

JAMMING METHOD AND DEVICE WITH CONFINED LINEAR EFFECT

The invention relates to a jamming method and device using a linear antenna and a jamming device, the assembly being adapted for generating and broadcasting disrupting or jamming signals in a given closed or semi-open space without impact on the operation of the elements arranged outside of this space.

It is applicable for disrupting or preventing the operation of radiofrequency systems, or radio communication devices, the use of which is illegal, or of radiofrequency systems that do not have authorization to operate, within enclosures, prisons, examination rooms, etc.

In some environments such as prisons, examination centers, school establishments, certain rooms in embassies, experimental centers, etc., the use of radio communication devices, such as cell phones, is prohibited. One of the problems posed these days is how to eradicate all the unauthorized radio communications within a closed enclosure by controlling the containment of the signal used to prevent these communications by avoiding any nuisance for external users unaffected by this prohibition of radio communications.

The prior art known to the applicant describes detection systems and jamming systems which will block the illegal radio communications and systems which use them, from conventional radio antennas. These devices present numerous drawbacks; because of the geometrical losses at $20 \cdot \log_{10}(R)$ of the radiated power from a conventional antenna (R being the distance to the phase center of the antenna), they are not appropriate in terms of effectiveness, coverage, transmitted power; the containment is not satisfactory which results in complaints from the external operators and users unaffected by this prohibition; they are very difficult to install and maintain, and often costly when significant coverages have to be obtained.

The patent US 6 195 529 discloses a method and a device that make it possible to block the transmission from cell phones by transmitting interfering signals in the mobile radio frequency range.

The document entitled "Jamming Système for Mobile
5 Communications" by POUSADA-CARBALLO et al, Electronics Letters, IEE STEVENAGE, Vol. 34, No. 22, XP00601536, describes a jamming system for communications in a closed zone, based on generating noise signals in the transmission channel corresponding to the signal to be jammed.

The patent application WO 98 56192 describes a method that
10 makes it possible to regulate cellular communications.

There is currently a need to have a device that allows for a complete jamming of the radio communications considered illegal, a device that is applied inside a generally closed given space (or referred to as "indoor" space), of which the effectiveness is reliable, the coverage
15 controlled, the effect contained and the containment controlled. The expression "illicit or prohibited terminal" denotes a terminal, radio communication device, which does not have authorization to operate within a given perimeter and with the outside of this perimeter.

The expression "linear element" or "linear antenna" will be used
20 without distinction to designate a same element.

The object of the invention relies notably on the use of one or more antennas with linear geometry associated with effectors consisting of adapted jamming and coupling devices. The use of these effectors and the linear geometry of the antenna make it possible, equally, to:

- 25
- ensure a reliable coverage of the jamming,
 - control the containment of the jamming,
 - simultaneously transmit numerous jamming signals simultaneously addressing a large number of frequency intervals and a large number of radio communication systems whose frequency plans are included within
30 these intervals.

The invention relates to a contained jamming device arranged in a coverage zone in which there can be prohibited radio communication devices, the operation of which it is sought to prevent, characterized in that it comprises at least the following elements:

- 5 • at least one linear antenna comprising a plurality of orifices O_i allowing the radiation of jamming signals, the linear antenna being linked to one or more effectors via a connector,
- said effector element or elements, being adapted for injecting, at at least one end of the linear antenna, one or more jamming signals, the power flux $P_{j,f}$ of the jamming signal $J_{j,f}$ in the band $B_{j,f}$ of a carrier f is
- 10 chosen such that the ratio $P_{S,j,f}/P_{J,f}$ between the power flux $P_{S,j,f}$ of the signal $S_{j,f}$ potentially usable by the prohibited device on the carrier f and the power flux $P_{J,f}$ of the signal J_f present on the carrier f to prevent the prohibited device from operating is below the operating
- 15 threshold $Seuil_{S,j,f}$ of the prohibited device ($P_{S,j,f}/P_{J,f} \leq Seuil_{S,j,f}$).

According to a variant embodiment, the effector is adapted to generate, for a point $M(r,l)$ where a prohibited radio communication device is located, a value of the spectral density $N_{j,f}(r,l)$ of the jamming signal injected into the linear antenna via the connector such that, for the band $B_{i,f}$ of each

20 carrier f , the following applies:

$$10 \cdot \log_{10}(N_{j,f}(r,l) \cdot B_{i,f}) \geq 10 \cdot \log_{10}(P_{S,j,f}) - 10 \cdot \log_{10}(Seuil_{S,j,f}) + C(r_0) + P' \cdot (l - l_0) + 10 \cdot \log_{10}(r/r_0) + \eta$$

in which

- . r, l are the coordinates of a point M ,
- . l_0 designates a reference linear distance, r_0 designates a reference radial
- 25 distance to the linear element,
- . P' designates the rate of the linear losses along the antenna radiating from the distance l_0 ,
- . $-C(r_0)$ designates the losses by coupling in the band B_J at the reference radial distance r_0 ,

. η represents a safety margin taking account of the additional attenuations of the jamming signal in its propagation from the antenna to the prohibited terminal.

