



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
11.11.2009 Bulletin 2009/46

(51) Int Cl.:
E04H 9/10 (2006.01)

(21) Application number: **08020268.2**

(22) Date of filing: **21.11.2008**

(84) Designated Contracting States:
**AT BE BG CH CY CZ DE DK EE ES FI FR GB GR
HR HU IE IS IT LI LT LU LV MC MT NL NO PL PT
RO SE SI SK TR**
Designated Extension States:
AL BA MK RS

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(30) Priority: **05.05.2008 IT RM20080235**

(54) **External protection of plants against aircraft impact**

(57) The technical field of the invention is the protection of plants or installations (e.g. a nuclear power plant) against voluntary or accidental impact of an aircraft (e.g., New York September 11th 2001 event). This protection system is based on the use of a barrage net of cables; the net is mobile on ground rails and its height can be quickly adjusted; the net is supported by a number of aerostatic balloons. The barrage net is complemented

by a wall closer to the installation to be protected. At least two concentric independent barrage nets are envisaged in order to cope with a double (or multiple) strike by two or more consecutive aircrafts. Along the barrage cable of each balloon a wind turbine and radar aerals are located with the purpose, respectively, of usefulness of the system in absence of threats and of automatic detection of threats and of net position control.

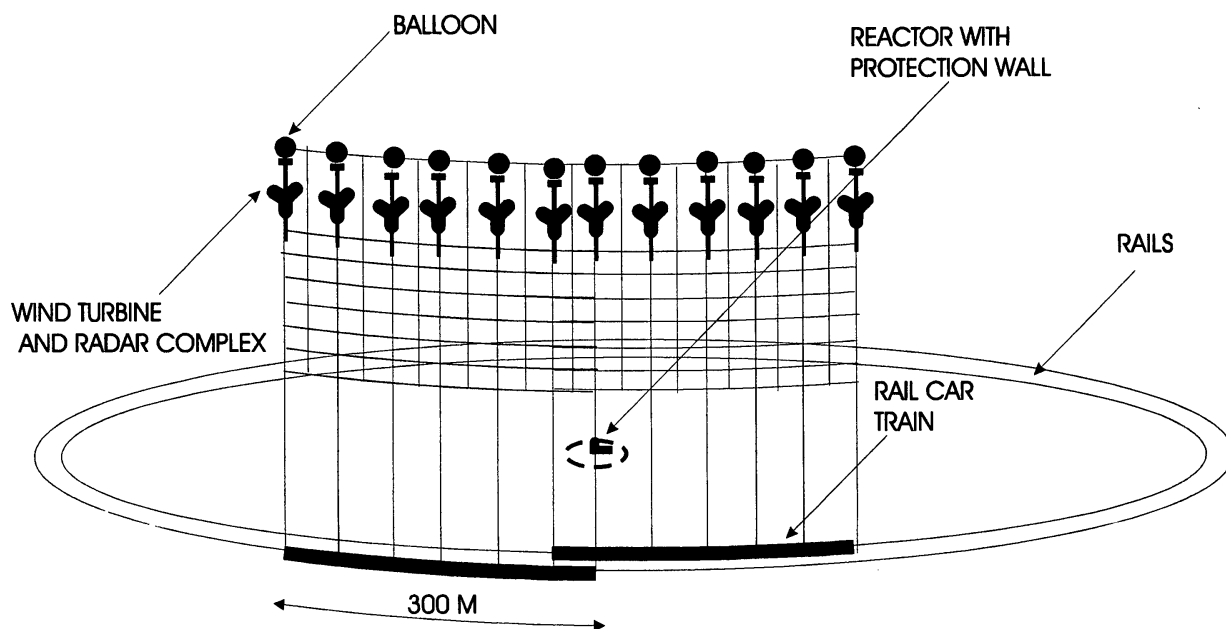


FIGURE 1: OVERALL VIEW

Description

[0001] [line 1] The technical field of the invention is the protection of plants or installations against voluntary or accidental impact of an aircraft (e.g. the New York September 11th 2001 event). This description refers to a nuclear power plant as a typical application. This protection system is based on the use of a barrage net of cables; this net is [line 5] mobile on the ground and its height can be rapidly adjusted; the net is supported by a number of aerostatic balloons (Figure 1). The barrage net is complemented by a (reinforced concrete) wall closer to the installation to be protected (Figure 1) and having a height and a width of some meters. For a plant located in open country, the protection may have the dimensions shown in Figure 1 and 2, which are able to protect the plant [line 10] against an aircraft directed against its target with a maximum angle of 30° with the horizontal or sliding on the ground. At least two concentric barrage nets are envisaged at a distance of about 50 m from each other (Figure 1). Each net is anchored to railway cars, mobile on circular rails; other plan paths can be adopted in order to fit to the ground shape. Any linear structure crossing the rails path (high voltage electric [line 15] lines, gas or water pipes) has to be put underground for the small distance necessary to cross the rails. Each net is laterally extended for a limited circular angle (or for a different track extension), indicatively for 300 m and is movable independently from the other. This arrangement can protect the plant against a double strike by two airplanes at some interval of time from each other. To this end, in case of an attack, the [line 20] net located on the rail farther from the arriving plane should be firstly used; then, in case of a second strike, the other net should be