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(54) System and method for automatic detection of moving vehicles.

(57) A system for the automatic detection of moving vehicles, with data exchange, particularly with automatic toll charging, comprising a fixed receiving and transmitting station capable of communicating with a plurality of on-board transceiver units (3) each of which is associated with one vehicle. To avoid confinement to a single-carriageway transit lane of vehicles passing the transceiver station, the invention specifies that the transceiver station is provided with a plurality of aerials (A.1-A.n), each of which forms a coverage area (C.1-C.n) of dimensions considerably smaller than the dimensions of the vehicles, so that only one vehicle can pass through each coverage area at one time and consequently only one on-board unit (3) can communicate with each aerial (A.1-A.n) at one time, while the signals received by each aerial (A.1-A.n) are processed separately from each other. The invention also specifies a particular method of application.

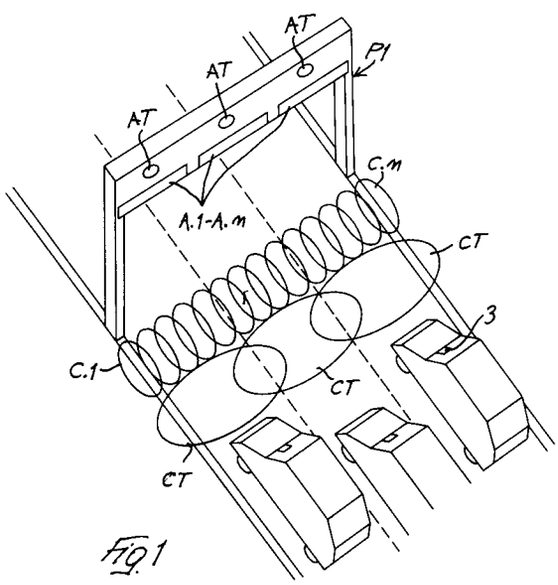


Fig.1

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The invention relates to a system for automatic detection of moving vehicles, with automatic data exchange, particularly with automatic toll charging, comprising:

- at least one fixed automatic transceiver station which is provided with local processing and control means for the transmission and reception procedures and for the identification of the users and the calculation of tolls to be charged to each identified user, this fixed station being disposed at a specific point on a vehicular through road;
- an on-board transceiver unit for each vehicle, this on-board unit being provided with processing and control means for the transmission and reception procedures, and with means of identifying the user or vehicle and means of recording the toll charged;
- the fixed station and each on-board unit being capable of two-way communication when commanded by the fixed station, by the exchange of data, relating for example to the user and to the toll charged, during the passage of the on-board unit through the area of the through road covered by the field of operation (coverage area) of at least one aerial of the fixed station.

In existing systems of this type, the vehicles are channelled into a transit lane within the area of the fixed station, and are made to pass one at a time through the coverage area of the aerial of the fixed station. The radio communication takes place in all cases between the fixed station and a single on-board station at a time. This also causes a degree of hindrance to the free circulation of the vehicles in transit. Indeed, the delays caused by conventional toll payment barriers are only partially reduced, so that it is not possible to benefit fully from the considerable speed of the radio transactions.

To avoid the confinement to single-carriageway transit lanes in the area of the fixed stations, the provision of a fixed transceiver station capable of operating on a number of channels simultaneously might be suggested. In this case, however, it is necessary to use transmission protocols which entail higher construction costs for the fixed stations and especially for the on-board units. In order to make the system widely accessible and reliable in operation, however, the trend is to make the on-board units cheap and as simple as possible.

The object of the invention is to provide a system of the type described initially, which enables the confinement of vehicles passing through the fixed station while keeping the costs of construction and installation of the fixed stations within limits and keeping the purchase price of the on-board units very low; it will also permit relatively high transit speeds, while ensuring that there is a very low probability of error and that vehicles passing illegally through the station are identified.

The invention achieves the objects stated above with a system of the type described initially, in which the fixed transceiver station has a plurality of transceiver aerials disposed above the vehicular through road and directed towards it, at a height greater than the maximum height of the vehicles, these aerials being distributed transversely with respect to the through road and being constructed in such a way that each generates a limited coverage area on the through road beneath, the said coverage areas being disposed side by side in the transverse direction with respect to the through road, while each coverage area has a width and length which are relatively small with respect to the plan dimensions of the vehicles and are such that they contain not more than one on-board unit at a time and consequently communicate with not more than one on-board unit at a time, the processing and control means being capable of processing separately the reception and transmission signals of each aerial.

The invention also relates to a particular method of operation of the said system, according to which the aerials are divided into two groups, each of which groups forms two sequences of coverage areas, the coverage areas of one of the two groups being alternated with those of the other group, while the aerials of one group are activated for radio communication alternately with those of the other group, for a half-cycle of the total activation time in each case.

To avoid interference between the aerials of each group, the aerials of each group use two different reception/transmission frequencies, the said frequencies being distributed alternately within each group among the corresponding aerials, while the fixed station and the on-board unit are of the type capable of transmitting and receiving at the said two frequencies.

The two frequencies are distributed alternately among the aerials of the two groups in such a way that the coverage area for the aerial of one of the two groups operates at the same frequency as the coverage area directly adjacent for the aerial of the other group of aerials.

According to an improvement, the local processing and control means are provided with means of analysing the answer signals from the on-board units which check the formal correctness of the said signals, so that, in the extremely rare eventuality that two on-board units come into conflict within a single coverage area of one aerial, only one aerial is enabled to communicate, when the interference due to the other on-board unit is at such a level that it does not compromise the intel-

ligibility of the answer signal from the first, while in the case of unintelligible answer signals communication is blocked for both the on-board units.

As a result of the arrangements described above, the system and method according to the invention enable automatic charging to be carried out with a number of vehicles passing in parallel, without the need to confine the vehicles to one single-carriageway lane. The coverage areas may be made with suitable dimensions so that, with allowance made for the minimum possible dimensions for the vehicles and for the minimum distance between them, only one on-board unit can be enabled to communicate at one time within the coverage area of one aerial of the fixed station. In this case, there is a very high probability that the on-board units of two vehicles passing through the fixed station side by side will communicate with different aerials of the station. This enables the inconvenient procedures of parallel transmission to be avoided, thus keeping down the costs of the fixed station and especially those of the on-board units. The subsequent improvements make it possible to reduce to a minimum the possible interference between the communications either in two adjacent coverage areas or in the case where two on-board units come into conflict in one coverage area.

By appropriately setting the maximum transit speed in such a way as to ensure complete execution of the transmission procedures between the fixed station and the on-board units in a half-cycle during which only one group of aerials is active, it is possible to reduce considerably, to an infinitesimal value, the possibilities of errors in communication.

It is also possible to determine with a certain degree of approximation the position of the vehicle according to the coverage area in which the communication has taken place.

According to an improvement, it is possible to associate a video system, for detecting the presence of a vehicle at the station, with the radio communication system. The video detection system is provided with means of identifying the position of the vehicle and with means of processing and correlating the position found by this means with the position of the vehicle found by the radio communication.

This makes it possible to establish whether a vehicle without an on-board unit has illegally passed through the fixed station or whether the communication with the corresponding on-board unit has not taken place correctly, so that no toll has been charged.

Preferably, the fixed station comprises two gates, each of which is associated with two groups of transceiver aerials of the type described above. In this case, the transaction communications are made in two successive phases corresponding to the first and second gates. In this way it is possible to accommodate higher maximum transit speeds, while further limiting the length of the coverage areas. The system is also capable of operating correctly even when the vehicles have transverse components of motion, or change lanes, at the fixed station.

The method according to the invention enables an on-board unit to communicate with more than one aerial.

The invention also relates to other characteristics which further improve the system and the method described above and which form the subject of the subsidiary claims.

The particular characteristics of the invention and the advantages derived therefrom will be understood in greater detail from the description of a preferred embodiment, illustrated by way of a non-restrictive example in the attached drawings, in which

Fig. 1 is a highly schematic perspective view of the system according to the invention, in which only one gate of the fixed station is indicated.

Fig. 2 is a side elevation of a fixed station according to the invention.

Fig. 3 is a front elevation of the second gate of the fixed station according to Fig. 2.

Fig. 4 shows a transceiver aerial panel of the fixed station according to an embodiment of modular construction.

Fig. 5 is a schematic illustration of the relative disposition of the coverage area obtained with the aerials of the fixed station according to the preceding figures.

Fig. 6 is a block diagram of the electronic circuit of the fixed station according to the preceding figures.

Fig. 7 is a general block diagram of the system according to the invention.

Fig. 8 is a block diagram of the on-board unit.

Fig. 9 is a block diagram of the electronic control circuit associated with the first gate of the system according to the preceding figures.

Fig. 10 is a block diagram of the control circuit associated with the second gate of the system according to the preceding figures.

Fig. 11 is a block diagram of the electronic control circuit for the part common to one station according to the preceding figures.

Figs. 12 to 15 show some examples of the operation of the system according to the preceding figures, in a condition of maximum criticality.

With reference to Fig. 7, a system according to the invention comprises at least one fixed transceiver station which interacts with on-board tran-

sceiver units 3 each of which is associated with one vehicle. The fixed transceiver station comprises local processing and control means for the transmission and reception procedures and for the identification of users and the calculation of the charges, these means being indicated as a whole by 1. The processing and control means 1 communicate by radio with the on-board transceiver unit 3 by means of aerials A.1-A.n. These means also communicate through transmission means 2 with a central control unit 15, for example a central processor. The on-board unit 3 may be of the type operating in connection with a card 4, for example of the microprocessor type or the type known as a smart card, which is used to supply the user's identification codes to the on-board unit 3 to be transmitted to the fixed station for the calculation of the charge, and in which are recorded the charges calculated by the fixed station and transmitted by it to the on-board unit 3. The card 4 may store, for example, a certain prepaid sum, from which the amounts of tolls charged by the fixed station are automatically deducted.

An example of an on-board unit 3 is illustrated in Fig. 8. The said unit has a transceiver aerial 5 to which is connected an automatic activation device 6. The aerial 6 is connected to a transmitter 7 and to a receiver 8 which are connected in turn to a control processor 10 through an encoder/decoder 9. The control processor 10 instructs a reader 11 of the card 4 to read the identification data and the total remaining credit recorded in it, and to record charge data, or to deduct the sum charged from the total remaining credit. A display unit 12 is also connected to the control processor 10. The on-board unit 3 is supplied by a sealed battery 13 and by a replaceable battery 14. The sealed battery 13 preferably supplies the activation device 6, the encoder 9, the receiver 8 and the transmitter 7, while the replaceable batteries 14 supply the control unit 10, the display unit 12 and the read/write unit 11 for the card 4.

With reference to Figs. 1 and 2, the fixed transceiver station is disposed at a specific point on a vehicular through road, for example a road with a number of carriageways. The fixed station consists of two gates, a first gate P1 and a second gate P2, only the first gate P1 of these being illustrated in Fig. 1. A plurality of transceiver aerials A.1 - A.n, which are distributed along an axis transverse with respect to the through road and which are directed towards the road surface of the carriageway, are supported on the housing spanning the gates P1 and P2. The on-board units 3 are indicated schematically in Fig. 1 and are fixed, for example, to the windscreens of vehicles in transit, or to the handlebars of motorcycles or similar.

