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(54) APPARATUS FOR DETECTING AND COUNTING MOVING OBJECTS

(71) We, AUTOSTRADE, Concessioni e Costruzioni Autostrade S.p.A., an Italian Company of 10, Via Antonio Nibby, 00161 Rome, Italy, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be described in and by the following statement:-

Detecting apparatuses are known which produce a thin curtain of the order of one to some tens of centimetres in thickness with a height suitable for the intended purpose.

With such known apparatuses the curtain is generally provided by a focussed optical beam, suitably modulated, such as for instance using infrared rays, laser or photocells which the output signal is produced using contacts normally open which close whenever an interruption due to the passage of a vehicle occurs.

Such curtains offer the drawback that they are jammed by sunlight and consequently they are not very reliable for outdoor applications.

The present invention concerns a new kind of apparatus for detecting and counting passing vehicles. The apparatus produces an electromagnetic wave curtain which is thin and of the desired height, which is unaffected by sunlight and weather disturbances and which is particularly suitable for registering data at determined strategic points along a road stretch which is equipped with a system for electronic traffic control in real time, for instances at entrances and exits and/or at branch points of a highway, where it is desirable that the noting of passing vehicles and their counting should be reliable and accurate.

The apparatus which is provided by the present invention is notable for the high reliability which is possible, particularly since mechanical moving parts are not necessary.

According to this invention apparatus is provided for detecting and counting vehicles, passing through a curtain of electromagnetic microwaves, wherein the apparatus comprises a transmitter for forming this microwave curtain, and a receiver formed of a plurality of elemental receivers, which are arranged vertically one above the other and are connected to a logic circuit for detecting the attenuation or the interruption of the curtain whenever at least a portion, or horizontal curtain slice, corresponding to one of the receivers is crossed by a moving object and wherein the transmitter comprises a microwave radiation source comprising a Gunn diode oscillator operating in the microwave region, together with a slit waveguide the slits of which are arranged in a fan-like manner such that through each of the slits a constant proportion of the generated signal is emitted, the source being located at the focus of a cylindrical-parabolic reflector adapted to reflect the microwave beam which is emitted by the source, thus forming a microwave beam having a thickness corresponding to the length of the chord of the parabola and height equal to the height of the unit constituted by the source and reflector, each element receiver comprising a crystal-video receiver tuned to the frequency of the transmitter and a low-gain horn antenna.

Further features and advantages of the invention will appear from the following description, considered with reference to the accompanying drawing, which shows a preferred embodiment of the invention.

In the drawing:-

Figure 1 shows schematically an embodiment of a curtain with its transmitter and receiver.

Figure 2 is a schematic representation of the slit waveguide microwave radiation source of Figure 1., taken from the side of the slit face, coupled with a Gunn diode oscillator;

Figure 3 is a schematic view, taken from above, of the slit waveguide source of Figure 2, together with its cylindrical parabolic reflector.

Figure 4 shows, in the form of a block diagram, an embodiment of a receiver of apparatus according to the present invention, in which, for the sake of clarity in the drawing, the number of elemental receivers shown is only two;

Figure 5 shows, as a schematic representation, a curtain apparatus which consists of a transmitter and nine elemental receivers.

Figure 1 shows, as 40, a transmitter comprising a beam source 41, which operates by the coupling of a Gunn diode oscillator, 42, operating in the microwave region, with a waveguide 43 having transverse slits 44 (Figure 2) in a fanlike arrangement, such that a constant proportion of the generated power is emitted through each slit 44 with the object of obtaining a flat wave front having a constant phase.

Such source 41 is situated at the focus of a cylindrical-parabolic reflector 45, which is provided, for example, by a smooth metal surface, so that the wave beam emitted by the source 41 will be reflected parallel to the axis of the parabola generatrix of the reflector itself, forming a beam having a width, corresponding to the length of the chord of the parabola, and a height h, which is determined by the height of the assembly of the parts 41 and 45, which are enclosed within a container 46.

The receiver, shown at 47, is divided into a plurality of elemental receivers 48 in order to separate the controlled area into horizontal sections, or slices, with the object of achieving the sensitivity required to detect bodies even when they are of small size, interrupting the curtain such as for instance the drawbars which tie a trailer to the towing vehicle or tractor.

If the receiver consisted of only a single receiver unit, as is the case with known receivers, including radio-frequency receivers, the low sensitivity and selectivity of the apparatus could result, for instance, in the case of a trailer-truck, i.e. a tractor together with its trailer, in signals indicating the passage of two distinct and separate vehicles, thus deceiving the analyser or counter as to the number of vehicles interrupting the curtain.

On the other hand, the division of the controlled area of the curtain into a number of horizontal slices which are each able to sensitize at least one elemental receiver, causes the passing body, which in this case includes the drawbar, to be surveyed as a unit, thus giving a continuity to the signal which corresponds to the passage of only one vehicle, i.e. a trailer-truck.

Each elemental receiver 48 is composed of a crystal-video receiver 51 tuned to the frequency of the transmitter 40, and a low-gain horn antenna 52, which preferably, but not necessarily, has an aperture angle of approximately 70°.

The height of the antenna 52 determines the height i of the effectively watched area, or slice, of each elemental receiver 48.

Such height i must be comparable with or related to the minimum size of the body which is to be surveyed; for instance, in the case of the counting of passing vehicles, this dimension is determined by the height or thickness of the drawbars which connect towing vehicles with their trailers, and appears to be of the order of 10 to 12 centimeters.

The direct voltage of the output of each elemental receiver 5 duly amplified through a circuit 53 (Figure 4) is applied to a threshold comparator 54.

