, the two constituent ternary plates of a secondary plate are separated by a distance of between $\lambda/100$ and $\lambda/50$, measured in the sensitive direction;
- 15 – at least one of the plates among the base plate and the secondary or ternary plates may comprise a portion of sheet metal or metal grating, or a combination of at least one sheet metal portion and at least one metal grating portion. Optionally, a (some) portion(s) of perforated or multi-aperture sheet metal may be used, to reduce the
- 20 weight of the element and the amount of material consumed; and
- at least some of the secondary or ternary plates may be electrically connected to the base plate.

The invention also provides a surface wave generation assembly, which comprises:

- 25 – a radiation source, which is adapted to generate at least one electromagnetic radiation having a free space propagation mode; and
- at least one inductive surface element as described above, which is placed on the ground or partially buried or buried near the ground

surface, such that the base plate is parallel to an average boundary surface between the ground and an air half-space.

The radiation source is oriented so that an electric field component of the electromagnetic radiation at the location of the inductive surface element is not parallel to the base plate.

In addition, the radiation source is adapted so that a wavelength of the electromagnetic radiation is between $\lambda - 10\%$ and $\lambda + 10\%$, where λ is the dimension parameter of the inductive surface element.

In the context of the invention, the inductive surface element is considered to be buried near the surface of the ground when the distance between the base plate and the average boundary surface between the ground and the air half-space is less than λ .

The radiation source may in particular be adapted to produce the electromagnetic radiation with a radiation frequency that is between 0.2 MHz and 3000 MHz, and more particularly between 3 MHz and 30 MHz.

The radiation source may comprise a wire antenna, as the emission efficiency of this type of antenna is particularly high. In the case of a monopole or dipole wire antenna, the wire is preferably oriented so that a rectilinear antenna segment thereof is perpendicular to the base plate. Furthermore, the wired antenna may advantageously be positioned relative to the inductive surface element according to at least one of the following arrangement features:

- the rectilinear antenna segment is separated from the one of the secondary plates of the inductive surface element which is closest to the rectilinear antenna segment, by a distance which is less than or equal to $0.5 \times \lambda$ measured in the sensitive direction; and
- a point of the rectilinear antenna segment which is closest to the base plate is located at a height less than 1.5 times the height of the secondary plates, these heights being measured from the base plate

in a direction perpendicular to said base plate and on the side of the secondary plates.

The radiation source may comprise a loop type wire antenna, the plane loop being preferably parallel to the base plate. For the invention to work, the electromagnetic radiation from the source must have an electric field component that is not parallel to the base plate.

Finally, the invention also provides a surface wave detection assembly, which comprises:

- a radiation detector which is adapted to detect at least one electromagnetic radiation; and
- at least one inductive surface element as described above, placed on the ground or partially buried or buried near the ground surface, such that the base plate is parallel to an average boundary surface between the ground and an air half-space.

The radiation detector is oriented to detect the electromagnetic radiation when an electric field component of this radiation is not parallel to the base plate, and is effective for detecting the electromagnetic radiation when a wavelength of this radiation is between $\lambda - 10\%$ and $\lambda + 10\%$, where λ is the dimension parameter of the inductive surface element.

The feature where the inductive surface element is buried close to the surface of the ground also means that the distance between the base plate and the average boundary surface between the ground and the air half-space is less than λ .

The radiation detector can then be placed within the surface wave detection assembly, in a position relative to the inductive surface element that is identical to that of the radiation source within the surface wave generation assembly.

Other features and advantages of the invention will become apparent from the following description of some non-limiting exemplary embodiments, with reference to the accompanying drawings where:

- 5 – figure 1a is a perspective view which illustrates an implementation of an inductive surface element according to a first embodiment of the invention, in a surface wave generation assembly;
- figures 1b and 1c are respectively a plan view and a side view of the inductive surface element of figure 1a;
- figures 2a to 2c respectively correspond to figures 1a to 1c for a
10 second embodiment of the invention;
- figures 3a to 3c respectively illustrate three possible installations of the inductive surface element according to the invention; and
- 15 – figures 4a and 4b are respective diagrams of the transmission gain and the change in the reflection coefficient, according to the frequency of the electromagnetic radiation, for an inductive surface element of the invention.

