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(54) Lighting installation for motorway tunnels.

(57) The lighting installation - for the background illumination of motorway tunnels for the perception of both the tunnel track and the possible presence of obstacles along the roadway - comprises at least a row of luminous spots (31) substantially close to each other along one or both sides of the tunnel, said spots defining the track of the said tunnel, while the interruption of the spots of one row indicates in reverse mode the presence of an obstacle causing such interruption. The luminous spots are fed mostly with laser light.

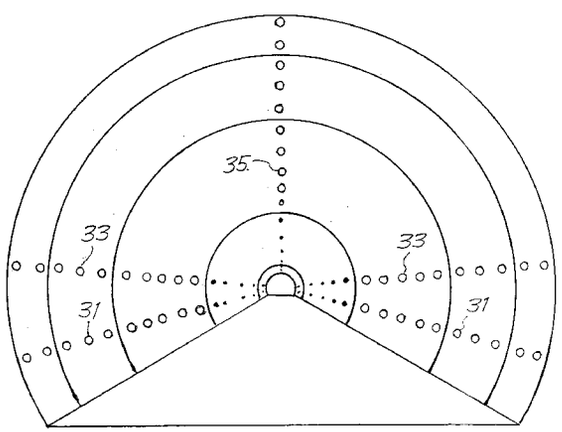

FIG. 1

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The invention relates to a special lighting system for motorway tunnels which helps perceiving possible obstacles and, at the same time, allows high savings in electric power consumption. These and other objects and advantages will be evident from a reading of the following description.

Substantially, the installation which is the subject of the present invention comprises at least a row of luminous spots which are arranged suitably close to each other along both the tunnel sides and which define the track of the said tunnel, while the interruption of the spots of one row indicates in reverse made the presence of an obstacle which causes such interruption.

Advantageously, at least two rows of luminous spots may be provided on each side at two different heights of the order of 80 and 160 cm from the roadway. This allows an easy perception of the dimension of the obstacle, inasmuch as it is possible to distinguish the presence of a car from that of an industrial motorvehicle.

The light of the luminous spots is substantially punctiform and may advantageously be a coherent light, mostly of laser type, and prefereably a polarized laser light transmitted via optical fibers, from generators which may be located even outside the tunnel so that no electrical conductors are required. Besides, the polarized light have a low degree of attenuation even over long distances.

A third longitudinal row of luminous spots may be provided substantially along the vertex of the tunnel.

For one-way tunnels, the luminous spots are advantageously oriented towards the incoming vehicles.

The above installation may advantageously be combined to an auxiliary plant having the function of avoiding the sudden passage from the conditions of natural, external, day-time light to the substantial darkness of the tunnel even if provided with background illumination, and allowing the gradual adaptation of the eye. All this is necessary during the daytime hours and does not involve, in practice, any consumption of additional electric power. Said auxiliary plant comprises:

- at least a sun light-intercepting unit outside the tunnel;
- bundles of optical fibers coupled to the lenses of the intercepting means and extending along the tunnel; and
- optical diffusers fed with luminous energy from the optical fibers and apt to illuminate the initial stretch of the tunnel starting from the entrance thereof.

This additional illumination is obtained during the day-time hours and fades away and disappears with the incoming darkness, when its function is no longer requested.

The diffusers may be so oriented as to meet the illumination requirements, and especially towards the vehicle coming into the tunnel.

This initial illumination of the tunnel requires a gradual attenuation of the light according to the distance from the entrance. This is at least partially achieved as a consequence of the loss of energy along the optical fibers.

The sun-light interceptors may be disposed close to the tunnel entrance, and the optical fibers associated thereto go into the tunnel from the entrance side thereof. Further sun-light interceptors may be disposed along the ground to reach the tunnel through its vault. This is possible when the ground above the tunnel is not particularly steep.

The invention will be best understood by following the description and the accompanying drawing, which shows a practical, not limiting example of the same invention. In the drawing:

Fig. 1 shows a system of lighting and obstacle detection installation according to the invention;

Fig. 2 shows schematically and in plan view the functioning of the lighting system of Fig. 1 for the detection of obstacles;

Fig. 3 shows a detail of a suitable luminous spot;

Fig. 4 is a partial local front view of two luminous spots;

Fig. 5 shows an application scheme of the invention with a light source of laser diodes type;

Figs. 6 and 7 are cross-section views showing how the lighting system operates the detection of the hindrances or obstacles according to the invention;

Fig. 8 shows a functional scheme of the auxiliary plant with a sun-light intercepting means;

Fig. 9 shows an embodiment of the installation according to the system of Fig. 8;

Fig. 10 shows a cross-section of the tunnel illuminated as above indicated; and

Fig. 11 shows a modified embodiment with respect to that of Fig. 9.