The effector is, for example, adapted for generating a transmission
5 power taking account of one or more of the following elements:

- the measurements of the levels of the beacon, control and traffic signals originating from transmitters present in the external networks and likely to enter into communication with the illegal devices,
- the rate P' of linear losses in the linear antenna,
- 10 - the losses by couplings $-C(r_0)$ of the linear antenna,
- margins η intended to compensate for the additional attenuations of various natures which can affect the jamming signal J in its propagation from the linear antenna to the device to be jammed.

According to a variant, the characteristics of the prohibited radio
15 communication devices and the characteristics of the antenna radiation regime are previously known or measured to parameterize and set the frequency bands of the jamming signal, the nature of the jamming signals transmitted and the levels at the output of the effector whose signal is injected into the antenna via the coupler.

20 At least one of the effectors is, for example, adapted for generating and transmitting jamming signals, and is a wideband generic jammer.

The effector is, for example, adapted for generating and transmitting jamming signals and consists of a set of dedicated jammers, the
25 output signals of which are transmitted to filtering and amplification and rectification modules, then injected into a coupler, the output of said coupler being injected into the linear antenna.

According to a variant, the effector is, for example, adapted for generating and transmitting jamming signals and comprises frequency-
30 selective filtering modules adapted for excising the jamming signal to free up

one or more carriers that can be used by a controlled radio communication sub-network.

The device can comprise a means adapted for duplexing the signal at the output of an effector and a device for injecting said signal into
5 two different linear antennas.

The device can also comprise a first effector arranged at a first end of the linear antenna and a second effector arranged at a second end of the linear antenna in order to inject a jamming signal J1, J2, at each end of the linear antenna.

10 The device can comprise a system of baffles adapted for locally optimizing the containment, baffles for which it is possible to use electric cable entry gratings with inverted mounting, gratings of various meshes and geometries.

The invention relates also to a method for contained jamming of
15 the operation of one or more radio communication devices prohibited in a given zone, implemented in the device having one of the preceding characteristics, the method being characterized in that it comprises at least the following steps:

- using at least one linear antenna comprising a plurality of orifices O_i
20 allowing the radiation of jamming signals, the linear antenna being linked to one or more effectors via a connector,
- injecting, at at least one end of the linear antenna, one or more jamming signals, the power flux $P_{j,f}$ of the jamming signal $J_{j,f}$ in the band $B_{j,f}$ of a carrier f being chosen such that the ratio $P_{S,j,f}/P_{J,f}$
25 between the power flux $P_{S,j,f}$ of the signal $S_{j,f}$ potentially usable by the prohibited device on the carrier f and the power flux $P_{J,f}$ of the signal J_f present on the carrier f to prevent the prohibited device from operating is below the operating threshold $Seuil_{S,j,f}$ of the prohibited device ($P_{S,j,f}/P_{J,f} \leq Seuil_{S,j,f}$).

For the implementation of the method, a value of the spectral density $N_{j,f}(r,l)$ is generated for the jamming signal injected into the linear antenna such that, for the band $B_{i,f}$ of each carrier f

$$10.\log_{10}(N_{j,f}(r,l).B_{i,f}) \geq 10.\log_{10}(P_{S,j,f}) - 10.\log_{10}(\text{Seuil}_{S,j,f}) + C(r_0) +$$

$$5 \quad P'.(l-l_0) + 10.\log_{10}(r/r_0) + \eta \text{ in which}$$

- . r, l are the coordinates of a point M ,
- . l_0 designates a reference linear distance,
- . r_0 designates a reference radial distance to the linear element,
- . P' designates the rate of the linear losses along the antenna radiating from
- 10 the distance l_0 ,
- . $-C(r_0)$ designates the losses by coupling in the band B_j at the reference radial distance r_0 ,
- . η represents a safety margin taking account of the additional attenuations of the jamming signal in its propagation from the antenna to the prohibited
- 15 terminal.

Other features and advantages of the method and of the device according to the invention will become more apparent on reading the following description of an exemplary embodiment given in an illustrative and nonlimiting manner, with attached figures which represent:

- 20 • figure 1, an example of a device according to the invention comprising a linear element, at the input of which a jamming device injects a jamming signal dedicated to the eradication of unauthorized radio communications,
- figure 2, a detail of the linear element,
- figure 3a, an example of the arrangement of a linear element provided at
- 25 each of its ends with an effector and implemented in a space with a preferred direction,
- figure 3b, a possible example of arrangement of a plurality of linear elements for the implementation of the method in a closed space of rectangular or square form of which the linear elements define the
- 30 perimeter, in which the jamming signal, emanating from two effectors present at the ends of a diagonal, is distributed in each half-perimeter,

- figure 4, a representation of a linear element with an effector connected at each end.

