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

System und Verfahren zum automatischen Erfassen von sich bewegenden Fahrzeugen

Système et méthode de détection automatique de véhicules roulants

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(73) Proprietor: **MARCONI S.p.A.**
I-16153 Genova-Cornigliano (IT)

(72) Inventors:
- **Cherubini, Fabrizio**
  I-16131 Bogliasco (Genoa) (IT)
- **Oddo, Mario**
  I-17100 Savona (IT)

(74) Representative: **Porsia, Dino, Dr.**
c/o Succ. Ing. Fischetti & Weber
Via Caffaro 3/2
16124 Genova (IT)

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- **ELECTRONICS AND COMMUNICATION ENGINEERING JOURNAL, vol. 3, no. 3 , June 1991 , LONDON, GB, pages 99 - 107; MANH ANH DO E.A.: 'New automatic vehicle identification system for detection of traffic without lane discipline'**
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Description

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 for identifying the user or vehicle and means for 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.

For solving the problem of avoiding confinement to single carriageway transit lanes in the area of the fixed stations, different systems of the above kind has been disclosed.

According to a first solution disclosed in the document EP 0 401 092, a fixed station for a multilane road comprises an aerial for each lane. The aerials generate footprints or coverage areas whose width is about the width of each associated lane. In order to discriminate the messages transmitted by the transponders of two different vehicles moving through the same coverage area, a sort of random time division multiplexing is suggested. The fixed station repeats consecutively an interrogating cycle of predeterminate lenght in time. Each cycle starts with an interrogating message to the transponder. The interrogating message is followed by a receiving subcycle during which the fixed station is ready to capture messages transmitted by the transponders being present in each coverage area. This receiving subcycle is divided in a plurality of equal subsequent receiving intervals, so called time slots. Each transponder being activated to transmission by the interrogating message send by the fixed station, is provided with means for choosing randomly one of the said receiving time slots for transmitting its message to the fixed station. While crossing through a coverage area the transponder repeats several time the message, each time choosing randomly a new time slot for transmission. Thus the messages of two or more transponder of respective vehicles crossing the same coverage area at the same time can be discriminated being the probability of a transmission of all the messages in the same time slot for each repetition infinitesimally small.

Document EP 0 416 692 discloses a different solution of the multilane problem with a system of the above described kind. In this solution the communication from the transponders are effected by the transponders suitably modulating their reflections of beams of microwave energy transmitted by the station from the aerials mounted on a gantry above the road, these aerials irradiating respective communication areas. In order to prevent communications from different transponders overlapping and hence interfering with each other, the transponders are enabled for their communications by microwave energy from further aerials, which energy has a higher frequency to enable it to be beamed at relatively small respective activation areas, the sizes of which are such that they can each only contain one vehicle and hence one transponder at any given time. The further aerials are activated, one at a time, successively and cyclically, so that the transponders are necessarily enabled in succession, the activation rate being, moreover, sufficent to ensure that all transponders passing through the relevant strech of road are in fact enabled. During each interval between the activation of each further aerial and the next the station transmits a command from the aerials associated with the further aerial which has just been activated ordering any transponder which has just been enabled to communicate its presence. If it receives such a communication the station transmits an address code from the relevant aerials which is stored in the relevant transponder and used subsequently to selectively address that transponder for further communication.

The article "New automatic vehicle identification system for detection of traffic without lane discipline" by Manh Anh Do and Jin Teong Ong (Electronics & Communication engineering Journal, Vol. 3, n° 3, June 1991, London GB, page 99-107) discloses a system of the above described kind in which in a multilane road an aerials-arrangment is chosen forming two bands of adiacent very small coverage areas which are markedly small with reference to the dimensions of vehicles, for example of about one meter. This system however is described as not able to discriminate two colliding messages transmitted by two different transponders and as inadeguate for detecting vehicles, such as motorbikes, or the like, attempting to cross the station in the shadow of other vehicles. For solving the above cited multilane problems a time division multiplexing communication protocoll is suggested.

In the above disclosed known systems in order to discriminate between colliding messages from different transponders 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 according to the preamble of claim 1 disclosed in EP-A-0 401 192 and further showing the combination of features according to the characterizing part of claim 1.

The invention also relates to a particular method of operation of the said system, according to claim 17.

To further 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.

Preferably 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 intelligibility 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 transceiver 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 <u>d</u> indicates the minimum transverse distances between the various on-board units in the different situations.

<u>Example 1</u>

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.

<u>Example 2</u>

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 trasmission and reception procedures and for the identification of the users and 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) foor identifying the user or vehicle and means (4,11) foor 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) of at least one aerial (A. 1-A.n) of the fixed station (P1,P2);
- the fixed transceiver station (P1,P2) having a plurality of transceiver aerials (A.1-A.n) disposed above the vehicular through road and directed toward it, at a height greater than the maximun 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,
- the processing and control means (1) being capable of processing separately the reception and trasmission signals of each aerial (A.1-A. n);
- the local processing and control means (1) being provided with second 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 aligned on the same transceive axis of the road (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),

characterised in that:

each coverage area (C.1-C.n) has a width and lenght which are relatively small with respect to the plan dimension 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 transceiver station (P1,P2) and the on-board units (3) are provided with transceiver means (20,120,220,26,27;7,8) capable of trasmitting 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) ;
- 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;
- the transceiver station (P1,P2) is provided with transceiver (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.

2. System according to claim 1 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 lenght of their minor axis.

3. System according to claims 1 or 2, 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 said signals, so that, in the extremly rare eventuality that two on-board units (3) come into a 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 unit (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 intellegibility of the answer signal form 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 unit (3) are indecipherable.

4. System according to one or 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 communication between on-board unit (3) and the transceiver station take place in two cronologically 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 minimun times necessary for the esecution of the radio trasmission of data only, at a predetermined maximun 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.

5. System according to one or 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.

6. System according to one or more of the preceding claims, characterised in that the 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.

7. System according to one or more of the preceding claims, characterised in that for a maximun speed of 120 km/hr parallele to the through road and a maximun speed of approximately 20 km/hr transversely with respect to the road, and a maximun comunication 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.

8. System according to one or more of the preceding claims, characterised in that the on-board unit (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).

9. System according to one or 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 on-board unit according to the aerial (A.1-A.n) with which it has communicated.

10. System according to one or 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.

11. System according to claim 10, 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 which each other tranversely with respect to the through road, and parallele to the coverage areas (C.1-C.n) of the aerials (A.1-A.n) and with their optical axis (0) 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 immediatly before the coverage areas (C.1-C.n) of the aerials (A.1-A.n).

12. System according to claim 11, characterised in that the television cameras (31) are associated with the second band (P2) of coverage areas (C.1-C.n).

13. System according to one or more of the preceding claims, characterised in that it is provided with optical/electronics 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.

14. System according to claim 13, characterised in that the optical/electronics 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 bands (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 nondetection of the answer signals from an on-board unit (3) by means of the said aerials (C.1-C.n).

15. System according to one or more of the preceding claims, characterised in that the transciever 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 numbers 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 panels (25) being associated with its own transceiver system (20,120,220,26,27,28).

16. System according to one or 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, 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.

17. A method for automatic detection of moving vehicles, with automatic data exchange in a system for automatic detection of moving 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, in which:

- subdivision into individual coverage areas (C. 1-C.n) of an individual (A.1-A.n) of a band of coverage areas, for comunication with on-board unit (3) is specified,
- the communication between each aerial (A. 1-A.n) and the on-board unit (3) in the aerials'coverage area (C.1-C.n) is processed separately from that taking place between others on-board unit (3) and other aerials (A.1-A.n);
- the aerials (A.1-A.n) are divided into two groups (A.2n-1,A.2n), each of which groups form two rows aligned on the same transverse axis of the road of coverage areas (C.2n-1,C.2n), the coverage areas (C.2n-1) of one of the two groups (A.2n-1) being alternate with those (C.2n) of the other groups (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;

characterised in that:

each coverage area (C.1-C.n) has dimensions markedly smaller than those of the vehicles and such that they contain statistically only one on-board unit (3) ;

- the aerials (A.2n-1,A.2n) of each group use two different reception/trasmission frequencies, the said frequencies being distributed, within each groups, 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.
- 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.

18. Method according to claim 17, characterised in that if two on-board units (3) are present in a single converage area (C.1-C.n) of one aerial (A.1-A.n), the answer signals from the on-board units (3), namely the one whose answer signal is correctly intellegible and at a higher level, being enabled to communicate, when the two signals are sufficently different from each other.

19. Method according to one or more of the preceding claims, characterised 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 band (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.

20. Method according to one or more of the preceding claims, characterised 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).

21. Method according to one or more of the preceding claims, 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 analysed, 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.

22. Method according to one or more of the preceding claims, characterised in that the activation time 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 aerials (A.1-A.n).

23. Method according to one or more of the processing claims, characterised in that the on-board unit (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.

24. Method according to one or more of the preceding claims, characterised in that it is used for the automatic detection, with data exchange, or packages, goods, or other moving bodies on conveying means, for example for monitoring and despaching to various stations by conveyor and movement lines in installation 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.

25. Method according to one or more of the preceding claims, characterised in that it is used for automatic detection, with data exchange, for example for the monitoring and despaching of goods, packages, pieces, or other types of bodies moved on conveyer lines, in goods movement or processing installation.

Patentansprüche

1. System zum automatischen Erfassen von sich bewegenden Fahrzeugen, mit automatischem Datenaustausch, insbesondere mit automatischer Entrichtung von Straßenbenutzungsgebühren, enthaltend:

- mindestens eine feste automatische Sender-/Empfängerstation (P1, P2), die mit lokalen Verarbeitungs- und Steuerungsmitteln (1) für die Übertragungs- und Empfangsprozeduren und für die Identifikation der Benutzer und die Berechnung von zu entrichtenden Straßenbenutzungsgebühren für jeden identifizierten Benutzer versehen ist, diese feste Station (P1, P2) an einem spezifischen Punkt an einer Vorfahrtstraße für Fahrzeuge eingerichtet ist;

- eine an-Bord-Empfänger-/Sendereinheit (3) für jedes Fahrzeug, wobei diese an-Bord-Einheit (3) mit Verarbeitungs- und Steuerungsmitteln (10) für die Übertragungs- und Empfangsprozeduren, und mit Mitteln (4) zur Identifizierung des Benutzers oder Fahrzeuges und Mitteln (4, 11) für die Aufzeichnung der entrichteten Straßenbenutzungsgebühren versehen ist;

- die feste Station (P1, P2) und jede an-Bord-Einheit (3) zu einer Zwei-Wege-Kommunikation geeignet ist, wenn sie durch die feste Station (P1, P2) dazu aufgefordert wird, zu dem Austausch von Daten, die beispielsweise zu dem Benutzer und zu den entrichteten Straßenbenutzungsgebühren gehören, während der Durchfahrt der an-Bord-Einheit (3) durch den Bereich der Vorfahrtstraße, der durch den Arbeitsbereich (C.1 - C.n) von mindestens einer Antenne (A.1 - A.n) der festen Station (P1, P2) abgedeckt ist;

