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(54) A VEHICLE COLLISION PREVENTING APPARATUS

(71) We, NISSAN MOTOR COMPANY, LIMITED, a Japanese Company, of No.2. Takara-cho, Kanagawa-ku, Yokohama-shi, Kanagawa-ken, Japan, and MITSUBISHI DENKI KABUSHIKI KAISHA, a Japanese Company, of 2-3 Marunouchi 2-chome, Chiyoda-ku, Tokyo, Japan, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:-

The present invention relates to a vehicle collision preventing apparatus using a radar. A conventional radar anticollision apparatus is illustrated schematically in Figure 1 of the accompanying drawings.

Referring to Figure 1, the reference numeral 1 designates a radar for detecting the distance between an obstacle and the vehicle in which the apparatus is installed and the relative velocity; 2 designates a danger determining circuit which determines the danger from the data of the radar 1. For example circuit 2 compares V^2 (V: relative velocity) and $2\alpha R$ (α: constant and R: relative distance). When $V^2 > 2\alpha R$, a danger signal output is generated. The reference numeral 3 designates a brake or an alarm device actuated by the danger signal output of the danger determining circuit 2.

In the conventional apparatus, the signal reflected from the obstacle varies substantially depending upon the relative position between the obstacle and the radar 1. When the reflection signal reduces below a certain level the radar is not effective for the detection of an obstacle. The data from the radar 1 is not available whereby the danger could not be determined and the danger signal output is not given even though an obstacle is dangerously close or fast approaching.

An object of the invention is to provide an improved vehicle collision preventing apparatus.

According to one aspect of the invention there is provided a vehicle collision preventing apparatus comprising a radar system for detecting the distance to an obstacle and the relative velocity, the radar system including a danger determining circuit responsive to radar data, and the apparatus further including an estimate arithmetic circuit which acts upon the radar data and which is effective to give an estimate of the distance to the obstacle and the relative velocity following disappearance of radar data to allow the danger to be determined.

According to another aspect of the invention there is provided a vehicle collision preventing apparatus which comprises a radar for detecting data of a distance to an obstacle and a relative velocity; a data detecting device for detecting the data of the radar; a memory device for memorizing the data of the radar; a command device for controlling the read-in of the data of the memory device depending upon the output of the data detecting device;

an obstacle disappearing time-generating device for generating a signal depending upon the time passed from disappearance of the data of the radar;

an estimate arithmetic device for estimating the place of the obstacle at the present from the output of the obstacle disappearing time-generating device and the output of the memory device;

a switching device for selecting either the data of the radar or the data of the estimate arithmetic device depending upon the detection of the data of the radar; and a danger determining circuit for determining the danger from the output of the switching device.

The invention will further be described with reference to Figures 2 to 4 of the accompanying drawings, of which:-

Figure 2 is a block diagram of one embodiment of the apparatus of the present inven-

tion;

Figure 3 is a circuit diagram of one embodiment of the apparatus of the present invention; and

Figure 4 is a time chart of transmissions, signal receipts and trigger signals.

A preferred embodiment of the vehicle collision preventing apparatus of the present invention will be described in detail by referring to Figure 2, wherein like reference numerals designate identical or corresponding parts to those of Figure 1.

The reference numeral 4 designates a memory circuit for memorizing the data of the distance from the radar 1 to the obstacle and the relative velocity; 5 designates an estimate arithmetic circuit for estimating the place of the obstacle by operating on the data of the memory circuit 4 and a "disappearing" time to be described. A switching circuit 6 gives outputs of either the data of the radar 1 or the data of the estimate arithmetic circuit to the danger determining circuit (2). A command circuit 7 instructs read-in, rewrite or erase for the data of the memory circuit 4. A data detecting circuit 8 detects the data from the radar 1. An obstacle disappearing time-generating circuit 9 generates a signal proportional to the time elapsed from the disappearance of the radar data. A driving distance-determining circuit 10 operates on the difference between the estimated distance and the obstacle-disappeared distance to determine whether the difference is more than a predetermined distance.

If the radar can operate normally radar data concerning the distance from the radar to the obstacle and the relative velocity are given. The operation is the same as that of the conventional apparatus.

The output of the radar 1 is fed through the switching circuit 6 to the danger determining circuit 2 wherein the danger of the obstacle is determined from the distance to the obstacle and the relative velocity. When a dangerous situation arises a danger signal is given to actuate the brake or the alarm device 3.