In order to provide a better understanding of the object of the invention, the description is given in an illustrative and nonlimiting manner for an application aiming to prevent the operation (transmission/reception) of a cell phone whose use is prohibited within a prison, that is to say that everything will be done to ensure that the signaling signals intended for this cell phone can be neither decoded nor interpreted thereby, which makes any access to the network, any call request or any answering of calls impossible.

This example can be extended to all the radio communication devices whose operation is not authorized within a given space.

Figure 1 schematically represents a first exemplary embodiment of the device according to the invention comprising an antenna with linear geometry 1, associated with a disturbing wave generation device or effector 2, via a connector 3. The cell phone 4 which is not authorized to receive communications or data is located in this figure in the vicinity and in the zone of efficiency of the linear antenna.

The effector 2 is composed, for example, of:

- one or more devices for generating and transmitting jamming signals 5, 5',
- one or more filtering modules and amplification and rectification stages 6, 6', for the signals transmitted by the abovementioned generation and transmission devices, these filtering and amplification modules making it possible to finely set the bands, the carriers and the output levels,
- a coupler 7 making it possible to construct the signal actually injected into the linear antenna 1 via the connector 3.

Such an arrangement makes it possible to produce a wideband jamming signal or a multiband jamming signal, of adapted frequency bands, carriers and levels within given zones where cell phones 4 whose operation it is sought to prevent may be located. In practice, the jamming signal is injected into the linear antenna via the connector 3 with a level adjusted to each band and to each carrier within these bands to jam and prevent, on

these carriers, all the exchanges of data between the mobile terminal and prohibited communication networks, and do so, within all of the zone covered by the linear antenna. That is to say that, in the example of figure 1, the power P_J of the resulting jamming signal J, considered at the level of the prohibited terminal, for each of the carriers potentially usable by the prohibited terminal, is defined as a function of the power P_S of the signals heard by the prohibited terminal, such that the ratio P_S/P_J is below the operating threshold $Seuil_S$ of the prohibited cell phone on each usable carrier (this operating threshold $Seuil_S$ being known to those skilled in the art for each radio communication network to be prohibited by consulting the standards for these networks).

The antenna with linear geometry 1 exhibits, for example, radiation characteristics which, combined with adapted effectors as described above, make it possible to disturb the operation of a cell phone present at the point $M(r,l)$ by accurately controlling the radiated power flux $P_J(r,l)$ as a function of the linear distance l and of the radial distance r which define the positions $M(l)$ of one or more illegal devices (i.e. the positions of the cell phones 4 within the zone covered by the linear antenna). The linear distance l is defined, for example, relative to the connector 3 of the linear element. The radial distance r is determined by the measurement of the perpendicular to the linear element which meets the point $M(r,l)$, for example.

More specifically, the jamming power flux $P_J(l,r)$ radiated by the antenna within a jammed band B_J at the point $M(r,l)$ identified by the linear distance l and the radial distance r , is given in decibels (dB) by the "cylindrical" radiation regime expressed by the following formula:

$$10.\log_{10}(P_J(l,r)) = 10.\log_{10}(P_0(l_0)) - C(r_0) - P' \cdot (l-l_0) - 10.\log_{10}(r/r_0) \quad (1)$$

. l designating the linear distance,
. r designating the radial distance to the linear element,
. l_0 designating a reference linear distance (generally, those skilled in the art consider l_0 to be zero or very low and correlate l_0 for example to the output of the coupler 7) and $P_0(l_0)$ designating the corresponding power in the band B_J

resulting from the injection of the jamming signal into the antenna via the connector 3,

. P' designating the rate of the linear losses along the antenna radiating from the reference linear distance l_0 (loss that is assumed, to simplify the writing but with no limitation on generality, constant within the band B_J , itself assumed sufficiently narrow), this value is a general manufacturer datum or a
5 quantity paired by measurement in each of the bands B_J , this value is at most a few dB per 100 m of propagation in the antenna,

. r_0 designating a reference radial distance to the linear element (generally,
10 those skilled in the art consider $r_0 = 2$ m),

. $-C(r_0)$ designating the losses by coupling in the band B_J at the reference radial distance r_0 ; $-C(r_0)$, manufacturer datum in general, or paired by measurement, exhibits a value of the order of -55 dB to -70 dB at reference radial distance $r_0 = 2$ m, uniform over the length of the antenna),

. $P_J(l, r)$ is the power flux in the band B_J of the signal J at the point $M(r, l)$. In the case where there are a number of jamming signals, the power P_J considered is global and can correspond to a number of sub-bands (in this case, what counts for the effectiveness of the jamming is $P_S / P_J < \text{Seuil}_S$ in the band previously denoted B_J of the carrier of S).