Fig. 1 shows an arrangement according to the invention for detecting the roadway pattern inside a tunnel and the possible presence of obstacles which may not be visible with a traditional type of lighting. The lighting according to the invention is obtained with at least a row of lights on one or both sides of the roadway for the purposes indicated below. The lights may be fed by individual local sources or by spaced apart sources feeding respective lights via optical fibers, also in conjunction with light generators located outside the tunnel.

As can be seen in Fig. 1, two rows of lights 31 and 33, respectively, are provided on each side at different levels with respect to the roadway surface and, for example, at a height of about 80 cm respectively of about 160 cm, for the purposes indicated below. A further central row of lights 35 may be predisposed for indicating the track of the tunnel. The two rows of

lights 31 and/or 33, having lights relatively close to each other, are intended to ease the detection of the roadway pattern or track within the tunnel. The two rows of lights 31 allows the perception "in negative" of the presence of obstacles such as cars, whose height does not usually exceed 150 cm. In order to perceive the larger dimensions of vehicles of industrial type, the second row of lights 33 may be provided at the height of approximately 160 cm as above mentioned. Two types of obstacles can thus be distiguished depending whether they are made visible by the single row of lower lights or by both the rows of upper and lower lights 31 and 33.

Advantageously, the lights of the rows 31 and 33 are oriented towards the incoming vehicle, that is, in a direction opposite to arrow fA (see Fig. 2) which indicates the direction of the vehicles, so that the driver of a vehicle V1 can perceive not only the pattern or track of the roadway, but also the presence of hindrances or obstacles of minor or major size when the continuous perception of the lights of the various rows is interrupted by the presence of such an obstacle intercepting the visibility of these lights in certain regions, as clearly shown in Fig. 2. Depending whether the interruption, i.e. the visibility in negative mode of a hindrance involves the lights of the lower row only or the lights of both upper and lower rows, the driver of vehicle V1 will perceive the presence of a car or of an industrial-type vehicle exceeding 150 cm of height. Figs. 7 and 8 illustrate some conditions of reverse signalling of the presence of hindrances likely to occur along the road path inside the tunnel illuminated with the rows of lights 31 and 33 as above indicated.

Particularly useful for powering the lights of the subject installation is the use of a coherent light mostly of laser type; when supplied via optical fibers, such light may be advantageously a polarized light allowing a minor loss of energy along the optical fiber, as known from the technical literature in the field.

Fig. 5 shows a supply system with an electrical line 401 leading to a laser diodes-feeding supply 402 apt to feed energy to a laser diode system which defines a light source for the optical fibers 404, the latter reaching the light-diffusion devices indicated by 405, which correspond to those indicated by 31, 33.

Shown in Fig. 3 is a possible embodiment of a light for illumination of the inside of a tunnel with the use of optical fibers which, however, may also be operated by individual, direct sources. Numeral 11 indicates a raceway apt to hold cables such as bundles of fibers 13 or leads; the raceway may be disposed either on the surface or embedded in the wall of the tunnel along a row of lights. Numeral 15 indicates a lid - made up of a continuous structure or of discrete and intermittent sections - on which the lights are provided. One of these is indicated by 17 and is provided with a clamp 17A for clamping a fiber 13A (or a cable) associated thereto, a device 17B for the orientation of the light whose swiveling part 17C comprises the clamp 17A, the diffusion lens 17E (or the electro-optical transducer) and a protection 17F. The light may be suitably oriented according to its required function.

Shown in Fig. 4 is a schematic arrangement for a plurality of lights 17 which may be distributed along the raceway and the respective lid.

An auxiliary plant may be advantageously associated to the above installation, as previously mentioned, to avoid (during the day-time hours) an abrupt passage to the conditions of darkness and background illumination which the majority of vehicles' drivers must endure. This auxiliary plant is illustrated in Figs. 8 and 11.