employed. This sequence would avoid that the second net functionality be jeopardized by the fall of the first net impacted. If protection against more than two consecutive strikes is sought, more than two rails can be used. In the indicative scheme described, the balloons are 7 for each [line 25] train (14 in total). Along the anchorage cable of each balloon a wind-turbine, indicatively with an output power of 10 kW, is secured by a stabilizing rigid bar; the electric power generated by the turbine will recharge accumulator banks located on the railway cars below; these accumulators, in turn, can be used for the movement of the train, for the supply of electric power to essential plant auxiliaries, even in case of [line 30] emergencies, or for the production of hydrogen. The complex of the wind turbines (of about 140 kW power in total) makes the whole protection installation permanently useful, even if no aerial threat ever materializes. The considerable height, at which the turbines are located, better insures the presence of a sufficient wind velocity. Some balloons, in addition, bring the aerals of a radar detection, alarm and [line 35] control system, which is installed in addition and independently from the air space control insured by the competent institutions. The local radar system is also used to position the barrage nets in the most convenient

way on the basis of the motion of the incoming aircraft. The height of the balloons from ground can be adjusted, by winches located on the railway cars, from the ground level up to about 650 m elevation. [line 40] The net proper, namely the part of the cable or cable and chain system having also horizontal elements, is here assumed to have an height of about 100 m. A light but strong object (steel or carbon fibre bar) can be secured to each of the knots of the nets in order to help damage and arrest the engines of the impacting aircraft. The system has to be protected against lightening by the usual provisions; it also complies with any [line 45] applicable regulation. The reference balloons have a spherical shape but a different shape (e.g. ellipsoidal with tail pieces) can be used for an higher stability in strong winds.

[0002] Some indicative data of the system components are listed in the following:

- Equivalent diameter of each balloon, about 22 m
- [line 50] helium (if this gas is used) loss from one of the balloons, less than 300 m³ per month
- lift of each balloon, at least 4.8 t
- steel or synthetic fibre mooring cables with a diameter of at least 22 mm,
- weighting about 2.5 kg/m and with a failure load of at least 45 t (doubled)
- [line 55] dimension of the principal net mesh, 50 m
- wind turbines weighting about 500 kg, with a power of about 10 kW each
- instead of a single balloon per cable, more than one balloon can be installed, even on the same vertical line

[0003] It is estimated that the inertia of each net plus its failure strength are sufficient to assure [line 60] the fall of a large airliner within 1000 m from the impact; a 767 airliner as the ones which were used against the World Trade Center in N.Y on September 11 2001 has been considered in calculations; possibly the impact against the net would immediately destroy or detach form the plane body wings and engines [1] [2]. A larger aircraft can also be stopped.