20 In the above formulation (1):

. the rate of linear losses P' by propagation in the antenna is low, which guarantees a level of radiation of the antenna that is uniform over the lengths targeted by the invention, the linear distance typically bearing out $l \in [l_0, L]$;
 $L \leq 100$ m,

25 . the cylindrical regime (expressed in dB per $-10 \cdot \log_{10}(r/r_0)$ in the formulation (1)) of the propagation losses by radiation depends linearly on the inverse of the radial distance r to the linear antenna and not quadratically on the inverse of the absolute distance R (real distance/phase center) to the phase center of the antenna as in the case of the conventional systems described in the prior
30 art.

The dimensions of the linear antenna element, its diameter Φ , its length L and its orientation relative to the geometry of the zone to be covered, as well as the distribution of the orifices O_i allowing the broadcasting of the jamming signals J and the positioning of any baffles to facilitate the containment are chosen notably as a function of the radio communication devices whose operation is to be eradicated, and of the geometry of the zone in which the operation of the illegal radio communications is to be eradicated.

When the zone to be covered has overriding directions (corridors, passageways) as in figure 3a, the orientation of the linear elements is performed for example tangentially to these overriding directions. When the zone to be covered is a closed enclosure with no overriding direction, as in figure 3b, the antennas are arranged for example tangentially to the edges of this enclosure.

The transmission powers of the effector 2 are set, for example, by taking account of one or more of the following elements:

- the measurements of the corresponding field levels originating from the transmitters 8, 9, 10, 11 present in the external networks and likely to enter into communication with the illegal terminals for which the radio communications are to be eradicated, and
- the linear losses regime explained by the above formula (1), and
- margins η intended to compensate for the additional attenuations of various natures which can affect the jamming signal J in its propagation from the linear antenna 1 to the transmission device to be jammed, 4 (walls, doors, human body, etc.).

The objective is to obtain a jamming signal J of a level at least such that, in each band B_j $j = 1 \dots J$ and for each beacon or control channel f in each band B_j corresponding to the external transmitters likely to enter into communication with the illegal transmitting/receiving terminals for which the radio communications are to be eradicated, the power flux $P_{j,f}$ of the jamming signal $J_{j,f}$ in the band $B_{j,f}$ of the carrier f is such that the signal $S_{j,f}$ potentially

usable by the prohibited terminal (index i) on the carrier f, of power flux $P_{S,i,f}$, is received with a ratio $P_{S,i,f}/P_{J,f}$ below the operating threshold $Seuil_{S,j,f}$ of the prohibited portable terminal (this operating threshold $Seuil_{S,j,f}$ being known to those skilled in the art for each radio communication network and for each type of beacon carrier f to be prohibited, by consulting the standards for these networks). Or else, the ratio $P_{S,j,f}/P_{J,f}$ between the power flux $P_{S,j,f}$ of the signal $S_{j,f}$ potentially usable by the prohibited device on the carrier f and the power flux $P_{J,f}$ of the signal J_f present on the carrier f to prevent the prohibited device from operating is below the operating threshold $Seuil_{S,j,f}$ of the prohibited device ($P_{S,j,f}/P_{J,f} \leq Seuil_{S,j,f}$). This is expressed in decibels:

$$10.\log_{10}(P_{S,j,f}) - 10.\log_{10}(P_{J,f}) \leq 10.\log_{10}(Seuil_{S,j,f}) \text{ in the band } B_{i,f} \text{ of the carrier } j, f, j \text{ being the index of the band of the terminal, } f \text{ that of the carrier, or else:}$$

$$10.\log_{10}(P_{J,f}) \geq 10.\log_{10}(P_{S,j,f}) - 10.\log_{10}(Seuil_{S,j,f}) \text{ in the band } B_{i,f} \text{ of the carrier } f.$$

Considering a prohibited terminal at the point $M(r,l)$, the spectral density $N_{j,f}(r,l)$ of the jamming signal injected into the linear antenna via the connector 3 must therefore bear out, for the band $B_{i,f}$ of each carrier f:

$$10.\log_{10}(N_{j,f}(r,l).B_{i,f}) - C(r_0) - P' \cdot (l - l_0) - 10.\log_{10}(r/r_0) \geq 10.\log_{10}(P_{S,j,f}) - 10.\log_{10}(Seuil_{S,j,f}) + \eta$$

or else:

$$10.\log_{10}(N_{j,f}(r,l).B_{i,f}) \geq 10.\log_{10}(P_{S,j,f}) - 10.\log_{10}(Seuil_{S,j,f}) + C(r_0) + P' \cdot (l - l_0) + 10.\log_{10}(r/r_0) + \eta \quad (2)$$

in which η represents a certain safety margin to take account of the additional attenuations of the jamming signal in its propagation from the antenna to the prohibited terminal 4.