The aerials A.1 - A.n of each gate P1, P2 are of the parabolic type and have coverage areas C.1-C.n with a length L1 and width L2 markedly smaller than the plan dimensions of the vehicles. In particular, the aerials A.1 - A.n are constructed so that they generate an intersection of elliptical form, between the lobe of the aerial measured at -3 dB (with respect to the maximum radiation point) and the plane parallel to the road surface passing through these points, this intersection constituting the actual coverage area C.1-C.n, while any secondary lobes have considerably lower signal levels. The elliptical coverage areas C.1-C.n are disposed adjacent to each other in the transverse direction with respect to the through road, in such a way that they form a transverse coverage band with respect to the through road. According to Fig. 5, the centres of the two adjacent coverage areas are spaced apart by an amount L3 smaller than the width L2, in such a way that the coverage areas C.1-C.n are superimposed on each other in the lateral peripheral regions. The coverage areas C.1-C.n are positioned immediately in front of the corresponding gates P1, P2.

The horizontal plane I, in which the coverage areas C.1-C.n of the aerials A.1 - A.n have their significant dimensions, as described above, may advantageously be positioned at a height L4 above the road surface substantially corresponding to a mean of the levels at which the on-board units 3 in the various vehicles are disposed, for example at a height L4 = 1 m.

Each gate P1, P2 also has aerials AT for activating the on-board units 3. The activating aerials AT are designed to transmit only signals for activating the on-board units 3, with which they control the activation device 6 of the on-board units and which generate coverage areas CT which are also elliptical, which have larger dimensions than those of the coverage areas C.1-C.n and which form an activation band in front of the said coverage areas C.1-C.n.

Fig. 6 shows a more detailed block diagram of the local processing and control means 1. The said means comprise radio frequency transceiver means 20 for each gate P1, P2 to which are connected the corresponding aerials A.1 - A.n and the activation aerials AT. The transceiver means 20 of each gate P1, P2 are controlled by gate control units 21, 21' which are controlled in turn by a local station control unit 22, with which they communicate through a two-way network 23, for example one of the type known as a LAN. The local station control unit 22 communicates in turn through a multiplexer 24 and transmission means 2, for example a device known as a modem, or similar, with the central processor 15 (Fig. 7).

One embodiment of the gate control units 21, 21' and of the radio frequency transceiver means 20 for the gates P1 and P2 is illustrated in greater detail in Figures 9 and 10. In this case, the embodiments illustrated refer to a modular construction of the system. With particular reference to Fig. 4, the aerials A.1 - A.n of each gate are distributed over a plurality of supporting panels 25. The supporting panel has eight aerials A.1-A.8 divided into two sets, S1 having the aerials A.1-A.4 and S2 having the aerials A.5-A.8. The two sets of aerials S1, S2 are associated with an activation aerial AT. Fig. 5 shows the relative coverage areas C.1-C.8 of the aerials A.1-A.8 and their disposition with respect to each other.

Each gate control unit 21, 21' comprises a central control processor 121, 121' connected to storage units 221, 221', a control system 321, 321' for the activation aerial AT, a control system 421, 421' for the transceiver means 20 and an interface for a communications network, of the type known as Ethernet for example, 521, 521' for communication with the local station control unit 22.

The modular construction of the aerial support panels according to Fig. 4 corresponds to a similar modular construction of the control systems 321, 321', 421, 421' for the activation aerials AT and for the transceiver aerials A.1-A.8 and for the transceiver systems 20. These systems 321, 321', 421, 421' and 20 may be constructed with an extendable structure using circuit cards, with the provision, for example, of a transceiver system 20 for the aerials A.1-A.8 and AT of each panel 25, and with each control system 321, 321' for the aerials AT and one control system 421, 421' for the aerials A.1-A.8 capable of simultaneously controlling the transceiver systems 20 of a certain number of panels 25. In Figures 9 and 10, only one panel 25 of aerials A.1-A.8 and AT with the corresponding transceiver system 20 is illustrated, for the sake of simplicity. The transceiver system 20 consists of a transceiver module 120 for the set S1 of aerials A.1-A.4 and AT of the panel 25 and a transceiver module 220 for the set S2 comprising the aerials A.5-A.8. Each of the two modules 120, 220 has a power supply 29 and two transceivers 26, 27. The transceivers 26 of each transceiver 120, 220 operate at a single identical frequency f1, while the transceivers 27 operate at an identical frequency f2 which is different from that of the transceivers 26. The transceivers 26 are connected to aerials A.1, A.2 and A.5, A.6, while the transceivers 27 are connected to aerials A.3, A.4 and A.7, A.8. The transceiver module 120 associated with the first set of aerials S1 also has a transmitter 28 which operates at a further different frequency f3 and is connected to the activation aerial AT.

The gate control units 21, 21' may be provided with means of analysing the answer signals of the on-board units 3 captured by each aerial A.n, in order to check the formal correctness of the answer signals from the on-board units 3, permitting, for example, communication with only one on-board unit when two of these units come into conflict in the coverage area of a single aerial and when, in this case, the intelligibility of the answer signal from one of the said two on-board units is not compromised by the interference due to the answer signal from the other on-board unit, for example because of a marked difference in the level of the said two signals.

The receiver 8 and the transmitter 7 of the on-board units 3 are of the type capable of transmitting and receiving at the two frequencies f1, f2.

The disposition of the aerials A.1-A.8 on the panel and the particular activation of the aerials at different frequencies f1, f2 determines the particular distribution of the coverage areas with different frequencies as shown in Fig. 5.

As is also shown in Fig. 4, the aerials A.1-A.8 are disposed on panels with a length of twice L5 and a width of L6, with their major axes orientated perpendicular to the major axes of the coverage areas C.1-C.8. The parabolic aerials have elliptical bases and have a major axis of length L7 and a minor axis of length L8, while their centres are spaced apart by a distance L9. The aerials A.1-A.8 are disposed in two parallel rows aligned with the major axes, the aerials A.1, A.3, A.5, A.7 of one row being staggered in the longitudinal direction of the row with respect to the aerials A.2, A.4, A.6, A.8 of the other row. The activation aerial AT has a circular base and has a diameter of L10.

Fig. 11 shows a more detailed example of the local station control unit 22. This has a central control processor 122, storage units 222, read/write devices 322 and 322' for a removable storage medium and for a resident storage medium respectively, and different types of input/output interface 422, 422', 422'', for example a parallel interface, a serial synchronous interface and a serial asynchronous interface to which may be connected various auxiliary devices of the station, indicated in a general way by 30, such as signalling devices, automatically controlled barriers, etc., and through which the station control unit 22 communicates, by means of a multiplexer 24 and transmission means 2, with the central processor 15. An interface 522 for a communications network, for example a network of the type known as Ethernet, by means of which the local station control unit 22 communicates with the gate control units 21, 21', is also provided.

With reference to the method according to the invention, in order to ensure a very small length L1

and width L2 of the coverage areas C.1, C.n combined with a relatively high transit speed, making it possible to achieve infinitesimal probabilities of error and complete execution of the charging procedures, the communication between the fixed transceiver station and the on-board units 3 is carried out in two successive phases and in chronologically separate time intervals, corresponding to the two gates P1, P2. The dimensions of the coverage areas are limited according to the minimum time required for transmission and reception, while the different internal procedures take place in the time intervals immediately preceding the entry of the on-board units 3 into the coverage areas C.1, C.n, and in those between the two communication phases corresponding to the two gates P1, P2. In a plan of application the following dimensions were found to be suitable: with transaction times of approximately 300 ms, it is possible to ensure a probability of error of the order of 10^{-8} with a maximum speed, in a direction parallel to the major axis of the coverage areas C.1-C.n, of approximately 120 km/hr and with maximum transverse components of approximately 18 km/hr, while the coverage areas C.1, C.n have lengths L1 = 1.5 m and widths L2 = 0.5 m and the centres of the individual coverage areas C.1, C.n are spaced apart by L3 = 0.375 m, the minimum distance L12 between the coverage areas C.1 - C.n of the two gates P1, P2 being chosen in this case to be greater than 10 m, and in particular, for the reasons stated subsequently, 13.5 m, which corresponds to a distance L13 of 15 m between the two gates. In this case, the aerials A.1-A.n will have a major axis L7 = 0.517 m, a minor axis L8 = 0.1725 m and a centre spacing of L9 = 0.375 m. The aerials are disposed with an inclination of 9° with respect to the horizontal plane at a height L15 of approximately 6 m above the carriageway surface. In order to obtain coverage areas CT of the activation aerials AT sufficiently large to ensure that the procedures of internal initialisation of the on-board units 3 are performed before entry into the coverage areas C.1-C.n of the transceiver aerials A.1-A.n it is preferable to use an aerial AT with a diameter L10 = 0.1185 m.

According to a further characteristic of the method, the aerials A.1-A.n are divided into two groups which are activated by the corresponding control system 421, 421' in two half-cycles of which one immediately follows the other. The groups of aerials comprise aerials A.2n-1 and aerials A.2n respectively, forming two transverse rows with coverage areas C.2n-1 and C.2n respectively, the coverage areas C.2n-1 of one of the two groups being alternated with the coverage areas C.2n of the other group. The method also specifies that within each group of aerials the transmission frequencies f1 and f2 are distributed alternately among the said aerials C.2n-1 and C.2n, each aerial A.2n-1 which produces the coverage area C.2n-1 of one group associated with the frequency f1 being directly adjacent to the aerial A.2n which produces the coverage area C.2n associated with the same frequency f1. According to the plan mentioned above, the aerials of each group A.2n-1 and A.2n are activated for a time interval of 15 ms. The method of operation of the aerials is clearly shown in Figs. 5 and 12 to 15, in which the aerials C.2n-1 and C.2n of the inactive group are shown in broken lines. The whole may advantageously be designed in such a way as to ensure a repetition for at least two consecutive times of the transmission within each coverage area C.1-C.n.

As a result of the above arrangements, each coverage area is able to contain only one on-board unit. In this way, an aerial A.1-A.n communicates with only one on-board unit at a time, thus making it possible to avoid both a multiple channel transmission protocol, with a consequent increase in costs, and confinement to a single-carriageway lane at the station. The system according to the invention also enables vehicles to pass through the coverage areas with a certain transverse velocity, operating correctly even in the case of overtaking and lane changing. The improvements to the method advantageously enable the transmission interference between the aerials associated with adjacent coverage areas to be significantly limited, thus subsequently limiting the transmission errors to very low levels.

According to a further improvement, as shown in Fig. 7, the station is provided, in addition to the radio communication system, with a video device 37 to detect the presence of vehicles in transit and to identify their position with respect to one gate, in particular gate P2. As illustrated in Figs. 2 and 3, the gate P2 of the fixed station is associated with a plurality of television cameras 31 which are distributed at equal intervals along an axis transverse with respect to the carriageway, at a height greater than the maximum height of the vehicles, and are aimed at the through road. The optical axes 0 of the television cameras 31 are spaced apart by a distance L16 to provide a resolution of L17, or the detection of a sufficient minimum separation distance L17 between two vehicles side by side. In the cited plan, the distance L16 is equal to 0.75 m and provides a resolution L17 of 0.25 m.