[0004] [line 65] References (both containing a large number of other references):

- [1] Gianni Petrangeli, Nuclear Safety, Elsevier, Oxford 2006, pages 189 and following
- [2] Gianni Petrangeli, Large Aircraft impact on a Nuclear Plant, ICAPP 2007, Nice, France, paper 7081

Claims

1. the system is essentially passive, mobile and flexible (possibility of automatic horizontal and vertical adjustment to a threat)
2. the system can also be installed around an already

built installation

3. The system is effective even against large airliners
4. the system offers protection against a double or multiple strike too 5
5. the system is sufficiently visible to represent a dissuasion factor for a planned attack and, at the same time, sufficiently not intrusive for the normal plant operation 10
6. the system is useful in normal conditions also because it incorporates a small (order of 140 kW) wind farm for the generation and storage of electric energy 15
7. the system can also replace or help the elevated plant stack for the discharge of gaseous waste
8. the system can be adjusted for an offshore installation (LNG terminal etc.) by the replacement of railway cars with barges. 20

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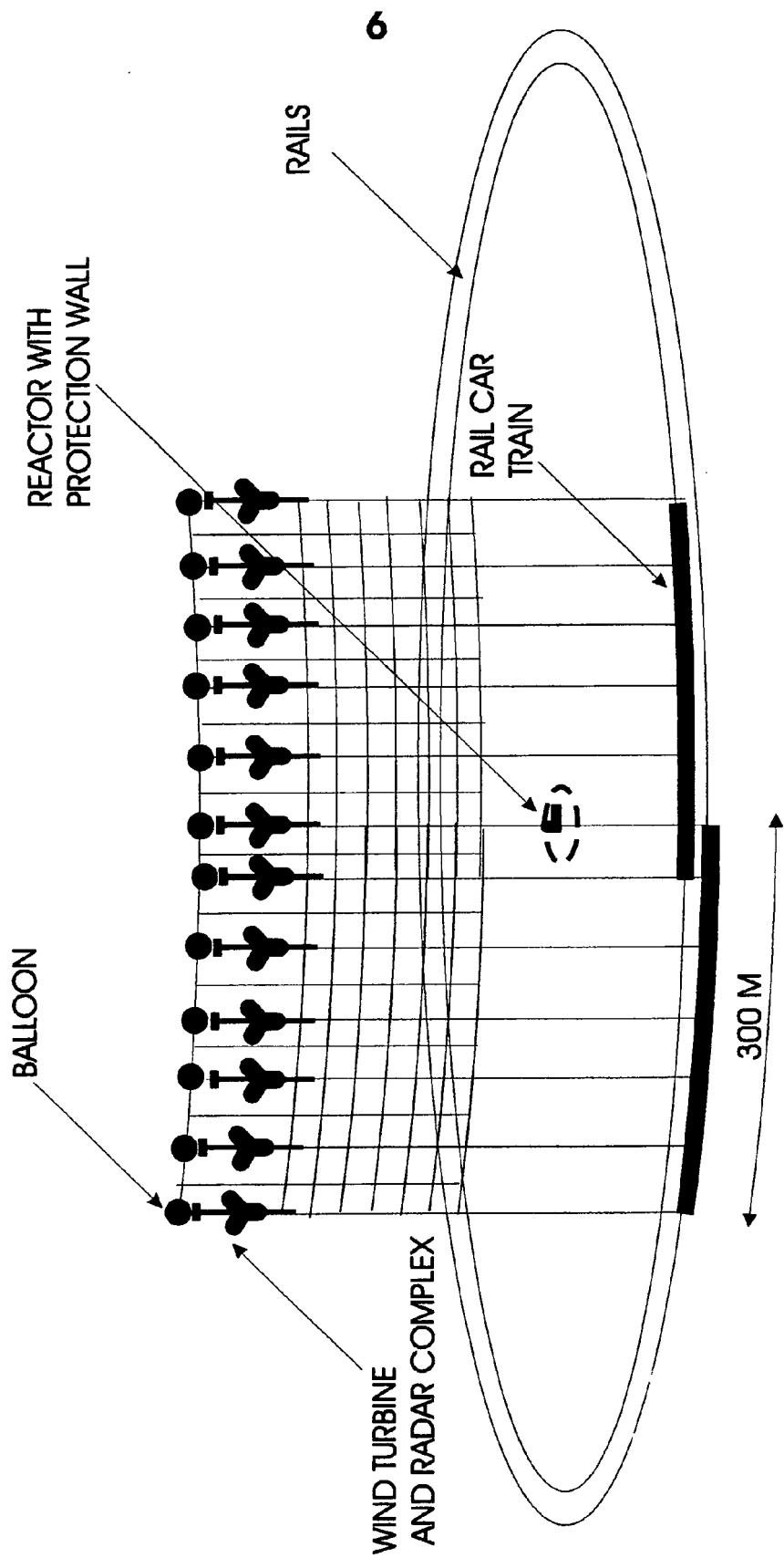