If the radar signal weakens appreciably or is lost, another mode of operation is automatically brought into effect. Presence of the data of the radar 1 is detected by the data detecting circuit 8. When the data is not present a signal indicating disappearance of the data is fed to the command circuit 7. When a signal indicating receipt of radar data is received by the command circuit 7, a read-in command is fed to the memory circuit. When the data disappears, the read-in command is not fed to the memory whereby the memory memorizes the distance and the relative velocity just before the time of "disappearance" of the obstacle. The disappearance signal is fed to the obstacle disappearing time-generating circuit 9 wherein a time signal proportional to the disappearing time is generated and fed to the estimate arithmetic circuit 5. The signal is also fed to the switching circuit 6 which switches the signal so as to feed the output of the estimate arithmetic circuit 5 to the danger determining circuit 2.

The data of the distance R before disappearance of the obstacle and the relative velocity V are given from the memory circuit 4 to the estimate arithmetic circuit 5. The data of the obstacle disappearing time Δt is given from the obstacle disappearing time-generating circuit 9 to the estimate arithmetic circuit 5 whereby the estimated distance to the obstacle R_s ($R_s = R - V \times \Delta t$) is calculated.

The data of the estimated distance R_s and the relative velocity V are fed through the switching circuit 6 to the danger determining circuit 2 wherein the danger of the obstacle is determined. When there is danger, the signal for danger is fed to actuate the brake or the alarm device 3.

The data of the estimated distance R_s is given from the estimate arithmetic circuit 5 to the driving distance-determining circuit 10 and the data of the distance R before the time of disappearance of the obstacle is given from the memory circuit 4 to the driving distance-determining circuit 10 wherein the subtraction of the data is made. When the difference is more than a predetermined value, the signal is fed to the command circuit 7 to erase the data in the memory circuit 4.

As described above, even though the data from the radar 1 has disappeared, the distance to the obstacle is estimated by operating on the data just before disappearance. The relative velocity is also estimated from the data just before disappearance. For a short time after the disappearance of the obstacle the function of the vehicle collision preventing apparatus is effectively maintained.

If the obstacle completely disappears, the danger determining function is released by the driving distance-determining circuit 10 when the estimated driving distance after the time of disappearance of the obstacle reaches a predetermined distance.

In the described embodiment, the data of the distance and the relative velocity just before the time of disappearance of the obstacle are used for estimating the distance and the relative velocity of the obstacle. However, if there is acceleration of the obstacle the estimates are not precisely accurate.

In order to reduce this error, more data of distances and relative velocities in the past are read into the memory circuit 4 and the acceleration is calculated by using the data in the estimate arithmetic circuit 5 whereby the distance and the relative velocity at the present can be estimated more accurately.

Referring to Figure 3 and Figure 4, the operation of the vehicle collision preventing apparatus will be further described.

The digital data of the distance to the obstacle R and the relative velocity V are given from the radar 1 at the times T_1. For example, when the maximum measurable distance is 150 m, the digital data is given in 8 bits as 1 m per bit. When the maximum measurable relative velocity is 100 Km/h., the digital data is given in 7 bits as 1Km/hr. per bit. When no obstacle is detected, the data of the distance R and the relative velocity are respectively zero.

The data given by the radar 1 is fed into the data detecting circuit 8 to detect presence or absence of the data. The data detecting circuit 8 is an OR circuit to which the data of the distance R and the relative velocity are applied. When both the distance R and the relative velocity V are zero (no data), the signal L is given. When R and/or V are not zero (certain data is present), the signal H is given. (H:H level of IC and L: L level of IC).

The command circuit 7 comprises AND circuits. When the data is given, T_2 trigger is fed as a read-in command to the memory circuit 4 by the signal H of the data detecting circuit 8, whereby new data of the distance R and the relative velocity V are read in. When the data is not given, the signal L is applied from the data detecting circuit 8 and the T_2 trigger is not fed to the memory circuit 4, whereby the data of the distance R and the relative velocity V just before disappearance of the obstacle remain in the memory circuit 4.

The signal L for no data is fed to the obstacle disappearance time-generating circuit 9 which comprises a GATE circuit and a COUNTER circuit. When the signal L is received, the GATE circuit is opened to count the T_3 trigger in the COUNTER circuit. The output n of the COUNTER circuit is proportional to the disappearing time Δt as shown by the equation

$$\Delta t = n \times Tr$$

wherein n: counts of the COUNTER circuit; Tr: radar transmission repeating period; t: disappearing time.

The signal L is fed to the switching circuit 6 which switches to feed the output of the estimate arithmetic circuit 5 to the danger determining circuit 2. Circuit 2 receives the data of the distance R and the relative velocity V just before disappearance of the obstacle (referred to as R_o, V_o) from the memory circuit 4 and receives the counter output signal n from the obstacle disappearance time-generating circuit.