With reference to Fig. 6, the outputs of the television cameras 31 are connected to a video control unit 32 which may also be constructed in modular and expandable form, as described for the gate control units 21 and the transceiver systems 20 of the aerials A.1-A.n. The video control units 32 are connected to an image processor 33 which

communicates through a LAN network 23 with the gate control units 21, 21' and with the local station control unit 22. In this case, it is suitable to use television cameras 31 of the type known as the linear scan type. The framing fields of the television cameras 31 are positioned immediately in front of the coverage areas C.1-C.n. Given the construction of the radio communication system described above and the television cameras 31, it is possible to detect the presence of a vehicle in the coverage area C.1-C.n of the gate 2 and to determine its position twice, particularly in the transverse direction with respect to the through road, once by means of the aerial A.1-A.n with which the corresponding on-board unit 3 of the vehicle communicates, and once by means of the television cameras 31. This may be used both to reduce any errors of communication in the system and to detect any users who do not have an on-board unit 3 and who attempt to pass illegally through the station, or those users for whom, owing to particular conditions and the infinitesimal but finite probability of error, the charging transaction has not taken place correctly. The invention specifies that the data relating to the two separate determinations of position are compared with each other in the station control unit 22. When a video detection does not correspond to a position detection obtained by transmission through the active aerial A.1-A.n, the vehicle in transit is passing illegally through the station. When the said data coincide, but the radio transaction has not been executed correctly, an error is detected. In this way, therefore, it is possible to discriminate between the users passing illegally through the fixed station and those for whom the automatic charging has not been carried out for reasons not associated with the users.

According to a further characteristic, the station is associated with a device 38 (Fig. 7) for video recording of the vehicles passing illegally through the station and of those for which the radio transaction has not been successful. With reference to Figs. 2 and 6, a plurality of television cameras 35 are provided on the first gate P1 and are aimed towards the second gate P2, their framing area 135 being positioned directly in front of the coverage areas C.1-C.n, so that they photograph the rear parts of the vehicles which carry the number plate. It should be noted that the framing area 135 of the television cameras 35 contributes to the determination of the distance L13 between the two gates. The recording television cameras 35 are controlled by an image recording and control unit indicated by 36 in Fig. 6, which receives the data from the control unit 21' of the gate P2, from the station control unit 22 and from the image processor 33 of the television cameras 31 for detecting the presence of vehicles and their position. In the two cases of violation and error described previously, the image recording and control unit 36 stores the recorded images of the number plate of the vehicle and transmits them, through the multiplexer 24 and the transmission means 2, to the central processor 15, while the continuously recorded images of the vehicles correctly passing through the fixed station are erased.

With reference to Fig. 10, the gate control unit 21' for the gate P2 has an interface 621 for communication with the said video recording device 38.

Examples of the operation in different conditions of extreme maximum criticality of the system and method according to the invention are illustrated schematically for a single gate in Figs. 12 to 14, in which are indicated the alternately activated coverage areas C.2n-1 and C.2n and the frequencies associated with them, while d indicates the minimum transverse distances between the various on-board units in the different situations.

Example 1

There is a single on-board unit at the point X1, in the central area of the coverage area C.3 which is active in the first half-cycle in Fig. 12. The following considerations are valid for a certain limited region around the position X1. In the said half-cycle, transmission within the coverage area C.3 is sufficiently protected from interference from transmissions at the frequency f1 in the coverage areas C.1 and C.5, the immediately adjacent coverage areas C.2 and C.4 being inactive. In the following half-cycle, illustrated in Fig. 13, in which the coverage area C.3 is inactive, the level of gain at the frequency f1 in the coverage area C.2 and at the frequency f2 in the coverage area C.4 at point X1 is insufficient to cause transmission between the station and the on-board unit. The correct transaction therefore takes place in the first half-cycle (Fig. 12), in the coverage area C.3, which in this case is used as an indicator of the vehicle position. There is no possibility of uncertainty due to an adjacent vehicle, since the minimum distance of 0.25 m between the vehicles which is detectable by the video device 37 means that this response could only have come from a vehicle occupying the area indicated in Figs. 12 and 13. Although an additional vehicle might have approached, this vehicle would have caused a communication of the said vehicle within the coverage areas C.2 and C.3, with the additional vehicle on the left, or C.3 and C.4 with the additional vehicle on the right.

Example 2

In this case, the on-board unit is located at point X2 of Figures 12 and 13, in the area of superimposition of two adjacent coverage areas C.4 and C.5 or in the vicinity of this area.

In the first half-cycle, the transmission is sufficiently protected from a transmission at the frequency f2 in the coverage area C.3 and C.7, enabling the on-board unit to communicate with the fixed station at the frequency f1 in the coverage area C.5. In the second half-cycle (Fig. 13), the transmission is sufficiently protected against a transmission at the frequency f1 in the coverage areas C.2 and C.6, enabling the on-board unit to communicate in the coverage area C.4 at the frequency f2. If the transaction had taken place in only one of the two half-cycles, the on-board unit would have been detected in the coverage area C.4 or C.5. This would have caused ambiguities in the presence of an additional vehicle detected at the minimum separation distance of 0.25 m. In fact, if the response had taken place in coverage area C.4 only, it would also have been possible for an additional vehicle to be present in the coverage area C.4, and until this vehicle had also successfully executed the transaction (and its position had consequently been detected), it would not be clear which of the two vehicles had executed the transaction. This is also true of the coverage area C.5. This uncertainty is eliminated by enabling the on-board units to communicate with more than one aerial A.1-A.n, since only the vehicle occupying the position X2 of the on-board unit can have communicated within the coverage areas C.4 and C.5.

The scenarios described above have demonstrated that the uncertainty as to the position is eliminated when the on-board units can communicate with all the aerials of the gate P1, P2 in whose coverage areas C.1-C.n they are. This uncertainty as to position detection will not, therefore, be considered further in the following examples, except when the multiple transaction is blocked.

Example 3

With reference to Figs. 12 and 13, two on-board units are assumed to be at positions X1 and X2 respectively, spaced apart by a distance d = 0.5 m.

According to the information in the preceding examples, in the first half-cycle the on-board unit at X1 communicates at the frequency f2 in the coverage area C.3, and that at position X2 communicates at the frequency f1 in the coverage area C.5. In the second half-cycle, the on-board unit at X1 does not communicate at all, while that at X2 can communicate at the frequency f2 in the coverage area C.4.

Example 4

In Figures 12 and 13, two on-board units are assumed to be at points X2 and X3, with d = 0.5 m.

In the first half-cycle, the transmissions are generally insufficiently protected from each other within the coverage area C.5 at the frequency f1, and there will therefore be no communication with either of the two on-board units. It may be possible to have communication with one of the two on-board units when the answer signals of the two units are significantly different, so that it is possible for either the on-board unit at X2 or that at X3 to communicate successfully in the coverage area C.5. In the second half-cycle, the on-board unit at X2 will communicate successfully in the coverage area C.4 at the frequency f2, while that at X3 will communicate in the coverage area C.6 at the frequency f1.

In the worst case, communication will take place only in the second half-cycle. Since the vehicles associated with the on-board units must cover the positions indicated, it is clear that there is no ambiguity of correlation between the vehicle and the on-board unit.

Example 5

The on-board units are at positions X5 and X6 in Figs. 14 and 15, with d = 0.5 m.

In the first half-cycle (Fig. 14) the on-board unit at X5 may or may not communicate at the frequency f2 in the coverage area C.1, while the on-board unit at X6 communicates at the frequency f1 in the coverage area C.3. In the second half-cycle (Fig. 15), the on-board unit at X5 communicates at the frequency f2 in the coverage area C.2 and that at X6 may or may not communicate at the frequency f1 in the coverage area C.4. The two on-board units at X5 and X6 will therefore be detected, the first in the coverage areas C.1 and C.2 and the second in the coverage area C.3.

Example 6

The on-board units are disposed at X7 and X5' in Figs. 14 and 15, with d = 0.5 m.

In the first half-cycle, the answer signals from the two on-board units are generally insufficiently protected from interference with one another, and there will consequently be no communication at the frequency f2. In a similar way to that described in Example 4, one of the two on-board units can possibly communicate successfully in the coverage area C.5. In the second half-cycle, the unit at X7

communicates at the frequency f1 in the coverage area C.4, and the unit at X5' communicates at the frequency f2 in the coverage area C.6, giving a result similar to that in Example 4.

Example 7

The case of three on-board units disposed at X1, X2, and X3, each at a distance d = 0.5 m from the adjacent unit, in Figs. 12 and 13 will now be considered.

In the first half-cycle, the unit at X1 communicates at the frequency f2 in the coverage area C.3, while in general neither of the two units at X2 and X3 communicates at the frequency f1 in the coverage area C.5, or else only one of them succeeds in communicating, as described previously in Example 4. In the second half-cycle, there is no communication by the unit at X1, while the unit at X2 communicates in the coverage area C.4 and that at X3 communicates in the coverage area C.6, providing unambiguous identification of the vehicles to which the on-board units at X1, X2, and X3 belong.

Example 8

The on-board units are disposed at X5, X6 and X7 in Figs. 14 and 15 at a distance d = 0.5 m from each other.

In the first half-cycle, the unit at X5 may or may not communicate at the frequency f2 in the coverage area C.1. The unit at X6 communicates at the frequency f1 in the coverage area C.3, and that at X7 communicates at the frequency f2 in the coverage area C.5.

In the second half-cycle, the unit at X5 communicates at the frequency f2 in the coverage area C.2, while for the units at X6 and X7 communication may or may not take place, as described previously in Example 6.

The unit at X5 will therefore be located in the coverage area C.2, or possibly to the left of this area if communication has also taken place in the coverage area C.1. In the worst case, the unit at X6 will be located in the coverage area C.3, and that at X7 will be located in the coverage area C.5. In this case also, there is no remaining uncertainty concerning the correlation between a vehicle and the on-board unit.

Example 9

The on-board units are disposed at X6, X7 and X5' in Figs. 14 and 15.

In the first half-cycle, the unit at X6 communicates at the frequency f1 in the coverage area C.2, while for the on-board units at X7 and at X5' in C.3 communication at the frequency f2 is impossible for both or may be possible for only one of the two, as described in Example 6. In the second half-cycle the unit at X5' communicates at the frequency f2 in the coverage area C.6, while, in a similar way to that described in the preceding examples, neither of the units at X6 and X7 can communicate in the coverage area C.5 at the frequency f1, or else only one of them may be able to communicate successfully when the answer signals of the units are at sufficiently different levels.

In the worst case, therefore, the unit at X6 will communicate in the coverage area C.3, the unit at X5' will communicate in the coverage area C.6, and the unit at X7 will not be able to communicate at all.

With the aid of the video position identification and detection system 37, the vehicle associated with the on-board unit at X7 will be detected and identified at the gate P2. However, when chronological recordings in the transaction data for the units at X6 and X5' are used, it is possible that the vehicle associated with the unit at X7 will be granted the benefit of the doubt, and that the absence of a transaction will be considered to be a communication error, instead of a violation.

In this case, it must be emphasised that this scenario is extremely rare, since it requires in practice the chronological coincidence of the passage of three on-board units in alignment with each other and spaced apart by 0.5 m.

It is also possible to avoid the occurrence of such a problem by reducing the lateral dimensions of the coverage areas C.1-C.n. This, however, entails a greater number of aerials A.1-A.n, and therefore, in view of the extremely low probability of the recurrence of the said situation in practice, this arrangement is not entirely justified.

Example 10

Example 10 refers to Figs. 12 and 13, in which more than four vehicles pass simultaneously through the coverage areas C.1-C.10, the corresponding on-board units being disposed at points X1 to X3 and X1', X2', X3', X3'' and spaced apart by 0.5 m.

This situation may be reduced to the preceding examples, since it may be broken down into the following sub-groups: three on-board units in positions X1, X2 and X3, two units in positions X1' and X2', and two units in positions X2' and X3'; one unit in position 1 and one unit in position X2, the positions X1', X2', X3' and X3'' being similar to positions X1, X2 and X3, but in different coverage areas.

