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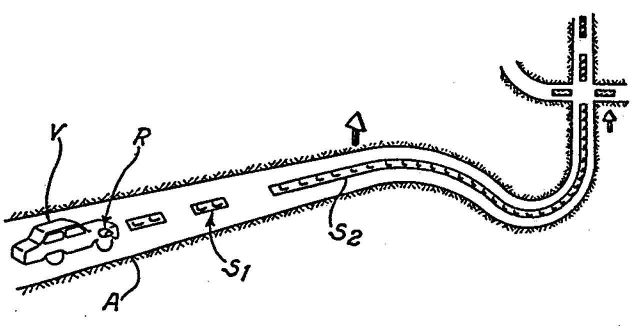
(54) **System for providing information to the vehicles' driver, including a coding and decoding system.**

(57) A road-marking strip and a road marking system with this strip for providing information to motorists on the road. The system includes the combination of transmitting and receiving active electronic components, typically "secondary radar" aboard the vehicle and designed for emitting energy in the direction of travel along the road, passive components which are located beneath the prefabricated strip and designed for returning said energy to the receiving components on board of the vehicle, and horizontal road-marking light-reflective components also formed on that strip and designed for positively providing optical information to the motorist; in a system as above an automatic arrangement for coding and decoding the provided information, operated in conjunction with active electronic components on a vehicle and including synchronizing marking components, key marking components and code marking components positioned on the marking one after another.



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SYSTEM FOR PROVIDING INFORMATIONS TO THE VEHICLES' DRIVER, INCLUDING A CODING AND DECODING SYSTEM

BACKGROUND OF THE INVENTION

The present invention refers to a system which in its entirety is formed by the cooperative combination of a plurality of active and, respectively, passive electronic components, jointly fitted for positively providing an electromagnetic information, and of horizontal markings, suited for positively providing an optical information. The present invention also concerns a method for carrying out road markings.

It is known that, due to the increase of traffic and the trend to raise the average speed of the vehicles, the problems related to the road markings, which serve to provide complete information from the road to the vehicles' drivers, are evermore heavier. It is believed that it is necessary to systematically provide for such information to the drivers for improving the completeness and the reliability of the data which are to be supplied to the vehicles' drivers, for example for timely warning them about approaching dangerous crossings and/or potentially dangerous road sections, and so on.

Such problems are well far of being solved, notwithstanding the plurality of proposals and attempts made. According to some widely considered proposals, this problem is at the present time faced by anticipating the installation of active transmitter components, located at about the critical section of the thoroughfare road and designed for supplying to receiving components arranged aboard the vehicles the required data of information.

This mode of solving the above problems is complicated and extremely costly, either because of the number of the active components, which are necessary to cover and protect the critical spots and situations, or because of the necessity of uninterrupted operation, or the necessity of installation of feeding and control means. It is evident that the absence or defective reception of a critical signal could lead to serious crashes.

On the other hand, it is acknowledged that the current road markings, either the vertical ones or even more efficient horizontal markings, are well far from providing in a proper manner the solution of the above problem. The present markings, or road signalization systems, except of the substantially uncommon acoustical signals, are exclusively dependent upon the sight detection of the signals and upon the fact that a constant attention must be paid by a driver to the direction of travel. This sight detection is affected by the visibility conditions which are influenced by seasonal and weather factors, and therefore it is essential to provide the vehicles with means suitable for receiving, decoding and signalling to the driver (and/or to the vehicle instruments) road data which at the present time are assumed to be important for the safety of the vehicle traffic.

Marking strips which are normally used for delineating the edges or sides of roads and highways are very important for traffic safety. These marking strips are normally either white or yellow in color and form an uninterrupted line along the edge of the road or highway, thereby providing a motorist with a good reference point for maintaining the proper distance of the vehicle from the edge of the road. When the weather conditions are particularly bad, however, as in the case of fog, these strips are practically useless.

The applicant has developed a road marking strip including optical and electromagnetic elements, capable therefore to give to the vhicles' driver optical and electromagnetic informations concerning the road situation.

For said invention a Patent has been granted in the UK (No. 2. 050.769 of 24th August 1983), in Belgium (No. 883.208 of 30th May 1980), in Switzerland (No. 641.585 of 29th February 1984), in Canada (No. 1.149.491 of 5th July 1983), in Spain (No. 491. 399 of 16th February 1981), while the application is pending in many other countries.

SUMMARY OF THE INVENTION

Object of this invention is to provide an improved road marking strip situated at the edge of the road and a road surface marking system in conjunction with a device emitting electronic energy assembled aboard a vehicle.

A further object is an automatic system fitted for positively providing the driver of a motor vehicle with traffic informations by means of microwaves reflectors.

The microwave reflectors are arranged and appropriately combined below the road marking tape, one after the other, - following the direction of the course of the vehicles.

In order to provide such information the vehicle is equipped with an electronic transmitting and receiving system radiating microwave energy in the direction of the road marking tape, the microwave energy being returned by means of the reflectors. The evaluation of the information received will be done by an associated microcomputer.