- die feste Sender-/Empfängerstation (P1, P2) aufweisend eine Vielzahl von Sender-/Empfängerantennen (A.1 - A.n), angeordnet über der Vorfahrtstraße für den Verkehr und zu ihr hin gerichtet, in einer Höhe größer als der maximalen Höhe der Fahrzeuge, diese Antennen (A.1 - A.n) in Bezug auf die Vorfahrtstraße quer dazu verteilt angeordnet und in einer solchen Weise konstruiert, daß jede einen begrenzten Erfassungsbereich (C.1 - C.n) auf der Vorfahrtstraße nebenan generiert, dazu geeignet, nur mit der zugehörigen Antenne (A.1 - A.n) innerhalb jedes der besagten Erfassungsbereiche (C.1 - C. n) zu kommunizieren, die besagten Erfassungsbereiche (C.1 - C.n) Seite an Seite in der Querrichtung bezogen auf die Vorfahrtstraße angeordnet;

- die Verarbeitungs- und Steuerungsmittel (1) geeignet zur getrennten Verarbeitung der empfangenen und übertragenen Signale von jeder Antenne (A.1-A.n);

- die lokalen Verarbeitungs- und Steuerungsmittel (1) mit zweiten Steuerungsmitteln (21, 421, 21', 421') ausgestattet sind, die wechselweise für einen Halbzyklus einer gesamten Aktivierungsperiode zwei Gruppen von Antennen (A. 2n - 1, A.2n) der Antennen (A.1 - A.n) aktivieren, die Antennen (A.2n - 1, A.2n) mit zwei Reihen von an der gleichen Empfänger-/Sender-Achse der Straße ausgerichteten Erfassungsbereichen (C.2n - 1, C.2n) verbunden sind, die in Bezug auf die Vorfahrtstraße quer dazu ausgerichtet sind, die Erfassungsbereiche (C.2n - 1) der Gruppe der Antennen (A.2n - 1) abwechselnd mit den Erfassungsbereichen (C.2n) der Gruppe von Antennen (A.2n) angeordnet sind,

dadurch gekennzeichnet, daß

- jeder Erfassungsbereich (C.1 - C.2) eine Breite und Länge hat, die relativ klein in Bezug auf die ebenen Abmessungen der Fahrzeuge sind, und die derart sind, daß sie nicht mehr als eine an-Bord-Einheit (3) zu einer Zeit enthalten und daher mit nicht mehr als einer an-Bord-Einheit (3) zu einer Zeit kommunizieren;

- die Sender-/Empfängerstation (P1, P2) und die an-Bord-Einheiten (3) mit Sender-/Empfängermitteln (20, 120, 220, 26, 27; 7, 8) ausgerüstet sind, die auf zwei verschiedenen Frequenzen zum Senden und Empfangen in der Lage sind, die besagten zwei Frequenzen wechselweise zwischen den Antennen (A.2n - 1, A.2n) innerhalb jeder Gruppe von Antennen (A.2n - 1, A. 2n) verteilt sind;

- die beiden Frequenzen sind unter den Antennen (A.2n - 1, A.2n) der zwei Gruppen in solch einer Weise verteilt, daß jede Antenne (A.2n -1) von einer Gruppe verbunden mit einer Frequenz benachbart zu einer Antenne (A.2n) der anderen Gruppe verbunden mit der gleichen Frequenz ist;

- die Sender-/Empfängerstation (P1, P2) mit Sendern/Empfängern (26, 27) versehen ist, von denen jede bei einer unterschiedlichen Frequenz arbeitet und mit denen abwechselnd die Antennen (A.2n - 1, A.2n) von jeder der beiden Gruppen verbunden sind.

2. System entsprechend Anspruch 1, **dadurch gekennzeichnet, daß** die Erfassungsbereiche (C.1 - C.n) von elliptischer Form sind und mit ihrer Hauptachse parallel zu der Längsachse der Vorfahrtstraße orientiert sind, während ihre Nebenachsen miteinander ausgerichtet quer in Bezug auf die Vorfahrtstraße sind, die Mittelpunkte von zwei benachbarten Erfassungsbereichen (C.n, C.n + 1) voneinander beabstandet um einen Betrag kleiner als die Länge ihrer Nebenachsen.

3. System entsprechend Anspruch 1 oder 2, **dadurch gekennzeichnet, daß** die lokalen Verarbeitungs- und Steuerungsmittel (1) mit Mitteln (21, 21', 421, 421', 121, 121') zum Analysieren der Antwortsignale von den an-Bord-Einheiten (3) versehen sind, die die formelle Korrektheit der besagten Signale prüfen, so daß in der extrem seltenen Eventualität, daß zwei an-Bord-Einheiten (3) in Konflikt innerhalb eines einzelnen Erfassungsbereiches (C.1 - C.n) von einer Antenne (A.1 - A.n) kommen, es möglich ist, eine der zwei an-Bord-Einheiten (3) zur Kommunikation zu veranlassen, wenn die Interferenz aufgrund der zweiten an-Bord-Einheit (3) auf einem solchen Niveau ist, daß die Verständlichkeit des Antwortsignales von der ersten an-Bord-Einheit (3) nicht beeinträchtigt ist, während die Kommunikation für beide an-Bord-Einheiten (3) blockiert wird, wenn die Antwortsignale von den beiden an-Bord-Einheiten (3) unentzifferbar sind.

4. System entsprechend einem oder mehreren der vorstehenden Ansprüche, **dadurch gekennzeichnet, daß** jede Station zwei Gruppen von Antennen (A.1 - A.n) aufweist, die mit einem Abstand zwischen ihnen in der Richtung der Durchfahrt angeordnet sind und deren Erfassungsbereiche (C.1 - C. n) zwei Streifen von in Richtung der Durchfahrt beabstandeten Erfassungsbereichen bilden, während die Kommunikation mittels Funkwellen zwischen der an-Bord-Einheit (3) und der Sender-/Empfängerstation in zwei chronologisch getrennten Phasen stattfindet, eine für jedes Band von Erfassungsbereichen (C.1 - C.n), die Abmessungen (L1, L2) der besagten Erfassungsbereiche (C.1 - C.n) und die Aktivierungszeiten angepaßt an die minimalen Zeiten ist, die notwendig für Ausführung der Übertragung lediglich von Daten mittels Funkwellen ist, bei einer vorher bestimmten maximalen Durchfahrtgeschwindigkeit, die internen Prozeduren der Sender-/Empfängerstation und der an-Bord-Einheit (3) in dem Zeitinvervall zwischen den beiden Bändern der Erfassungsbereiche (C.1 - C.n) ausgeführt werden und vor dem ersten Band von Erfassungsbereichen (C.1 - C.n), die beiden Bänder von Erfassungsbereichen (C.1 - C.n) zumindestens voneinander beabstandet (L12) in Übereinstimmung mit den Zeiten, die zur Ausführung der besagten internen Prozeduren benötigt wird.

5. System entsprechend einem oder mehreren der vorstehenden Ansprüche, **dadurch gekennzeichnet, daß** die Antennen (A.1 - A.n) von dem parabolischen Typ mit einer elliptischen Grundfläche sind, und eine erste Strahlungskeule (bei - 3 db) mit hoher Verstärkung entsprechend dem verbundenen Erfassungsbereich (C.1 - C.n) und zweite Strahlungskeulen, falls überhaupt, in einer sehr geringen Intensität, bilden.

6. System entsprechend einem oder mehreren der vorstehenden Ansprüche, **dadurch gekennzeichnet, daß** die ersten Abmessungen der Erfassungsbereiche (C.1 - C.n) gemacht sind, um in einer horizontalen Ebene (1) bei einer Höhe (L4) zu liegen, zum Beispiel 1 m, geschätzt als die mittlere Höhe der an-Bord-Einheiten (3) oberhalb der Vorfahrtstraße.

7. System entsprechend einem oder mehreren der vorstehenden Ansprüche, **dadurch gekennzeich-**

net, daß für eine maximale Geschwindigkeit von 120 km/h parallel zu der Vorfahrtstraße und für eine maximale Geschwindigkeit von näherungsweise 20 km/h quer im Verhältnis zu der Straße und für eine maximale Kommunikationszeit von 15 ms die Erfassungsbereiche der individuellen Streifen Hauptachsen (L1) von 1,5 m, Nebenachsen (L2) von 0,5 m und einen Abstand der Mittelpunkte (L3) von 0,375 m haben, während die beiden Bänder voneinander um mindestens 10 m getrennt angeordnet sind.

8. System entsprechend einem oder mehreren der vorstehenden Ansprüche, **dadurch gekennzeichnet, daß** die an-Bord-Einheiten (3) mit einer Aktivierungseinheit (6) ausgestattet sind, die die Einheiten unmittelbar vor dem Eintritt in die Streifen der Erfassungsbereiche (C.1 - C.n) aktivieren, wenn sie durch die Sender-/Empfängerstation (P1, P2) dazu veranlaßt werden, einem Streifen von Erkennungsbereichen (CT), produziert durch mindestens eine mit den Antennen (A.1 - A.n) verbundene Aktivierungsantenne (AT) und arbeitend bei einer verschiedenen Frequenz von dieser, angeordnet vor jedem Streifen von Erfassungsbereichen (C.1 - C. n), während die lokalen Verarbeitungs- und Steuerungsmittel (1) mit einem Steuerungssystem (321, 321') ausgestattet sind und mit Übertragungsmitteln (28), die mit besagter Aktivierungsantenne (AT) verbunden sind.

9. System entsprechend einem oder mehreren der vorstehenden Ansprüche, **dadurch gekennzeichnet, daß** die lokalen Verarbeitungs- und Steuerungsmittel (1) mit Mitteln (21, 21') ausgerüstet sind, die zur Bestimmung der Position der an-Bord-Einheit entsprechend der Antenne (A.1 - A.n) in der Lage ist, mit der diese kommuniziert hat.

10. System entsprechend einem oder mehreren der vorstehenden Ansprüche, **dadurch gekennzeichnet, daß** die Sender-/Empfängerstation mit optischen Mitteln (37) zur Erkennung der Anwesenheit eines Fahrzeuges und zur Identifizierung der Position ausgestattet ist, verbunden mit Mitteln (22) zur Korrelation der durch die besagten optischen Mittel (37) aufgefundenen Position mit der durch die Antennen (A.1 - A.n) gefundenen Position, mit der die korrespondierende an-Bord-Einheit (3) in Kommunikation getreten ist.

11. System entsprechend Anspruch 10, **dadurch gekennzeichnet, daß** die optischen Mittel (37) eine Vielzahl von Femsehkameras (31) enthalten, vorzugsweise von einem Linear-Scan-Typ, die mit Steuerungsmitteln (32) und Bildverarbeitungsmitteln (33) verbunden sind, die Femsehkameras (31) jeweils zueinander ausgerichtet quer in Bezug auf die Vorfahrtstraße angeordnet sind, und parallel zu den Erfassungsbereichen (C.1 - C.n) der Antennen (A.1 - A.n) und mit ihren optischen Achsen (0) weit genug voneinander entfernt, um eine maximale Meßauflösung (L17) kleiner als die Nebenachse des Erfassungsbereiches (C.1 - C.n) zu erhalten, vorzugsweise von 0,25 m, während die Bildfangbereiche der Fernsehkameras (31) unmittelbar vor den Erfassungsbereichen (C.1 - C.n) der Antennen (A.1 - A.n) angeordnet sind.