This condition expressed in the formula (2), that has to be borne out for a zone defined by a radius $r_0 \leq r \leq r_{\max}$, $l_0 \leq l \leq L_{\max}$, a sufficient condition is to bear it out for $r = r_{\max}$, $l = L_{\max}$, $\eta = \eta_{\max}$

$$10.\log_{10}(N_{j,f}.B_{i,f}) \geq 10.\log_{10}(P_{S,j,f}) - 10.\log_{10}(Seuil_{S,j,f}) + C(r_0) + P' \cdot (L_{\max} - l_0) + 10.\log_{10}(r_{\max}/r_0) + \eta_{\max} \quad (3).$$

The illustrative and nonlimiting example of figure 1 shows radio communication signals S_8 , S_9 , S_{10} , S_{11} originating from the external

transmitters 8, 9, 10, 11 in the bands B_8, B_9, B_{10}, B_{11} , the transmitters being likely to enter into communication with the illegal terminal 4 for which the radio communications are to be eradicated. For this configuration, if a beacon or control carrier is considered for each external transmitter, with the carrier frequencies respectively denoted f_8, f_9, f_{10}, f_{11} , and with the bands respectively denoted $B_{J,8}, B_{J,9}, B_{J,10}, B_{J,11}$, if $P_{S,8} P_{S,9} P_{S,10} P_{S,11}$ is used to denote the corresponding power fluxes received by the illegal terminal 4, if $Seuil_{S,8} Seuil_{S,9} Seuil_{S,10} Seuil_{S,11}$ is used to denote the operating points (known to those skilled in the art) of the illegal terminal 4 in the bands $B_{J,8}, B_{J,9}, B_{J,10}, B_{J,11}$ of the carriers f_8, f_9, f_{10}, f_{11} , the minimum jamming signal levels $P_{J,8} P_{J,9} P_{J,10} P_{J,11}$ which must be received by the illegal terminal 4 in the bands $B_{J,8}, B_{J,9}, B_{J,10}, B_{J,11}$ bear out the following conditions.

In real quantities:

$$\begin{aligned}
 &P_{S,8} / P_{J,8} \leq Seuil_{S,8} \text{ in the band } B_{J,8} \text{ of the carrier } f_8 \\
 &P_{S,9} / P_{J,9} \leq Seuil_{S,9} \text{ in the band } B_{J,9} \text{ of the carrier } f_9 \\
 &P_{S,10} / P_{J,10} \leq Seuil_{S,10} \text{ in the band } B_{J,10} \text{ of the carrier } f_{10} \\
 &P_{S,11} / P_{J,11} \leq Seuil_{S,11} \text{ in the band } B_{J,11} \text{ of the carrier } f_{11}
 \end{aligned}$$

In decibels:

$$\begin{aligned}
 &10.\log_{10}(P_{J,8}) \geq 10.\log_{10}(P_{S,8}) - 10.\log_{10}(Seuil_{S,8}) \text{ in the band } B_{J,8} \text{ of the carrier } f_8 \\
 &10.\log_{10}(P_{J,9}) \geq 10.\log_{10}(P_{S,9}) - 10.\log_{10}(Seuil_{S,9}) \text{ in the band } B_{J,9} \text{ of the carrier } f_9 \\
 &10.\log_{10}(P_{J,10}) \geq 10.\log_{10}(P_{S,10}) - 10.\log_{10}(Seuil_{S,10}) \text{ in the band } B_{J,10} \text{ of the carrier } f_{10} \\
 &10.\log_{10}(P_{J,11}) \geq 10.\log_{10}(P_{S,11}) - 10.\log_{10}(Seuil_{S,11}) \text{ in the band } B_{J,11} \text{ of the carrier } f_{11} \text{ and do so,}
 \end{aligned}$$

over the zone covered by the linear antenna.

It is deduced therefrom that the power spectral density levels injected $N_{S,8} N_{S,9} N_{S,10} N_{S,11}$ into the linear antenna via the connector 3 must bear out the following conditions in decibels:

$$\begin{aligned}
 &10.\log_{10}(N_{J,11}(r,l).B_{J,11}) \geq 10.\log_{10}(P_{S,11}) - 10.\log_{10}(Seuil_{S,11}) + C(r_0) + P'.(l-l_0) \\
 &\quad \quad \quad + 10.\log_{10}(r/r_0) + \eta_{11} \\
 &10.\log_{10}(N_{J,10}(r,l).B_{J,10}) \geq 10.\log_{10}(P_{S,10}) - 10.\log_{10}(Seuil_{S,10}) + C(r_0) + P'.(l-l_0)
 \end{aligned}$$

$$\begin{aligned}
& +10.\log_{10}(r/r_0)+\eta_{10} \\
10.\log_{10}(N_{J,9}(r,l).B_{J,9}) & \geq 10.\log_{10}(P_{S,9})-10.\log_{10}(\text{Seuil}_{S,9})+C(r_0)+P'.(l-l_0) \\
& +10.\log_{10}(r/r_0)+\eta_9 \\
10.\log_{10}(N_{J,8}(r,l).B_{J,8}) & \geq 10.\log_{10}(P_{S,8})-10.\log_{10}(\text{Seuil}_{S,8})+C(r_0)+P'.(l-l_0) \\
5 \quad & +10.\log_{10}(r/r_0)+\eta_8
\end{aligned}$$

in which $\eta_8 \eta_9 \eta_{10} \eta_{11}$ represent certain safety margins for taking account of the additional attenuations of the jamming signal in its propagation from the antenna to the prohibited terminal 4 in the bands B_8, B_9, B_{10}, B_{11} .

