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Bailie et al.

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(54) **METHOD FOR COMMUNICATING DATA IN A REMOTE TIRE PRESSURE MONITORING SYSTEM**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/245,577**

(22) Filed: **Feb. 5, 1999**

Related U.S. Application Data

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(51) **Int. Cl.**[7] **B60C 23/00**
(52) **U.S. Cl.** **340/445**; 340/442; 340/447
(58) **Field of Search** 340/442, 443, 340/444, 445, 446, 447, 448, 10.2; 73/146.2, 146.3, 146.4, 146.5; 370/448

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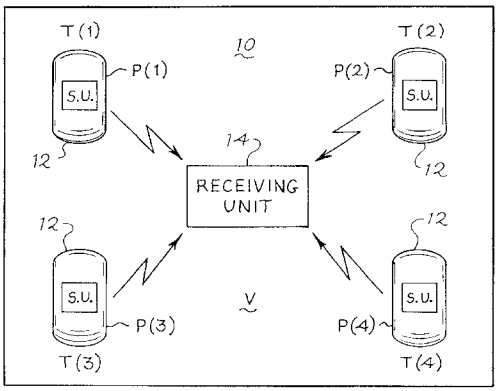
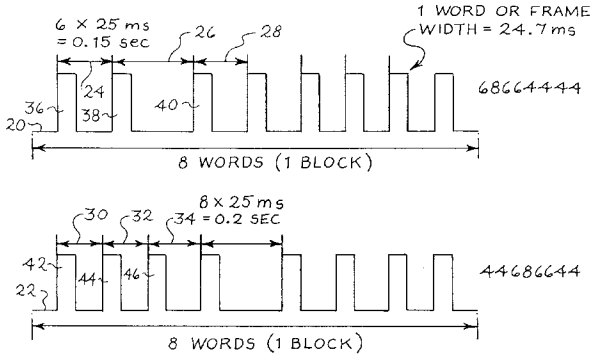
(57) **ABSTRACT**

A method and apparatus for communicating data in a remote tire pressure monitoring system **(10)** which includes a plurality of transmitters **(12)** associated with tires (T**(1)**, T**(2)**, T**(3)**, and T**(4)**) of a vehicle (V) and a receiver **(14)** in radio communication with the plurality of transmitters. At each tire, data is collected **(82)**, the data being representative of a tire characteristic, such as tire pressure. Data representative of the tire characteristic is transmitted **(86)**. After a time delay **(94, 96)** next data are transmitted **(98)** until a predetermined number of data words have been transmitted. The time delay for each respective data word is defined according to a repeating pattern common to the plurality of tires so that data words are transmitted during a plurality of aperiodic time windows.

26 Claims, 3 Drawing Sheets





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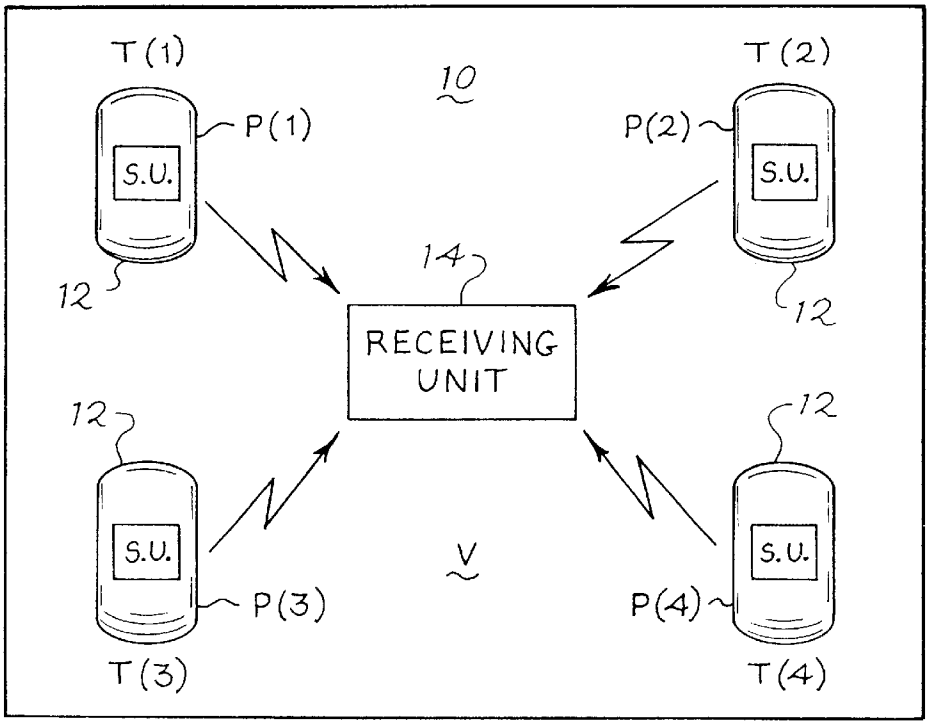

