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GB A 2087197
GB A 2014796
GB A 2003703
GB 1599138
GB 1596322
GB 1516006
GB 1311027
GB 1091437
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(54) Transponder detection systems

(57) An a.c. signal from a relatively moving transponder travelling along path P is detected by an elongated receive aerial 10 which comprises two parallel loops 12, 13 connected in a figure-of-eight configuration, the path P passing along the length of loop 12. A transmit aerial (20, Figure 2 not shown) may also be provided which is of similar size and shape as the receive aerial 10 and is arranged symmetrically relative thereto.

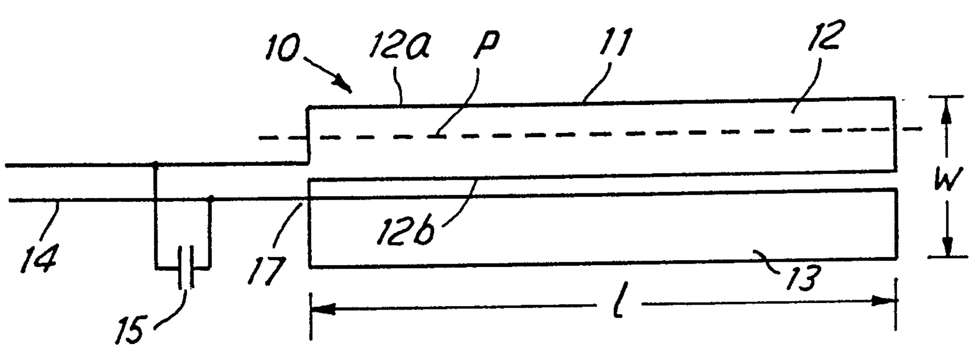

FIG.1

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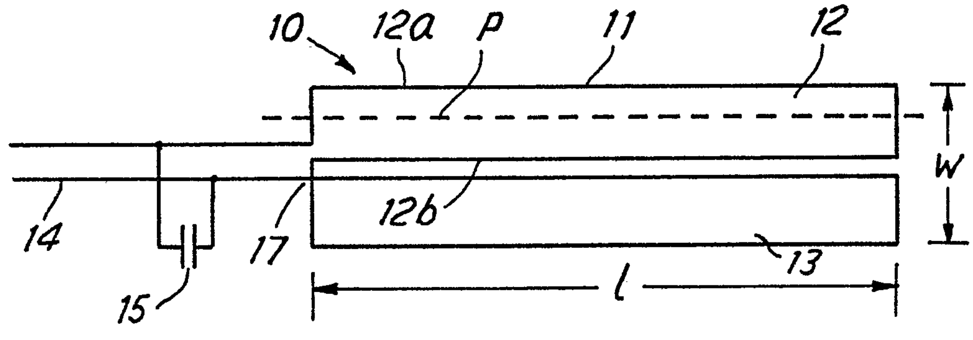