The effector device 2 making it possible to generate and transmit
10 jamming signals is composed, for example, of a wide band generic jammer or else a set of jammers each dedicated to one of the radio communication networks prohibited in the zone covered, adjusted in amplitude if necessary, and the outputs of which are coupled according to methods well known to those skilled in the art before injection into the linear antenna so as to
15 process a number of bands B_j and multiple carriers f_j simultaneously. Its characteristics are, for example, chosen as a function of the illicit devices likely to be located in a monitored zone. This makes it possible in a way to construct an "à la carte" effector specifically adapted to the radiofrequency configuration processed and to the networks for which the communications
20 have to be locally neutralized.

For example, it is possible to use dedicated second, third and fourth generation cellular radio jammers, GPS (global positioning system) jammers, jammers operating in the industrial band ISM (industrial, scientific and medical) (of Bluetooth short-range radio type, or according to the WiFi
25 wireless protocol), etc. (see figure 1, 5 and 5'). These dedicated jammers exhibit a low power per sub-band ($< 1 \text{ W}$), a low cost (odg $\leq 100 \text{ \$ unit}$ x a few units per device).

It is also possible to use an additional device adapted for adjusting power levels by amplification and dedicated filtering of each sub-band to
30 compensate, if necessary, for a frequency dispersion of the necessary transmission levels (see figure 1) and in particular:

- a non-uniformity of the cable losses as a function of frequencies (dispersive linear antennas),

- a non-uniformity of the levels of signals S_8 , S_9 , S_{10} , S_{11} received by the illegal radio communication systems and that are to be jammed.

5 According to another variant embodiment, a frequency excision, a process known to those skilled in the art, will be carried out for one or more carriers in the jamming signal by a filtering adapted to the level of the amplification and adjustment stages (6, 6'), so as to allow for the use of these carriers for radio communications controlled by the operator of the system,
10 emergency calls, authorized radio communication sub-network, etc.

The method according to the invention associated with the example of figure 1 comprises, for example, the following steps:

- 1) defining the arrangement of the linear antennas in a zone to be controlled in which the illegal radio communications have to be prevented,
- 15 2) defining parameters for a jamming signal: frequency band, jamming power flux levels in the zone to be controlled expressed as a function notably of the radial distances from the different points of the zone to the linear antennas arranged to cover said zone, field level measurements or abovementioned elements,
- 20 3) transmitting a power signal adapted for jamming the illicit devices present in the controlled zone from linear antennas which are arranged therein, the signal level being such that the ratio between the operating power flux of the illegal device and the power flux of the jamming signal is below the operating threshold value of the illegal device.

25 Figure 2 is a detail of an example of linear cable comprising a plurality of orifices arranged so as to allow the passage of jamming waves into the zone to be monitored. The linear antenna comprises a plurality of orifices O_i distributed along the element according to the desired application, the orifices are separated by sections 21 which do not allow the passage of
30 jamming signals.

Figure 3a schematically represents a variant embodiment of the invention in an enclosure with overriding direction of corridor type, in which there have been installed a single element 301, on a ceiling, and two effectors 305, 306 at the opposite ends of the element, according to the
5 above description.

The orifices of the linear element allow for the transmission of jamming signals J_1 , J_2 , the cell phone 4 situated in the corridor cannot decode the signals transmitted from outside. The jamming and power level parameters will notably be chosen as a function of the linear organization of
10 these linear elements.

Figure 3b schematically represents a variant embodiment of the invention in an enclosure not having any overriding direction, in which there have been installed four linear elements 311, 312, 313, 314, of respective lengths L_2 , L_1 , L_2 , L_1 , on walls that are not represented of a room of square
15 geometry to be monitored and two effectors 315, 316 at the opposite ends of one of the diagonals of the room, according to the above description. The effector 315 is linked according to an organization described in figure 1 to the two linear elements 311, 312, the effector 316 is linked with the linear elements 313, 314. The orifices of the four linear elements allow the
20 transmission of jamming signals J_1 , J_2 , J_3 , J_4 , the cell phone 4 situated in the room cannot decode the signals transmitted from outside. The jamming parameters, for the power level, will notably be chosen as a function of the square organization of these linear elements.