Fig. 1

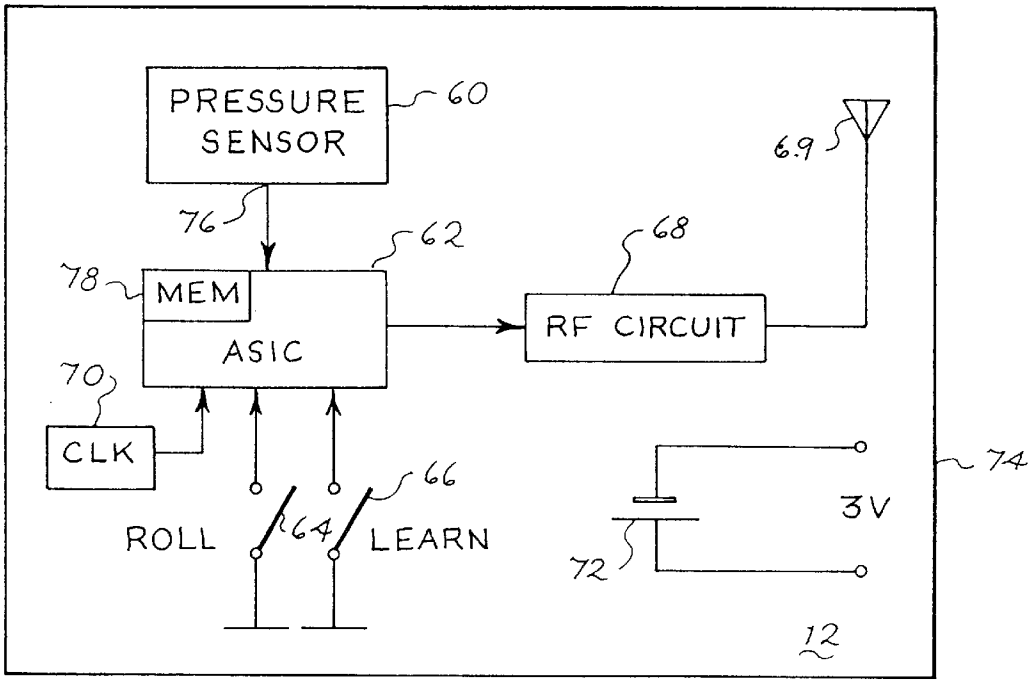

Fig. 4

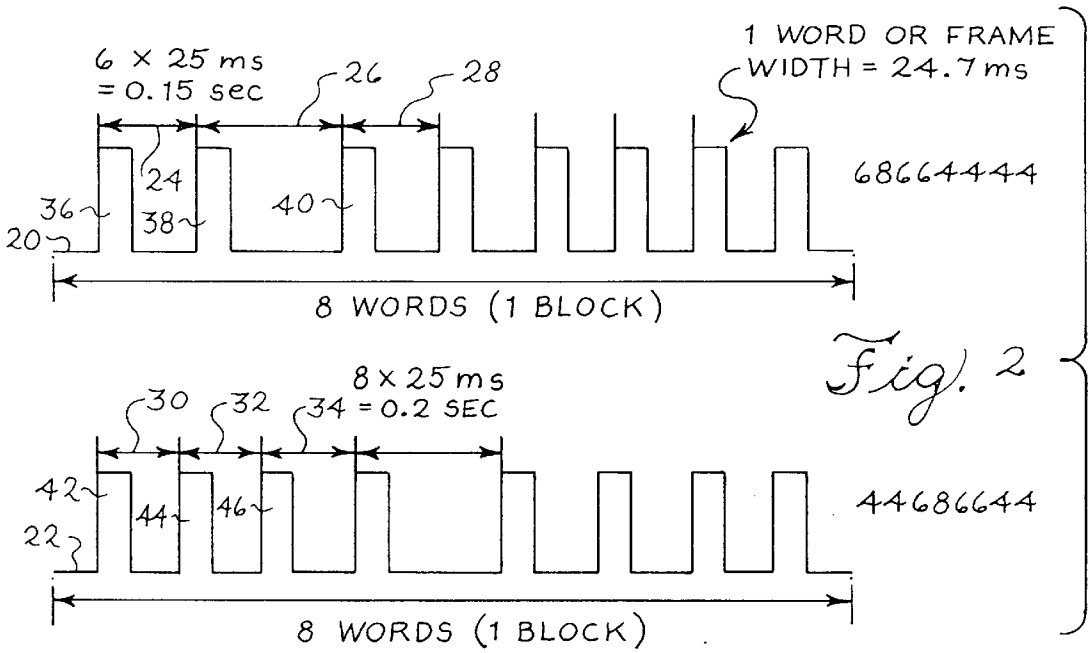

Fig. 2

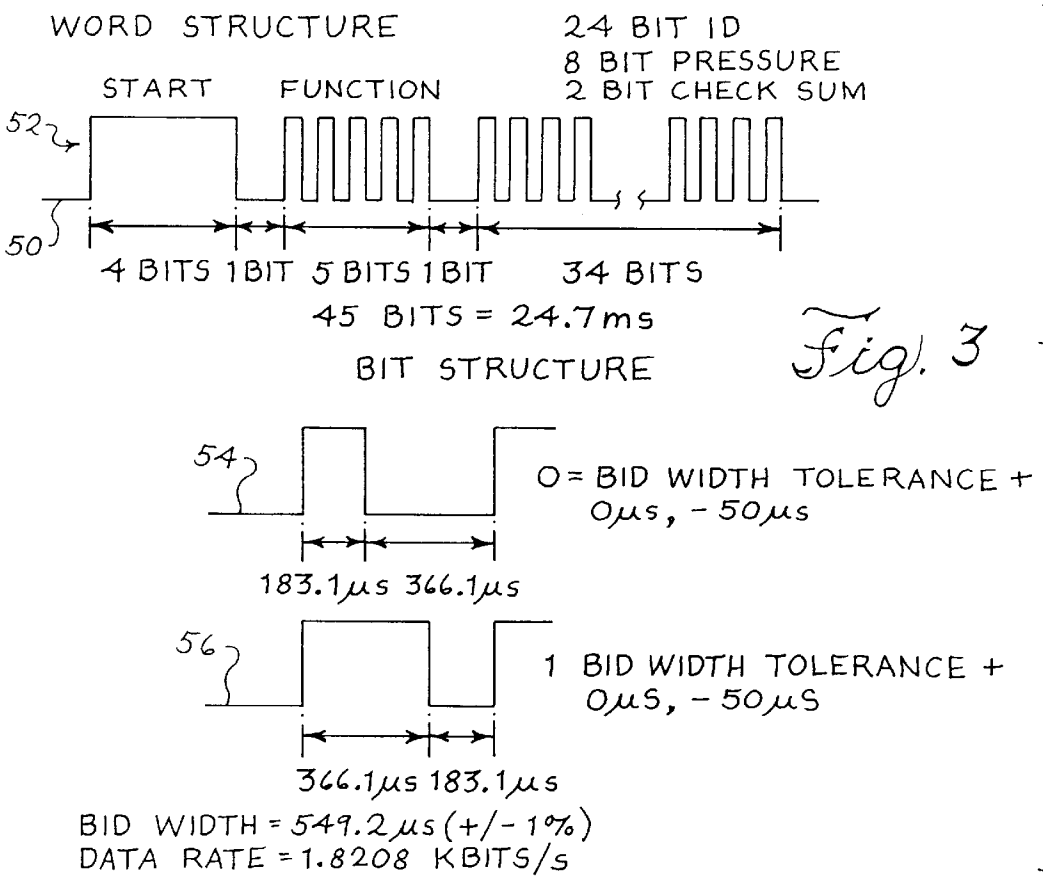

Fig. 3

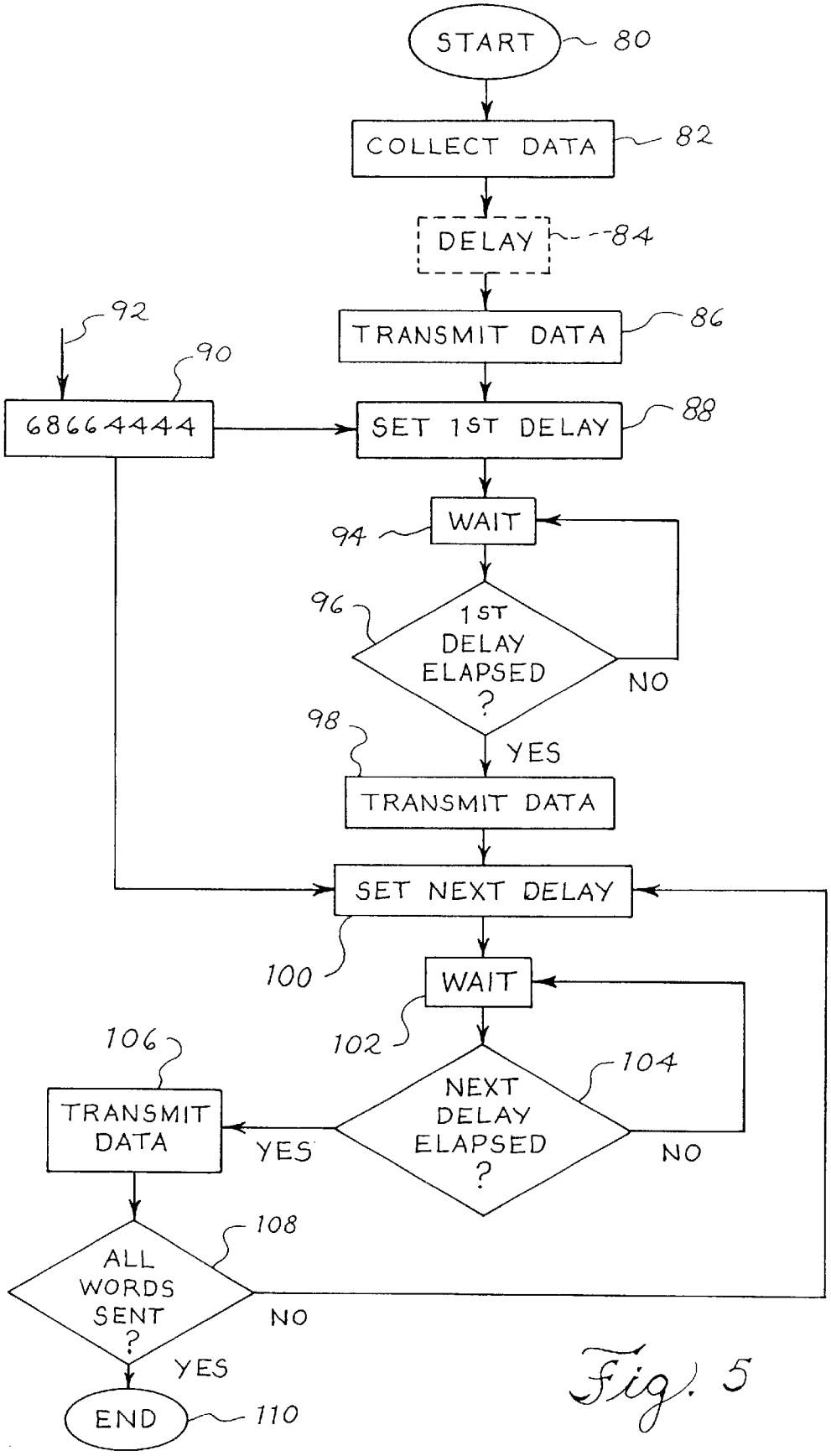

Fig. 5

METHOD FOR COMMUNICATING DATA IN A REMOTE TIRE PRESSURE MONITORING SYSTEM

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims priority of U.S. provisional application serial No. 60/099,820, filed Sep. 10, 1998.

FIELD OF THE INVENTION

The present invention relates to a method for communicating data in a remote tire pressure monitoring system.

BACKGROUND

Remote tire pressure monitoring systems have been developed using radio technology for providing centralized tire pressure information to an operator of a vehicle. Such systems typically include a plurality of sending units or transmitters associated with the tires of a vehicle, such as an automobile, truck or other wheeled vehicle along with a receiving unit. The transmitters measure a tire characteristic such as tire air pressure, and communicate data corresponding to the tire characteristic to the receiver. The receiver takes some action in response to the data, such as providing an alarm or providing a display indicative of the tire characteristic, for the operator of the vehicle.