FIG.1

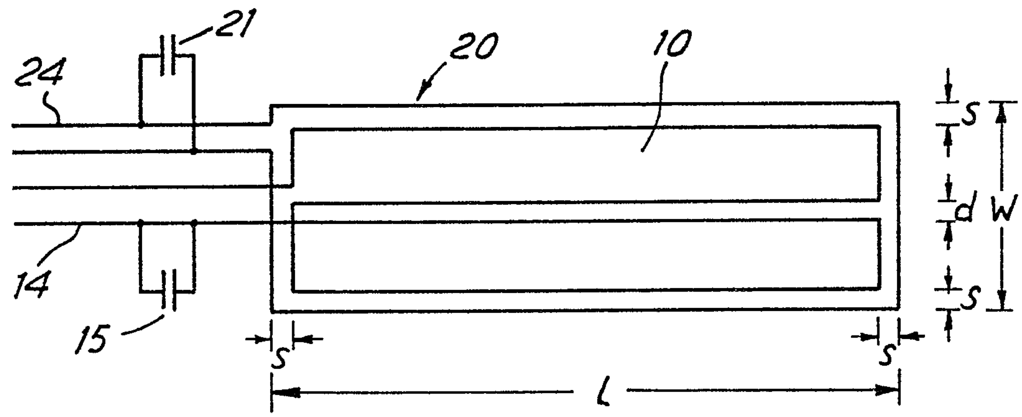

FIG.2

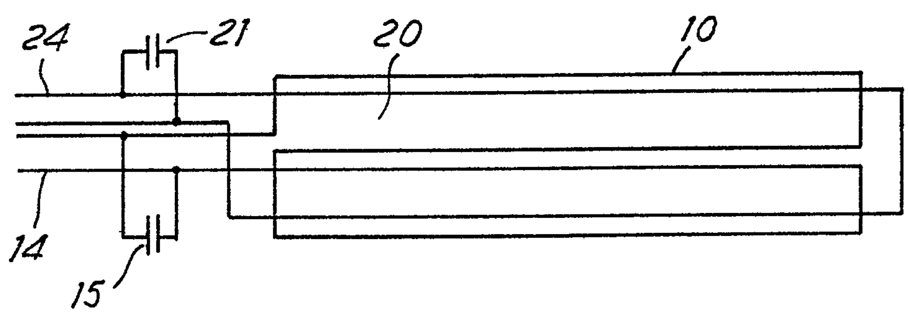

FIG.3

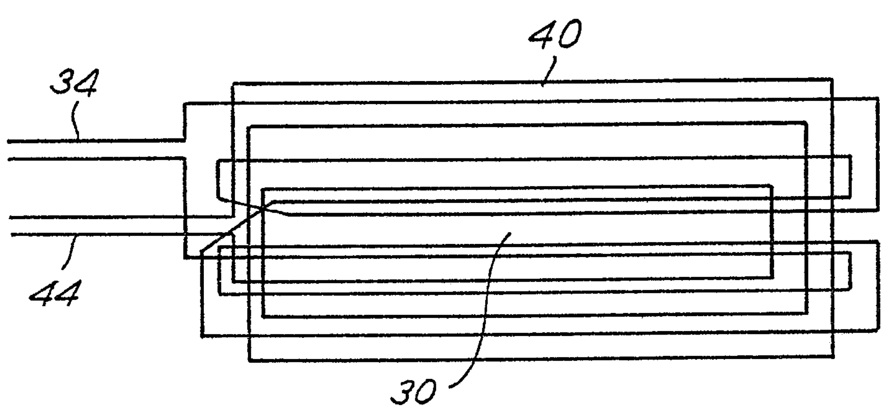

FIG.4

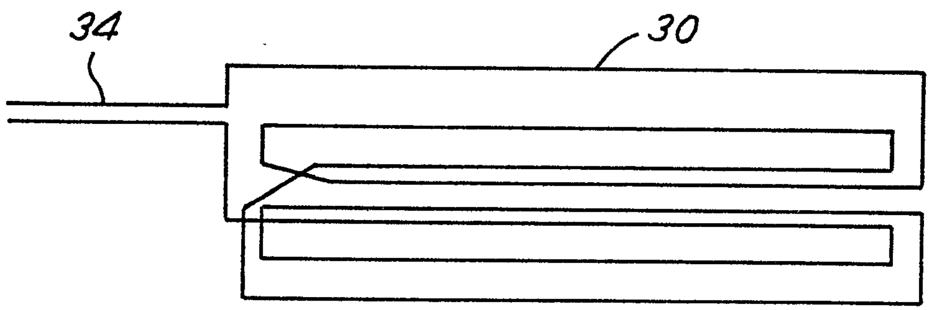

FIG. 5

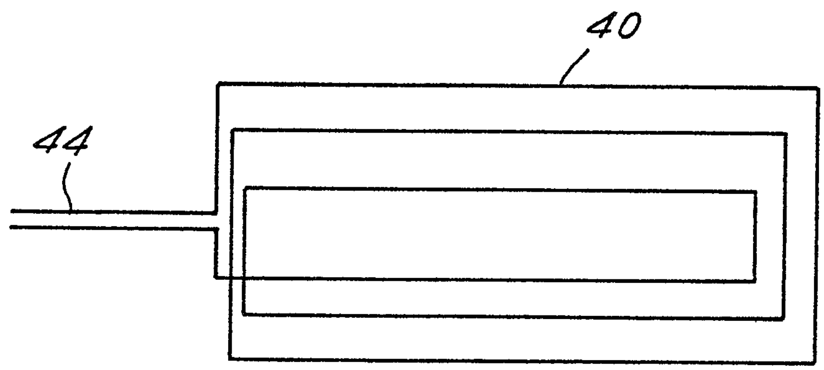

FIG. 6

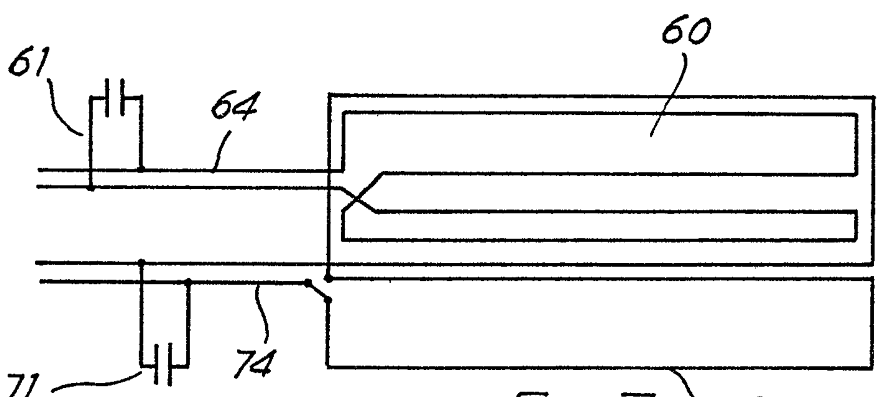

FIG. 7

SPECIFICATION

Transponder Detection Systems

The present invention relates to an aerial and in particular to an aerial for transponder detection systems.

Such a system is described in U.K. Patent G.B. 2017454B and may be used to identify moving bodies such as vehicles, animals, personnel etc. Because of the relatively limited range of existing aerials, the systems in use at present employ as series of receiver aerials arranged along the detection zone. When the body is moving relatively fast, there is a danger in existing systems that the detected signals may suffer from phase disturbances. This is because there are null positions between the receiver aerials due to the phase differences at the aerials in signals from a moving transmitter. There is also the problem of variations in the received signal strength due to changes in the relative orientation between the receiver and transmitter aerials.

The present invention seeks to avoid or reduce one or more of the above disadvantages.

According to the present invention there is provided an arrangement for detecting an a.c. signal from a relatively moving source comprising means defining a path for the source and a receive aerial comprising first and second generally parallel elongated loops arranged in a figure-of-eight configuration, the second loop being located to one side of the first loop, and the path extending along the length of the first loop.

The aerial is preferably employed at relatively low frequencies where the magnetic effects of the electro-magnetic field predominate and a signal is inductively coupled to the aerial.

Preferred embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings, of which:

Figure 1 shows a receiving aerial for use in an aerial arrangement in accordance with a first embodiment of the invention;

Figure 2 shows associated transmitting and receiving aerials for use in an aerial arrangement in accordance with a second embodiment of the invention;

Figure 3 shows an arrangement similar to Figure 2 but in accordance with a third embodiment of the invention;

Figure 4 shows associated transmitting and receiving aerials for use in an aerial arrangement in accordance with a fourth embodiment of the invention;

Figure 5 shows the receiving aerial of the embodiment of Figure 4;

Figure 6 shows the transmitting aerial of the embodiment of Figure 4; and

Figure 7 shows an aerial arrangement in accordance with a fifth embodiment of the present invention.