BRIEF DESCRIPTION OF THE DRAWING

Fig. 1 is a schematic top view of a roadway portion with a marking strip according to the invention attached thereto;

Fig. 2 schematically illustrates the strip S provided with a dipole D consisting of a thin pressworked aluminum plate;

Fig. 3 schematically illustrates a modified embodiment of the dipole, provided with a variable oscillating circuit D_S;

Fig. 4 diagrammatically and fragmentarily illustrates an embodiment of supplemental coding;

Fig. 5 diagrammatically illustrates a signal-transmitting and receiving system of the prior art;

Fig. 6 schematically illustrates a code marking system according to the invention;

Fig. 7 shows a graph of the flow of the output voltage in the direction of traveling ;

Fig. 8 shows graphs illustrating the operation of the Schmitt-trigger; and

Fig. 9 is a diagram showing a determination of the periodical time scale.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The road marking system and the road-marking strip will be explained with reference to Figs. 1-4. Vehicle V is provided with a known radar R which serves as an active component for emitting energy in the direction of travel along the road. The radar R comprises a dipole antenna secured below the same vehicle and arranged to receive information provided by dipoles D. The vehicle travels along the roadway A and follows the path defined and indicated by horizontal signalling means. The active component R is suitably computerized for decoding the informations provided by the waves reemitted by the dipoles positioned on the signalling strip S. This signalling strip can be either uninterrupted or arranged in sections spaced from one another, such as indicated at S_2 or respectively at S_1 for providing by itself the information that overtaking of the vehicle is prohibited, or, respectively, permitted. The corresponding information (an uninterrupted series of spaced signals) is transmitted to the vehicle by the computerized active component R.

A single dipole D is shown in Fig. 2. Dipole D may be formed of a thin aluminum plate which may be, for example, press-worked of aluminum strip or any other suitable material.

Dipoles located on the lower side of the prefabricated marking strip form a microwave system.

The dipoles, which are made of metal and are very thin, can either be incorporated in the body of the marking strip, glued to the lower side of the strip, or incorporated in the molten adhesive primer of the marking strip.

Roadway marking strips, which are designed for location along the sides of a road or highway, are generally laid down in an uninterrupted line and they are minimally disturbed by the passing traffic.

The transmitting and receiving antenna or antennas are mounted on the top or on the side of the vehicle. The results of the applicant's research are summed up in the following description of the electrical characteristics of a roadside marking strip and a system which provides the motorist with certain information through the use of special metallic reflectors, mounted under the strip, and a transceiver. It was discovered, first of all, that the best results were obtained by using the microwave band between 1 and 50 GHz. A continuous microwave signal is transmitted from the moving vehicle to the strip where it is reflected back by a system of metal reflectors located under the marking strip. The return signal is received by the moving vehicle and elaborated so as to provide the desired information. The information can be coded by appropriately spacing the metallic reflectors along the strip, as will be explained in detail below.

Fig. 4 illustrates an example of supplemental coding, in which differing series of signals, for example a uniform sequence, while differing groups of signals G_1, G_2 and G_3 have suitably coded meanings. The resonance circuit consisting of the dipoles reemits the energy in the form of a plurality of harmonics, the third one of which is preferably taken advantage of, because that third harmonics is the strongest one.

By giving to the antenna of the resonance circuit a dimension in proper relationship with the strip S_1 or S_2, which embodies within its layers the metal sheet dipoles, rather high frequencies are obviously able to be used.

For example, the transmitting-receiving assembly, that is the secondary radar R arranged on the vehicle and embodying the active component of the system, may be preferably used for transmission of microwaves between 0.6 and 1.2 GHz.

Practically, for the best results, the transmitting antenna of the secondary radar R and the resonance dipoles are arranged transversely to the signalling line. This fact sets up a limitation of the lowest frequency (a straight dipole 25cm long corresponds to a frequency of 600 MHz.) Such limitation does not exist for the high frequencies. Because of the higher costs, the greater sensitivity to humidity and the increase of the loss coefficients of the materials, the frequencies, which will be practically selected for the anticrash radar equipment, will establish the frequencies of the equipment under discussion. Just as an example, in conditions when a transmitter has a frequency of 1GHz and an output of 0.5 watt, a vehicle travels at a distance of 5m from the signalling strip, and at a speed of 20 km/h, and in condition of dry road surface, a response on the third harmonic of 1.4 microvolt has been obtained while in the occurrence of wet road surface the response has been of 1.55 microvolt. Obviously the new composite device has been described and illustrated, limited to its essential components, and as an indicative but not limiting example only. The passive dipoles, generally indicated at D in Figs. 2 and 3 can well have a differing geometry and complication, provided that they can form a resonance circuit responsive to the signals emitted by the secondary radar R. Similarly, the characteristics of the secondary radar could be modified, provided that high frequencies may be used.

The signal transmitting and receiving system is shown in Fig. 5 and needs no further explanation on the base of the considerable number of existing reports and patents. The reports in question were issued by the following companies:

- Thomson CSF, France
- RCA Laboratories, USA
- Group Research Center Joseph Lucas, Ltd., Great Britain
- V.D.O., Germany, and so on.

The automatic system for providing the driver information according to the present invention requires a particular coding and decoding arrangement. The developed information system is shown in Fig. 6 and consists of synchronizing marking components, key marking components and code marking components.