In the diagram of Fig. 8, numeral 1 indicates a system for intercepting the sun light, which may be of any type known from the technical literature of the pertinent technical field. Numeral 2 indicates optical fibers suitably disposed in bundles and fed with sun-derived light by the pick-up system 1 to feed individual diffusers 3 inside the tunnel in which, therefore, there is no need of providing lighting equipment with electrical power supply. Fig. 9 illustrates an arrangement in which a tunnel G is supplied (starting from its entrance) with two or more sun-light picking up means 101, 201, etc., whose optical fibers 102, 202, etc., go into the tunnel up to different distances from the entrance of the same tunnel to illuminate subsequent regions of the tunnel by means of the diffusers 103 and 203 which are of a type indicated above and described in more details in the following. The lights represented by the diffusers 3, 103, 203 may be disposed lined up on the vertex of the tunnel and so oriented as to illuminate the sides of the tunnel with beams like those indicated by F1 in Fig. 10, in order to achieve a suitable illumination able to compensate for the effects of the sudden light attenuation from the outside to the inside of the tunnel, a phenomenon harmful at day-time hours owing to the difficulty of a rapid adaptation of the driver's eyes to the darkness conditions suddenly occurring upon entering the tunnel.

The sun energy-operated lighting plant may be installed at the same location of the main system.

The sun-powered auxiliary plant is particularly suitable for illuminating the initial stretch of the tunnel starting from the entrance thereof, as the light intended for this form of illumination is substantially proportional to the amount of day-time light of which the interceting means, like those indicated by 1, 101 and 201, make use, while the lower picking-up capacity at dusk causes the additional lighting of the first length of the tunnel to become dim, when there is less need of such a lighting insofar as the external light is lower and so is the illumination gradient at the entrance of the tunnel.

The schematic representation in Fig. 11 shows an arrangement in which, owing to the steep slope of the ground at the entrance of the tunnel G, only one light-

ing system can be operated, starting from the same entrance of the tunnel, by means of an interceptor 301 and bundles of fibers 302 which allow an illumination with lights 303 extending over a relatively limited length inside the tunnel, because of the limited operating range of the optical fibers. In this case, provision may also be made for an integration of the sun light through other illumination means which may also be derived from outside the tunnel and with the aid of an optical-fiber transmission as well.

It is understood that the drawing shows an exemplification given only as a practical demonstration of the invention, as this may vary in the forms and dispositions without nevertheless coming out from the scope of the idea on which the invention is based.

Claims

1) Background lighting installation within motorway tunnels for the perception of the track and the possible presence of obstacles along the roadway, characterized in that it comprises at least a row of luminous spots substantially close to each other along each side of the tunnel, said lights defining the track of the same tunnel, while the interruption of the spots of one row indicates in reverse mode the presence of an obstacle causing such interruption.

2) Lighting installation according to the preceding claim, characterized in that it comprises on each side at least two rows of luminous spots at two different heights of the order of 80 and 160 cm from the roadway to ease the perception of the obstacle dimensions.

3) Lighting installation according to any preceding claim, characterized in that the light of the luminous spots is substantially punctiform and is a coherent light, mostly of laser type.

4) Lighting installation according to any preceding claim, characterized in that the light at the luminous spots is a polarized laser light which is transmitted via optical fibers and obtained by remote generators which may be arranged outside the tunnel inside which, therefore, no electrical leads are provided.

5) Lighting installation according to any preceding claim, characterized in that the luminous spots for one-way tunnels are oriented towards the incoming vehicle and are swivellingly adjustable.

6) Lighting installation according to at least one of claims 1 to 3 and 5, characterized in that it comprises a third longitudinal row of luminous spots substantially along the vertex of the tunnel, which are oriented towards the driver.

7) Lighting installation according to any preceding claim, characterized in that it is associated with an auxiliary lighting plant for a day-time illumination gradually becoming dim inside the tunnels starting from the entrance thereof, to avoid the sudden passage from conditions of natural, external illumination to substantial darkness with background illumination only, and to allow for a gradual adaptation of the eye.

8) Lighting installation according to claim 7, characterized in that said auxiliary plant comprises: at least a sun-light intercepting unit outside the tunnel; bundles of optical fibers coupled to the lenses of the interceptors and extending inside the tunnel; and optical diffusers fed with light energy from optical fibers and able to illuminate the initial stretch of the tunnel starting from the entrance thereof.

9) Lighting installation according to claims 7 and 8, characterized in that the diffusers are so oriented as to meet the illumination requirements.