Referring now to the drawings, Figure 1 shows a receiving aerial 10 comprising a wire 11 arranged in a shape which is substantially equivalent topologically to a figure-of-eight, with two loops 12 and 13 of substantially the same size and shape. The loop 12 at the top of Figure 1 is broken at one point for the connection of wires 14 which lead to a detector. A tuning capacitor 15 is connected across the wires 14. The loop 13 at the botom of Figure 1 is complete and a cross-over point 17 is provided between the two loops. It is ensured, e.g. by the provision of insulating material at point 17, that there is no electrical contact between the conductors.

The arrangement shown in Figure 1 means that the loops are in anti-phase. The length *l* of the aerial shown is large compared to its width *w*, which is in turn large compared to the size of the gap between the loops.

This aerial is primarily intended for use at close range, i,e, close related to the width, and signal wavelength. Generally, but not exclusively, the dimensions *l* and *w* will be much less than wavelength. Also the distance to the signal source will be less than a few times greater than *w*. For example, the distance from source to aerial will usually be less than 10 times *w*.

The arrangement may be operated at any frequency, but in general the free space wavelength will be large compared with the largst aerial dimension. Preferred frequencies are from quasi-DC to low microwave, e.g. 10 Hz to 1GHz.

The above described aerial may be employed as follows:

1. To receive signals from a transmitter or transponder attached to a vehicle travelling along the length of the aerial. The aerial is preferably located beneath a road, rail or other track so that a vehicle-mounted transmitter or transponder travels along the path P, i,e, substantially along the longitudinal axis of loop 12. By virtue of the resulting asymmetric response of the loops 12, 13, a signal appears at wires 14. The strength and phase of the received signal will be nearly constant, thus avoiding the phase disturbances and orientation problems referred to earlier. This system could for instance be used to monitor movement of trains or buses or even cars to which transponders are attached. It may further be used to advantage, with converyor belts or indeed any moving object.

2. It may be of advantage to fix the receive aerial or aerial set to the moving object, for example a train, and use it in association with a stationary transponder.

The aerial described above has the following advantages:

1. Ambient noise which has a source which is relatively distant from the aerial will have the effect of inducing similar but opposing currents in each half of the loop, with the result that the noise will tend to cancel itself.

2. It is possible to keep the signal source in a known orientation, and at a known distance from the loop as it moves along the length *l* with the result that the received signal strength remains nearly constant despite the fact that the source may be moving rapidly. This is due to the length of wires 12*a*, 12*b* along the opposite sides of loop 12 being parallel. In addition the phase of the signal will not vary.

3. The advantages of an elongated receiver loop 12 is that it permits reception of information from the relatively moving source for a relatively long time. For example, when using the coded information

arrangement disclosed in U,K, Patent Application GB 2077556 A, the time T taken for the coded tag transponder to pass over loop 12 must be at least long enough to permit two interrogation cycles to be completed. In general

$$T \geqslant nt$$

where n is the number of interrogation cycles in each interrogation procedure and it is the average time thereof. This means that

$$L \geqslant ntv$$

where v is the maximum expected speed of the source relative to the aerial.

Figure 2 shows a receiving aerial 10 as shown in Figure 1 in conjunction with a transmitting aerial 20 which surrounds aerial 10. Aerial 20 is tuned by a respective capacitor 21, across wires 24. The figure is purely schematic and in practice the separation *s* between the two aerials will generally be larger than the gap *d* between the two receiver loops 12 and 13.

The embodiment of Figure 2 has the same advantages as that of Figure 1. Furthermore it has the advantages of a good transmit range and ease of construction. Since the receiving aerial 10 is placed in a generally symmetric position with respect to the transmitter loop, the transmitter voltages and currents induced in one loop of the receiving aerial figure-of-eight will largely cancel those induced in the other receiver loop. However the embodiment of Figure 2 is still susceptible to the effects of conductive or magnetic objects located adjacent to the aerials and to one side of the centre line. The presence of such an object will be to change (usually reduce) the magnetic field in the region and thus the balance of the aerials will be upset.