Example 11

In a similar way to Example 10, the situation of more than four on-board units disposed in positions X5, X6, X7, X5', X6', X7' and X5'' may be broken down into the scenarios already discussed in the preceding examples: three units in positions X5, X6, and X7; two units in positions X8 and X6'; two units in positions X7' and X5'; one unit in position X5 and one unit in position X7, the considerations in Example 10 being valid.

Naturally, the invention is not limited to the embodiments described and illustrated herein, but may be widely varied and modified, particularly as regards construction; for example, the system and method described may be used for the detection of the transit of objects or bodies of various kinds, each being associated with an on-board unit, for example for the identification of pieces, parts, or similar moving along conveyors; the whole without departing from the guiding principle described above and claimed below.

Claims

1. System for automatic detection of moving vehicles, with automatic data exchange, particularly with automatic toll charging, comprising:

- at least one fixed automatic transceiver station (P1, P2) which is provided with local processing and control means (1) for the transmission and reception procedures and for the identification of the users and the calculation of tolls to be charged to each identified user, this fixed station (P1, P2) being disposed at a specific point on a vehicular through road;
- an on-board transceiver unit (3) for each vehicle, this on-board unit (3) being provided with processing and control means (10) for the transmission and reception procedures, and with means (4) of identifying the user or vehicle and means (4, 11) of recording the toll charged;
- the fixed station (P1, P2) and each on-board unit (3) being capable of two-way communication when commanded by the fixed station (P1, P2), by the exchange of data, relating for example to the user and to the toll charged, during the passage of the on-board unit (3) through the area of the through road covered by the field of operation (C.1-C.n) (coverage area) of at least one aerial (A.1-A.n) of the fixed station (P1, P2),

characterised in that

the fixed transceiver station (P1, P2) has a plurality of transceiver aerials (A.1-A.n) disposed above the vehicular through road and directed towards it, at a height greater than the maximum height of the vehicles, these aerials (A.1-A.n) being distributed transversely with respect to the through road and being constructed in such a way that each generates a limited coverage area (C.1-C.n) on the through road beneath, it being possible to communicate only with the corresponding aerial (A.1-A.n) within each of the said coverage areas (C.1-C.n), the said coverage areas (C.1-C.n) being disposed side by side in the transverse direction with respect to the through road, while each coverage area (C.1-C.n) has a width and length which are relatively small with respect to the plan dimensions of the vehicles and are such that they contain not more than one on-board unit (3) at a time and consequently communicate with not more than one on-board unit (3) at a time, the processing and control means (1) being capable of processing separately the reception and transmission signals of each aerial (A.1-A.n).

2. System according to Claim 1, characterised in that it comprises the local processing and control means (1) are provided [sic] with control means (21, 421, 21', 421') which alternately activate, for a half-cycle of an overall activation period, two groups of aerials (A.2n-1, A.2n) of the aerials (A.1-A.n), the aerials (A.2n-1, A.2n) being associated with two rows of coverage areas (C.2n-1, C.2n) which are aligned transversely with respect to the through road, the coverage areas (C.2n-1) of the group of aerials (A.2n-1) being alternated with the coverage areas (C.2n) of the group of aerials (A.2n).

3. System according to Claim 1 or 2, characterised in that the transceiver station (P1, P2) and the on-board units (3) are provided with transceiver means (20, 120, 220, 26, 27; 7, 8) capable of transmitting and receiving at two different frequencies, the said two frequencies being distributed alternately between the aerials (A.2n-1, A.2n) within each group of aerials (A.2n-1, A.2n).

4. System according to Claim 3, characterised in that the two frequencies are distributed among the aerials (A.2n-1, A.2n) of the two groups in such a way that each aerial (A.2n-1) of one group associated with one frequency is adjacent to an aerial (A.2n) of the other group associated with the same frequency.

5. System according to Claim 3 or 4, characterised in that the transceiver station (P1, P2)

is provided with transceivers (26, 27) each of which operates at a different frequency and to which are connected alternately the aerials (A.2n-1, A.2n) of each of the two groups.

6. System according to one ore more of the preceding claims, characterised in that the coverage areas (C.1-C.n) are of elliptical form and are orientated with their major axes parallel to the longitudinal axis of the through road, while their minor axes are aligned with each other transversely with respect to the through road, the centres of the two adjacent coverage areas (C.n, C.n + 1) spaced apart by an amount smaller than the length of their minor axis.

7. System according to one ore more of the preceding claims, characterised in that the local processing and control means (1) are provided with means (21, 21', 421, 421', 121, 121') of analysing the answer signals from the on-board units (3) which check the formal correctness of the said signals, so that, in the extremely rare eventuality that two on-board units come into conflict within a single coverage area (C.1-C.n) of one aerial (A.1-A.n), it is possible to enable one of the two on-board units (3) to communicate when the interference due to the second on-board unit (3) is at such a level that it does not compromise the intelligibility of the answer signal from the first on-board unit (3), while the communication is blocked for both the on-board units (3) when the answer signals from the two on-board units (3) are indecipherable.

8. System according to one ore more of the preceding claims, characterised in that each station has two sets of aerials (A.1-A.n) which are disposed with a space between them in the direction of transit and whose coverage areas (C.1-C.n) form two bands of coverage areas spaced apart in the direction of transit, while the radio communications between the on-board unit (3) and the transceiver station take place in two chronologically separate phases, one for each band of coverage areas (C.1-C.n), the dimensions (L1, L2) of the said coverage areas (C.1-C.n) and the activation times being adapted to the minimum times necessary for the execution of the radio transmission of data only, at a predetermined maximum transit speed, the internal procedures of the transceiver station and of the on-board unit (3) being executed in the time interval between the two bands of coverage areas (C.1-C.n) and before the first band of coverage areas (C.1-C.n), the two bands of coverage areas (C.1-C.n) being spaced apart (L12) at least in accordance with the times required for the execution of the said internal procedures.

9. System according to one ore more of the preceding claims, characterised in that the aerials (A.1-A.n) are of the parabolic type with an elliptical base, and form a principal lobe (at -3 dB) with high gain corresponding to the associated coverage area (C.1-C.n) and secondary lobes, if any, at a very low level.

10. System according to one ore more of the preceding claims, characterised in that the primary dimensions of the coverage areas (C.1-C.n) are made to lie in a horizontal plane (I) at a level (L4), for example 1 m, estimated to be the mean level of the on-board units (3) above the through road surface.

11. System according to one ore more of the preceding claims, characterised in that for a maximum speed of 120 km/hr parallel to the through road and a maximum speed of approximately 20 km/hr transversely with respect to the road, and a maximum communication time of 15 ms, the coverage areas of the individual bands have major axes (L1) of 1.5 m, minor axes (L2) of 0.5 m and a centre spacing (L3) of 0.375 m, while the two bands are spaced apart by at least 10 m.

12. System according to one ore more of the preceding claims, characterised in that the on-board units (3) are provided with an activation device (6) which activates the units immediately before the entry into the bands of coverage areas (C.1-C.n) when commanded by the transceiver station (P1, P2), a band of coverage areas (CT) produced by at least one activation aerial (AT) associated with the aerials (A.1-A.n) and operating at a different frequency from these being located before each band of coverage areas (C.1-C.n), while the local processing and control means (1) are provided with a control system (321, 321') and with transmitter means (28) connected to the said activation aerials (AT).

13. System according to one ore more of the preceding claims, characterised in that the local processing and control means (1) are provided with means (21, 21') capable of determining the position of the on-board unit according to the aerial (A.1-A.n) with which it has communicated.

14. System according to one ore more of the preceding claims, characterised in that the transceiver station is provided with optical means (37) of detecting the presence of a vehicle and of identifying the position, connected to means (22) of correlating the position detected by the said optical means (37) with that found through the aerial (A.1-A.n) with which the corresponding on-board unit (3) has entered into communication.

15. System according to Claim 14, characterised in that the optical means (37) comprise a plurality of television cameras (31), preferably of the linear scan type, which are connected to control means (32) and image processing means (33), the television cameras (31) being disposed in alignment with each other transversely with respect to the through road, and parallel to the coverage areas (C.1-C.n) of the aerials (A.1-A.n) and with their optical axes (O) spaced far enough apart to obtain a maximum measurement resolution (L17) less than the minor axis of the coverage area (C.1-C.n), preferably by 0.25 m, while the framing areas of the television cameras (31) are disposed immediately before the coverage areas (C.1-C.n) of the aerials (A.1-A.n).

16. System according to Claim 15, characterised in that the television cameras (31) are associated with the second band (P2) of coverage areas (C.1-C.n).

17. System according to one ore more of the preceding claims, characterised in that it is provided with optical/electronic means (38) of recording images of vehicles passing illegally through the transceiver station (P1, P2), or without the execution of a correct data exchange with the on-board units (3) of the vehicles.

18. System according to Claim 17, characterised in that the optical/electronic means (38) of recording images of vehicles in transit comprise one or more television cameras (35) which are aimed in the direction of transit of the vehicles towards the band (P2) of coverage areas (C.1-C.n) and whose framing area (135) is made to lie before the coverage areas (C.1-C.n), the said television cameras (35) being connected to a unit (36) for control and recording of the images captured, commanded by the means (1, 21', 22, 33) correlating the positions determined by the optical means (37) of detection of the presence and identification of the position of the vehicles, and by means of the aerial (C.1-C.n) provided at the said position, according to the detection or non-detection of the answer signals from an on-board unit (3) by means of the said aerials (C.1-C.n).

19. System according to one ore more of the preceding claims, characterised in that the transceiver station (P1, P2) is of modular construction, the aerials (A.1-A.n) and the activation aerials (AT) being distributed over a plurality of panels (25) each having an identical number of aerials (A.1-A.8), while the local processing and control means (1) are of the expandable card-based type and have a control unit (21, 21') designed to control a specific expandable number of aerial panels (25), each aerial panel (25) being associated with its own transceiver systems (20, 120, 220, 26, 27, 28).

20. System according to one ore more of the preceding claims, characterised in that the local processing and control means (1) have a station control unit (22) provided with means (24, 2) of communication with a central processor (15) and with means of communication with the means (21, 21', 20) of control of the aerials (A.1-A.n), with the optical means (37) of detecting the presence and identifying the position of vehicles, and with the optical/electronic means (38) of recording images, as well as with signalling units and other auxiliary station devices (30), such as barriers, signals, lights, or similar.

21. A method of automatic detection of moving vehicles, with automatic data exchange in a system for automatic detection of vehicles with automatic data exchange between a fixed transceiver station (P1, P2) and an on-board unit (3) for each vehicle according to one or more of the preceding claims 1 to 20, characterised in that it specifies subdivision into individual coverage areas (C.1-C.n) of individual aerials (A.1-A.n) of a band of coverage areas, for communication with on-board units (3), each coverage area (C.1-C.n) having dimensions markedly smaller than those of the vehicles and such that they contain statistically only one on-board unit (3), while the communication between each aerial (A.1-A.n) and the on-board unit (3) in the aerial's coverage area (C.1-C.n) is processed separately from that taking place between other on-board units (3) and other aerials (A.1-A.n).