10) Lighting installation according to any one of claims 7 to 9, characterized in that the loss of energy along the optical fibers is at least partly exploited for gradually attenuating the illumination as a function of the distance from the entrance.

11) Lighting installation according to any one of claims 7 to 10, characterized in that solar interceptors are disposed at least close to the entrance of the tunnel and that the optical fibers go into the gallery from the entrance thereof.

12) Lighting installation according to any one of claims 7 to 10 and possibly 11, characterized in that the solar interceptors are disposed along the ground work to reach the tunnel through the vault thereof.

13) Lighting installation according to any one of claims 7 to 12, characterized in that the sun-light interceptors are of swiveling type to follow the sun.

14) Lighting installation according to any one of claims 7 to 13, characterized in that it comprises auxiliary generators generating a light energy other than the solar one.

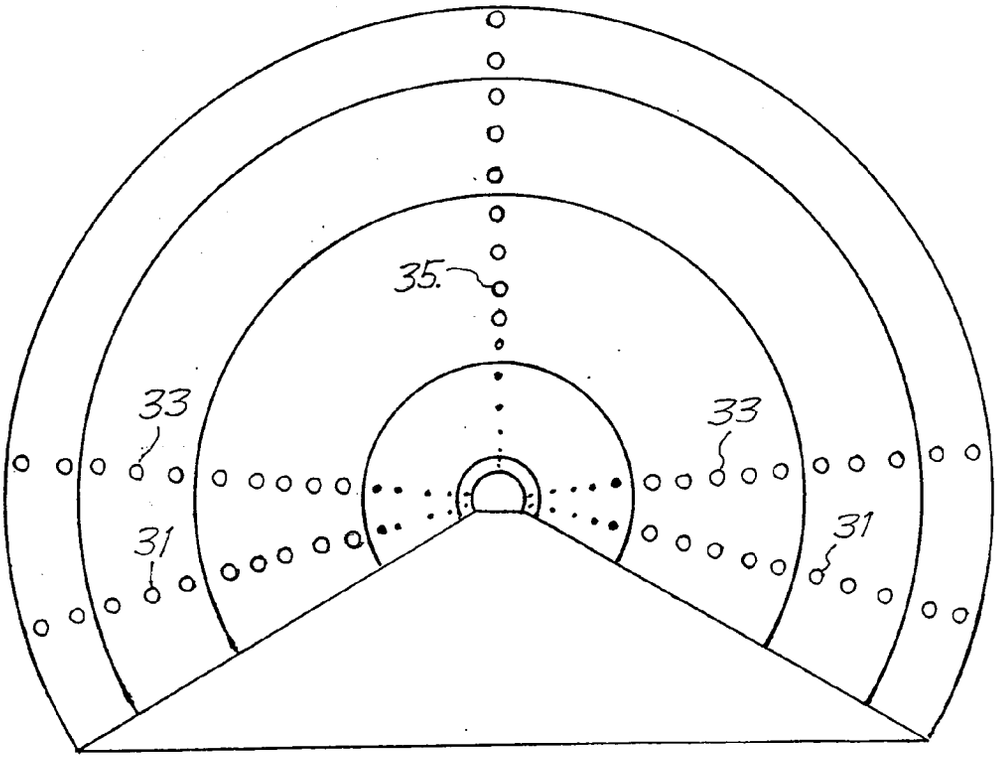


FIG. 1

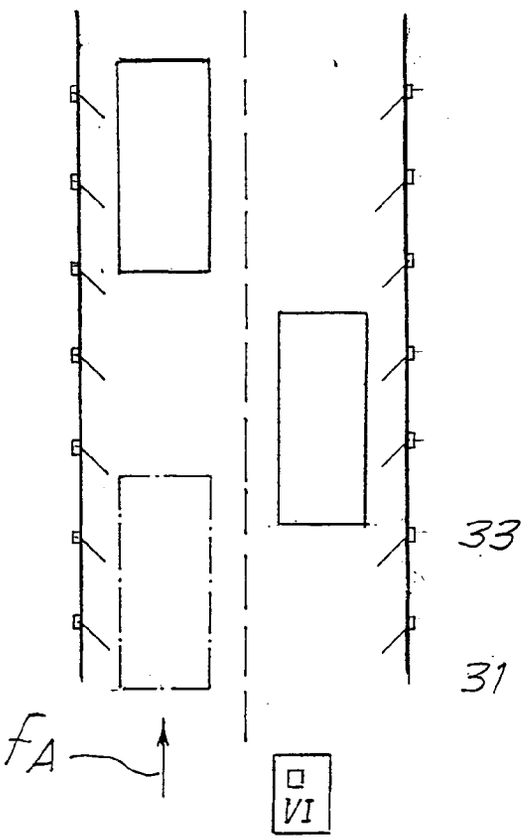


FIG. 2

FIG. 3

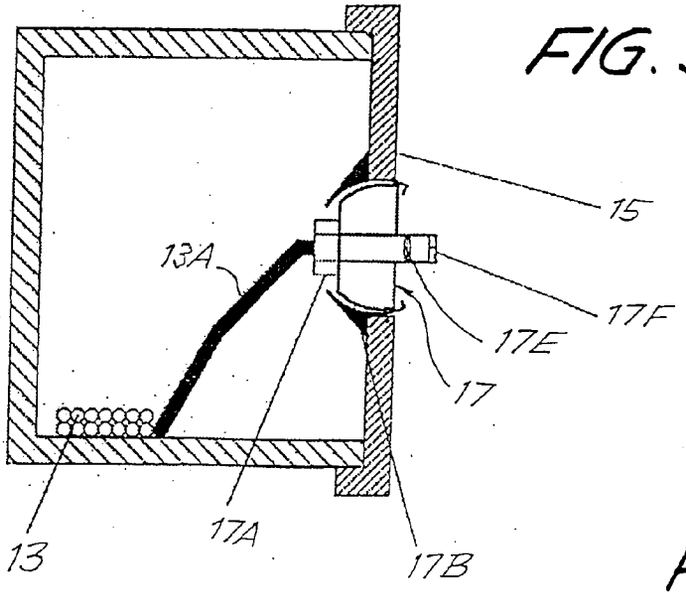


FIG. 4

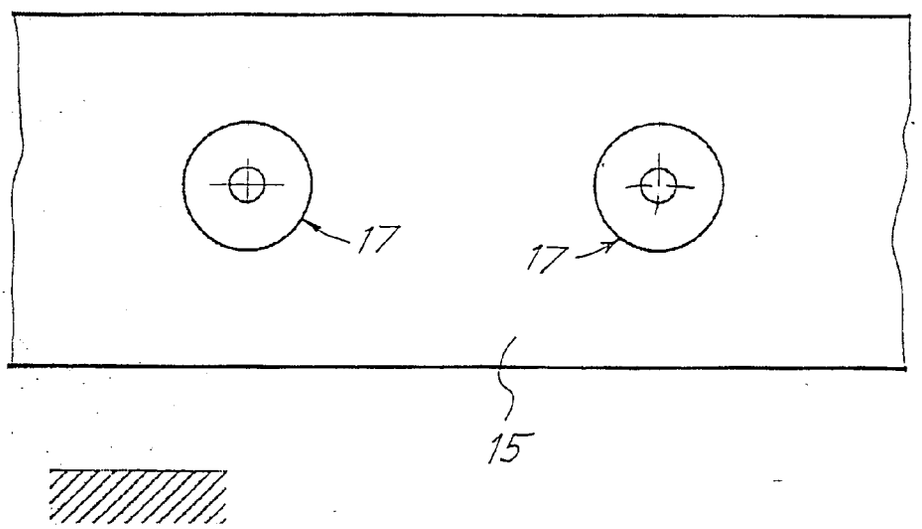
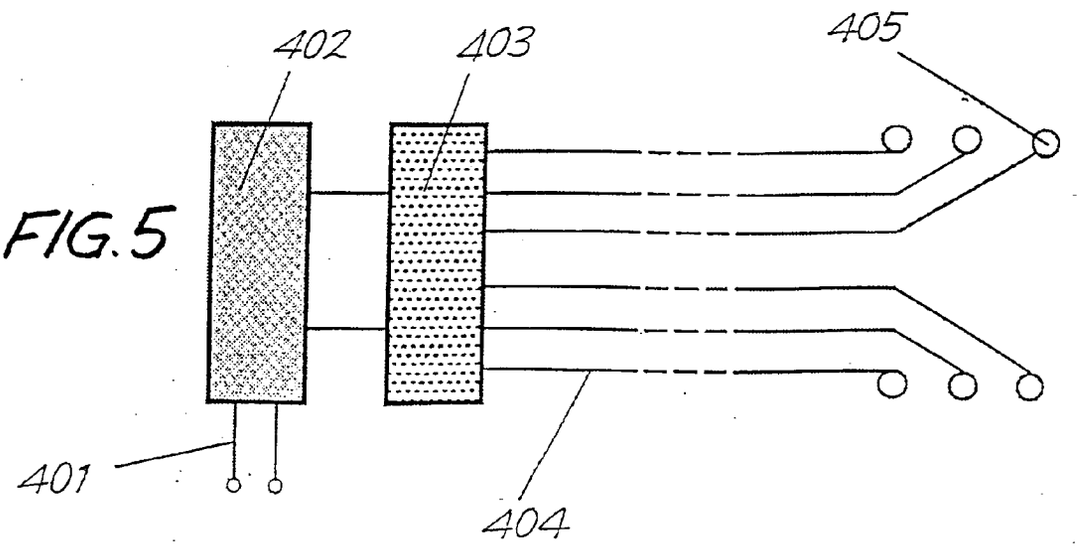