The gain of the amplifier 53 is regulated in such a way as to compensate for possible lack of perfect homogeneity of the signals picked up at the various heights of the whole wave front, corresponding to the heights of each elemental receiver, while an NOR logical circuit, indicated at 55, acts to control the state of the single elemental receivers 48 so as to produce an output signal operating a switch 56, which is normally open, but which is adapted to close during an interruption of a curtain slice, when at least one of the elemental receivers is affected by an interruption or an attenuation of the received signal above a predetermined threshold level. This threshold level may be adjusted by regulating the further input of each comparator 54.

In practice, apparatus according to the present invention which is particularly suited for the counting of passing vehicles is advantageously composed of a transmitter 40 having an antenna (i.e. source and reflector) with a height of one metre, and a receiver 47 which is divided into nine sections, or slices each of which has a height of approximately 11 centimetres. The output from the apparatus may be used to operate a conventional counting means.

The height i of the area surveilled by each elemental receiver 48 is thus about 12 centimeters, and the apparatus is sensitive to the passage of bodies having a height of about 8 centimeters.

It is feasible to vary the sensitivity of the barrier as a function of the height such as by varying the gain of the received signal amplifiers and/or varying the aperture angles of the receiving horns.

WHAT WE CLAIM IS:-

1. Detecting apparatus for detecting and counting vehicles, passing through a curtain of electromagnetic microwaves, wherein the apparatus comprises a transmitter for form-

ing this microwave curtain, and a receiver formed of a plurality of elemental receivers which are arranged vertically one above the other and are connected to a logic circuit for detecting the attenuation or the interruption of the curtain whenever at least a portion, or horizontal slice, corresponding to one of the receivers is crossed by a moving object and wherein the transmitter comprises a microwave radiation source comprising a Gunn diode oscillator operating in the microwave region together with a slit waveguide the slits of which are arranged in a fan-like manner such that through each of the slits a constant proportion of the generated signal is emitted, the source being located at the focus of a cylindrical - parabolic reflector arranged to reflect the microwave beam which is emitted by the source, thus forming a microwave beam having a thickness corresponding to the length of the chord of the parabola and a height equal to the height of the unit constituted by the source and reflector, each elemental receiver comprising a crystal-video receiver tuned to the frequency of the transmitter and a low-gain horn antenna.

2. Apparatus according to Claim 1, wherein the cylindrical-parabolic reflector has a smooth metal surface and the slit face of the source is directed towards the apex of the generatrix parabola.

3. Apparatus according to Claims 1 or 2, wherein the aperture angles of the low-gain horn antenna of the elemental receivers of the elemental receivers are approximately 70°.

4. Apparatus according to any of Claims 1 to 3, wherein the height *i* of the horizontal slice of the curtain corresponding to each elemental receiver is determined by the height of the corresponding antenna.

5. Apparatus according to Claim 4, wherein the height *i* of each horizontal slice of the curtain is from 10 to 12 centimetres.

6. Apparatus according to any of Claims 1 to 5, wherein a direct voltage at the output of each elemental receiver, after being amplified through an amplifier circuit, is applied to a threshold comparator, the gain of each amplifier being regulated in such a way as to allow for possible imperfect homogeneity of the signals picked up at the different heights, of the whole wave front, corresponding to the height of such elemental receiver while an NOR logical circuit is arranged to control the state of the single elemental receivers and to produce an output signal controlling a switch normally open which is caused to close as a result of an interruption or attenuation of the curtain when at least one of the elemental receivers is affected by an attenuation or interruption of the received signal above a predetermined threshold level.

7. Apparatus according to any of the preceding Claims, wherein the sensitivity of the barrier as a function of the height is variable by varying the gains of the received signal amplifiers or varying the aperture angles of the antenna horns.

8. Apparatus according to any of the preceding Claims, wherein the transmitter and the receiver are arranged on opposite sides of the space crossed by the moving objects, each transmitter or receiver being enclosed within its own casing, in which its parts are supported.

9. Apparatus as claimed in Claim 1, substantially as hereinbefore described with reference to the accompanying drawings.

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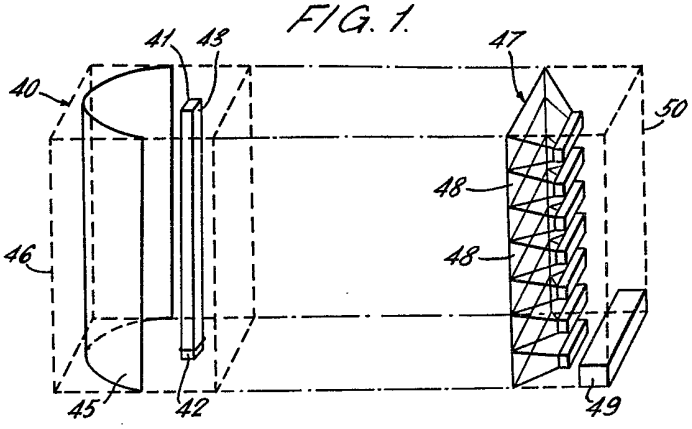
FIG. 1.



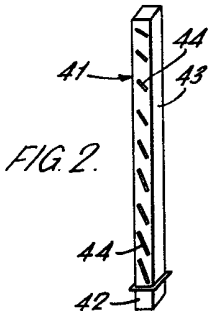


FIG. 2.

FIG. 3.

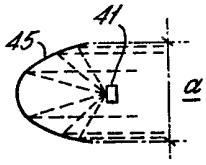


FIG. 4.

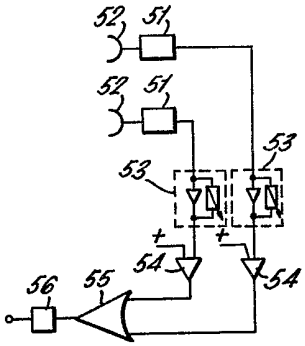


FIG. 5.