The estimate arithmetic circuit 5 comprises a multiplier and a subtractor to operate the calculation of the following equation

(estimated distance operation)

$$R_s = R_o - V_o \times n \times Tr$$

wherein R_s: estimated distance ; R_o, V_o, n and Tr are described above.

The data of R_s and V_o are passed through the switching circuit into the danger determining circuit 2 to determin the danger.

The driving distance-determining circuit 10 comprises a subtractor and a comparator. The subtractor is used for the calculation $R_o - R_s = R_m$. The comparator is used for comparing R_m with $R_{const.}$. In the case of $R_m \geqq R_{const.}$, the output (H level) of the comparator is fed to the command circuit 7 and T_4 trigger is fed as a clear trigger signal into the memory circuit 4 to erase the data in the memory circuit 4. The trigger circuit 11 generates various trigger signals.

WHAT WE CLAIM IS:-

1. A vehicle collision preventing apparatus comprising a radar system for detecting the distance to an obstacle and the relative velocity, the radar system including a danger determining circuit responsive to radar data, and the apparatus further including an estimate arithmetic circuit which acts upon the radar data and which is effective to give an estimate of the distance to the obstacle and the relative velocity following disappearance of radar data to allow the danger to be determined.

2. A vehicle collision preventing apparatus according to Claim 1 wherein when data is available from the radar the data is fed to the danger determining circuit and when data is not available from the radar, the output of the estimate arithmetic circuit is fed to the danger determining circuit.

3. A vehicle collision preventing apparatus according to Claim 1 or Claim 2 wherein when data is available from the radar the data is memorized in a memory circuit and when data is not available from the radar the distance to the obstacle and the relative velocity are estimated in the estimate arithmetic circuit from the data of the memory circuit and from the time the radar data disappeared.

4. A vehicle collision preventing apparatus which comprises a radar for detecting data of a distance to an obstacle and a relative velocity;

a data detecting device for detecting the data of the radar;

a memory device for memorizing the data of the radar;

a command device for controlling the read-in of the data of the memory device depending upon the output of the data detecting device;

an obstacle disappearing time-generating device for generating a signal depending upon the time passed from disappearance of the data of the radar;

an estimate arithmetic device for estimating the place of the obstacle at the present from the output of the obstacle disappearing time-generating device and the output of the

memory device;

a switching device for selecting either the data of the radar or the data of the estimate arithmetic device depending upon the detection of the data of the radar; and

a danger determining circuit for determining the danger from the output of the switching device.

5. A vehicle collision preventing apparatus substantially as hereinbefore described with reference to Figure 2 to 4 of the accompanying drawings.

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1587131 COMPLETE SPECIFICATION

3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

FIG. 1

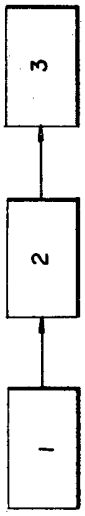
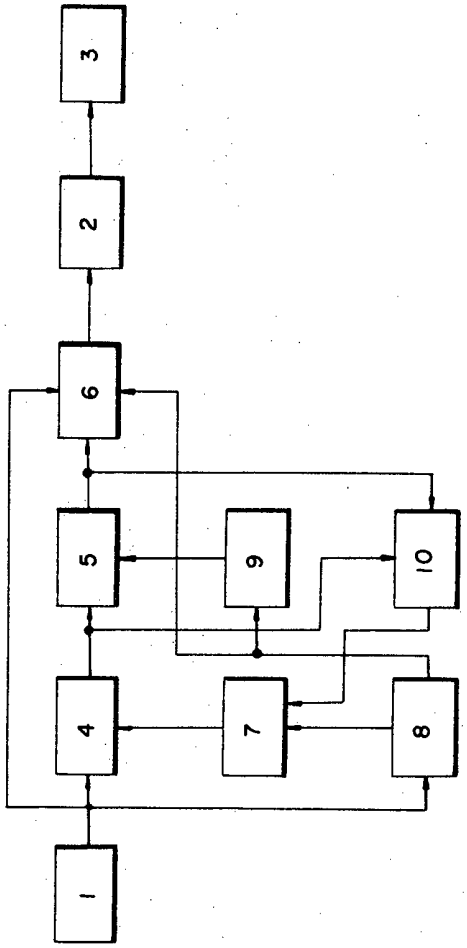