12. System entsprechend Anspruch 11, **dadurch gekennzeichnet, daß** die Fernsehkameras (31) mit dem zweiten Streifen (P2) der Erfassungsbereiche (C.1 - C.n) verbunden ist.

13. System entsprechend einem oder mehreren der vorstehenden Ansprüche, **dadurch gekennzeichnet, daß** es mit optischen/elektronischen Mitteln (38) zum Aufnehmen von Bildern von Fahrzeugen ausgestattet ist, die illegal durch die Sender-/Empfängerstation (P1, P2) passieren, oder ohne die Ausführung eines korrekten Datenaustausches mit den an-Bord-Einheiten (3) der Fahrzeuge.

14. System entsprechend Anspruch 13, **dadurch gekennzeichnet, daß** die optischen/elektronischen Mittel (38) zum Aufnehmen von Bildern der Fahrzeuge bei der Durchfahrt eine oder mehrere Fernsehkameras (35) enthalten, die in Richtung auf die Durchfahrt der Fahrzeuge auf die Streifen (P2) der Erfassungsbereiche (C.1 - C.n) gerichtet sind und deren Bildfangbereich (135) dazu gemacht ist, um vor den Erfassungsbereichen (C.1 - C.n) zu liegen, die besagten Femsehkameras (35) mit einer Einheit (36) zur Steuerung und zur Aufnahme von eingefangenen Bildern verbunden ist, gesteuert durch die Mittel (1, 21', 22, 33) zur Korrelation der Positionen, bestimmt mittels der optischen Mittel (37) zur Erkennung der Anwesenheit und Identifikation der Position von Fahrzeugen, und mittels der Antenne (C.1 - C.n), vorgesehen an besagter Position, entsprechend der Erkennung oder Nichterkennung der Antwortsignale von einer an-Bord-Einheit (3) mittels der besagten Antennen (C.1 - C.n).

15. System entsprechend einem oder mehreren der vorstehenden Ansprüche, **dadurch gekennzeichnet, daß** die Sender-/Empfängerstation (P1, P2) von einer modularen Konstruktion ist, die Antennen (A.1 - A.n) und die Aktivierungsantennen (AT) über eine Vielzahl von Paneelen (25) verteilt sind, jede eine identische Anzahl von Antennen (A.1 - A.8) aufweisend, während die lokalen Verarbeitungs- und Steuerungsmittel (1) von einem erweiterbaren kartenbasierten Typ sind und eine Steuerungseinheit (21, 21') haben, die zur Steuerung einer spezifischen erweiterbaren Anzahl von Antennenpaneelen (25) ausgelegt ist, jedes Antennenpaneel (25) mit seinem eigenen Sender/Empfängersystem (20, 120, 220, 26, 27, 28) verbunden ist.

16. System entsprechend einem oder mehreren der vorstehenden Ansprüche, **dadurch gekennzeichnet, daß** die lokalen Verarbeitungs- und Steuerungsmittel (1) eine Stations-Steuerungseinheit (22) haben, die mit Mitteln (24, 2) zur Kommunikation mit einem zentralen Prozessor (15) und mit Mitteln zur Kommunikation mit den Mitteln (21, 21', 20) zur Steuerung der Antennen (A.1 - A.n) ausgestattet sind, mit den optischen Mitteln (37) zur Erkennung der Anwesenheit und Identifikation der Position von Fahrzeugen, und mit optischen/elektronischen Mitteln (38) zum Aufnehmen von Bildern, ebenso wie mit Signalisierungseinheiten oder anderen Hilfsstationseinheiten (30), wie Barrie-ren, die beiden Gruppen in einer solchen Weise, daß die Erfassungsbereiche (C.2n - 1) relativ zu der Antenne (A.2n - 1) von einer der beiden Gruppen mit der gleichen Frequenz wie der unmittelbar benachbarte Erfassungsbereich (C.2n) relativ zu der Antenne (A. 2n) der anderen Gruppe von Antennen arbeitet.

17. Verfahren zum automatischen Erkennen von sich bewegenden Fahrzeugen, mit automatischem Datenaustausch in einem System zum automatischen Erkennen von sich bewegenden Fahrzeugen mit automatischem Datenaustausch zwischen einer festen Sender-/Empfängerstation (P1, P2) und einer an-Bord-Einheit (3) für jedes Fahrzeug entsprechend einem oder mehreren der vorstehenden Ansprüche, bei dem:

- eine Unterteilung in individuelle Erfassungsbereiche (C.1 - C.n) einer Antenne (A.1 - A.n) eines Streifens von Erfassungsbereichen, zur Kommunikation mit an-Bord-Einheiten (3) angegeben ist;

- die Kommunikation zwischen jeder Antenne (A. 1 - A.n) und der an-Bord-Einheit (3) in dem Erfassungsbereich (C.1 - C.n) der Antenne getrennt von derjenigen zwischen anderen an-Bord-Einheiten (3) und anderen Antennen (A.1 - A.n) ausgeführt wird

- die Antennen (A.1 - A.n) in zwei Gruppen (A.2n - 1, A.2n) getrennt sind, jede von diesen Gruppen zwei Reihen von Erfassungsbereichen (C. 2n - 1, C.2n) entlang der gleichen Querachse zu der Straße bildet, die Erfassungsbereiche (C.2n - 1) von einer der zwei Gruppen (A.2n - 1) sich abwechseln mit jenen (C.2n) der anderen Gruppe (A.2n), während die Antennen (A. 2n - 1) der einen Gruppe für die Kommunikation mittels Funksignalen abwechselnd mit denjenigen (A.2n) der anderen Gruppe aktiviert sind, in jedem Fall für einen Halbzyklus der gesamten Aktivierungsperiode,

dadurch gekennzeichnet, daß

jeder Erfassungsbereich (C.1 - C.n) Abmessungen deutlich geringer als diejenigen der Fahrzeuge und derart aufweist, daß sie statistisch nur eine an-Bord-Einheit (3) enthalten;

die Antennen (A.2n - 1, A.2n) von jeder Gruppe zwei verschiedene Empfangs-/Übertragungsfrequenzen benutzen, die besagten Frequenzen innerhalb jeder Gruppe abwechselnd unter den entsprechenden Antennen (A.2n - 1, A.2n) verteilt sind, während die feste Station und die an-Bord-Einheiten (3) von einem Typ sind, der zur Übertragung und zum Empfangen von besagten zwei Frequenzen in der Lage ist;

- die beiden Frequenzen sind abwechselnd zwischen den Antennen (A.2n - 1, A.2n) der zwei Gruppen verteilt sind, in solch einer Weise, daß der Erfassungsbereich (C.2n - 1) relativ zu der Antenne (A.2n - 1) von einer der zwei Gruppen mit der selben Frequenz wie der unmittelbar benachbarte Erfassungsbereich (C.2n) relativ zu der Antenne (A.2n) der anderen Gruppe von Antennen arbeitet.

18. Verfahren gemäß Anspruch 17, **dadurch gekennzeichnet, daß** wenn zwei an-Bord-Einheiten (3) in einem einzelnen Erfassungsbereich (C.1 - C.n) einer der Antennen (A.1 - A.2) vorhanden sind, die Antwortsignale von der an-Bord-Einheit (3), namentlich derjenigen, deren Antwortsignal korrekt verständlich und bei einem höheren Niveau ist, zur Kommunikation genutzt wird, wenn die beiden Signale ausreichend voneinander verschieden sind.

19. Verfahren gemäß einem oder mehreren der vorstehenden Ansprüche, **dadurch gekennzeichnet, daß** die Datenübertragung in zwei Phasen ausgeführt wird, von der jede in einem Streifen (P1, P2) von Erfassungsbereichen (C.1, C.2) von mindestens zwei aufeinanderfolgenden Streifen (P1, P2) von Erfassungsbereichen (C.1 - C.n) getrennt voneinander in Richtung der Durchfahrt angeordnet stattfindet, während die Distanz (L12) zwischen den beiden Streifen entsprechend zu der benötigten Zeit für die Durchführung der internen Prozeduren der Sender-/Empfängerstation und der an-Bord-Einheiten (3) und entsprechend zu der maximalen Durchfahrtgeschwindigkeit festgelegt ist.

20. Verfahren gemäß einem oder mehreren der vorstehenden Ansprüche, **dadurch gekennzeichnet, daß** die an-Bord-Einheiten (3) durch die Sender/

Empfängerstation vor dem ersten Streifen (P1) der Erfassungsbereiche (C.1 - C.n) aktiviert werden.

21. Verfahren gemäß einem oder mehreren der vorstehenden Ansprüche, **dadurch gekennzeichnet, daß** die Anwesenheit und Position des durch die Sender-/Empfängerstation durchfahrenden Fahrzeuges erkannt werden, während die Anwesenheit von Antwortsignalen an dem Ausgang der Antennen (A.1 - A.n) für die besagte erkannte Position des Fahrzeuges analysiert wird, das Bild des besagten Fahrzeuges, insbesondere der Bereich des Nummernschildes, aufgezeichnet wird, wenn kein Antwortsignal an dem Ausgang der vorher genannten Antennen (A.1 - A.n) erfaßt wird oder wenn die Kommunikation durch Fehler beeinflußt wird.

22. Verfahren gemäß einem oder mehreren der vorstehenden Ansprüche, **dadurch gekennzeichnet, daß** die Aktivierungszeit der Antennen (A.1 - A.n) in einer solchen Weise ausgerechnet wird, daß zumindestens der Austausch von Daten bei zwei aufeinanderfolgenden Ereignissen innerhalb des Erfassungsbereiches (C.1 - C.n) der selben Antennen (A.1 - A.n) sichergestellt ist.

23. Verfahren gemäß einem oder mehreren der vorstehenden Ansprüche, **dadurch gekennzeichnet, daß** die an-Bord-Einheit (3) mit allen Antennen (A. 1 - A.n) der zwei Streifen (P1, P2) von Erfassungsbereichen (C.1 - C.n) kommunizieren kann, in deren Erfassungsbereich (C.1 bis C.2) sie während der Durchfahrt durch die feste Sender-/Empfängerstation gefunden werden können.

24. Verfahren gemäß einem oder mehreren der vorstehenden Ansprüche, **dadurch gekennzeichnet, daß** es zur automatischen Erkennung mit Datenaustausch für Fahrzeuge oder Pakete, Güter oder andere auf Fördermitteln sich bewegende Körper genutzt wird, z. B. zur Überwachung und Abfertigung zu verschiedenen Station durch Fördermittel oder Bewegungslinien in Installationen eines industriellen Typs wie diejenigen zur Verarbeitung und zum Handling von Gütern, jede an-Bord-Einheit (3) dabei verbunden ist mit jedem Paket, Stück oder Körper, der bewegt wird.