Figure 4 represents another embodiment, where it will be possible
25 to connect a first effector 42a at a first end 41a of the linear antenna 41 via a first connector 43a and a second effector 42b at the second end 41b of the linear antenna 41 via a second connector 43b in order to inject a jamming signal J_1 , J_2 at each end of the linear antenna 41. In this case, the first and the second effectors have substantially identical characteristics (same
30 transmission levels, same frequency bands), but their signals are decorrelated according to a technique known to those skilled in the art in

order to avoid the interference and standing wave phenomena in their propagation in the linear antenna.

This embodiment notably makes it possible:

- to make the level of the jamming signal J more uniform in the linear antennas by virtue of a two-way propagation, and guarantee a better coverage of the jamming,
- to reduce the transmission levels of the jamming signal at the ends of the linear antenna and thereby guarantee a better containment of the jamming.

Without departing from the scope of the invention, other variant implementations of the invention are possible.

For example, it is possible to add baffles to the device to locally optimize the containment. For the nature, the form and the size of the baffles, it is possible to use: electric cable entry gratings (frequencies > 900 MHz) with inverted mounting, gratings of various meshes and geometries. The example of a rectangular flat grating of aperture $\geq (\lambda/2)^2$ (λ : jamming transmission wavelength) leads to a directivity of approximately 120°, a front/back ratio of the order of 10 to 15 dB. This facilitates the containment of the jamming signal upon installation in a "semi-open environment", for example for prison windows or examination/conference room windows, or when there are diffraction problems (metal ducts, or the like).

Another variant consists in adding a metrology in the installation/maintenance phase which makes it possible to facilitate the installation and the setting of the device. For that, it is possible to use a spectrum analyzer, or even mobile spectrum monitoring stations known to those skilled in the art.

According to another variant embodiment, it is possible to add a totally controlled wired communication "sub-network", or even a power line communication "sub-network", etc.

According to another variant embodiment, it is possible to add a totally controlled "à la carte" radio communication "sub-network", by means of the following elements:

- choice of carrier frequencies according to a prior survey of the frequency schedules of the external networks according to methods known to those skilled in the art,
- if necessary, frequency excision of the jamming signal to "free up" the carriers and make them usable,
- installation of a micro local area network making use of the carriers freed up and relays to an external network.

Examples of components that can be used on the carriers freed up for such a sub-network are DECT (Digital Enhanced Cordless Telephone) wireless access points, pico/femto cells of the third generation UMTS (Universal Mobile Telecommunications System) system or of the LTE (Long Term Evolution) standard, WiFi or WiFi Direct access points, "device-to-device" UMTS terminals or LTE manet (Release 12) terminals known to those skilled in the art, etc.

The device and the method according to the invention notably offer the following advantages:

- a total eradication of radio communications in the 0.3 - 3 GHz range, with a single device according to the invention,
- a containment of the jamming in a given zone without impact on the external environment, because of the linear nature of the antenna and of the cylindrical losses regime which devolves therefrom according to the formulation (1),
- installation flexibility, with an "à la carte" deployment of devices,
- ease of maintenance,
- numerous possibilities for extension in terms of added functions and in terms of services.

CLAIMS

1 – A contained jamming device arranged in a coverage zone in which there can be prohibited radio communication devices, the operation of which it is sought to prevent, characterized in that it comprises at least the following elements:

- at least one linear antenna (1) comprising a plurality of orifices O_i allowing the radiation of jamming signals, the linear antenna (1) being linked to one or more effectors (2) via a connector (3),
- 10 • said effector element or elements (2), being adapted for injecting, at at least one end of the linear antenna (1), one or more jamming signals, the power flux $P_{j,f}$ of the jamming signal $J_{j,f}$ in the band $B_{j,f}$ of a carrier f is chosen such that the ratio $P_{S,j,f}/P_{J,f}$ between the power flux $P_{S,j,f}$ of the signal $S_{j,f}$ potentially usable by the prohibited device on the carrier f and the power flux $P_{J,f}$ of the signal J_f present on the carrier f to prevent the prohibited device from operating is below the operating threshold $Seuil_{S,j,f}$ of the prohibited device ($P_{S,j,f}/P_{J,f} \leq Seuil_{S,j,f}$) and in that
- 15 • the effector (2) is adapted to generate, for a point $M(r,l)$ where a prohibited radio communication device (4) is located, a value of the spectral density $N_{j,f}(r,l)$ of the jamming signal injected into the linear antenna via the connector (3) such that, for the band $B_{i,f}$ of each carrier f , the following applies:

$$10 \cdot \log_{10}(N_{j,f}(r,l) \cdot B_{i,f}) \geq 10 \cdot \log_{10}(P_{S,j,f}) - 10 \cdot \log_{10}(Seuil_{S,j,f}) + C(r_0) + P' \cdot (l - l_0) + 10 \cdot \log_{10}(r/r_0) + \eta$$
in which
 - r, l are the coordinates of a point M ,
 - l_0 designates a reference linear distance, r_0 designates a reference radial distance to the linear element,
 - P' designates the rate of the linear losses along the antenna radiating from the distance l_0 ,
- 20
- 25
- 30

. $-C(r_0)$ designates the losses by coupling in the band B_J at the reference radial distance r_0 ,

. η represents a safety margin taking account of the additional attenuations of the jamming signal in its propagation from the antenna to the prohibited terminal.

