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Myers

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[54] TRAFFIC SENSOR STRIP

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[52] **U.S. Cl.** ..... 340/38 R; 174/113 A

[51] **Int. Cl.²** G08G 1/00

[58] **Field of Search** ..... 340/38 R; 177/136

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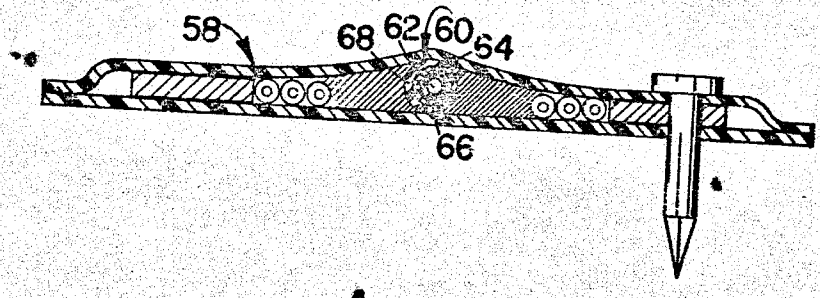
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Primary Examiner—Thomas B. Habecker
Attorney, Agent, or Firm—Richards, Harris & Medlock

[57] **ABSTRACT**

An elongated traffic sensor strip having a plurality of separate segments each appropriately spaced along the sensor to monitor traffic in separate lanes of a multi-lane roadway. A sealed envelope encloses segmented pressure-sensitive elements and a plurality of conductors connected to the individual elements. Metallic plates are positioned in the envelope along the length of the strip for attaching the strip to the surface of the roadway. In one embodiment, the elements have a pair of conductor plates normally held in spaced parallel relationship and movable to contact each other upon compression of the elements. In another embodiment, the elements have a coaxial cable which produces an electrical effect when subjected to pressure.