FIG. 5



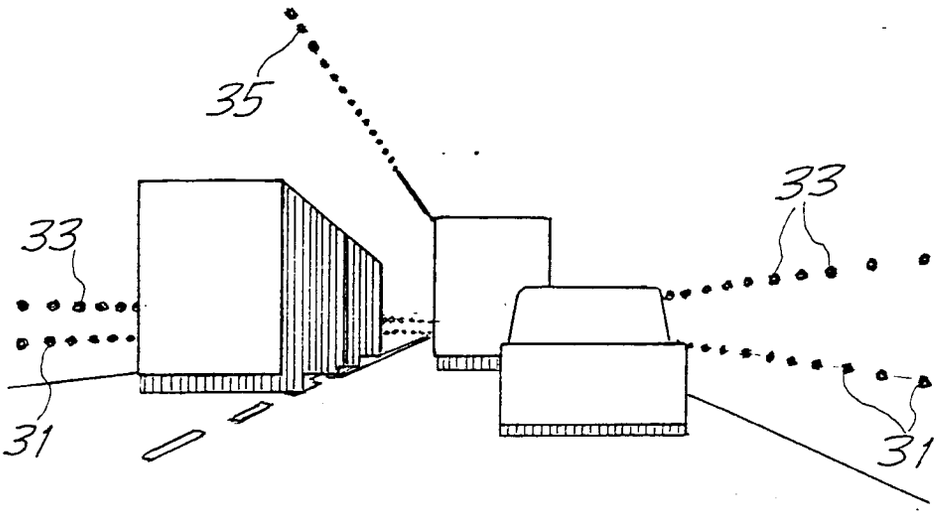
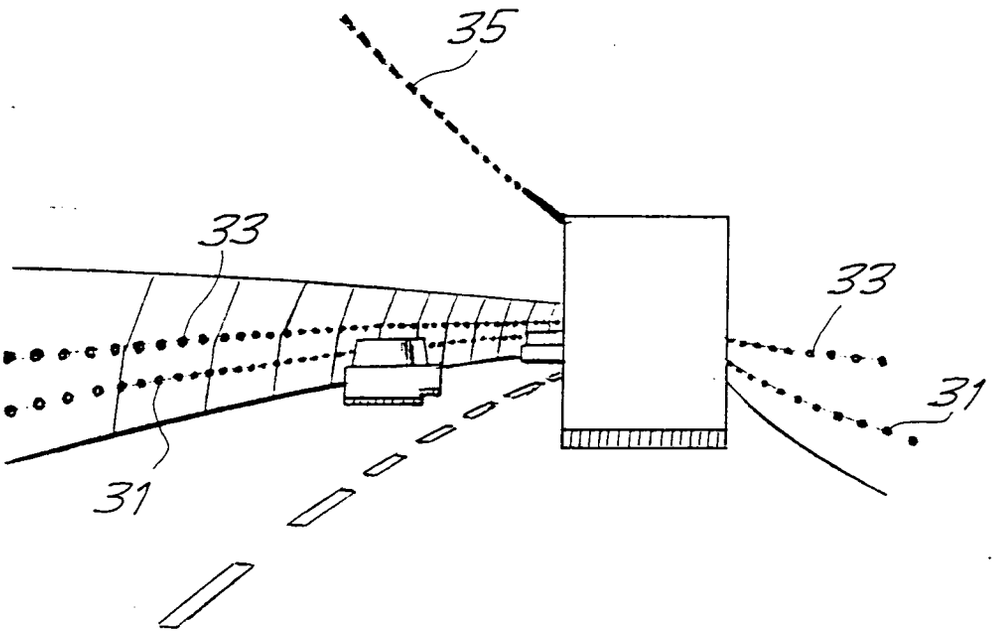