For clarity, the dimensions of the elements or element portions shown in these figures do not correspond to the actual dimensions or actual dimensional ratios. In addition, identical references in the various figures denote identical
20 elements or elements that have identical functions.

Figures 1a to 1c show an inductive surface element according to the invention which comprises a series of secondary plates, and the element of figures 2a to 2c comprises a series of secondary plates each consisting of a pair of ternary plates. The references indicated in the figures have the
25 following significance:

1	base plate
2	secondary plates
2a, 2b	ternary plates

	LS	centerline of base plate, preferably longitudinal
	Lopm	length of base plate measured parallel to centerline LS
5	Lpm	width of base plate measured perpendicularly to centerline LS
	L, Ldl	width of each secondary or ternary plate measured perpendicularly to centerline LS
	H, Hdl	height of each secondary or ternary plate measured perpendicularly to base plate
10	Nbl, Nbdl	number of secondary plates in each series, preferably greater than or equal to six
	P	spacing between the secondary plates, measured along centerline LS and constituting an arrangement period of the secondary plates
15	D	offset between two ternary plates of a pair forming a secondary plate, measured along centerline LS
	3	antenna emitting the electromagnetic radiation
	4	HF signal source, denoted GEN. HF
20	Hant	placement height of antenna 3 above the plane of base plate, measured for a low point of antenna 3
	Dant	distance between antenna 3 and nearest secondary plate
	z	axis perpendicular to base plate
25	OL	electromagnetic wave with free space propagation mode, produced by antenna 3 in the direction of the inductive surface element

	E	electric field of electromagnetic wave OL, which is perpendicular to the propagation direction of wave OL
5	E_z	electric field component of electromagnetic wave OL along axis z
	θ	lowering or elevation angle of the propagation direction of electromagnetic wave OL relative to a plane parallel to base plate
10	OS	surface wave generated by the inductive surface element from electromagnetic wave OL

All the secondary 2 or ternary 2a, 2b plates can have the same dimensions. They are all perpendicular to the centerline LS, and therefore all parallel to each other. Moreover, they are all centered on centerline LS, and the period P of the secondary plates is constant. When the inductive surface element comprises a series of secondary plates where each secondary plate consists of a pair of ternary plates, the period T is identical between the ternary plates of two adjacent pairs.

As an illustrative example, the base plate 1 can be rectangular, as can be each secondary 2 or ternary 2a, 2b plate.

In these circumstances, centerline LS is the direction of emission of the surface wave OS generated by the inductive surface element from electromagnetic wave OL, when antenna 3 is placed perpendicular to centerline LS. When the inductive surface element generates a beam of surface waves, this beam is centered in azimuth about centerline LS, in a plane parallel to base plate 1. For this reason, centerline LS is referred to as the sensitive direction in the general portion of this description.

A surface wave generation assembly is formed by associating the inductive surface element of figures 1a-1c and 2a-2c with a source of electromagnetic radiation. Such a source of radiation comprises the

transmitting antenna 3 and signal source 4, which is connected in order to feed the transmission signal to antenna 3. Antenna 3 may be a wire antenna, particularly a quarter wave monopole type antenna. Such an antenna is known to the person skilled in the art. It includes a rectilinear antenna segment
5 capable of producing electromagnetic radiation that initially propagates in free space, from the antenna segment. Antenna 3 and source 4 may be adapted so that the electromagnetic radiation has a frequency f in the HF band between 3 MHz and 30 MHz. The wavelength of wave OL that is produced by antenna 3 is then $\lambda = C/f$, where C is the speed of light in the medium, equal to C_0/N
10 where N is the refractive index of the medium and C_0 is the speed of light in vacuum. The wavelength is then between 10 m (meters) and 100 m in air for the HF band mentioned above.