10 Claims, 12 Drawing Figures



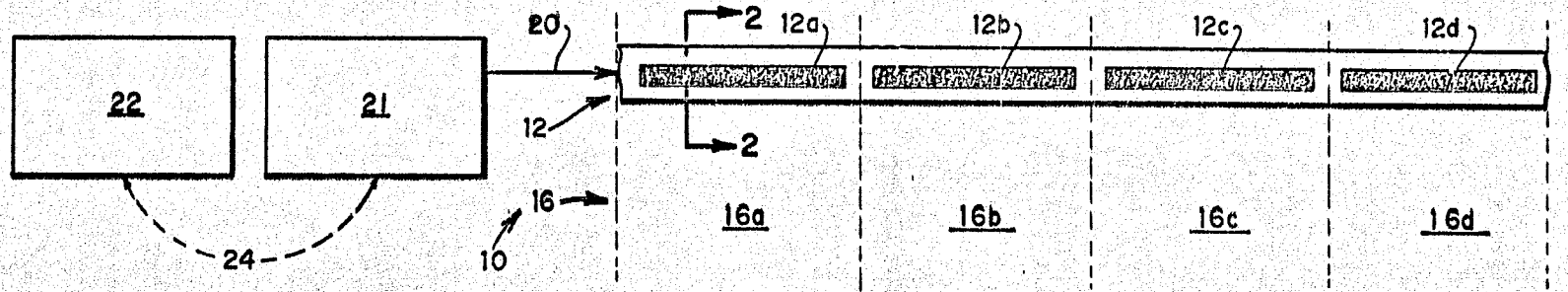


Figure 1

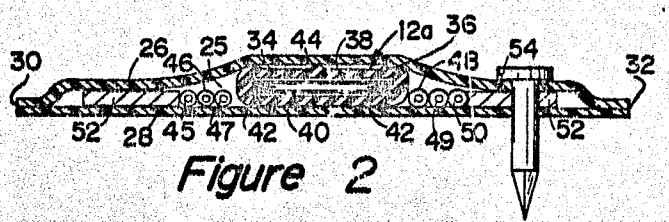


Figure 2

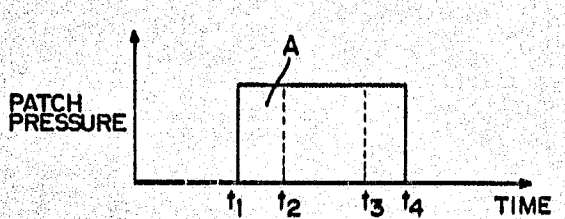


Figure 4

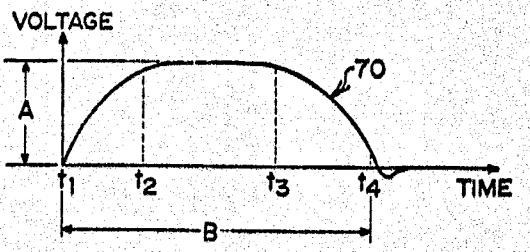


Figure 5

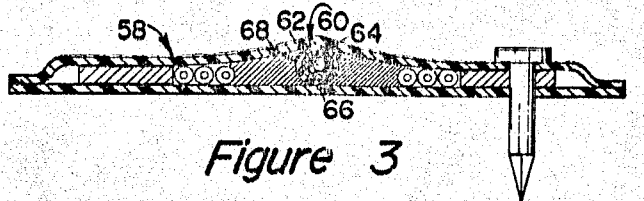


Figure 3

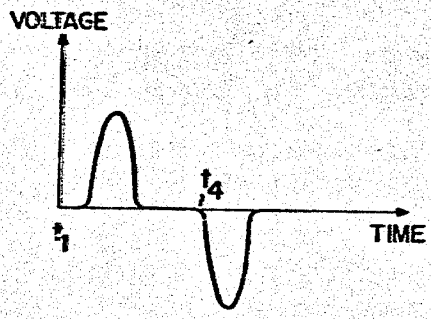


Figure 6

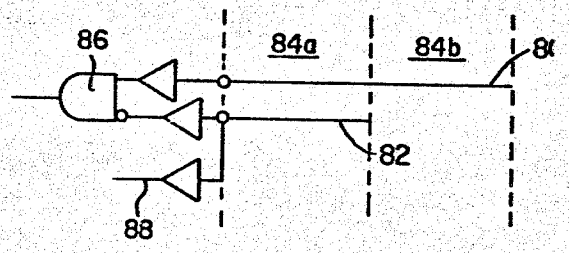


Figure 7

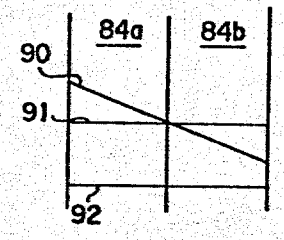


Figure 8

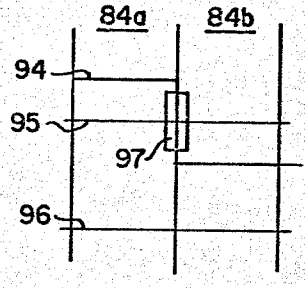


Figure 9

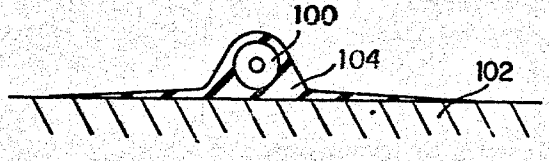


Figure 10

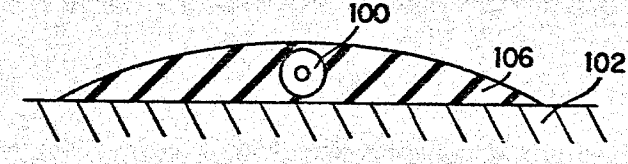


Figure 11

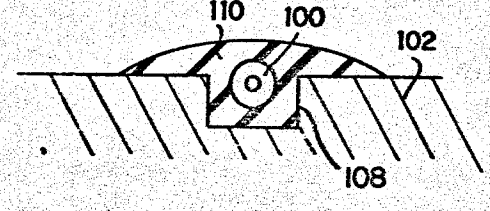


Figure 12

TRAFFIC SENSOR STRIP

BACKGROUND OF THE INVENTION

The present invention relates to traffic sensors for use in separately and simultaneously monitoring the traffic moving in a plurality of different lanes of a roadway.