One problem evident in such a system is clashing of data at the receiver. If two transmitters transmit data at the same time, a clash can occur, in which case the receiver is unable to reliably decode the two transmissions. Any overlap of two transmissions from sending units can prevent reception of data from both sending units.

One known solution involves interrupting transmission of data during selected repeating time periods at each transmitter. The total transmission time is divided into a number of sections, such as ten. During selected sections, for example, two of the ten, transmission is suspended to provide a quiet time when data from other sending units may be transmitted and received successfully. If the quiet times of three of four sending units align during a time when the fourth sending unit is transmitting, no clash will occur. If two transmissions from the same sending unit are decoded and are identical, the data is considered valid and reliable.

While this technique has been acceptable, it would be advantageous to further limit clashing to more reliably and more quickly communicate tire characteristic information to the vehicle operator. Accordingly, there is a need for an improved method and apparatus for transmitting data in a remote tire pressure monitoring system which reduces clashing of data.

SUMMARY

The present invention is directed to a method for transmitting data in a remote tire pressure monitoring system. One embodiment of the system includes transmitters located at each tire of a vehicle and a receiver mounted on the vehicle.

By way of introduction, the method includes collecting data on a tire characteristic at tires of a vehicle. The data are formatted and transmitted by the transmitter according to a predefined protocol. In one embodiment, each transmitter sends the data during a sequence of aperiodic time windows. Because the time windows are aperiodic, the likelihood of simultaneous or overlapping transmission by two or more transmitters is reduced. In another embodiment, each transmitter waits a variable time delay before beginning its transmission of data. Because the transmitters begin transmitting at differing times, the likelihood of overlapping transmission by two or more transmitters is reduced.

The foregoing description of the present invention has been provided only by way of introduction. Nothing in this section should be taken as a limitation on the following claims, which define the scope of the invention.

BRIEF DESCRIPTION OF SEVERAL VIEWS OF THE DRAWINGS

FIG. **1** is a block diagram of a remote tire pressure monitoring system;

FIG. **2** is a timing diagram illustrating data transmission by the transmitter of FIG. **2**;

FIG. **3** is a series of timing diagrams showing an example of word and bit structure for data transmitted in accordance with the timing diagram of FIG. **2**;

FIG. **4** is a block diagram of a transmitter for use in the remote tire pressure monitoring system of FIG. **1**; and

FIG. **5** is a flow diagram illustrating a method for operating the transmitter of FIG. **2**.

DETAILED DESCRIPTION OF THE PRESENTLY PREFERRED EMBODIMENTS

Turning now to the drawings, FIG. **1** shows a block diagram of a vehicle V that includes in this example four tires. The vehicle V includes a remote tire pressure monitoring system **10** that, in this example, includes four sending units or transmitters **12** and a receiving unit **14**. Each of the transmitters **12** includes a battery powered, radio frequency (RF) transmitter that periodically transmits RF signals indicative of pressure or other tire characteristic of the associated tire. In this example, the tires are labelled T(**1**), T(**2**), T(**3**), T(**4**), and the associated tire pressures are identified as P(**1**), P(**2**), P(**3**), P(**4**). Structure and operation of the transmitters **12** will be described in further detail in connection with FIG. **4**. The receiving unit **14** receives RF signals from the transmitters **12** and provides a warning to the operator of the vehicle V when the indicated tire pressure of any of the tires is outside a predetermined range.

FIG. **2** is a timing diagram illustrating a method for transmitting data in a remote tire pressure monitoring system, such as the system **10** illustrated in FIG. **1**. FIG. **2** includes two waveforms, including a first waveform **20** illustrating data transmission from a first sending unit or transmitter of the remote tire pressure monitoring system and a second waveform **22** illustrating data transmission from a second transmitter of the remote tire pressure monitoring system. FIG. **2** illustrates one block or frame of transmitted data. Each block or frame includes transmission of eight words of data during eight respective time windows. Blocks are preferably repeated at a repetition rate or update frequency. The update frequency may be selected to be on the order of seconds, minutes or hours, or any other suitable rate. Also, as will be discussed below, the update frequency may be varied depending on the mode of operation of the tire including the transmitter, such as stationary or rolling.

In the illustrated embodiment, data representative of a tire characteristic, such as tire pressure data, are transmitted in a pattern represented by the waveforms of FIG. **2**. Preferably, identical data words are transmitted during sequential time windows. Thus, the first transmitter transmits a data word

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