The embodiment of Figure 3 is constructed to reduce this harmful effect. The embodiment of Figure 3 is similar to that of Figure 2, but the transmitter aerial 20 lies within the aerial 10 along the lengths of the loop. Also the separation of the loops at their ends differs from the separation along their lengths. The arrangement is generally symmetric.

By suitable placing of the transmit aerial wire in the embodiment of Figure 3, which has magnetic fields of opposite polarity on each side of it, it is possible to independently balance each loop of the receiving aerial figure-of-eight. Accordingly a conductive or magnetic object has a lesser effect compared to the embodiment of Figure 2; each quarter of the aerial set suffers from a reduced imbalance effect, dependent on the respective range of the object.

One example where conductive objects can cause imbalance effects is when the aerial sets are placed between the rails of railway. The mismatch caused by the passage of a metallic truck will be approximately self-cancelling. The aerial sets may be positioned not only between train tracks but also in bus lanes, in corridors or adjacent conveyor belts etc. They may also be carried by a moving object, such as a train, to interrogate and identify fixed transponders.

The embodiment of Figure 3 has the advantage of being less susceptable to metallic objects moving close to the aerial set and especially transversely to the length of the aerial set. This is particularly advantageous when it is necessary to place an aerial set at a level crossing, where cars will cross the aerial, or in a bus lane. This embodiment is also less susceptible to the effects of an adjacent metallic object positioned asymmetrically; for instance in the case of an aerial set under a bus lane where a bus is not centrally positioned.

The transmit field in the embodiment of Figures 2 and 3 may be concentrated in a long and narrow region.

Figures 4, 5 and 6 show a more complex aerial set which has an improved performance in respect of reducing the adverse effects of adjacent conductive or magnetic objects.

Figure 4 shows an aerial set comprising a receiver aerial 30 and a transmitter aerial 40 having respective connection wires 34, 44. Figure 5 shows the receiver aerial 30 alone which has a figure-of-eight configuration. Figure 6 shows the transmitter aerial 40 alone which has a spiral-like configuration. The embodiment of Figure 4 may be used where the interfering objects are closer to the aerial set than with the embodiments of Figures 2 and 3. This is because there are more elemental zones of the aerial, each with a lesser imbalance effect.

The above described aerials permit an increase in signal range, thus overcoming the problems mentioned at the outset. Whereas previously several aerials were needed to cover an extended zone, a single aerial in accordance with the invention may be used to provide a constant signal level with no phase disturbances. In addition the advantages of long range noise reduction and short range signal enhancement are also provided.

The above described aerials may be positioned below, to the side of, or above a zone where transponders are to be detected. The length, width and separations of the loops may be selected to any suitable value, and the loops of a figure-of-eight aerial do not need to be symmetric. The length to width ratio *l* to *w* of the aerial arrangement may be any value from 1 to 1 upwards, preferably at least 2 to 1. For relatively fast moving bodies ratios of 4 to 1 and above are suitable. When the aerial arrangement lies along a railway track *w* may be 90cm and *l* may be from 350 to 600cm.

The lengths of wire 12*a*, 12*b* forming the opposite sides of the loop 12 do not need to be exactly parallel. There can be a relative small acute angle between their directions provided that the signal strength does not vary too much along the aerial. In addition, the cross-over point, i,e, where the wires cross at the meeting points of loops 12, 13, need not be at the end of the aerial as shown, but can be at any desired position along its length.

The path P of the source and/or the sides of the aerial loops may be curvilinear. Each loop may comprise one or more turns depending on the nature of the operating environment. Where the aerials are formed of wires, they may be insulated throughout. Alternatively insulation is provided only at cross-over points. The aerials can be formed of conductors on printed circuit boards; again insulation is provided at cross-over points. Tuning capacitors are optional.