FIG. 2



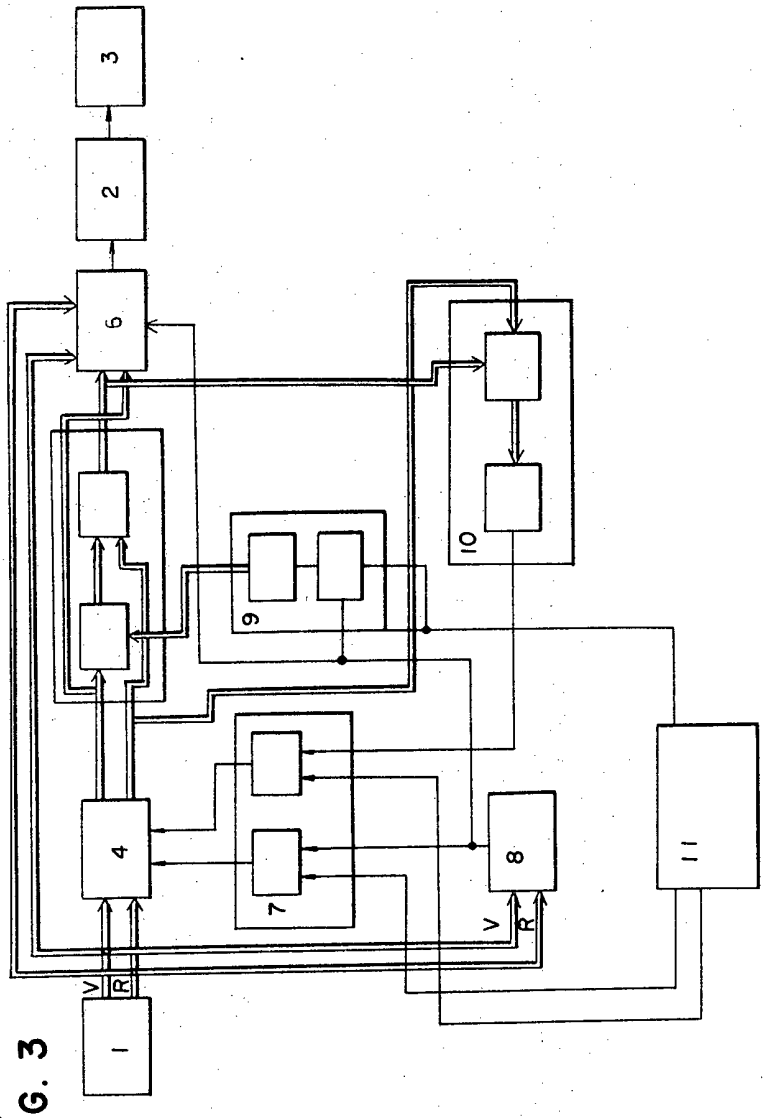
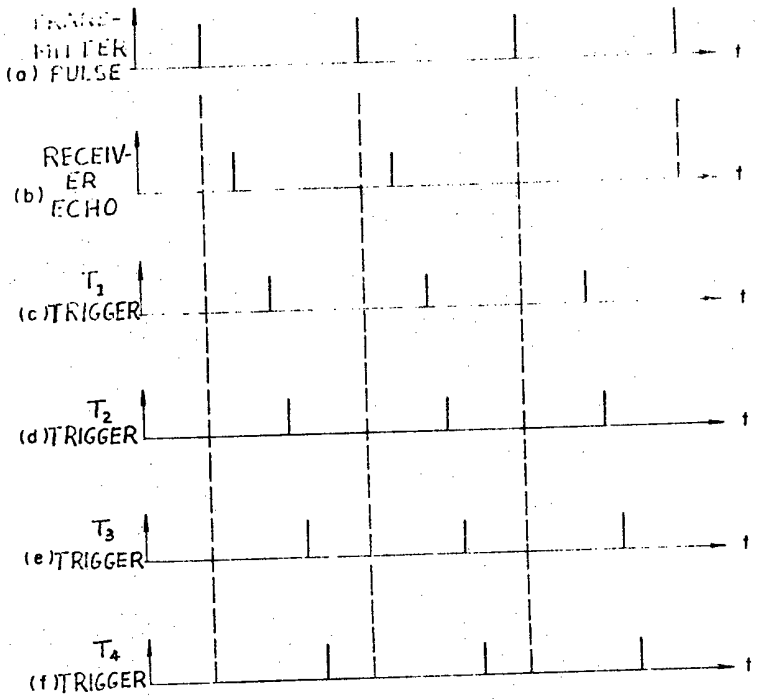


FIG. 3

FIG. 4


TRANSMITTER
(a) PULSE
RECEIVER
(b) ECHO
T1
(c) TRIGGER
T2
(d) TRIGGER
T3
(e) TRIGGER
T4
(f) TRIGGER
t