The synchronizing marking components consist of several reflectors equidistantly spaced fixing the time graticule t_v, thus permitting to measure the speed of the vehicle.

In order to avoid errors which could be caused by objects spaced at regular intervals (fences, etc.) along the roadside, reading of the traffic information code will be released only after correct recognition of the key.

During the continuous measuring operations, only those measurements will be processed further, which have overstepped a fixed threshold value; the threshold is chosen to guarantee recognition of the reflector.

By means of synchronized marking components, the time elapsed between two oversteps of the threshold will occur first of all, i.e. the time taken by the vehicle to move from one reflector to the other. For greater accuracy the measurement is taken automatically several times in order to eliminate possible errors in calculating the average time.

The next step of the program consists in testing the key marking components by comparing the bit configuration (Example: Configuration 101011 in Fig. 6) with the key word that has been fed in. Only if they are identical will the final detection of the code marking follow.

To obtain the decoding of the traffic information the rectified output signals generated by the receiver antenna must be elaborated such as to be fed into a microprocessor for evaluation. To this end the flow of the output voltage of a supposed combined reflector system (see Fig. 7) is shown as an example. The combined reflector system located at the right edge of the road and consequently read from right to left, consists of four reflectors (1 to 4) representing the bit configuration or in other words, the local distance between two reflectors; when measured at the reflector center, respectively, that local distance between reflectors will amount to 60 cm from reflectors 1 to 2, another 60 cm to reflector 3 and 120 cm to reflector 4. The configuration of the bit is obtained by plotting first some equidistant points along a straight line at the edge of the road and by placing an about 30 cm long reflector at an equal distance below the marking tape, or not. It will be useful to synchronize the center points of the reflectors with the plotted points of the straight line along the road edge. Placing a reflector at a given point corresponds to the binary expression 1, i.e. radiation will generate a reflected beam. Failure to place a reflector at a given point will generate no reflection, corresponding to 0 binary expression.

The purpose of decoding will therefore be the reconstruction of an existing bit configuration according to the flow of the output voltage picked up by the receiver antenna (Fig. 1) at vehicle pseeds from approximately 5 km/h to 180 km/h with the aid of an appropriate circuit, and to supply binary information to the vehicle. Certain properties of the reflection diagram will require an additional description for the scope of realizing the solution suggested further on.

1) The magnitude of the reflecting amplitude is not linear

but is applied in decibels since it is customary to represent voltage magnitudes in problems of transmission first of all by logarithmic scale -- this method permits reading the quotient of two voltages at the first attempt and to understand that the quotient of two voltages always shows equal difference on the decibel scale, independently of the voltage magnitude. Thus a voltage flow can be represented in a more distinct and rational manner, above all superior in decimal powers, as compared with a linear scale. The elaboration of a voltage flow given in decibels is more simple with the present program than that of a linear voltage flow; a block is therefore provided in the operation diagram 3 by which the linear voltage flow is converted into a logarithmic flow after having been rectified as shown in Fig. 7.

2) The reflection diagram is split into peaks without ascending to the maximum amplitude and then drop again to a minimum both in an equally monotonous manner. Secondary peaks are unavoidable considering that a reflector is about 20 times as long as a wave length for instance. The latter consideration becomes necessary in order to obtain a sufficiently wide reflecting surface to furnish the reflected input voltage with an adequate useful voltage for signal elaboration in respect of all the unavoidable jam tensions. It should now be the task to create an efficacious main maximum of 40 cm approximate width for the present reflector layout for instance -- the width depending on the distance at which a vehicle passes the reflectors, without any interference by secondary

maximum and minimum peaks, i.e. eliminating them during the subsequent process of elaboration.

To have an idea concerning the times we are dealing with here, the following indications will prove to be useful: a speed of 1 m/sec = 1 m/s is identical with 3. 6 km/h = 3. 6 km/h. To cover a distance of 40 cm at 3, t km/h = 1 m/s velocity, consequently requires 400 m/s = 400 ms.

At a speed of 36 km/h for a 40 cm distance = 40 ms

At a speed of 72 km/h for a 40 cm distance = 20 ms.

At a speed of 144 km/h for a 40 cm distance = 10 ms

At a speed of 288 km/h for a 40 cm distance = 5 ms = 5000 ms

A "very long" time for electronic elaboration . . .

The Schmitt trigger , a special bistable lever switch, is particularly indicated for determining the point of time of the main maximum while eliminating the secondary maxima to the greatest extent. Without entering into construction particulars and the internal operative aspects of the device, Fig. 4 contains a description of its performance. Installing at the input side a linear ascending tension --linear ascension in the present case -- a high-adjustable voltage of about 1 ms ascension time will occur at output U_a, having a low potential at the beginning, as soon as the input voltage U_1 exceeds the value U_{1top}. If voltage U_1 stays above U_{1top}, the condition of the output voltage will be maintained. Only if U_1 falls below the adjustable voltage threshold $U_{1bottom}$, the output voltage and its 1 ms drop time will return to the previous inferior tension value, remaining there until input voltage U_1 passes threshold U_{1top} in the upward direction again. Fig. 7 will serve as means of a more accurate illustration of the switch efficacy and for a more detailed discussion on the voltage values U_{1top} and $U_{1bottom}$ to be adjusted.