25. Verfahren gemäß einem oder mehreren der vorstehenden Ansprüche, **dadurch gekennzeichnet, daß** es zur automatischen Erfassung mit Datenaustausch z. B. für die Überwachung und die Abfertigung von Gütem, Paketen, Stücken oder anderen Typen von Körpern eingesetzt wird, die auf Förderlinien, in der Güterbewegung oder -Verarbeitung der Installationen genutzt wird.

Revendications

1. Système pour la détection automatique de véhicules en mouvement, avec échange automatique de données, et en particulier avec imputation automatique de taxes, comprenant :

- au moins une station émettrice-réceptrice automatique fixe (P1, P2) qui est munie de moyens locaux de traitement et de commande (1) pour des procédures d'émission et de réception et pour l'identification des utilisateurs et le calcul de taxes à imputer à chaque utilisateur identifié, cette station fixe (P1, P2) se trouvant en un point spécifique sur une autoroute;
- une unité émettrice-réceptrice embarquée (3) pour chaque véhicule, cette unité embarquée (3) étant munie de moyens de traitement et de commande (10) pour les procédures d'émission et de réception, et de moyens (4) pour identifier l'utilisateur ou le véhicule, et de moyens (4, 11) pour enregistrer la taxe imputée;
- la station fixe (P1, P2) et chaque unité embarquée (3) étant capables d'effectuer une communication bidirectionnelle, à la demande de la station fixe (P1, P2), par l'échange de données, concernant par exemple l'utilisateur et la taxe imputée, pendant le passage de l'unité embarquée (3) à travers la zone de l'autoroute qui est couverte par le champ d'action (C.1 - C.n) d'au moins une antenne (A.1 - A.n) de la station fixe (P1, P2);
- la station émettrice-réceptrice fixe (P1, P2) ayant un ensemble d'antennes émettrices-réceptrices (A.1 - A.n) disposées au-dessus de l'autoroute et dirigées vers elle, à une hauteur supérieure à la hauteur maximale des véhicules, ces antennes (A.1 - A.n) étant réparties transversalement par rapport à l'autoroute et étant réalisées d'une manière telle que chacune d'elles génère une zone de couverture limitée (C.1 - C.n) sur l'autoroute, au-dessous d'elle, la communication n'étant possible qu'avec l'antenne correspondante (A.1 - A.n) à l'intérieur de chacune des zones de couverture (C. 1 - C.n), ces zones de couverture (C.1 - C.n) étant disposées côte à côte dans la direction transversale par rapport à l'autoroute;
- les moyens de traitement et de commande (1) étant capables de traiter séparément les signaux de réception et d'émission de chaque antenne (A.1 - A.n);
- les moyens locaux de traitement et de commande (1) comportant des seconds moyens de commande (21, 421, 21', 421') qui activent en alternance, pendant un demi-cycle d'une période d'activation globale, deux groupes d'anten-

nes (A.2n-1, A.2n) parmi les antennes (A.1 - A.n), les antennes (A.2n-1, A.2n) étant associées à deux rangées de zones de couverture alignées sur le même axe d'émission-réception de l'autoroute (C.2n-1, C.2n), qui sont alignées transversalement par rapport à l'autoroute, les zones de couverture (C.2n-1) d'un groupe d'antennes (A.2n-1) étant disposées en alternance avec les zones de couverture (C.2n) de l'autre groupe d'antennes (A.2n); caractérisé en ce que :

- chaque zone de couverture (C.1 - C.n) a une largeur et une longueur qui sont relativement faibles par rapport aux dimensions en plan des véhicules, et qui sont telles que chaque zone de couverture ne contienne pas plus d'une unité embarquée (3) à la fois et, par conséquent, ne communique pas avec plus d'une unité embarquée (3) à la fois;
- la station émettrice-réceptrice (P1, P2) et les unités embarquées (3) comportent des moyens émetteurs-récepteurs (20, 120, 220, 26, 27; 7, 8) capables d'émettre et de recevoir à deux fréquences différentes, ces deux fréquences étant réparties de façon alternée entre les antennes (A.2n-1, A.2n) dans chaque groupe d'antennes (A.2n-1, A.2n);
- les deux fréquences sont réparties parmi les antennes (A.2n-1, A.2n) des deux groupes d'une manière telle que chaque antenne (A.2n-1) d'un groupe associé à une fréquence soit adjacente à une antenne (A.2n) de l'autre groupe associée à la même fréquence;
- la station émettrice-réceptrice (P1, P2) comporte deux émetteurs-récepteurs (26, 27), chacun d'eux fonctionnant à une fréquence différente, et les antennes (A.2n-1, A.2n) de chacun des deux groupes étant connectées de manière alternée à chacun des émetteurs-récepteurs.

2. Système selon la revendication 1, caractérisé en ce que les zones de couverture (C.1 - C.n) sont de forme elliptique et sont orientées avec leurs grands axes parallèles à l'axe longitudinal de l'autoroute, tandis que leurs petits axes sont mutuellement alignés, transversalement par rapport à l'autoroute, les centres des deux zones de couverture adjacentes (C.n, C.n+1) étant mutuellement espacés d'une distance inférieure à la longueur de leur petit axe.

3. Système selon les revendications 1 ou 2, caractérisé en ce que les moyens locaux de traitement et de commande (1) comportent des moyens (21, 21', 421, 421', 121, 121') pour analyser les signaux de réponse provenant des unités embarquées (3), avec un contrôle du caractère correct de ces signaux, du point de vue formel, de façon que, dans l'éventualité extrêmement rare où deux unités embarquées (3) entrent en conflit à l'intérieur d'une seule zone de couverture (C.1 - C.n) d'une antenne (A.1 - A.n), il soit possible de permettre à l'une des deux unités embarquées (3) de communiquer lorsque le brouillage qui est dû à la seconde unité embarquée (3) est à un niveau tel qu'il ne compromet pas l'intelligibilité du signal de réponse provenant de la première unité embarquée (3), tandis que la communication est bloquée pour les deux unités embarquées (3) lorsque les signaux de réponse qui proviennent des deux unités embarquées (3) sont indéchiffrables.

4. Système selon une ou plusieurs des revendications précédentes, caractérisé en ce que chaque station comprend deux jeux d'antennes (A.1 - A.n) qui sont disposés avec un espace entre eux dans la direction de transit, et dont les zones de couverture (C.1 - C.n) forment deux bandes de zones de couverture mutuellement espacées dans la direction de transit, tandis que la radiocommunication entre une unité embarquée (3) et la station émettrice-réceptrice a lieu en deux phases séparées au point de vue chronologique, à savoir une pour chaque bande de zones de couverture (C.1 - C.n), les dimensions (L1, L2) des zones de couverture (C.1 - C.n) et les intervalles de temps d'activation étant adaptés aux durées minimales nécessaires pour l'exécution de la transmission par radio de données seulement, à une vitesse de transit maximale prédéterminée, les procédures internes de la station émettrice; réceptrice et de l'unité embarquée (3) étant exécutées dans l'intervalle de temps entre les deux bandes de zones de couverture (C.1 - C.n) et avant la première bande de zones de couverture (C.1 - C.n), les deux bandes de zones de couverture (C.1 - C.n) étant mutuellement espacées (L12), au moins conformément aux durées nécessaires pour l'exécution des procédures internes.

5. Système selon une ou plusieurs des revendications précédentes, caractérisé en ce que les antennes (A.1 - A.n) sont de type parabolique avec une base elliptique, et elles forment un lobe principal (à -3 dB) avec un gain élevé correspondant à la zone de couverture associée (C.1 - C.n) et des lobes secondaires, éventuellement, à un niveau très faible.

6. Système selon une ou plusieurs des revendications précédentes, caractérisé en ce que les dimensions principales des zones de couverture (C.1 - C.n) s'étendent dans un plan horizontal (I) à un niveau (L4), par exemple 1 m, qui est estimé être le niveau moyen des unités embarquées (3), au-dessus de l'autoroute.

7. Système selon une ou plusieurs des revendications précédentes, caractérisé en ce que pour une vitesse maximale de 120 km/h parallèlement à l'axe de l'autoroute, et une vitesse maximale d'environ 20 km/h dans une direction transversale par rapport à la route, et une durée maximale de communication de 15 ms, les zones de couverture des bandes individuelles ont des grands axes (L1) de 1,5 m, des petits axes (L2) de 0,5 m et un écartement entre centres (L3) de 0,375 m, tandis que les deux bandes sont mutuellement espacées d'au moins 10 m.

8. Système selon une ou plusieurs des revendications précédentes, caractérisé en ce que les unités embarquées (3) comportent un dispositif d'activation (6) qui active les unités immédiatement avant l'entrée dans les bandes de zones de couverture (C.1 - C.n) sous l'effet d'un ordre donné par la station émettrice-réceptrice (P1, P2), une bande de zones de couverture (CT) qui est produite par au moins une antenne d'activation (AT) associée aux antennes (A.1 - A.n) et fonctionnant à une fréquence différente de celles-ci, étant placée avant chaque bande de zones de couverture (C.1 - C.n), tandis que les moyens locaux de traitement et de commande (1) comportent un système de commande (321, 321') et des moyens émetteurs (28) qui sont connectés aux antennes d'activation (AT).

9. Système selon une ou plusieurs des revendications précédentes, caractérisé en ce que les moyens locaux de traitement et de commande (1) comportent des moyens (21, 21') capables de déterminer la position de l'unité embarquée, conformément à l'antenne (A.1 - A.n) avec laquelle elle a communiqué.

10. Système selon une ou plusieurs des revendications précédentes, caractérisé en ce que la station émettrice-réceptrice est équipée de moyens optiques (37) pour détecter la présence d'un véhicule et pour identifier la position, connectés à des moyens (22) destinés à corréler la position détectée par les moyens optiques (37) avec celle qui est trouvée au moyen de l'antenne (A.1 - A.n) avec laquelle l'unité embarquée (3) correspondante est entrée en communication.

11. Système selon la revendication 10, caractérisé en ce que les moyens optiques (37) comprennent un ensemble de caméras de télévision (31), de préférence du type à balayage linéaire, qui sont connectées à des moyens de commande (32) et des moyens de traitement d'image (33), les caméras de télévision (31) étant disposées en alignement mutuel, dans une orientation transversale par rapport à l'autoroute, et parallèlement aux zones de couverture (C.1 - C.n) des antennes (A.1 - A.n), et avec leurs axes optiques (0) suffisamment espacés les uns des autres pour obtenir une résolution de mesure maximale (L17) inférieure au petit axe de la zone de couverture (C.1 - C.n), cet espacement étant de préférence de 0,25 m, tandis que les champs de cadrage des caméras de télévision (31) sont disposés immédiatement avant les zones de couverture (C.1 - C.n) des antennes (A.1 - A.n).

12. Système selon la revendication 11, caractérisé en ce que les caméras de télévision (31) sont associées à la seconde bande (P2) de zones de couverture (C.1 - C.n).

13. Système selon une ou plusieurs des revendications précédentes, caractérisé en ce qu'il comprend des moyens optiques/ électroniques (38) pour enregistrer des images de véhicules qui traversent illégalement la station émettrice-réceptrice (P1, P2), ou sans l'exécution d'un échange de données correct avec les unités embarquées (3) des véhicules.