FIG. 6

FIG. 7



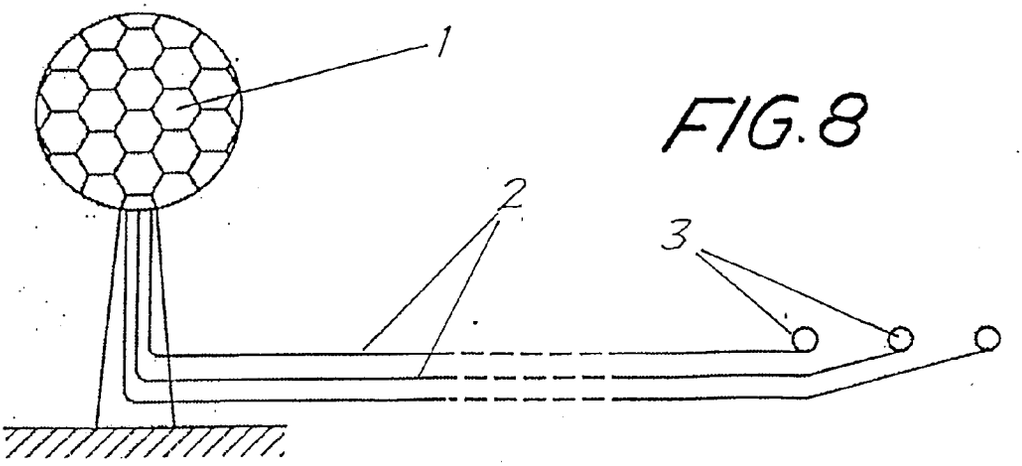


FIG.8

FIG.9

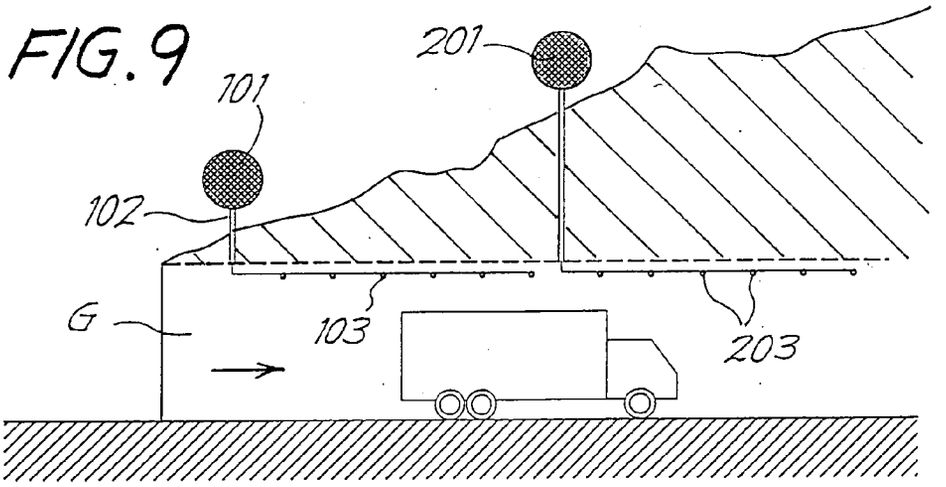
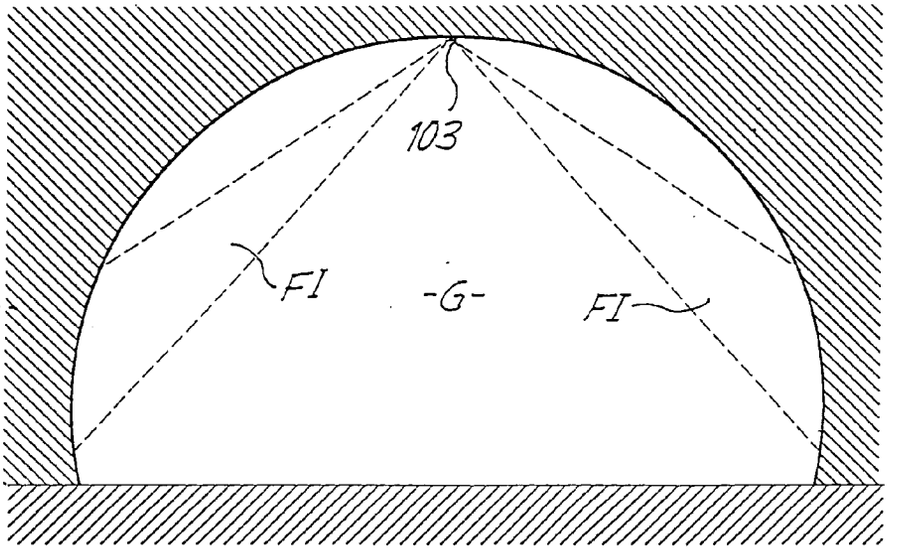