As the vehicle supposedly moves from right to left according to Fig. 7, the time scale is to be looked at from the right to the left in contrast with the usual illustration.

The voltage U_{1top} must be established in a way that the main maxima of all reflectors will exceed that value by about 4-8 dB, i.e. by a factor between 1·5 and 2·5 on a linear ordinate scale. Such threshold value U_{1top} has been fixed at about 8 dB from the upper scale edge (Fig. 7). When rising toward the main maximum the Schmitt trigger will tilt toward the times indicated as T_1, T_2 and T_3, but the switch will tilt fully to the left even at the fourth impulse without elaboration by the microprocessor though and to become of no importance. Above the threshold U_{1top} U_1 is allowed to vary as long as it takes to fall below the value $U_{1bottom}$ at the descent to the left of the ascension.

In this case the trigger will jump again from the upper output value to the inferior value remaining there until the next impulse causes the value U_{1op} to be exceeded again. Minima and maxima caused in the meantime by the secondary peaks have no bearing on the operation as long as $U_{1bottom}$ and U_{1top}, respective- are not below rating or exceeded.

As the secondary peaks near the main maxima in the rule are smaller than those within the minimum between two principal maxima, it can be expected that threshold U_{1top} can always be fixed at a sufficiently high value to avoid similar excesses.

The principle of the Traffic Information System as shown in Fig. 7 is based on arranging three reflectors at equidistant spacing (synchro-reflectors) and the possibility of installing additional reflectors or less at an equidistant interval according to the disirable quantity of information to be transmitted. Fig. 7 illustrates two positions only of equidistantly placed reflectors for the most simple transmission of information. In order to ascertain the previously established number of equidistant spaces (two only in Fig. 7) equipped with information reflectors, it will be necessary with the aid of the periodical time scale produced by the synchro reflectors, to make contact with the time points arranged at equidistant time intervals in respect of the synchro reflectors and to find out whether or not reflectors have been installed at those points. Lastly is ascertain whether reflection has taken place at the periodical time points in which case a reflector exists, or less so (no reflector installed). The measured time differences t_2-t_1 and t_3-t_2 being exactly identical ones, the periodical time scale with its period $t=t_2-t_1=t_3-t_2$ will be made to follow the time point t_3 directly. Failure of the time differences to be identical, the starting point of the time scale is to be established in such a manner that the time scale extending toward time point t_1 will come to be as near as possible to the points t_1, t_2 and t_3. the optimal value is determined through the Gaussian principle of the smallest square sum, i.e. the differences are formed between the time scale displaced by ^{at} and the times of the point of gravity t_1, t_2 and t_3. These differences are then squared, varying ^{at} as long until the square sum reaches a minimum; this consideration will result in value ^{at} (see Fig. 9).

Following the above indications, the principle of decoding the proposed traffic information system can be taken as solved. The installation (see Fig. 7) serving to exemplify the system, consists of three synchronized reflectors and a single two-bit information channel. Apart from binary information 01 (read from the right in Fig. 7), the installation of differently combined reflectors makes the transmission of four different kinds of information possible. When applying the time from right toward left the combinations will appear as follows:

Binary information		Synchronized reflectors	Binary information (from right to left)	
---	---	--- --- ---	1	1
---		--- --- ---	1	0
	---	--- --- ---	0	1
		--- --- ---	0	0

—— t

Each of the four binary information systems may be associated with whatever kind of information, in the case always remaining equal per combination. If four different kinds of information are insufficient, three information reflectors may be employed for the transmission of $2^3 = 8$ different types of information.

It will be understood that each of the elements described above, or two or more together, may also find a useful application in other types of coding and decoding systems differing from the types described above.

While the invention has been illustrated and described as embodied in a coding and decoding system for providing driver information, it is not intended to be limited to the details shown since various modifications and structural changes may be made without departing in any way from the spirit of the present invention.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can, by applying current knowledge, readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention.

What is claimed as new and desired to be protected by Letters Patent is set forth in the appended claims.

CLAIMS

1. A prefabricated road-marking strip installed on the edges of roads or highways for transmitting information about the road to moving vehicles and operative in conjunction with active electronic components located on a movable vehicle and provided with energy emitting and energy receiving means, comprising passive electrical components located on the lower side of the strip, said passive components being so arranged that they are able to receive radiant energy from said active components in the direction which is perpendicular to the line of motion of the vehicle and send said energy back to the energy receiving means so as to obtain precise information from said passive components in the form of signals; and light re flecting horizontal markings providing a vehicle driver with clear visual information about the road.

2. The strip as defined in claim 1, wherein said passive components are attached to the road-marking strip.

3. The strip as defined in claim 1, wherein said passive components consist of dipoles of such dimensions and arrangemant as to reflect radiant energy in the direction of the energy receiving means of said active components, and which are formed of thin metallic plates.