5

2 – The jamming device as claimed in claim 1, characterized in that said effector (2) is adapted for generating a transmission power taking account of one or more of the following elements:

- 10 - the measurements of the levels of the beacon, control and traffic signals originating from transmitters (8, 9, 10, 11) present in the external networks and likely to enter into communication with the illicit devices,
- the rate P' of linear losses in the linear antenna,
- the losses by couplings $-C(r_0)$ of the linear antenna,
- 15 - margins η intended to compensate for the additional attenuations of various natures which can affect the jamming signal J in its propagation from the linear antenna (1) to the device (4) to be jammed.

3 – The jamming device as claimed in claim 1, in which the characteristics of the prohibited radio communication devices and the characteristics of the antenna radiation regime are previously known or measured to parameterize and set the frequency bands of the jamming signal, the nature of the jamming signals transmitted and the levels at the output of the effector whose signal is injected into the antenna via the coupler (3).

25

4 – The jamming device as claimed in one of the preceding claims, characterized in that at least one of the effectors (2) is adapted for generating and transmitting jamming signals and is a wideband generic jammer.

30 5 – The jamming device as claimed in one of the preceding claims, characterized in that the effector (2) is adapted for generating and

transmitting jamming signals and is composed of a set of dedicated jammers, the output signals of which are transmitted to filtering and amplification and rectification modules (6, 6'), then injected into a coupler (7), the output of said coupler (7) being injected into the linear antenna (1).

5

6 – The jamming device as claimed in one of the preceding claims, characterized in that the effector (2) is adapted for generating and transmitting jamming signals and comprises frequency-selective filtering modules adapted for excising the jamming signal to free up one or more
10 carriers that can be used by a controlled radio communication sub-network.

7 – The jamming device as claimed in one of the preceding claims, characterized in that it comprises a means adapted for duplexing the signal at the output of an effector and a device for injecting said signal into two
15 different linear antennas.

8 – The jamming device as claimed in one of the preceding claims, characterized in that it comprises a first effector (42a) arranged at a first end (41a) of the linear antenna (41) and a second effector (42b) arranged at a
20 second end (41b) of the linear antenna in order to inject a jamming signal J_1 , J_2 , at each end of the linear antenna (41).

9 – The jamming device as claimed in one of the preceding claims, characterized in that it comprises a system of baffles adapted for locally
25 optimizing the containment, such as electric cable entry gratings with inverted mounting, gratings of various meshes and geometries.

10 – A method for contained jamming of the operation of one or more radio communication devices prohibited in a given zone, implemented in the device
30 as claimed in one of claims 1 to 9, characterized in that it comprises at least the following steps:

- using at least one linear antenna (1) comprising a plurality of orifices O_i allowing the radiation of jamming signals, the linear antenna being linked to one or more effectors (2) via a connector (3),
- injecting, at at least one end of the linear antenna (1), one or more jamming signals, the power flux $P_{j,f}$ of the jamming signal $J_{j,f}$ in the band $B_{j,f}$ of a carrier f being chosen such that the ratio $P_{S,j,f}/P_{J,f}$ between the power flux $P_{S,j,f}$ of the signal $S_{j,f}$ potentially usable by the prohibited device on the carrier f and the power flux $P_{J,f}$ of the signal J_f present on the carrier f to prevent the prohibited device from operating is below the operating threshold $Seuil_{S,j,f}$ of the prohibited device ($P_{S,j,f}/P_{J,f} \leq Seuil_{S,j,f}$).

11 – The contained jamming method as claimed in claim 10, characterized in that a value of the spectral density $N_{j,f}(r,l)$ is generated for the jamming signal injected into the linear antenna such that, for the band $B_{i,f}$ of each carrier f :

$$10.\log_{10}(N_{j,f}(r,l).B_{i,f}) \geq 10.\log_{10}(P_{S,j,f}) - 10.\log_{10}(Seuil_{S,j,f}) + C(r_0) + P'.(l - l_0) + 10.\log_{10}(r/r_0) + \eta \text{ in which}$$

- . r, l are the coordinates of a point M ,
- . l_0 designates a reference linear distance,
- . r_0 designates a reference radial distance to the linear element,
- . P' designates the rate of the linear losses along the antenna radiating from the distance l_0 ,
- . $-C(r_0)$ designates the losses by coupling in the band B_j at the reference radial distance r_0 ,
- . η represents a safety margin taking account of the additional attenuations of the jamming signal in its propagation from the antenna to the prohibited terminal.