14. Système selon la revendication 13, caractérisé en ce que les moyens optiques/électroniques (38) pour enregistrer des images de véhicules en transit comprennent une ou plusieurs caméras de télévision (35) qui sont pointées dans la direction de transit des véhicules, vers les bandes (P2) de zones de couverture (C.1 - C.n), et dont le champ de cadrage (135) est établi de façon à s'étendre avant les zones de couverture (C.1 - C.n), ces caméras de télévision (35) étant connectées à une unité (36) qui est destinée à la commande et à l'enregistrement des images captées, qui est commandée par les moyens (1, 21', 22, 33) corrélant les positions déterminées par les moyens optiques (37) de détection de la présence et d'identification de la position des véhicules, et au moyen de l'antenne (A.1 - A.n) se trouvant à la position considérée, conformément à la détection ou à l'absence de détection des signaux de réponse provenant d'une unité embarquée (3), au moyen de ces antennes (A.1 - A.n).

15. Système selon une ou plusieurs des revendications précédentes, caractérisé en ce que la station émettrice-réceptrice (P1, P2) est de structure modulaire, les antennes (A.1 - A.n) et les antennes d'activation (AT) étant réparties sur un ensemble de panneaux (25) ayant chacun un nombre identique d'antennes (A.1 - A.8), tandis que les moyens locaux de traitement et de commande (1) sont du type extensible, basé sur des cartes, et ils ont une unité de commande (21, 21') qui est conçue pour commander un nombre extensible spécifique de panneaux d'antennes (25), chaque panneau d'antennes (25) étant associé à son propre système émetteur-récepteur (20, 120, 220, 26, 27, 28).

16. Système selon une ou plusieurs des revendications précédentes, caractérisé en ce que les moyens locaux de traitement et de commande (1) ont une unité de commande de station (22) équipée de moyens de communication (24, 2) avec un processeur central (15), et de moyens de communication avec les moyens de commande (21, 21', 20) des antennes (A.1 - A.n), avec les moyens optiques (37) destinés à détecter la présence et à identifier la position de véhicules, et avec les moyens optiques/électroniques (38) pour l'enregistrement d'images, ainsi qu'avec des unités de signalisation et d'autres dispositifs auxiliaires (30) de station, tels que des barrières, pour les deux groupes, de manière que la zone de couverture (C.2n-1) relative à l'antenne (A. 2n-1) de l'un des deux groupes fonctionne à la même fréquence que la zone de couverture immédiatement adjacente (C.2n) relative à l'antenne (A.2n) de l'autre groupe d'antennes.

17. Un procédé de détection automatique de véhicules en mouvement, avec échange automatique de données, dans un système pour la détection automatique de véhicules en mouvement, avec échange automatique de données, entre une station émettrice-réceptrice fixe (P1, P2) et une unité embarquée (3) pour chaque véhicule, conforme à une ou plusieurs des revendications précédentes, dans lequel :

- on spécifie une subdivision d'une bande de zones de couverture en zones de couverture individuelles (C.1 - C.n) d'antennes (A.1 - A.n), pour la communication avec une unité embarquée (3);
- la communication entre chaque antenne (A.1 - A.n) et l'unité embarquée (3) dans la zone de couverture des antennes (C.1 - C.n) est traitée séparément de celle qui a lieu entre d'autres unités embarquées (3) et d'autres antennes (A. 1 - A.n);
- les antennes (A.1 - A.n) sont divisées en deux groupes (A.2n-1, A.2n), chacun de ces groupes formant deux rangées de zones de couverture (C.2n-1, C.2n), alignées sur le même axe transversal de la route, les zones de couverture (C. 2n-1) de l'un des deux groupes (A.2n-1) étant disposées en alternance avec celles (C.2n) de l'autre groupe (A.2n), tandis que les antennes (A.2n-1) d'un groupe sont activées pour la radiocommunication en alternance avec celles (A.2n) de l'autre groupe, dans chaque cas pendant un demi-cycle de la période d'activation globale; caractérisé en ce que :
- chaque zone de couverture (C.1 - C.n) a des dimensions notablement inférieures à celles des véhicules, et telles que chaque zone de couverture contienne, statistiquement, une seule unité embarquée (3);
- les antennes (A.2n-1, A.2n) de chaque groupe utilisent deux fréquences de réception/émission différentes, ces fréquences étant réparties, dans chaque groupe, de façon alternée entre les antennes correspondantes (A.2n-1, A.2n), tandis que la station fixe et les unités embarquées (3) sont du type capable d'émettre et de recevoir à ces deux fréquences;
- les deux fréquences sont réparties de façon alternée entre les antennes (A.2n-1, A.2n) des deux groupes, d'une manière telle que la zone de couverture (C.2n-1) relative à l'antenne (A. 2n-1) de l'un des deux groupes fonctionne à la même fréquence que la zone de couverture immédiatement adjacente (C.2n) relative à l'antenne (A.2n) de l'autre groupe d'antennes.

18. Procédé selon la revendication 17, caractérisé en ce que si deux unités embarquées (3) sont présentes dans une seule zone de couverture (C.1 - C.n) d'une antenne (A.1 - A.n), l'une des unités embarquées (3), c'est-à-dire celle dont le signal de réponse est correctement intelligible et est à un niveau supérieur, est autorisée à communiquer, lorsque les deux signaux sont suffisamment différents l'un de l'autre.

19. Procédé selon une ou plusieurs des revendications précédentes, caractérisé en ce que la transmission de données est exécutée en deux phases, chacune d'elles ayant lieu dans une bande (P1, P2) de zones de couverture (C.1, C.2) parmi au moins deux bandes successives (P1, P2) de zones de couverture (C.1 - C.n) mutuellement espacées dans la direction de transit, tandis que la distance (L12) entre les deux bandes est déterminée conformément à la durée nécessaire pour l'exécution des procédures internes de la station émettrice-réceptrice et des unités embarquées (3), et conformément à la vitesse de transit maximale.

20. Procédé selon une ou plusieurs des revendications précédentes, caractérisé en ce que les unités embarquées (3) sont activées par la station émettrice-réceptrice avant la première bande (P1) de zones de couverture (C.1 - C.n).

21. Procédé selon une ou plusieurs des revendications précédentes, caractérisé en ce que la présence et la position du véhicule qui traverse la station émettrice-réceptrice sont détectées, tandis que la présence de signaux de réponse à la sortie des antennes (A.1 - A.n) pour la position détectée du véhicule est analysée, l'image de ce véhicule, en particulier l'image de la région de la plaque d'immatriculation, étant enregistrée lorsque aucun signal de réponse n'est détecté à la sortie des antennes précitées (A. 1 - A.n), ou lorsque la communication est affectée par des erreurs.

22. Procédé selon une ou plusieurs des revendications précédentes, caractérisé en ce que la durée d'activation des antennes (A.1 - An) est calculée de manière à garantir au moins l'échange de données à deux occasions consécutives à l'intérieur de la zone de couverture (C.1 - C.n) des mêmes antennes (A. 1 - A.n).

23. Procédé selon une ou plusieurs des revendications précédentes, caractérisé en ce que les unités embarquées (3) peuvent communiquer avec toutes les antennes (A.1 - A.n) des deux bandes (P1, P2) de zones de couverture (C.1 - C.n), dans les zones de couverture (C.1 - C.n) dans lesquelles elles se trouvent au cours de leur passage à travers la station émettrice-réceptrice fixe.

24. Procédé selon une ou plusieurs des revendications précédentes, caractérisé en ce qu'il est utilisé pour la détection automatique, avec échange de données, de paquets, de marchandises ou d'autres corps mobiles sur des moyens convoyeurs, par exemple pour le contrôle et la distribution à diverses stations par des lignes de convoyeur et de déplacement dans des installations de type industriel, comme celles prévues pour le traitement ou la manipulation de marchandises, chaque unité embarquée (3) étant associée à chaque paquet, pièce ou corps qui est transporté.

25. Procédé selon une ou plusieurs des revendications précédentes, caractérisé en ce qu'il est utilisé pour la détection automatique, avec échange de données, par exemple pour contrôler et distribuer des marchandises, des paquets, des pièces ou d'autres types de corps transportés sur des lignes de convoyeur, dans une installation de traitement ou de transport de marchandises.

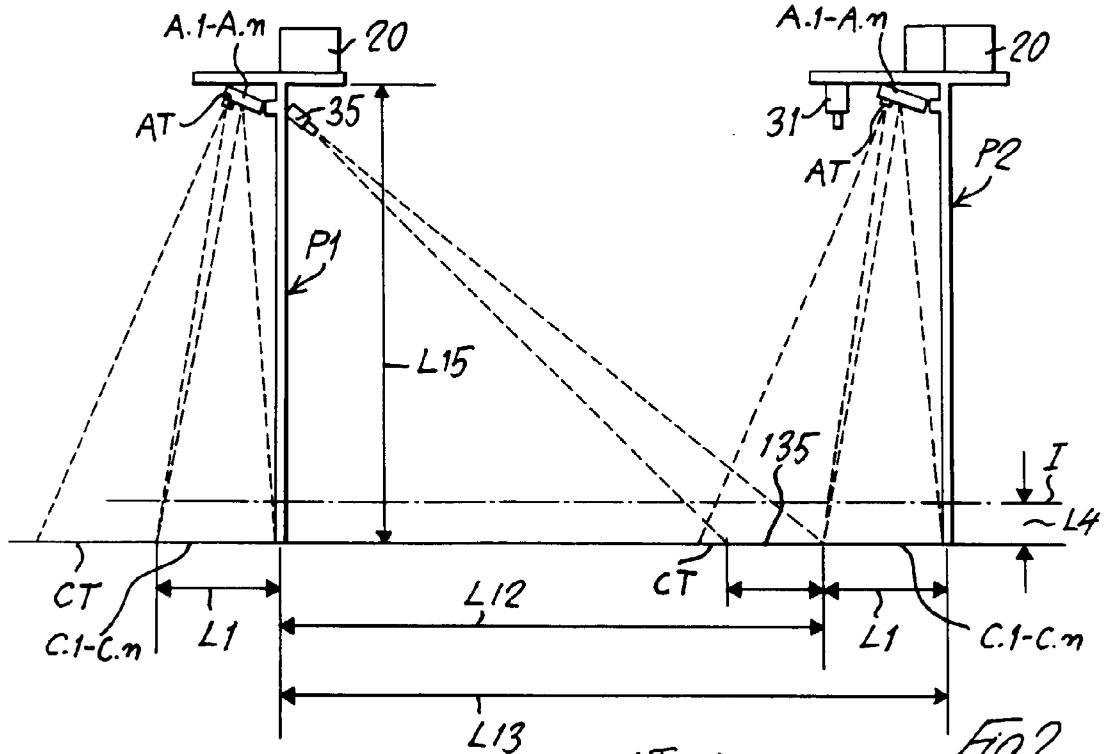
A.1-A.n
20
AT
35
A.1-A.n
20
31
AT
P2
P1
L15
135
I
L4
CT
C.1-C.n
L1
L12
CT
L1
C.1-C.n
L13