FIGURE 1: OVERALL VIEW

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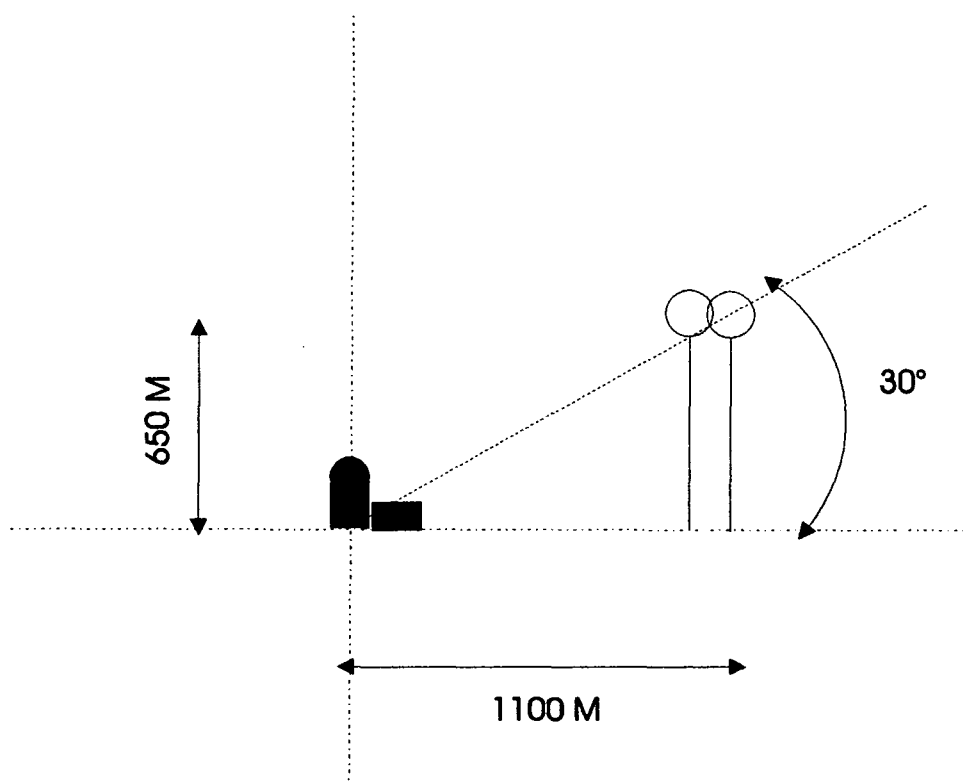


FIGURE 2: OVERALL LATERAL VIEW

REFERENCES CITED IN THE DESCRIPTION

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Non-patent literature cited in the description

- **Gianni Petrangeli.** Nuclear Safety. Elsevier, 2006, 189 [0004]
- **Gianni Petrangeli.** Large Aircraft impact on a Nuclear Plant. ICAPP, 2007 [0004]