4. A road surface marking system comprising a prefabricated road-marking strip installed on the edges of roads or highways for transmitting information about the road to moving vehicles and including a plurality of light reflecting horizontal markings providing a vehicle driver with clear visual information about the road and a plurality of passive electrical components located on the lower side of the strip; and ac-

tive electronic components located on a movable vehicle and provided with energy emitting and energy receiving means, passive electrical components being operative for receiving electric energy from said electronic means, reemitting this energy and returning the same to said active electronic means for provision of positive electromagnetic information in the form of signals about the road to the vehicle driver.

5. The system as defined in claim 4, wherein said active elctronic means located on a movable vehicle include a secondary radar for emitting energy to the road and an antenna for receiving said reemitted energy from said passive components.

6. The system as defined in claims 4 and 5, wherein said plurality of passive electronic components are dipoles so dimensioned and oriented that they operate in the range of said secondary radar.

7. A method of operating a road surface marking system including a prefabricated strip positioned on road pavements and having a plurality of light reflecting markings positioned transversely to a drive way and a plurality of passive electric components positioned in the direction lengthwise of the road and located on the lower side of said strip, and active electronic means mounted aboard a vehicle, the method comprising the steps of selectively sending electrical signals generated by said active electronic means to said passive electric components and receiving the signals reemitted by said components to provide a vehicle driver for positive electromagnetic information about the road simultaneously with receiving an optical informa-

tion about the status of the road.

8. The method as defined in claim 7, further comprising the step of irradiating an infrared energy from an infrared source arranged on the vehicle to a part of said light reflecting markings selectively arranged on the road and receiving the modulated returning signals therefrom to obtain a complemental information about the road.

9. In a system for providing a driver information, comprising a prefabricated road-marking strip installed on the edges of roads or highways for transmitting information about the road to moving vehicles; active electronic components located on a movable vehicle and provided with energy emitting and energy receiving means and operated in conjunction with said strip; passive electrical components located on the lower side of the strip, said passive components being so arranged that they are able to receive radiant energy from said active components in the direction which is perpendicular to the direction of motion of the vehicle and send said energy back to the energy receiving means so as to obtain precise information from said passive components in the form of signals; and light reflecting horizontal markings providing a vehicle driver with clear visual information about the road, the improvement comprising an automatic system providing informations to the driver and including a coding and decoding arrangement including synchronizing marking components, key marking components and code marking components, said key marking components and said code marking components being positioned on said marking strip one after another.