Fig.2

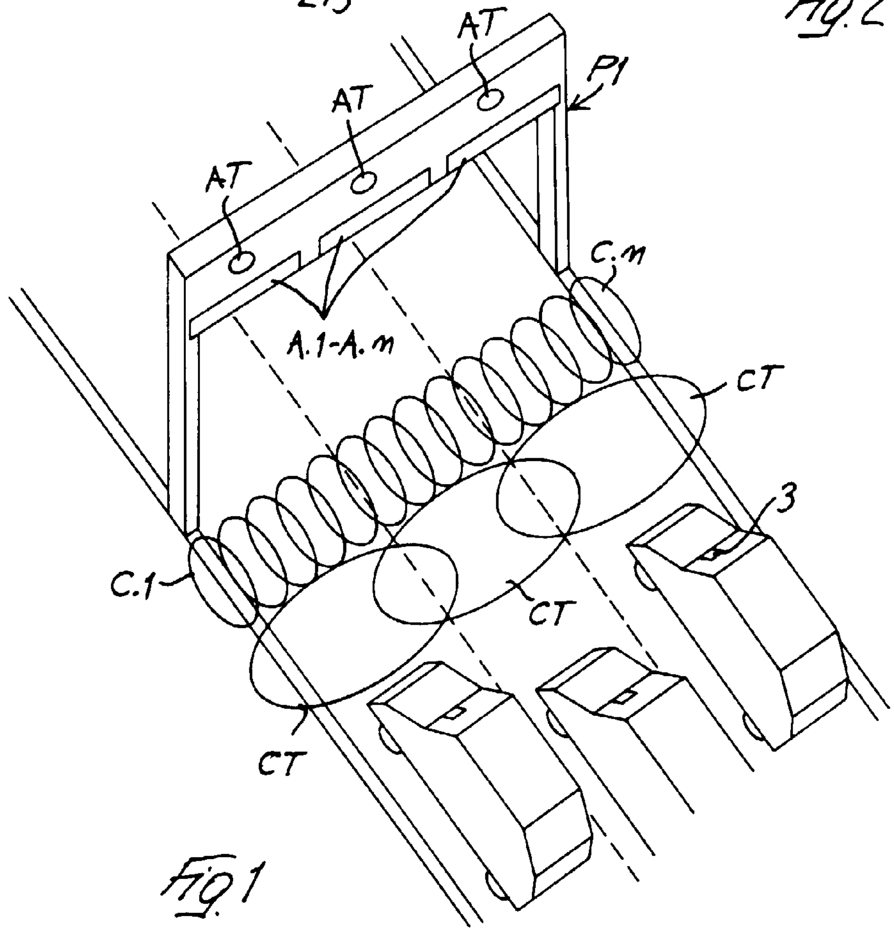
AT
P1
AT
AT
C.n
A.1-A.n
CT
3
C.1
CT
CT

Fig.1

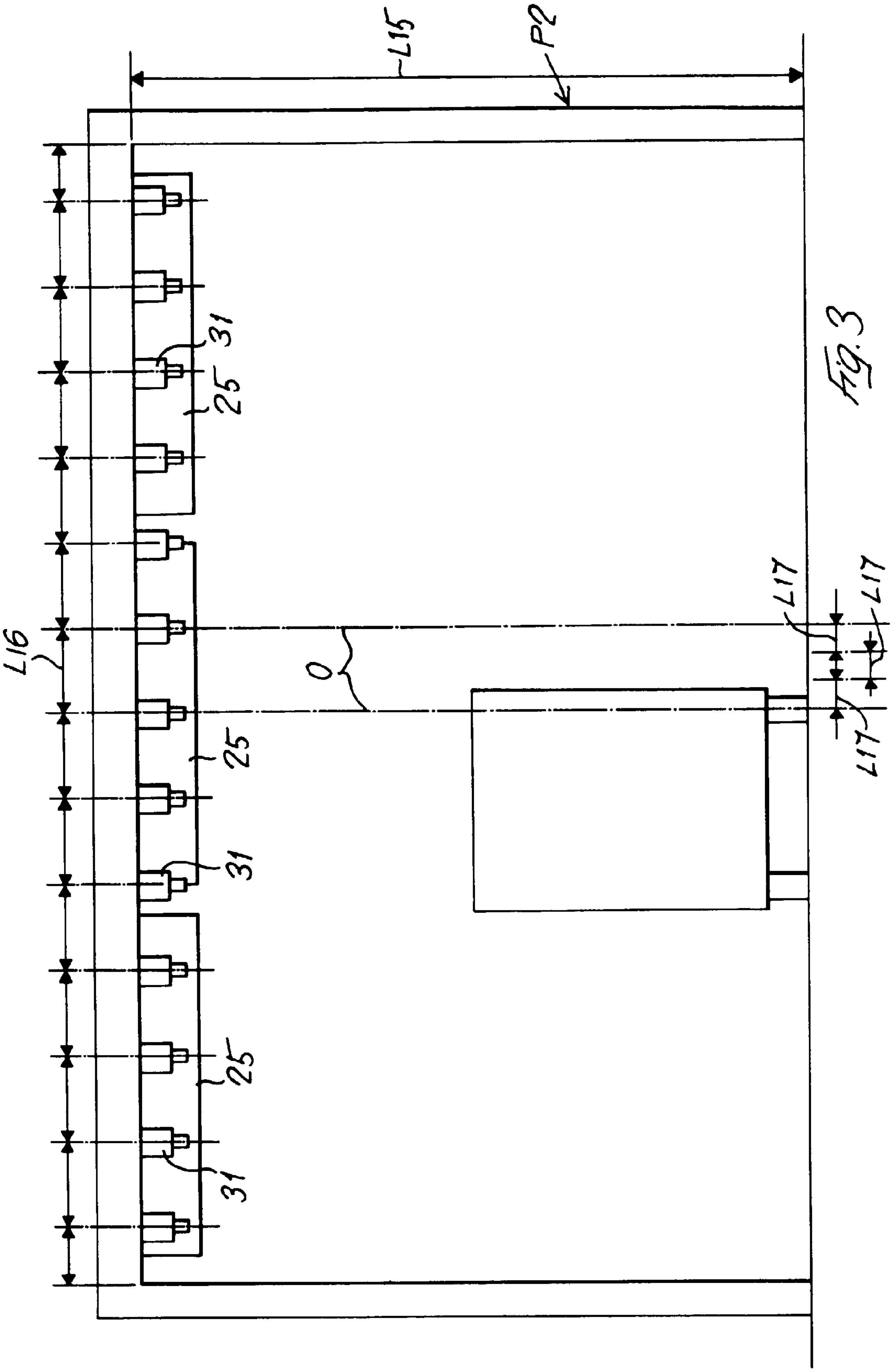

Fig. 3

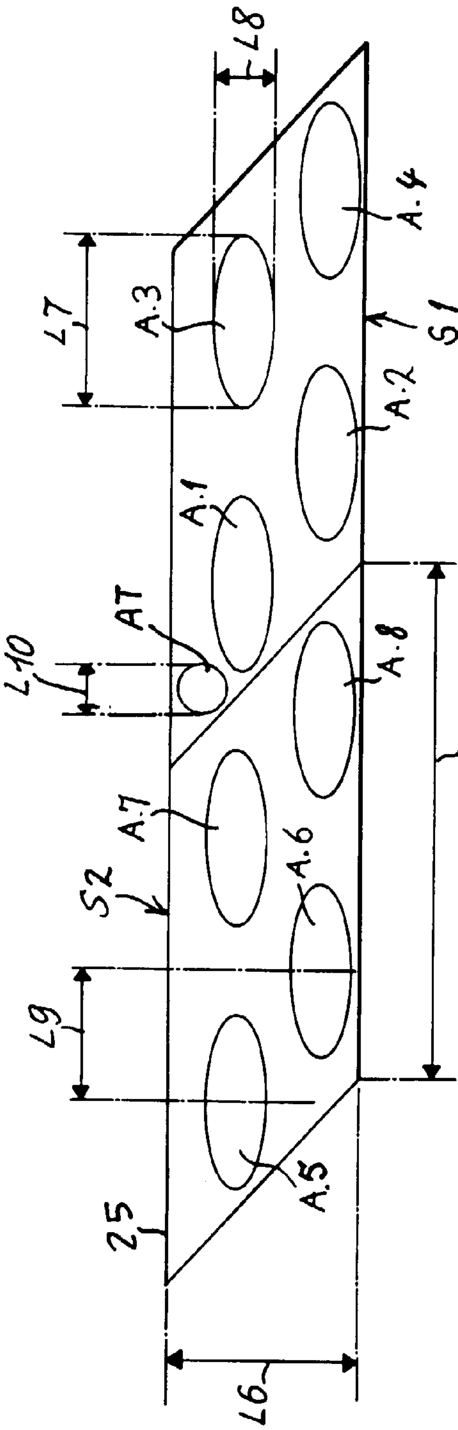
L8
L7
A.3
A.4
S1
A.2
A.1
AT
L10
A.8
L5
A.7
A.6
S2
L9
A.5
25
L6

Fig.4

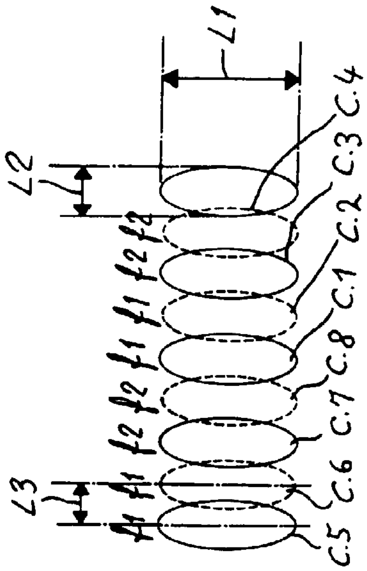
L1
L2
L3
C.4
C.3
C.2
C.1
C.8
C.7
C.6
C.5