FIG.10



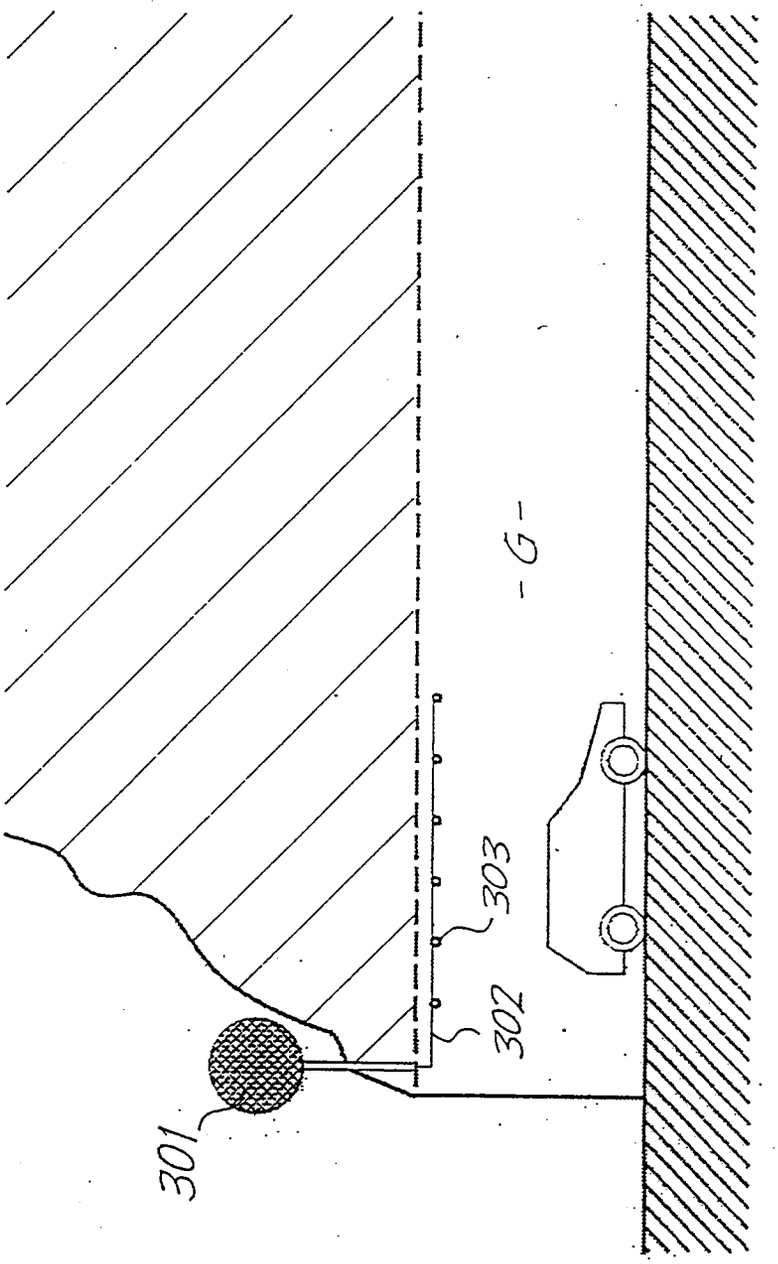


FIG. 11