22. A method according to claim 21, characterised in that the aerials (A.1-A.n) are divided into two groups (A.2n-1, A.2n), each of which groups forms two rows of coverage areas (C.2n-1,

C.2n), the coverage areas (C.2n-1) of one of the two groups (A.2n-1) being alternated with those (C.2n) of the other group (A.2n), while the aerials (A.2n-1) of one group are activated for radio communication alternately with those (A.2n) of the other group, in each case for one half-cycle of the overall activation period.

23. A method according to claim 21 or 22, characterised in that the aerials (A.2n-1, A.2n) of each group use two different reception/transmission frequencies, the said frequencies being distributed, within each group, alternately among the corresponding aerials (A.2n-1, A.2n), while the fixed station and the on-board units (3) are of the type capable of transmitting and receiving at the said two frequencies.

24. A method according to one or more of claims 21 to 23, characterised in that the two frequencies are distributed alternately among the aerials (A.2n-1, A.2n) of the two groups, in such a way that the coverage area (C.2n-1) relative to the aerial (A.2n-1) of one of the two groups operates at the same frequency as the immediately adjacent coverage area (C.2n) relative to the aerial (A.2n) of the other group of aerials.

25. A method according to one or more of the preceding claims 21 to 24, characterized in that if two on-board units (3) are present in a single coverage area (C.1-C.n) of one aerial (A.1-A.n), the answer signals from the on-board units (3) are analyzed in relation to their formal correctness, only one on-board unit (3), namely the one whose answer signal is correctly intelligible and at a higher level, being enabled to communicate, when the two signals are sufficiently different from each other.

26. A method according to one or more of claims 21 to 25, characterized in that the data transmission is executed in two phases, each of which takes place in one band (P1, P2) of coverage areas (C.1, C.2) of at least two successive bands (P1, P2) of coverage areas (C.1-C.n) spaced apart in the direction of transit, while the distance (L12) between the two bands is determined according to the time required for the execution of the internal procedures of the transceiver station and of the on-board units (3) and according to the maximum transit speed.

27. A method according to one or more of the preceding claims 21 to 26, characterized in that the on-board units (3) are activated by the transceiver station before the first band (P1) of coverage areas (C.1-C.n).

28. A method according to one or more of claims 21 to 27, characterised in that the presence and position of the vehicle passing through the transceiver station are detected, while the presence of answer signals at the output of the aerials (A.1-A.n) for the said detected position of the vehicle is analyzed, the image of the said vehicle, particularly of the number plate area, being recorded when no answer signal is detected at the output of the aforesaid aerials (A.1-A.n) or when the communication is affected by errors.

29. A method according to one or more of the preceding claims 21 to 28, characterized in that the activation times of the aerials (A.1-A.n) are calculated in such a way as to ensure at least the exchange of data on two consecutive occasions within the coverage area (C.1-C.n) of the same aerial (A.1-A.n).

30. A method according to one or more of the preceding claims 21 to 29, characterized in that the on-board units (3) can communicate with all the aerials (A.1-A.n) of the two bands (P1, P2) of coverage areas (C.1-C.n) in whose coverage areas (C.1-C.n) they are found during their passage through the fixed transceiver station.

31. System according to one ore more of claims 1 to 20, characterized in that it is used for the automatic detection, with data exchange, of packages, goods, or other moving bodies on conveying means, for example for monitoring and despatching to various stations by conveyor and movement lines in installations of the industrial type such as those for the processing or handling of goods, each on-board unit (3) being associated with each package, piece or body which is moved.

32. A method according to one or more of claims 21 to 30 and according to claim 31, characterized in that it is used for automatic detection, with data exchange, for example for the monitoring and despatching of goods, packages, pieces, or other types of bodies moved on conveyer lines, in goods movement or processing installations.