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Fig. 1

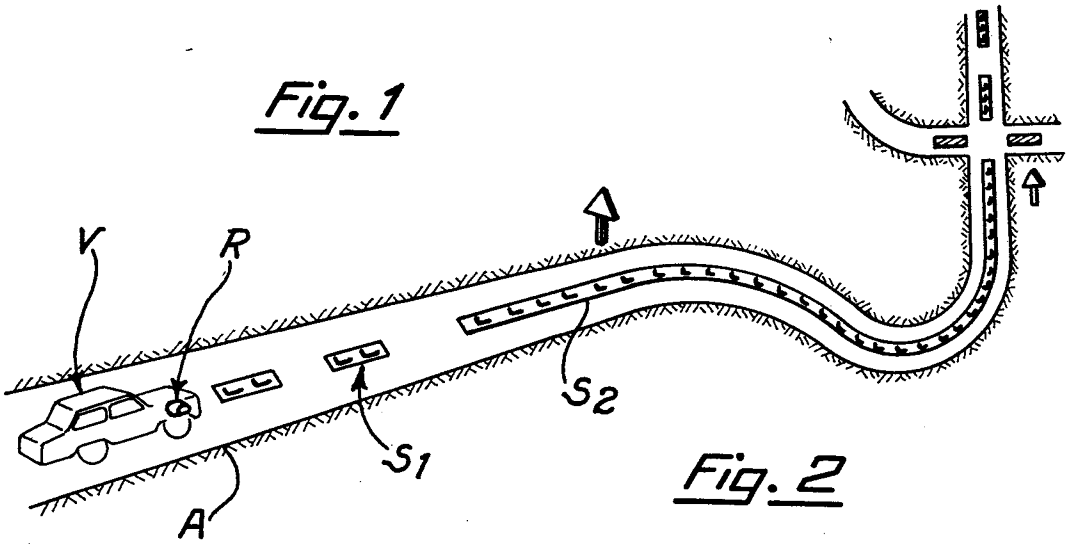


Fig. 2

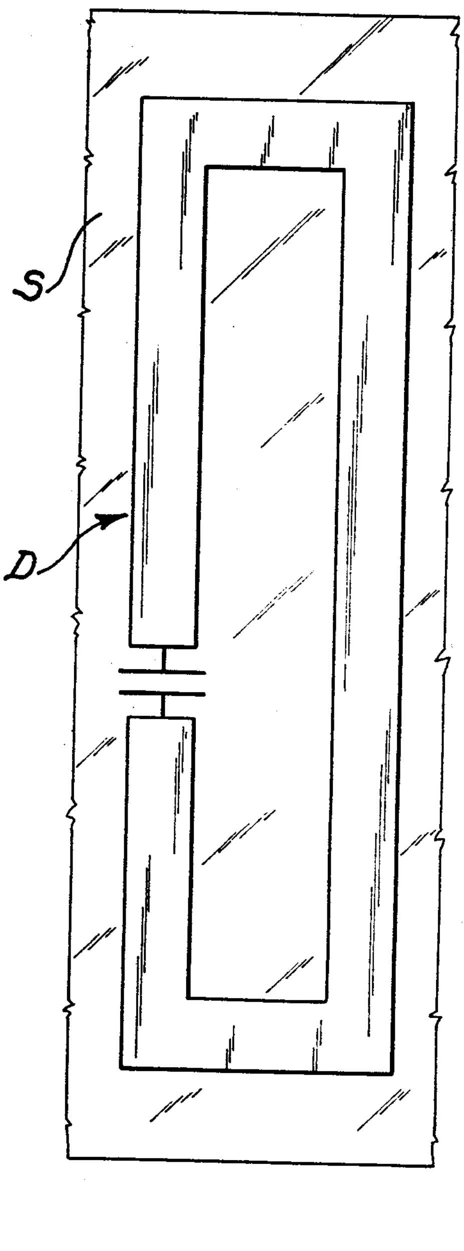
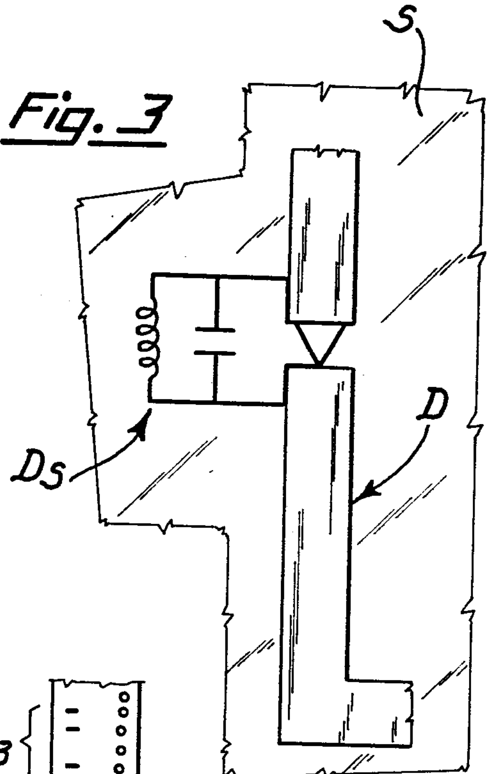