To generate surface wave OS, which is intended to propagate on the ground surface, from wave OL, with good power transfer efficiency between
15 the two waves, the arrangement of the surface wave generation assembly satisfies the following conditions:

- the inductive surface element is placed near the surface of the ground;
- dimensions of the inductive surface element are appropriately
20 selected relative to the wavelength of the electromagnetic radiation produced by antenna 3; and
- the rectilinear segment of antenna 3 is placed and oriented appropriately relative to the inductive surface element.

The inductive surface element may be either placed on the ground
25 (figure 3a), partially buried (figure 3b), or completely buried (figure 3c). In all cases, base plate 1 is parallel or substantially parallel to an average boundary surface S between the ground and the air half-space above. The actual ground surface may be irregular, but the average boundary surface S of the ground is flat. Furthermore, the inductive surface element is oriented with its secondary
30 plates 2 being vertical and upward above base plate 1. The depth K of base

plate 1 below the average boundary surface S of the ground is preferably less than λ or possibly even less than $\lambda/2$. When the inductive surface element is partially buried, the upper edges of at least some of the secondary plates 2 protrude above the ground into the air half-space. In the use of the invention
5 which is described below, the inductive surface element is placed on the ground (figure 3a).

As an illustrative example, the inductive surface element used is as shown in figures 1a-1c with the following specific characteristics: the number N_{bl} of secondary plates 2 is equal to 21, the spacing P between two
10 successive secondary plates 2 is constant and equal to $0.0697 \times \lambda$, the height H of each secondary plate 2 is equal to $0.1651 \times \lambda$, the width L of each secondary plate 2 is equal to $0.6678 \times \lambda$, the width L_{pm} of base plate 1 is equal to the width L of secondary plates 2 plus $0.5 \times \lambda$, and the length L_{opm} of base plate 1 is equal to $1.931 \times \lambda$. Deviations of $\pm 10\%$ from these dimensions
15 may be adopted without significantly impacting the operation of the surface wave generation assembly for the same radiation frequency produced by antenna 3. Given the large dimensions that the inductive surface assembly may have, at least some of its component plates may advantageously be made of metal grating or perforated metal sheet, to reduce the weight and
20 amount of raw material used. The thickness of the plates has no significant effect, as the plates may be regarded as two-dimensional conductive surfaces. Each secondary plate is held stationary relative to base plate 1, but does not need to be electrically connected to base plate 1. Each secondary plate may therefore be electrically insulated with respect to base plate 1.

25 Antenna 3 is preferably oriented so that the rectilinear antenna segment is vertical and therefore perpendicular to base plate 1. Distance D_{ant} may be equal to $0.5 \times \lambda$, and height H_{ant} of the antenna segment above base plate 1 may be zero.

One operating condition of the surface wave generation assembly is
30 that component E_z of electric field E of the electromagnetic wave OL generated

by antenna 3 is not zero. In other words, electric field E of wave OL is not parallel to base plate 1. The inductive surface element then modifies the propagation conditions of component E_z by converting a portion of wave OL into surface wave OS. When antenna 3 is placed in alignment with centerline LS on one side of the inductive surface element, then wave OS emerges above the inductive surface element with a propagation direction which is parallel to centerline LS. Wave OS has the structure of a surface wave, with an amplitude of the electric field which decays exponentially in direction Z in the air half-space, from the average boundary surface SI of the inductive surface element.

Figures 4a and 4b correspond to an inductive surface element as described above, which has been sized for a wavelength value of wave OL equal to approximately 27.3 cm (centimeters). In other words, dimension parameter λ is equal to 27.3 cm. This wavelength value corresponds to a frequency f of electromagnetic radiation which is equal to 1.1 GHz (gigahertz).

In the diagram of figure 4a, the solid curve characterizes a transmission efficiency between the radiation source and a detector placed at a distance, using the inductive surface element in combination with the radiation source. The dotted curve characterizes the same transmission efficiency, but with no inductive surface element. Using the inductive surface element provides a transmission gain of about 20 dB for a radiation frequency of 1.1 GHz.