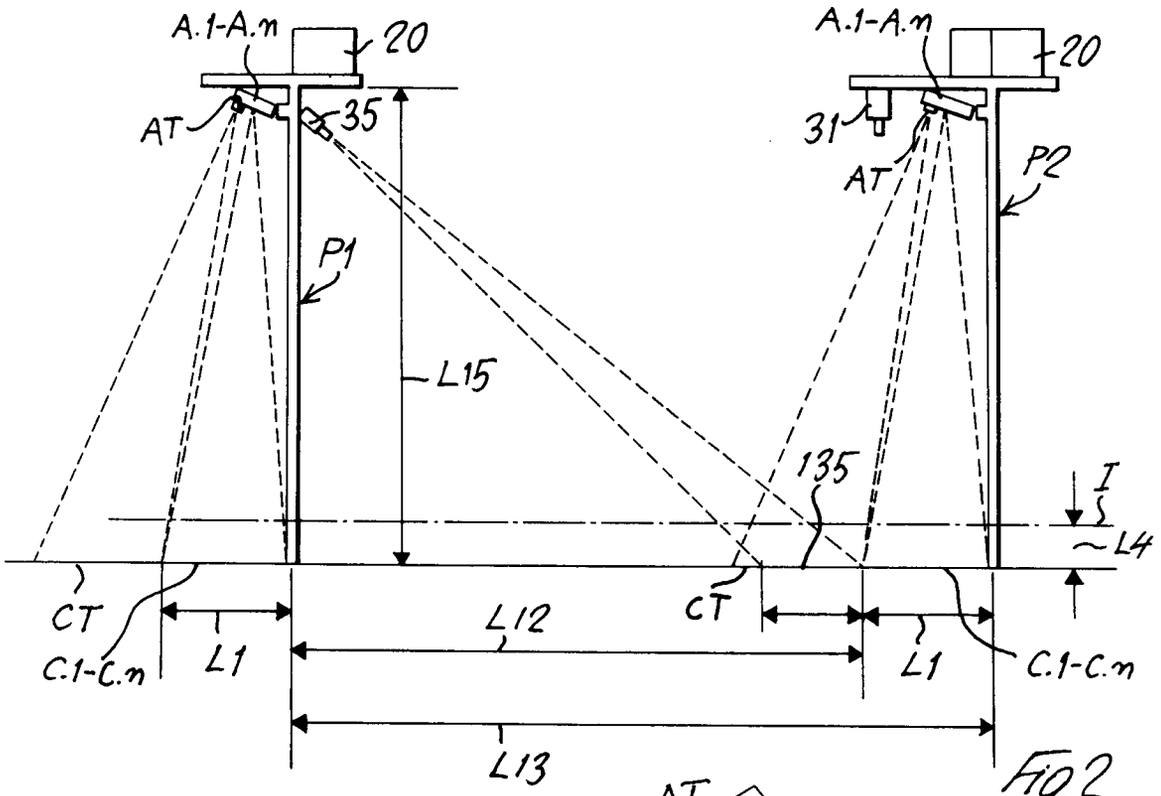

A.1-A.n
20
AT
35
P1
L15
A.1-A.n
20
31
AT
P2
135
I
L4
CT
C.1-C.n
L1
L12
CT
L1
C.1-C.n
L13

Fig.2

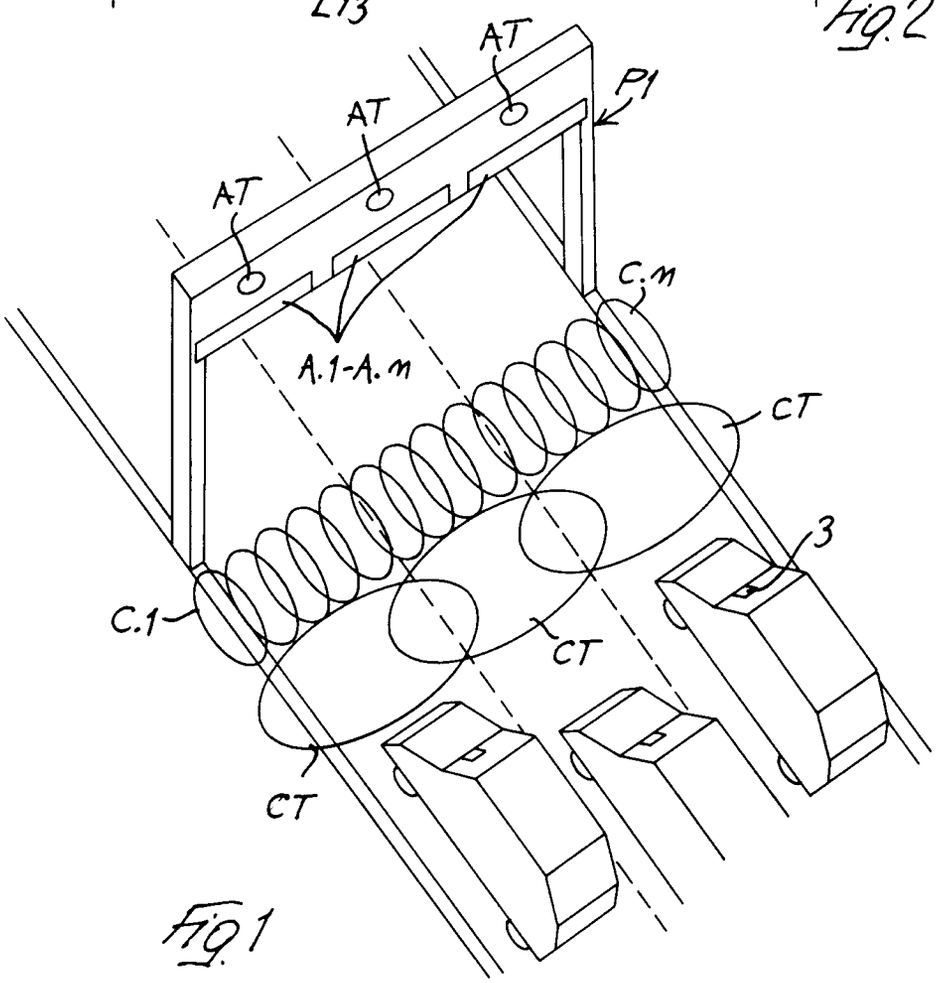

AT
P1
AT
AT
C.n
A.1-A.n
CT
3
C.1
CT
CT

Fig.1

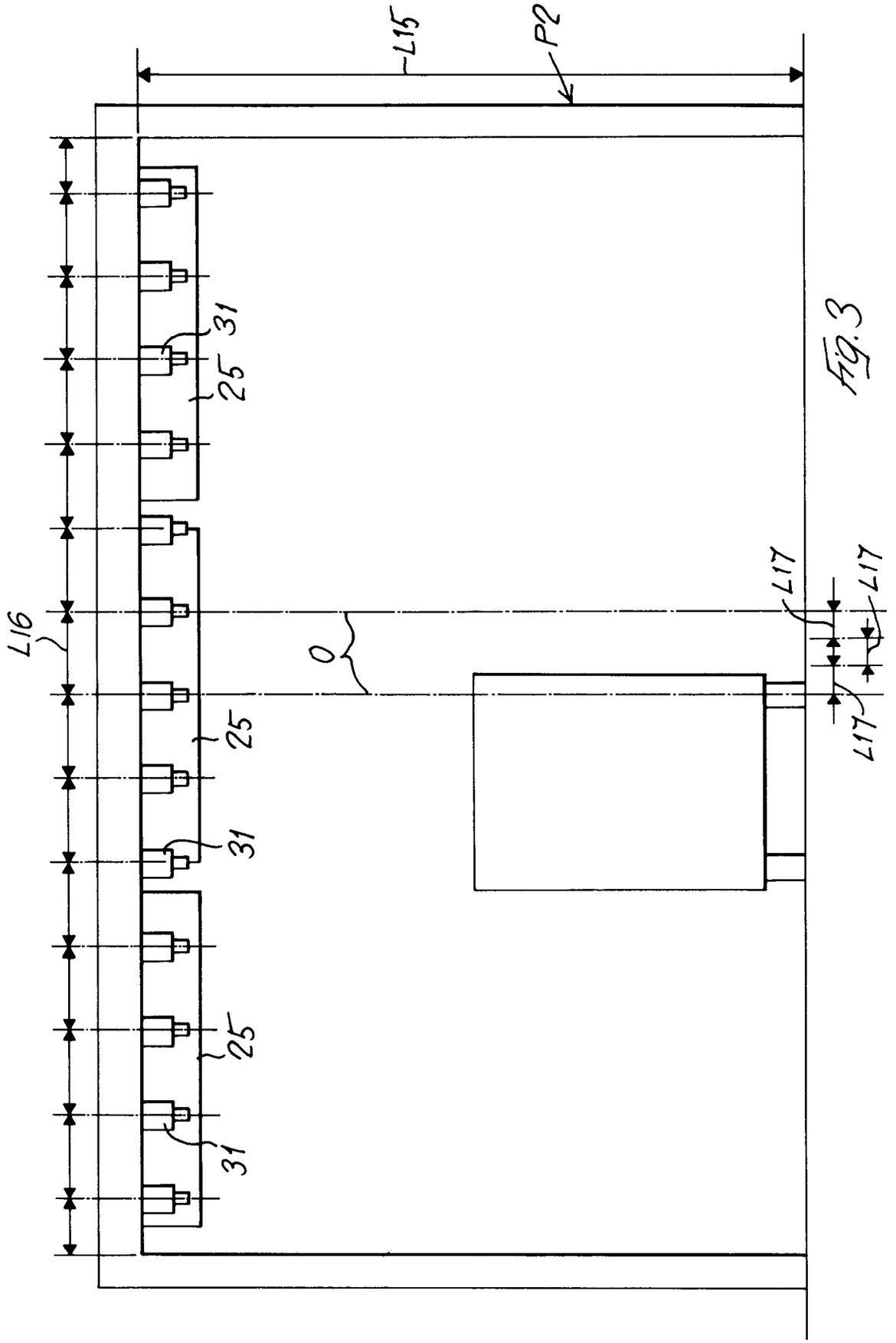


Fig. 3

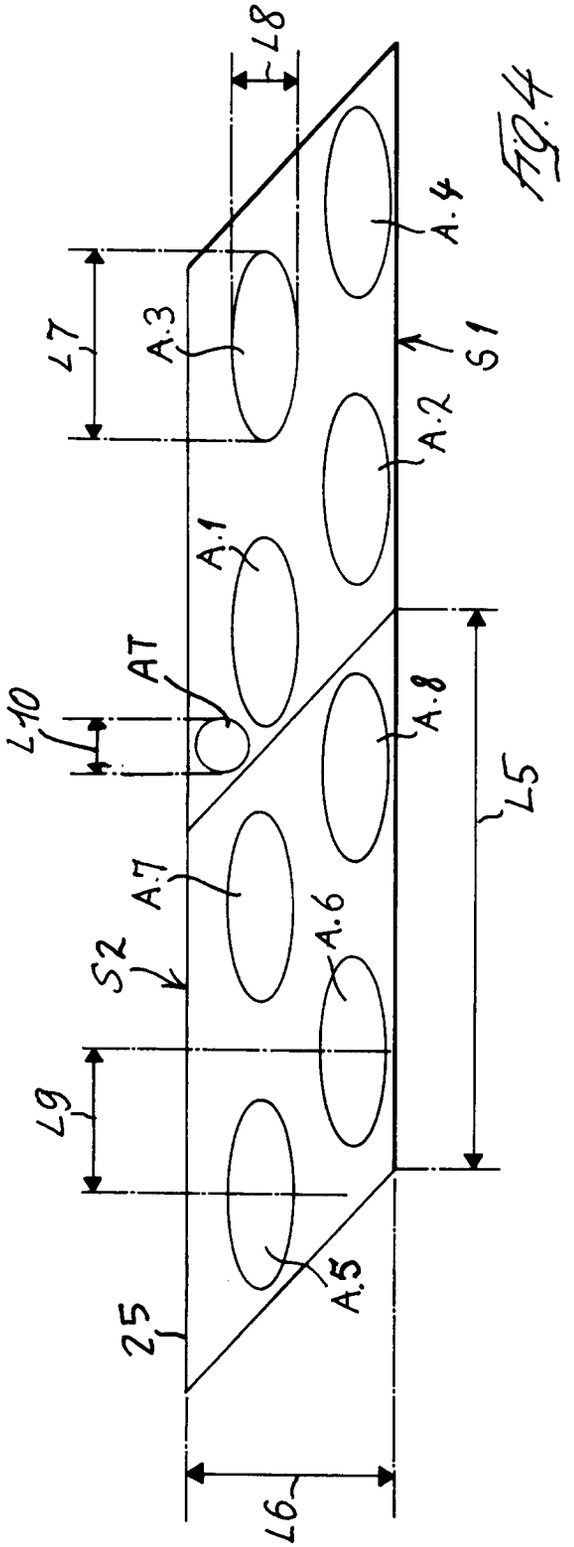

L8
L7
A.3
A.4
S1
A.2
A.1
AT
L10
A.8
L5
A.7
S2
A.6
L9
A.5
25
L6

Fig.4

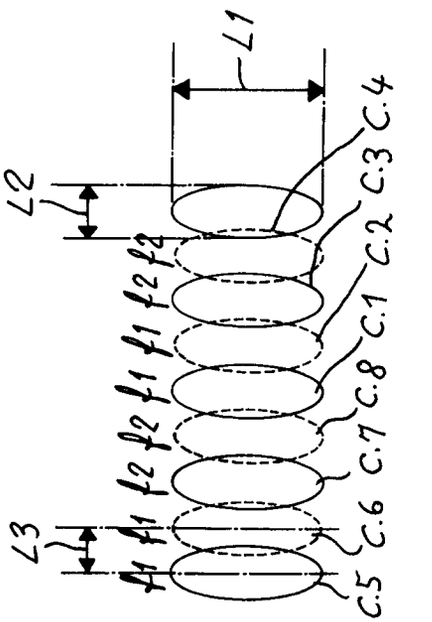

L1
L2
L3
f1 f2
C.1
C.2
C.3
C.4
C.5
C.6
C.7
C.8

Fig.5

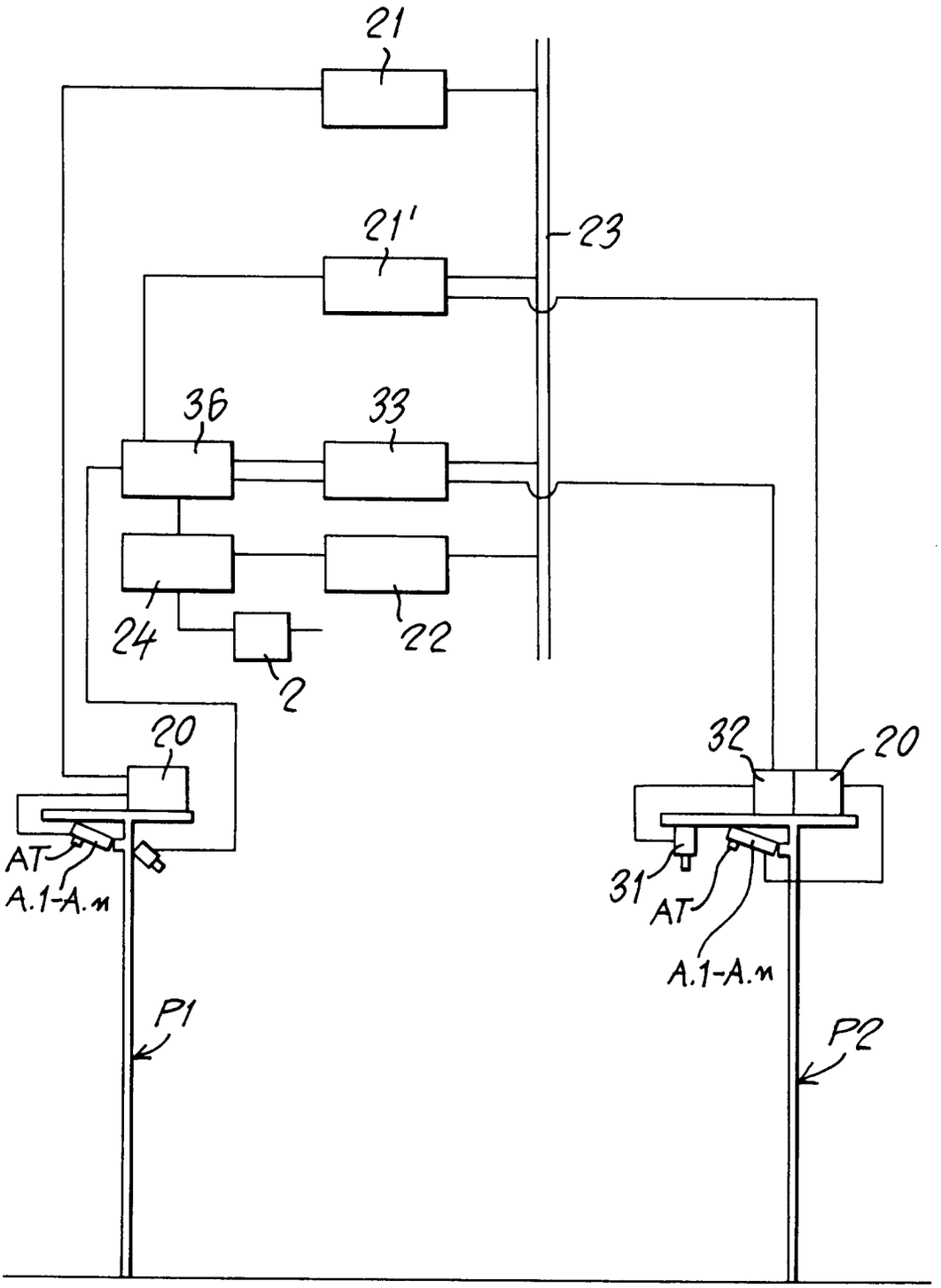


Fig. 6

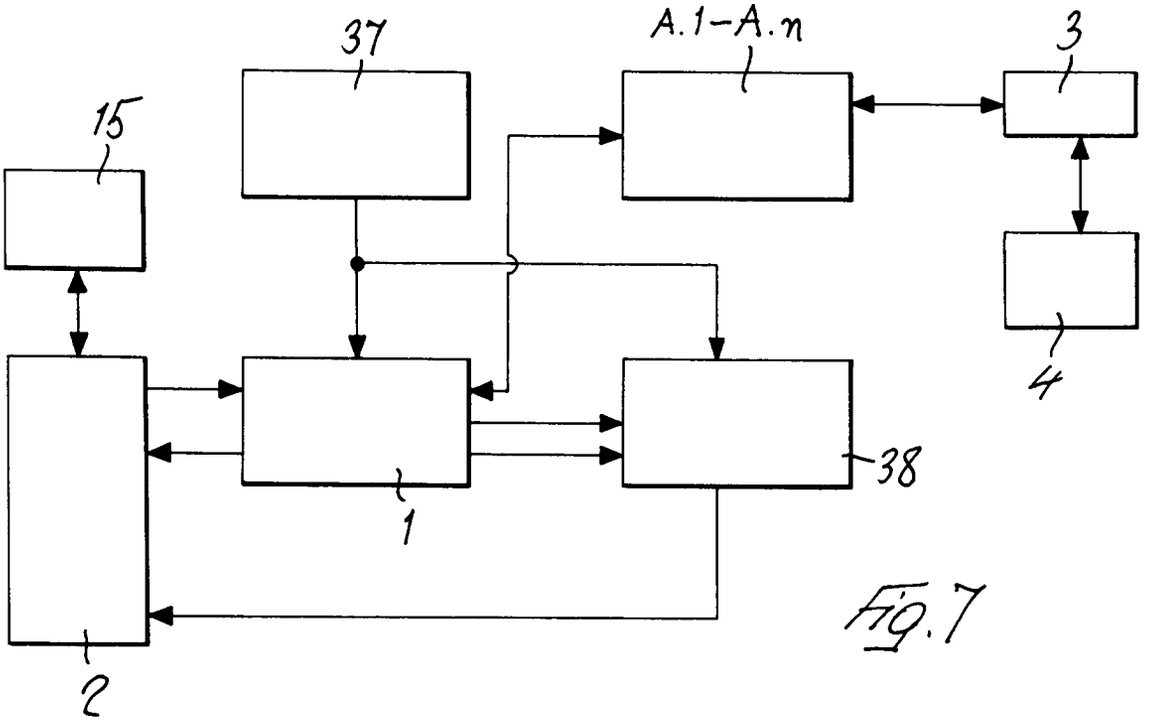


Fig. 7

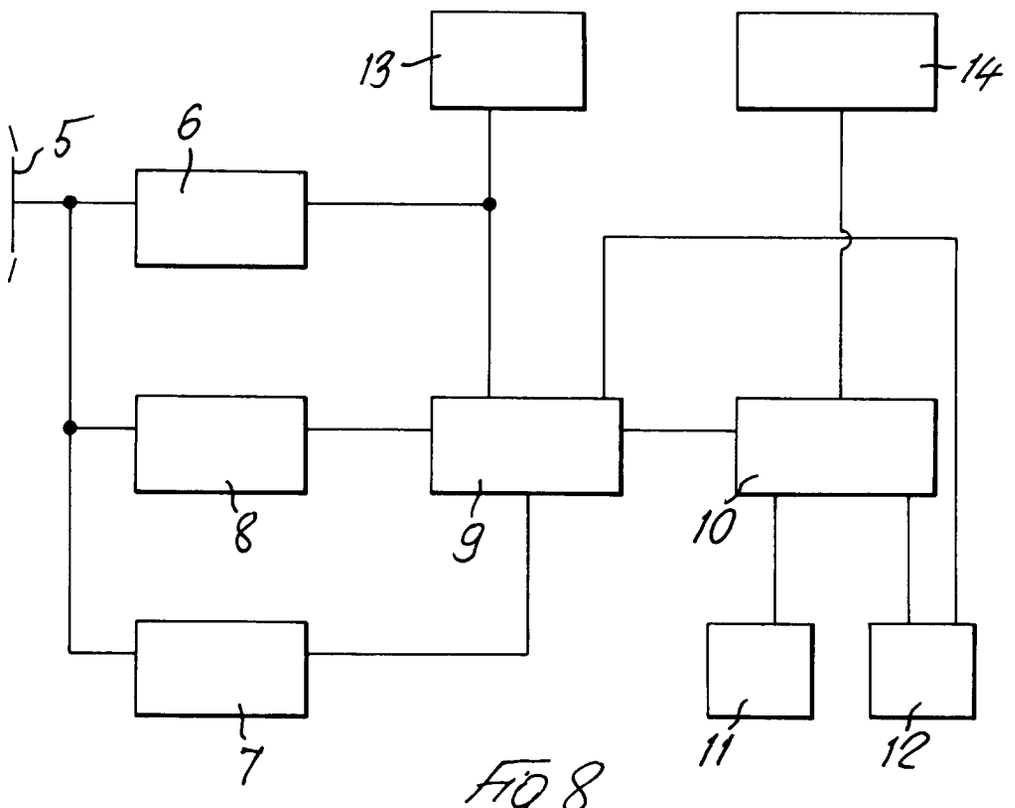


Fig. 8

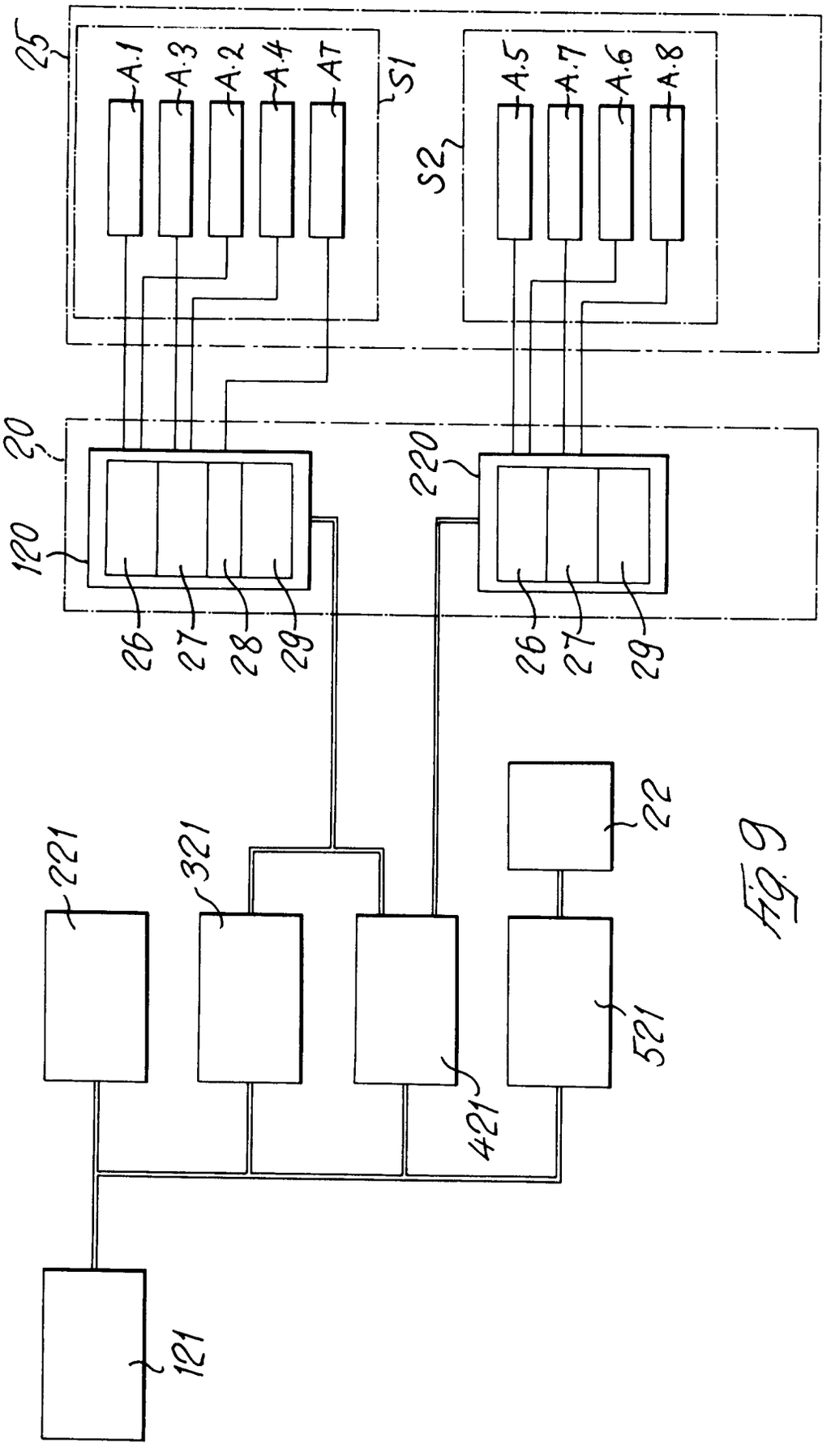

25
A.1
A.3
A.2
A.4
AT
S1
A.5
A.7
A.6
A.8
S2
20
120
220
26
27
28
29
26
27
29
22
221
321
421
521
121

Fig. 9

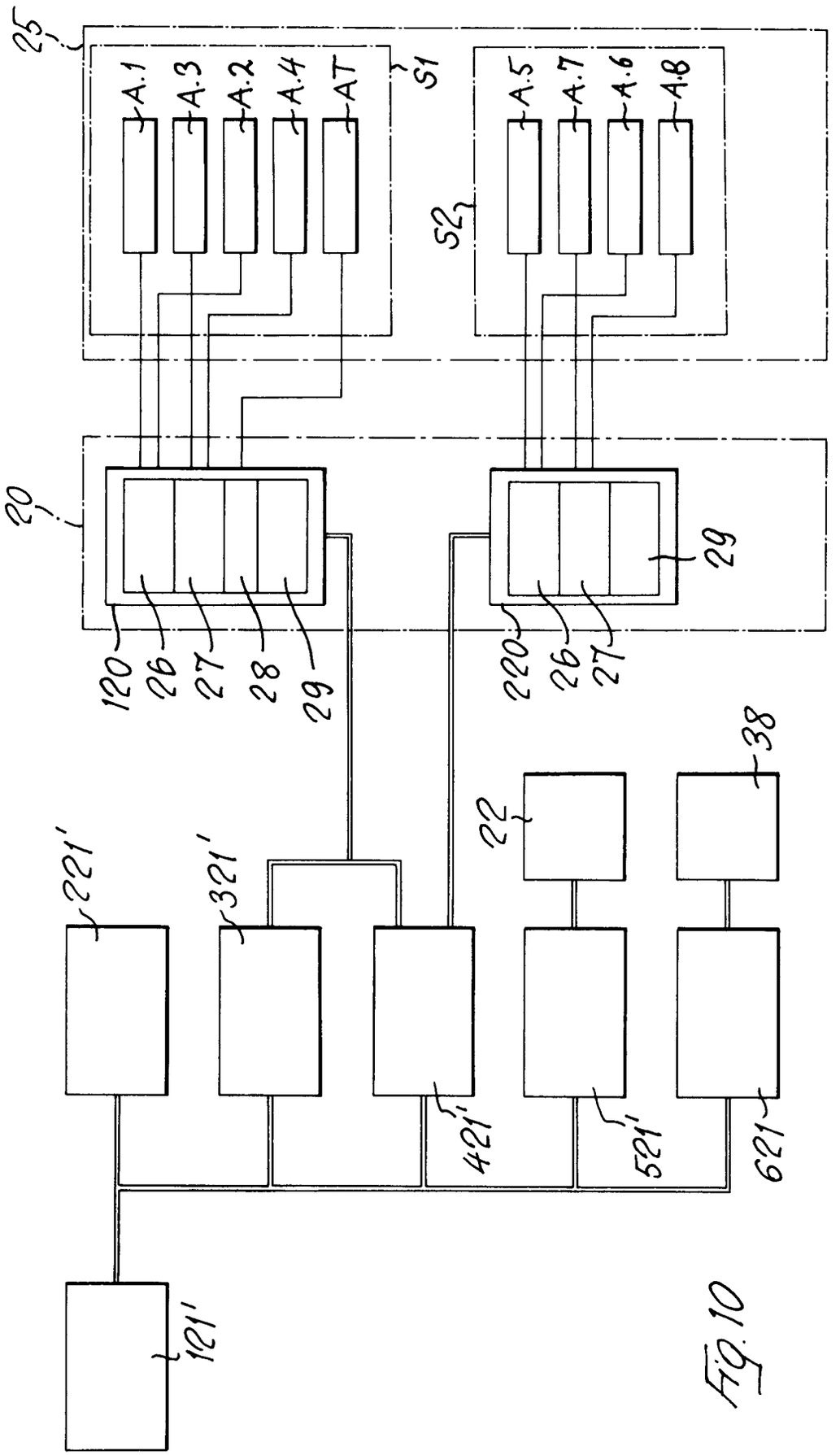

25
A.1
A.3
A.2
A.4
AT
S1
A.5
A.7
A.6
A.8
S2
20
29
120
26
27
28
29
220
26
27
38
22
221'
321'
421'
521'
621
121'

Fig. 10

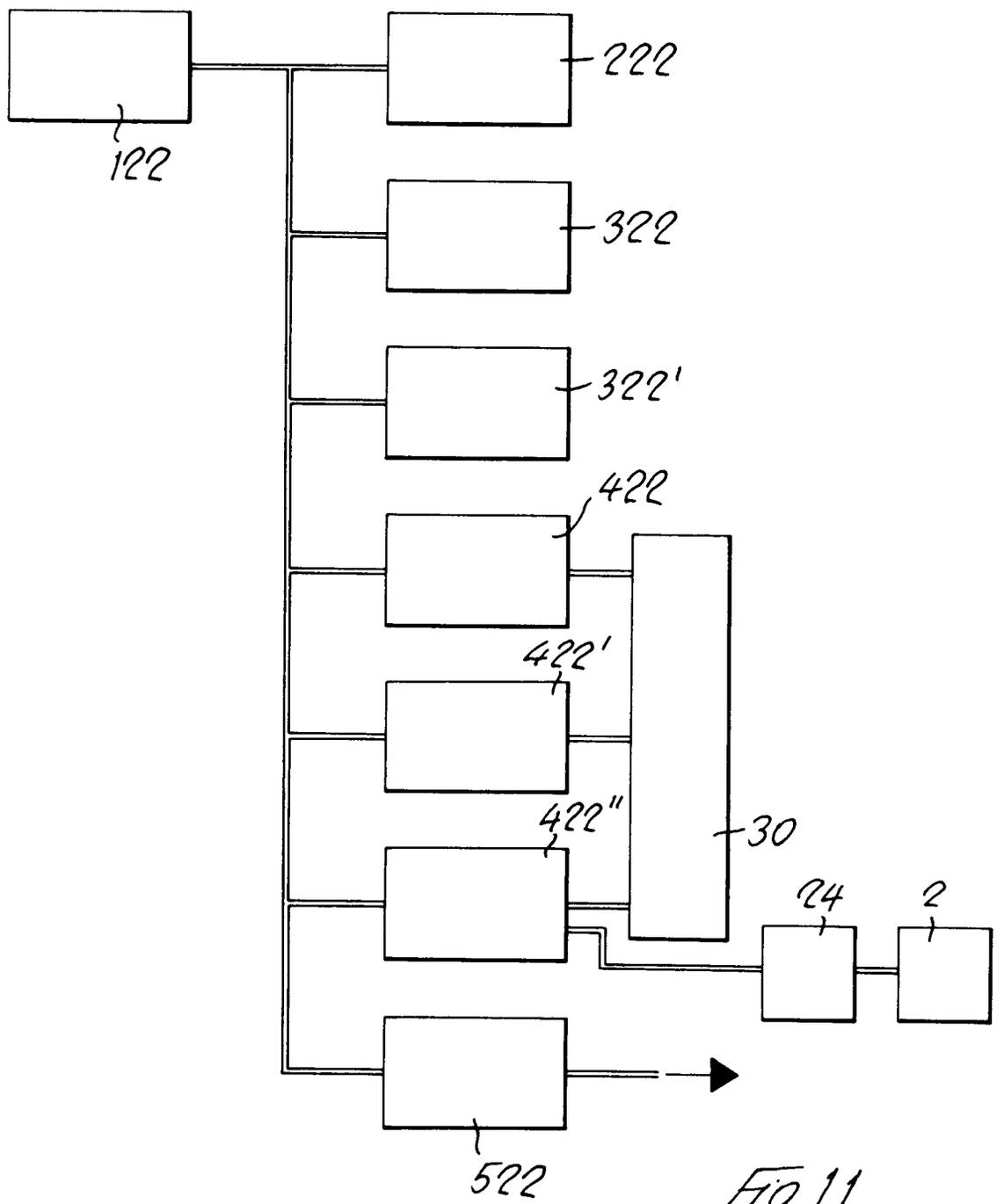


Fig. 11

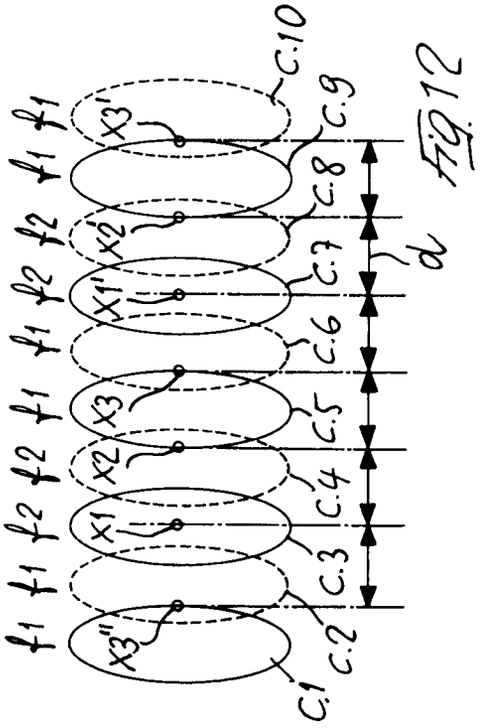