As well as, the receiving aerial having a figure-of-eight configuration in the previous embodiments, the transmitter aerial may also have a figure-of-eight configuration. In the embodiment of Figure 8 both receiver aerial 60 and transmitter aerial 70 have a shape which is substantially equivalent topologically to a figure-of-eight. Aerial 60 has connection conductors 64 and a tuning capacitor 61 and aerial 70 has connection conductors 74 and a tuning capacitor 71. The receiving aerial 60 is formed so that the field 15 from the transmitter aerial is effectively nulled. An advantage of having the transmitter loop formed with a figure-of-eight configuration is that at all heights above the axis of the aerial the magnetic field will be parallel to the plane of the aerial, i.e. generally horizontal where the aerial is arranged horizontally. This will minimise the interference caused by the passage of metallic objects across the aerial.

Although the transmitter aerial has been disclosed as being generally co-planar with the receiver aerial, this is not essential. For example the receiver aerial may be at floor level (e.g. incorporated in a mat) and the transmitter aerial may be on or embedded in an adjacent wall.

CLAIMS

1. An arrangement for detecting an a.c. signal from a relatively moving source comprising means defining a path for the source and a receive aerial comprising first and second generally parallel elongated loops arranged in a figure-of-eight configuration, the second loop being located to one side of the first loop, and the path extending along the length of the first loop.

2. An arrangement according to claim 1, wherein the elongated sides of at least the first loop are substantially parallel.

3. An arrangement according to claim 1 or 2, wherein the first and second loops are of substantially the same size and shape.

4. An arrangement according to any preceding claim wherein the ratio of the length *l* to the width *w* of the arrangement is at least 2 to 1.

5. An arrangement according to claim 4 wherein the ratio is 4 to 1 or greater.

6. An arrangement according to any preceding claim, wherein the source is movable and the aerial is stationary.

7. An arrangement according to any of claims 1 to 4, wherein the source is stationary and the aerial is movable.

8. An arrangement according to any preceding claim wherein the source is a transponder and the arrangement further comprises a transmit aerial.

9. An arrangement according to claim 8 wherein the receive aerial defines a cylindrical region, the shape of which is defined by the periphery of the receive aerial and the axis of which is perpendicular to the plane of the receive aerial, and at least part of the transmit aerial lies within or adjacent to said cylindrical region.

10. An arrangement according to claim 9 wherein the receive and transmit aerials are substantially coplanar.

11. An arrangement according to claim 9 or 10 wherein the peripheries of the receive and transmit aerials have approximately the same size and shape.

12. An arrangement according to claim 10 or 11 wherein the transmit aerial surrounds the receiver aerial, at least along the length thereof.

13. An arrangement according to claim 10 or 11 wherein the transmit aerial lies within the receiver aerial, at least along the length thereof.

14. An arrangement according to any of claims 8 to 13 wherein the transmit aerial is in the form of a spiral.

15. An arrangement according to any of claims 8 to 13 wherein the transmit aerial also has a figure-of-eight configuration.

16. An arrangement according to any of claims 10 to 15 wherein the receive and transmit aerials are relatively symmetrically arranged.

17. An arrangement according to claim 8, or to any of claims 9 to 16 when dependent on claim 8, wherein the transponder stores coded information and, upon transmission of an interrogation signal from the transmit aerial, supplies said coded information in the form of said a.c. signal to the receive aerial.

18. An arrangement according to claim 17 wherein the length *l* of the receive aerial is greater than or equal to the product of *n*, *t* and *v*, where *n* is an integer equal to 1 or more and is the number of interrogation cycles in an interrogation procedure of the transponder, *t* is the average time of an interrogation cycle, and *v* is the maximum expected speed of the transponder relative to the aerial.

19. An arrangement for detecting an a.c. signal from a relatively moving source substantially as herein described with reference to Figure 1, Figure 2, Figure 3, Figures 4 to 6, or Figure 7 of the accompanying drawings.

20. A method of detecting an a.c. signal from a relatively moving source substantially as herein described with reference to Figure 1, Figure 2, Figure 3, Figures 4 to 6, or Figure 7 of the accompanying drawings.

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