The diagram in figure 4b shows the change in the power reflection coefficient of antenna 3, comparing its operation with (solid curve) and without (dotted curve) the inductive surface element. A decrease in the reflection which can reach 10 dB is obtained at 1.1 GHz using the inductive surface element.

The power of the electromagnetic radiation was measured near the end of the inductive surface element where the surface wave OS emerges, by the method of measuring the temperature rise. These measurements were obtained for the radiation frequency of 1.1 GHz, with the inductive surface

element being sized for this frequency. The measurements show that the inductive surface element produces a high concentration of the electromagnetic energy that is transmitted, near the ground surface and around centerline LS. Precise measurements confirm that the density of electromagnetic energy where it exits the inductive surface element decreases exponentially when the elevation angle relative to the ground increases. This confirms that wave OS is a surface wave.

One possible set of specifications for the inductive surface element of figures 2a-2c can be: the number Nbd1 of ternary plates 2a and ternary plates 2b are also equal to 21, the spacing P between two successive ternary plates 2a, or between two successive ternary plates 2b, is equal to $0.0953 \times \lambda$, the offset D between ternary plates 2a and 2b is $0.0229 \times \lambda$, the height Hdl of each ternary plate 2a or 2b is equal to $0.1074 \times \lambda$, and the width Lpm of base plate 1 is at least equal to the width Ldl of each ternary plate 2a or 2b, which in turn is equal to $0.6678 \times \lambda$. However, deviations of $\pm 20\%$ from these specific dimensions can be adopted without impacting the frequency of the source radiation that is used with the inductive surface element.

The arrangement of such an inductive surface element, having two series of ternary plates, relative to antenna 3 within the surface wave generation assembly can be the same as that described for the inductive surface element of figures 1a-1c.

An inductive surface element according to the invention can also be used in a surface wave detection assembly. For this, the inductive surface element is still placed on the ground, partially buried, or buried in the same manner, but with its centerline LS, or sensitive direction, oriented in a surface wave reception direction. A radiation detector may then be positioned substantially at the same location as antenna 3 in relation to the inductive surface element. Under these conditions, the inductive surface element partially transforms the received surface wave into a wave structure that

converges on the radiation detector. The surface wave which is received can thus be detected with high sensitivity.

It is understood that the invention can be reproduced by modifying some of the features that have been described as an example. An inductive
5 surface element according to the invention can be sized simply for any radiation frequency, using the design rules which have been given.

Finally, several inductive surface elements according to the invention can be arranged about a single source of electromagnetic radiation, in order to transmit the surface waves simultaneously in a plurality of directions.

CLAIMS

1. Inductive surface element for an electromagnetic radiation, said element comprising:

- an electrically conductive base plate (1) which extends in a plane not parallel to an electric field component of the electromagnetic radiation; and
- 5 – a series of electrically conductive secondary plates (2), the secondary plates extending perpendicularly to the base plate and in a same half-space on one side of said base plate, symmetrically with respect to a plane perpendicular to said base plate in a direction referred to as the sensitive direction,

said secondary plates (2) having a same height (H ; H_{dl}) to within $\pm 10\%$, said height being between $0.035 \times \lambda$ and $0.35 \times \lambda$, where λ is a dimension parameter of the inductive surface element;

the distance between the base plate and the facing edges of the secondary plates is between zero and half the height of the relevant secondary plates;

said secondary plates (2) being arranged parallel to each other with a period such that the product of the height of the secondary plates times the period is between $0.001 \times \lambda^2$ and $0.15 \times \lambda^2$ to within $\pm 10\%$;

said secondary plates (2) each extending for a total length of at least $0.0003 \times \lambda$ perpendicularly to the sensitive direction;

said inductive surface element thus being adapted to modify propagation conditions, in said half-space, of a projection of the electric field component which is perpendicular to the base plate (1), when a wavelength of the electromagnetic radiation is between $\lambda - 10\%$ and $\lambda + 10\%$,

so as to allow generating or detecting surface waves concentrated in azimuth about a direction of propagation parallel to a ground surface, when said inductive surface element is placed on the ground or is partially buried near the

ground surface, so that the base plate (1) is parallel to an average boundary surface between the ground and the air half-space.