Fig. 12

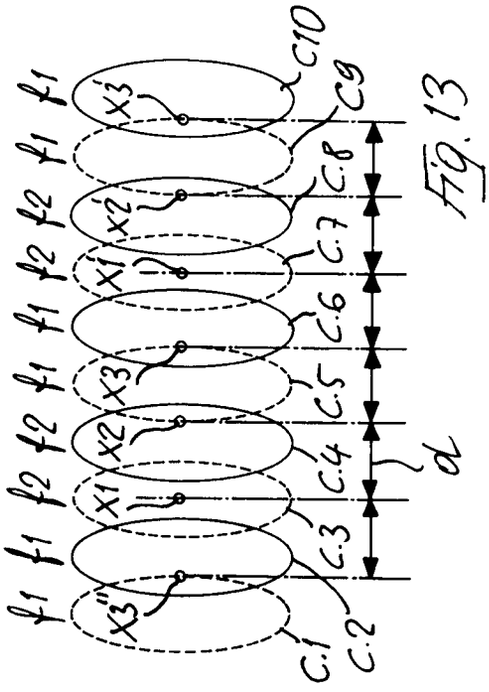


Fig. 13

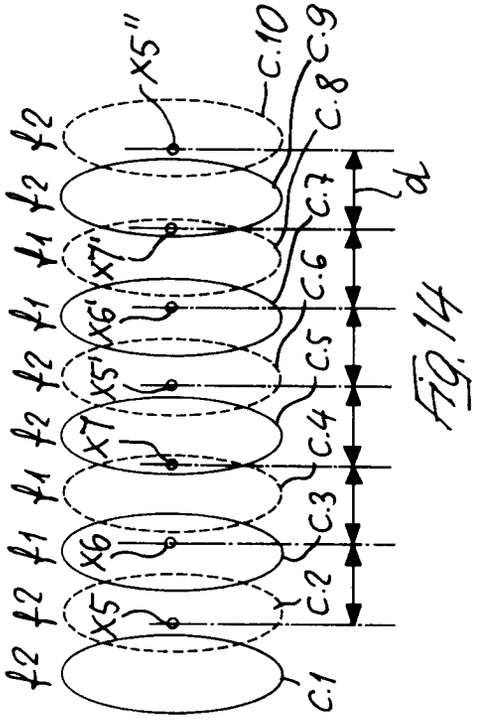


Fig. 14

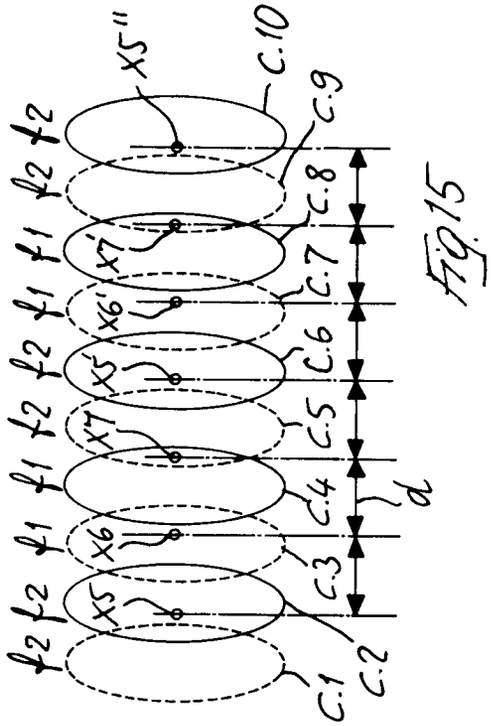


Fig. 15

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 93 11 3130

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
X	EP-A-0 401 192 (DE BAETS) * page 3, line 2 - line 58 * * page 8, line 13 - page 10, line 58 * * page 15, line 17 - page 16, line 38; figures *	1,2,21, 22	G07B15/00
Y A		3,4,23, 24,31,32 5-13,20, 25-30	

Y	FR-A-2 563 028 (SESAME ILE-DE-FRANCE) * page 8, line 14 - page 10, line 12; figures *	3,4,23, 24,31,32	

A	ELECTRONICS AND COMMUNICATION ENGINEERING JOURNAL vol. 3, no. 3 , June 1991 , LONDON GB pages 99 - 107 MANH ANH DO E.A. 'New automatic vehocle identification system for detection of traffic without lane discipline' * page 99, column 1, line 1 - page 105, column 2, line 9; figures *	1,2, 4-11, 14-17, 21,22, 24-26, 29,30	TECHNICAL FIELDS SEARCHED (Int.Cl.5) G07B G08G G07C

A	EP-A-0 413 948 (SIEMENS) * column 1, line 35 - column 5, line 33 * * column 13, line 53 - column 16, line 49; figures *	1,2,6-8, 21,22	

A	EP-A-0 416 692 (PHILIPS) * page 5, line 36 - page 6, line 20; figures *	1-9, 21-24, 29,30	

	-/--		

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	3 December 1993	Meyl, D

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

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EUROPEAN SEARCH REPORT

Application Number
EP 93 11 3130

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
A	EP-A-0 002 469 (SIEMENS) * page 3, line 31 - page 4, line 16; figures * ---	1,21	
A	GB-A-2 154 832 (THE PLESSEY COMPANY) * abstract; figures * ---	1,14-18	
A	US-A-4 325 146 (LENNINGTON) * abstract; figures * ---	1,12,21	
A	41ST IEEE VEHICULAR TECHNOLOGY CONFERENCE 19 May 1991 , ST. LOUIS USA pages 805 - 811 WALKER E.A. 'Automatic vehicle identification (AVI) technology design considerations for highway applications' -----		

TECHNICAL FIELDS SEARCHED (Int.Cl.5)

The present search report has been drawn up for all claims

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