Fig. 3



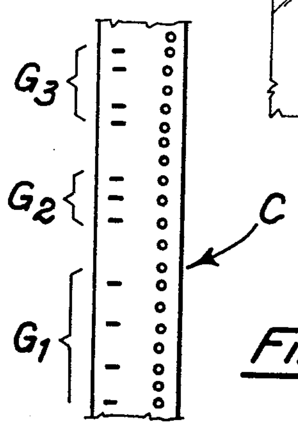


Fig. 4

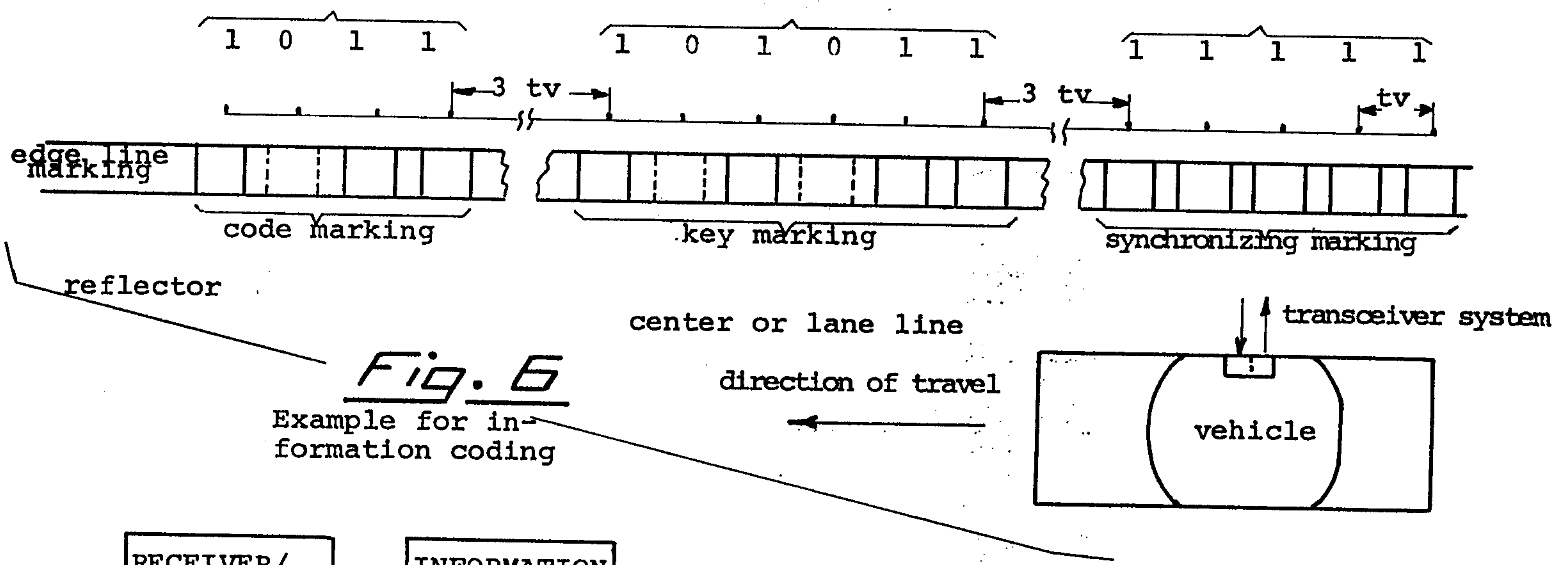


Fig. 6
Example for information coding

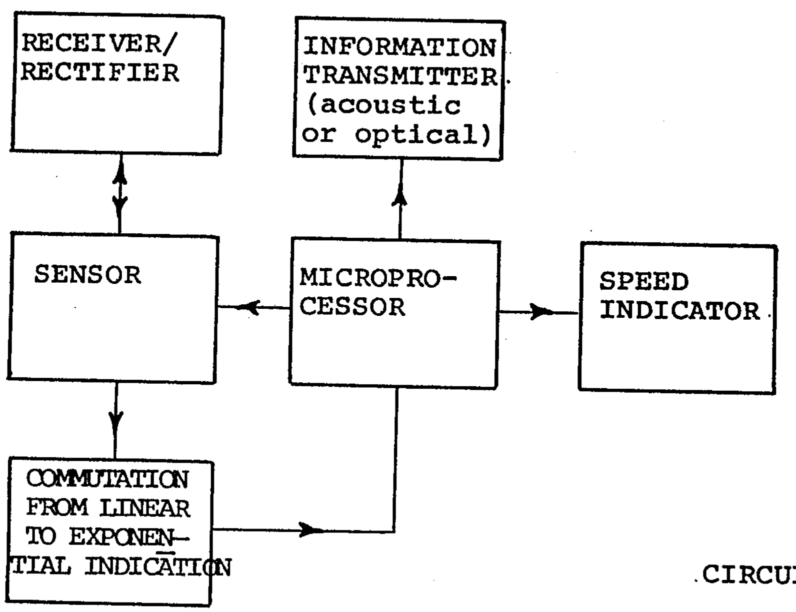


Fig. 5
CIRCUIT BLOCK OF SYSTEM COMPLETE
PRIOR ART

Fig. 7

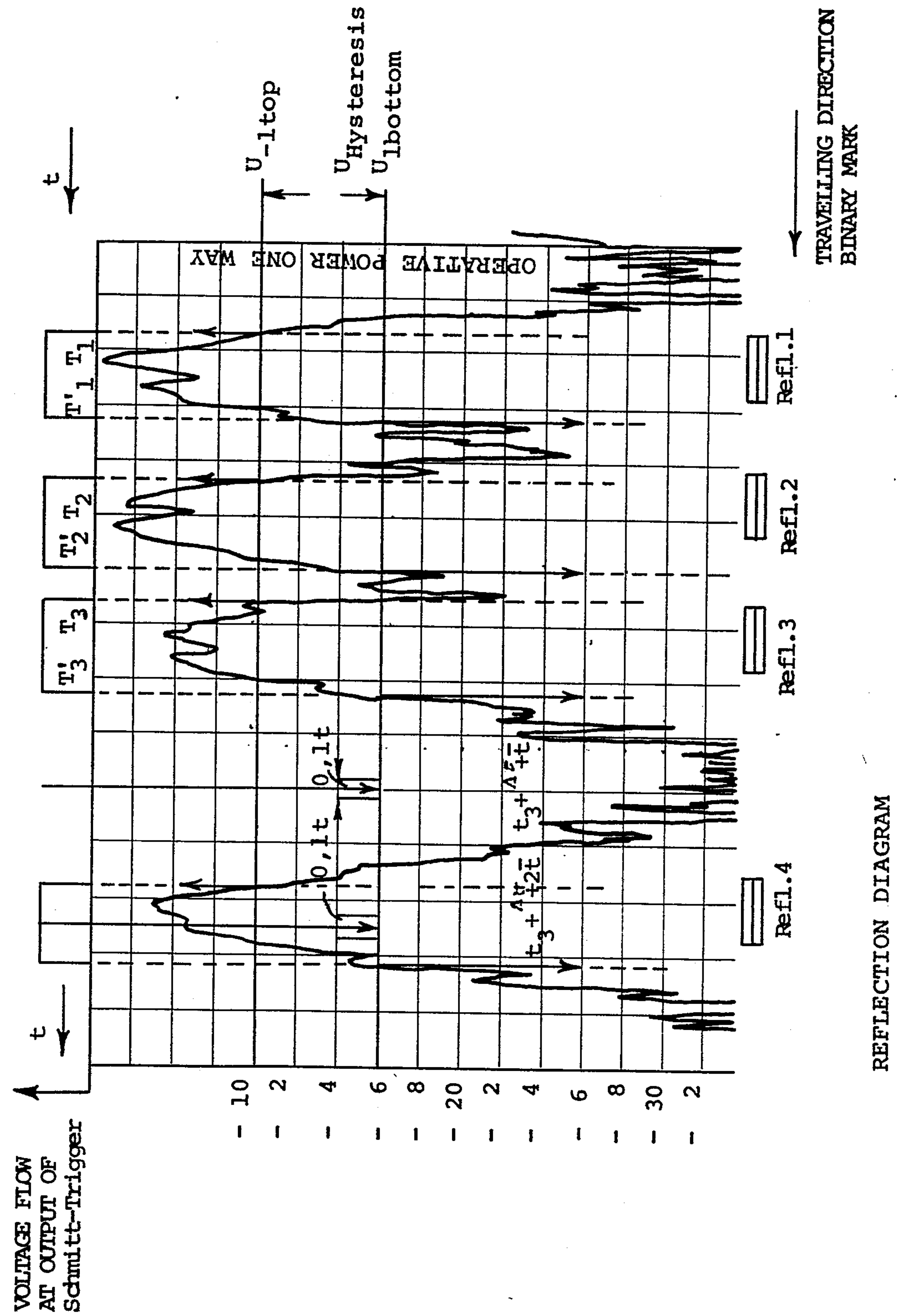
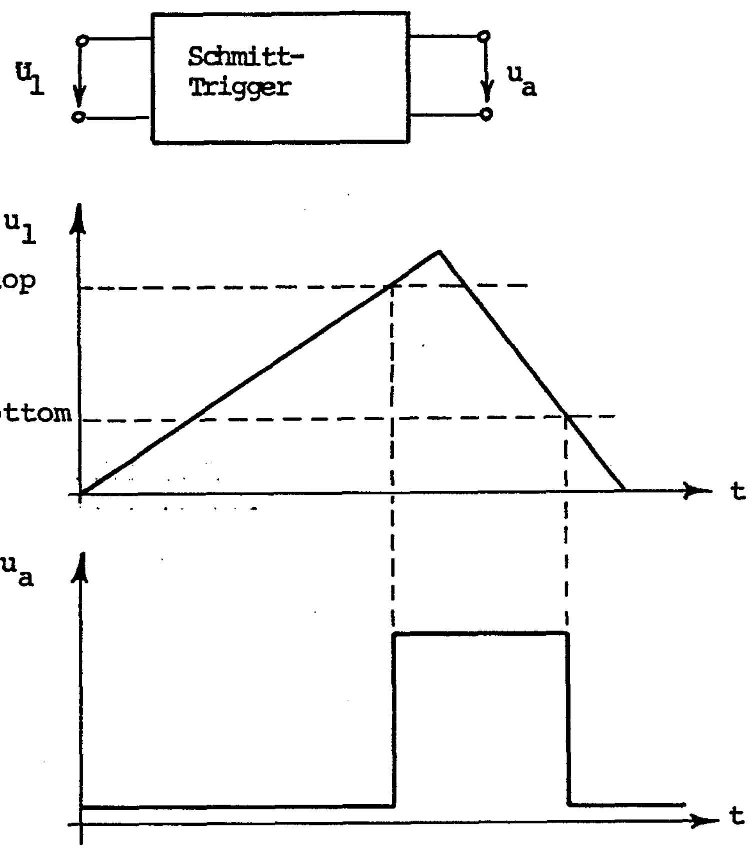
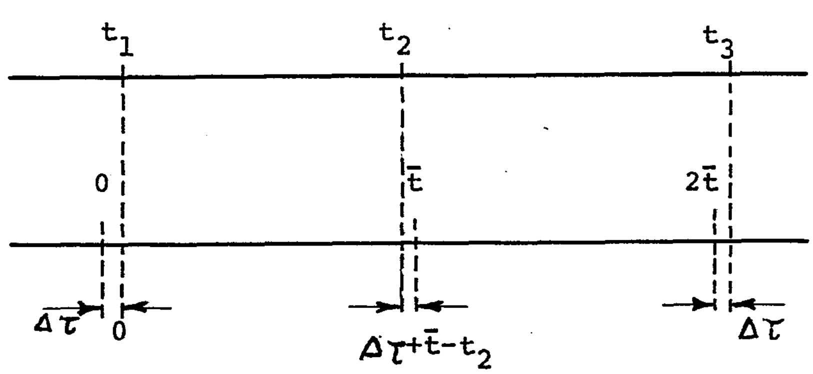

VOLTAGE FLOW AT OUTPUT OF Schmitt-Trigger
t
U-1top
UHysteresis
U1bottom
OPERATIVE POWER ONE WAY
T'1 T1
T'2 T2
T'3 T3
0,1t
0,1t
t3+Δt+t
t3+Δt+2t
Refl.1
Refl.2
Refl.3
Refl.4
10
2
4
6
8
20
2
4
6
8
30
2
TRAVELLING DIRECTION BINARY MARK
REFLECTION DIAGRAM

Fig. 8



OPERATIVE DIAGRAM
OF Schmitt-Trigger

Fig. 9 DETERMINATION OF THE PERIODICAL TIME SCALE



t_1, t_2, t_3 = measured and computed average values

For the determination of the initial point $\Delta\tau$ of the periodical time scale, the zero point is fixed at $t_1=0$