Fig.5

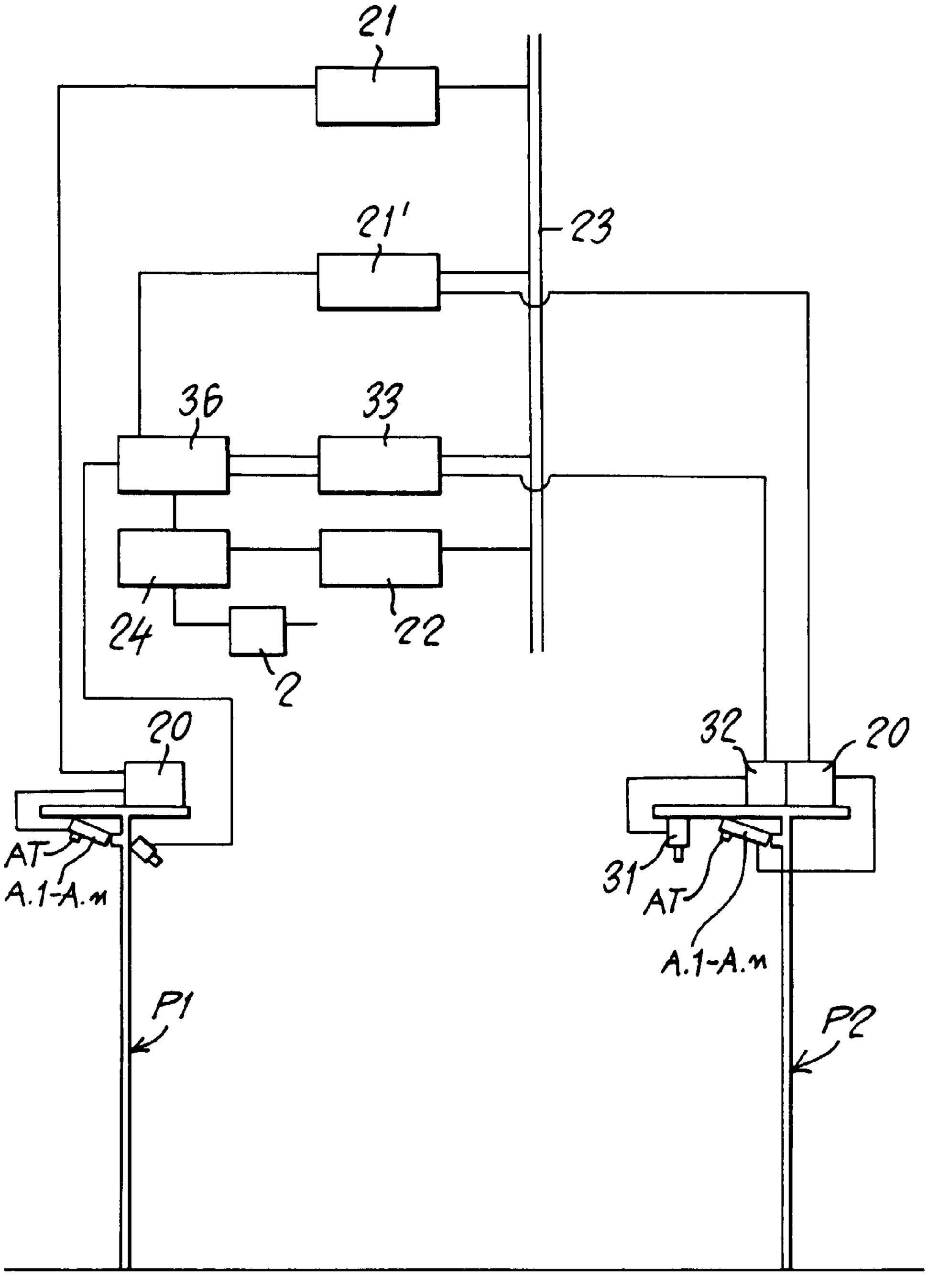

Fig. 6

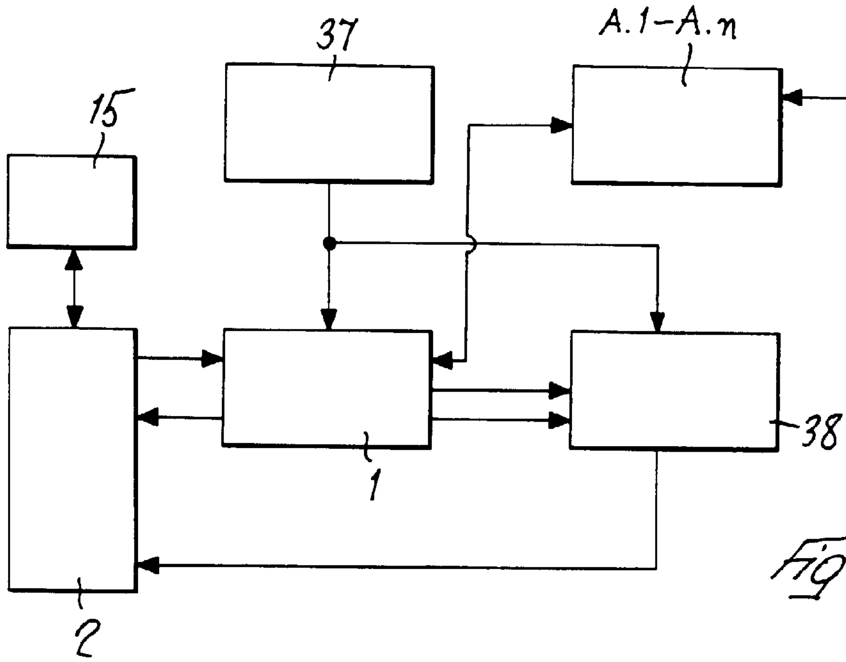

Fig. 7

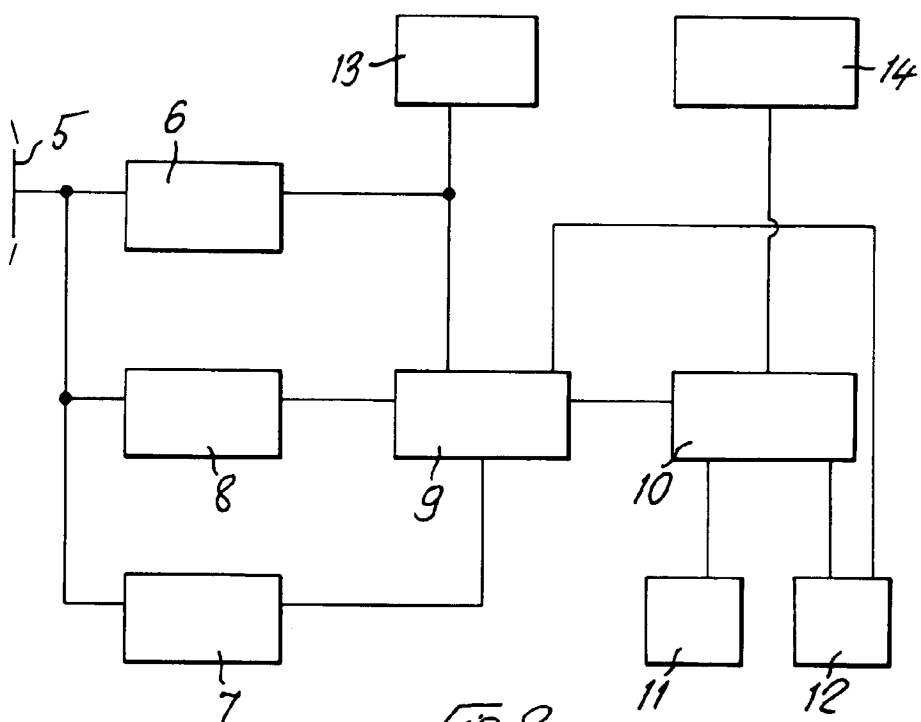

Fig. 8

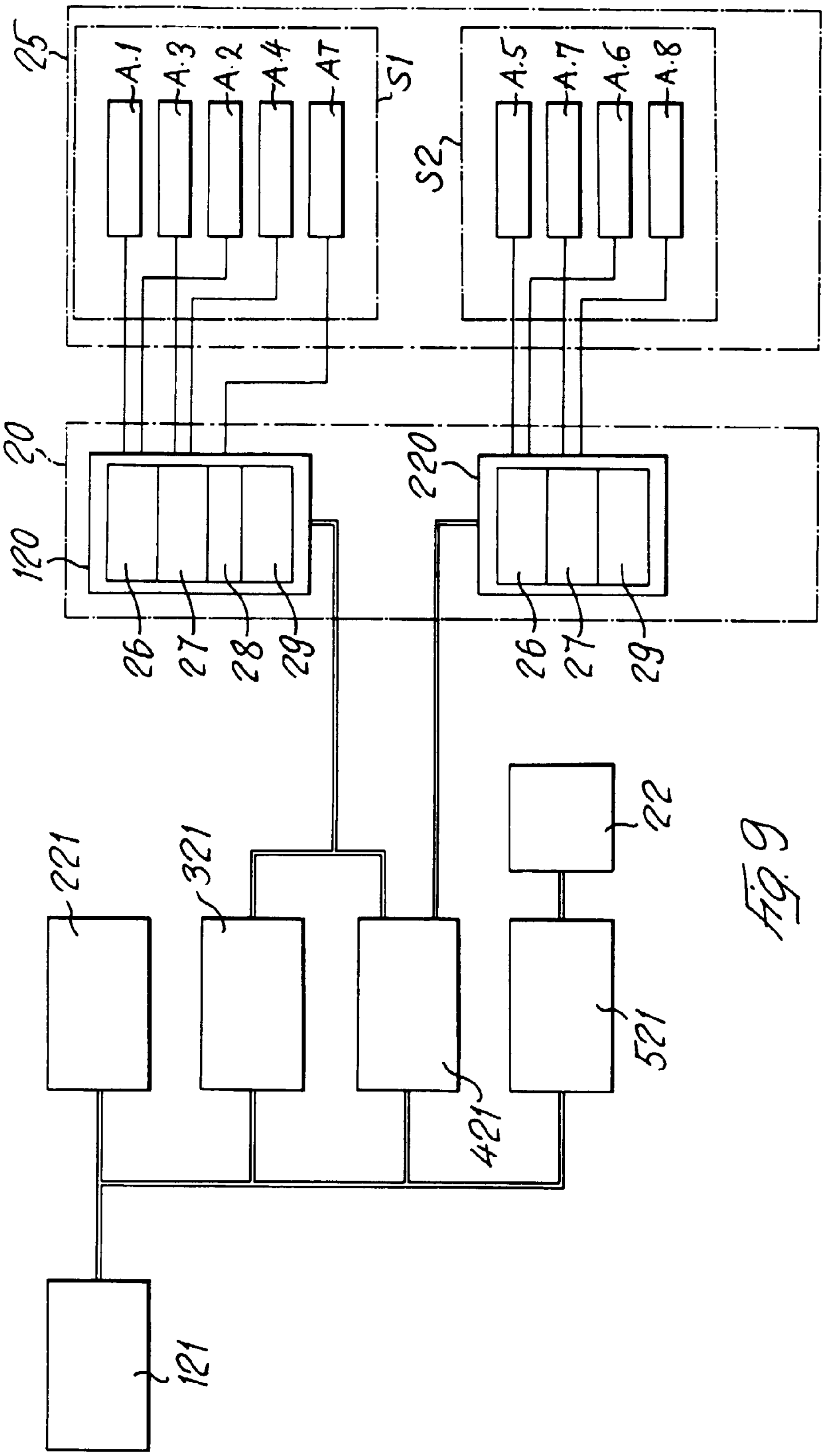
25
A.1
A.3
A.2
A.4
AT
S1
S2
A.5
A.7
A.6
A.8
20
120
220
26
27
28
29
26
27
29
221
321
421
521
22
121