2. Inductive surface element according to claim 1, wherein the series of secondary plates (2) comprises at least six secondary plates.

3. Inductive surface element according to claim 1 or 2, wherein a width (L ; L_{dl}) of at least one of the secondary plates (2) is between $\lambda/2$ and λ , measured parallel to the base plate (1) and perpendicularly to the sensitive line.

4. Inductive surface element according to any preceding claim, wherein the height (H ; H_{dl}) of the secondary plates (2) is between $\lambda/20$ and $\lambda/5$, measured perpendicularly to the base plate (1) and from said base plate.

5. Inductive surface element according to any preceding claim, wherein each secondary plate consists of a pair of ternary plates (2a, 2b).

6. Inductive surface element according to claim 5, wherein the ternary plates of each pair (2a, 2b) are separated by a distance of between $\lambda/100$ and $\lambda/50$, measured in the sensitive direction.

7. Inductive surface element according to any preceding claim, wherein at least one of the plates among the base plate (1) and the secondary (2) or ternary (2a, 2b) plates comprises a portion of sheet metal or metal grating, or a combination of at least one sheet metal portion and at least one metal grating portion.

8. Inductive surface element according to any preceding claim, wherein at least some of the secondary (2) or ternary (2a, 2b) plates are electrically connected to the base plate (1).

9. Surface wave generation assembly, comprising:

- a radiation source (3), which is adapted to generate at least one electromagnetic radiation having a free space propagation mode; and

- at least one inductive surface element according to any of claims 1 to 8, placed on the ground or partially buried or buried near the ground surface, such that the base plate (1) is parallel to an average boundary surface between the ground and an air half-space;

the radiation source (3) being oriented so that an electric field component of the radiation at the location of the inductive surface element is not parallel to the base plate (1); and

the radiation source (3) being adapted so that a wavelength of the electromagnetic radiation is between $\lambda - 10\%$ and $\lambda + 10\%$, where λ is the dimension parameter of the inductive surface element.

10. Surface wave generation assembly according to claim 9, wherein the radiation source (3) is adapted to produce the electromagnetic radiation with a radiation frequency of between 0.2 MHz and 3000 MHz.

11. Surface wave generation assembly according to claim 9 or 10, wherein the radiation source (3) comprises a wire antenna.

12. Surface wave generation assembly according to claim 11, wherein the wire antenna comprises a rectilinear antenna segment, and said wire antenna is oriented such that the rectilinear antenna segment is perpendicular to the base plate (1).

13. Surface wave generation assembly according to claim 12, wherein the wire antenna is positioned such that the rectilinear antenna segment is separated from the one of the secondary plates (2; 2a, 2b) of the inductive surface element which is closest to said rectilinear antenna segment, by a distance (D_{ant}) which is less than or equal to $0.5 \times \lambda$ measured in the sensitive direction.

14. Surface wave generation assembly according to claim 12 or 13, wherein the wire antenna is positioned such that a point of the rectilinear antenna segment which is closest to the base plate (1) is located at a height (H_{ant}) less than 1.5 times the height (H ; H_{dl}) of the secondary plates (2; 2a, 2b), said

heights being measured from the base plate (1) in a direction perpendicular to said base plate and on the side of the secondary plates.

15. Surface wave detection assembly comprising:

- a radiation detector which is adapted to detect at least one electromagnetic radiation; and
- at least one inductive surface element according to any of claims 1 to 8, placed on the ground or partially buried or buried near the ground surface, such that the base plate (1) is parallel to an average boundary surface between the ground and an air half-space;

the radiation detector being oriented to detect the electromagnetic radiation when an electric field component of said radiation is not parallel to the base plate (1), and being effective for detecting the electromagnetic radiation when a wavelength of said radiation is between $\lambda - 10\%$ and $\lambda + 10\%$, where λ is the dimension parameter of the inductive surface element.