Fig. 9

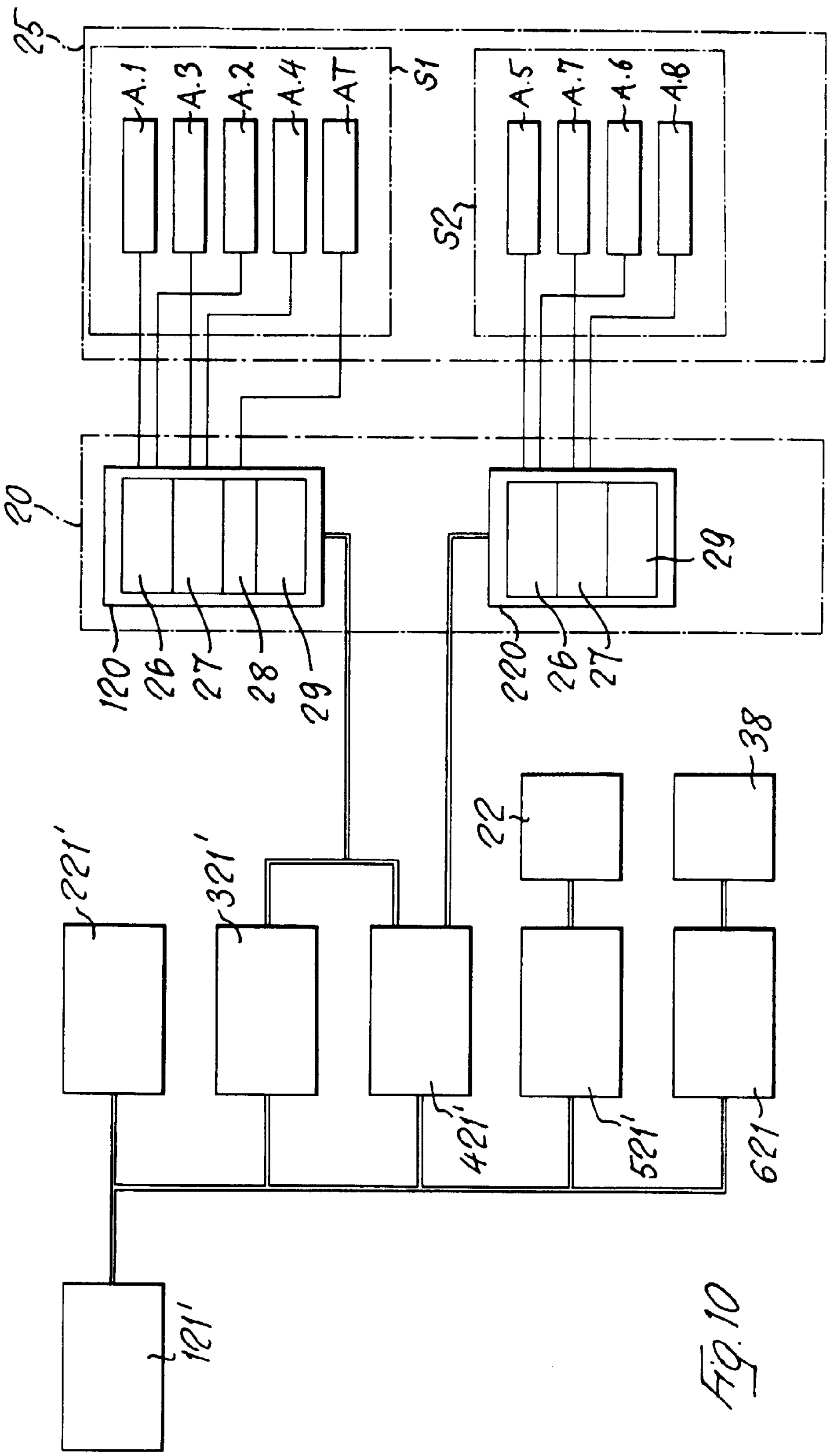
25
S1
A.1
A.3
A.2
A.4
AT
S2
A.5
A.7
A.6
A.8
20
120
26
27
28
29
220
26
27
29
22
38
221'
321'
421'
521'
621'
121'

Fig.10

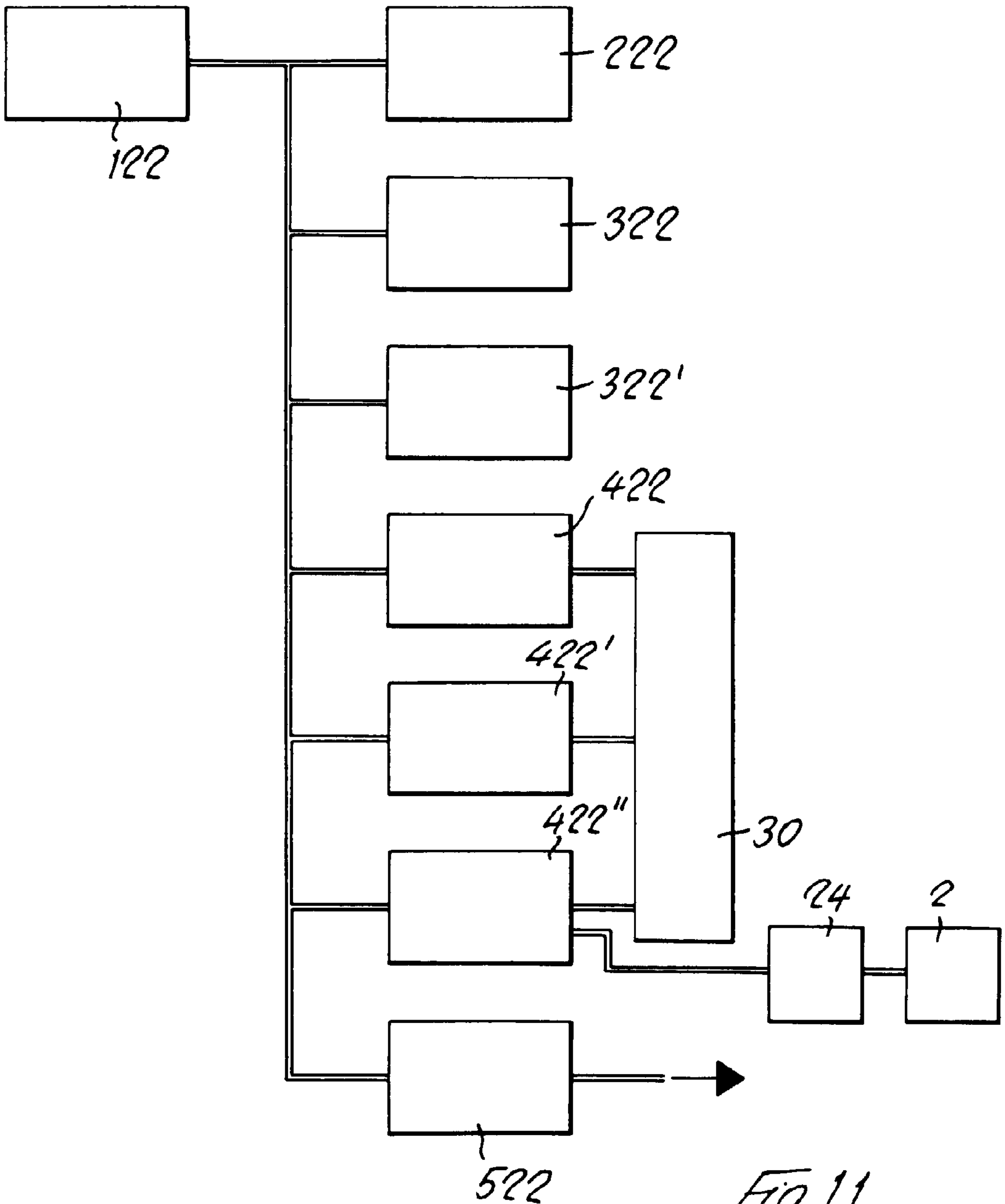

Fig. 11

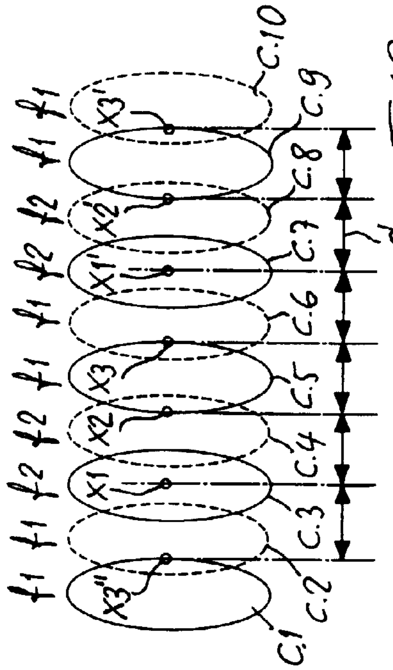

Fig. 12

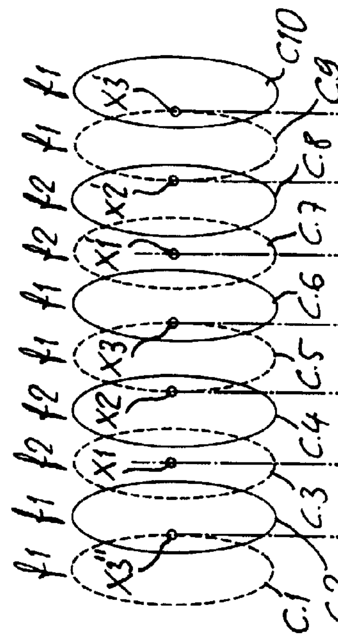

Fig. 13

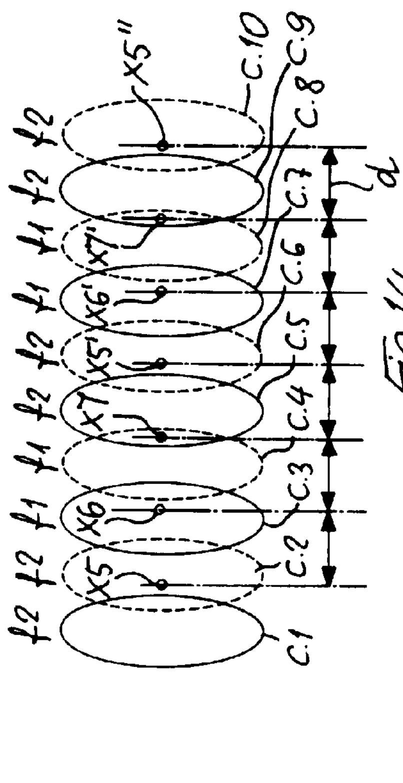

Fig. 14

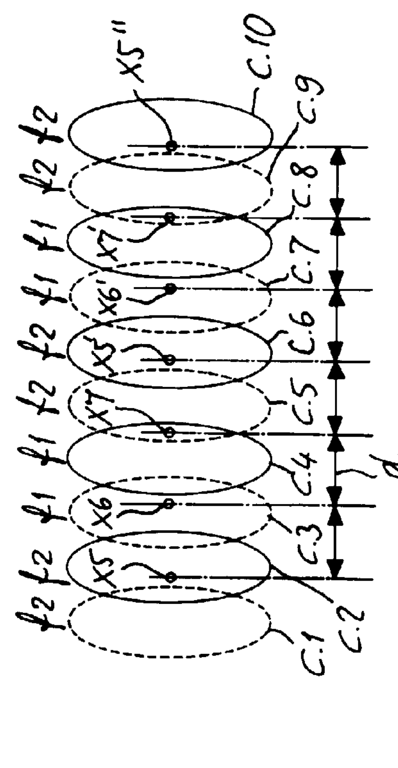

Fig. 15