In the design of roads, highways, bridges, and other structures and facilities, data concerning traffic speed and density; vehicle size, loading and type; and vehicle condition is used by traffic engineers. The complexity of the data required for complete evaluation and planning of these structures at times requires the monitoring of many roadways simultaneously, including multilane roadways. The volume and complexity of the data necessary to make a complete evaluation renders manual traffic counting impractical. Accordingly, automatic traffic recorders have been devised for recording data in a form which can ultimately be used with a computer in the design of these structures.

To provide the information for these automatic traffic recorders, sensors are placed across the roadway. These sensors must be able to monitor traffic in multilane roadways with complete lane isolation while sensing the variety of the data required. In addition, the sensors should have a low profile so that they are not readily visible by the motorists and have a gradual tapering profile to provide a smooth tire transition thereover. The sensors should be durable to resist wear and the possibility of damage from dirt or moisture. In addition, it is desirable that the sensors be provided with means for anchoring in the roadway so that they will remain in position over a prolonged period of time.

Therefore, according to one embodiment of the present invention, an improved traffic sensor is provided having a pressure-sensitive element enclosed in a sealed envelope. The envelope is formed between a pair of polyethylene sheets attached at their edges. The element is segmented along its length corresponding to the number of lanes of the roadway. A plurality of conductors are located in the envelope at the sides of the element. A pair of metallic strips are sealed in the envelope on the outsides of the conductor to provide tabs for anchoring the sensor to the roadway.

It has also been discovered that when compressed, a coaxial cable will produce an electrical effect by generating a voltage between the conductor and the shield of the cable. It is believed that the amplitude of the voltage is proportional to pressure on the cable and the frequency is a function of the speed and the tire patch length of the vehicle compressing the cable.

Therefore, according to another embodiment of the present invention, an improved sensor is provided having a coaxial cable generating an electrical effect upon compression thereof.

The objects and advantages of the present invention will be readily appreciated by those of ordinary skill in the art as the same becomes better understood by reference to the following Detailed Description when considered in connection with the accompanying Drawings in which:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates a plan view of an improved traffic sensor element of the present invention shown schematically connected to a recorder in position on a four-lane roadway;

FIG. 2 is an enlarged section of the device taken on line 2—2 of FIG. 1, looking in the direction of the arrows;

FIG. 3 is a sectional view similar to FIG. 2 illustrating an alternate embodiment of the present invention;

FIG. 4 is a graphical illustration of the tire patch contact as a function of time;

FIG. 5 is a graphical illustration of the electrical effect of a coaxial cable as it is compressed by a vehicle passing thereover;

FIG. 6 is a graphical illustration of a differentiated output of a cable;

FIGS. 7 through 9 illustrate plan views of other embodiments of an improved traffic sensor element of the present invention; and

FIGS. 10 through 12 are sectional views of various embodiments of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the Drawings, wherein like reference characters designate like or corresponding parts throughout the several views, the traffic analyzer system **10** with the improved sensor of the present invention is illustrated in FIG. **1**. Traffic analyzer system **10** is illustrated with a sensor strip **12** positioned transversely across a multi-lane roadway **16**. Roadway **16** is divided into lanes **16***a*, **16***b*, **16***c* and **16***d*. Strip **12** is connected by shielded cable **20** to an electrical assembly **21** for recording the electrical effects generated by strip **12** as a vehicle passes over the strip. Assembly **21** is self-contained and can be located a safe distance from roadway **16** out of view of the motorists. Assembly **21** is provided with means for recording the electrical effects generated by strip **12**.

A control unit **22** may also be provided and selectively connected by cable **24** to initiate the operation of assembly **21** and provide identifying inputs to assembly **21** as desired. Unit **22** can then be disconnected and removed allowing assembly **21** to record the flow of traffic information desired.

Strip **12** has individual sensor segments **12***a*, **12***b*, **12***c* and **12***d* spaced to correspond to lanes **16***a*, **16***b*, **16***c* and **16***d*. The individual segments are independently connected to assembly **21** to record vehicle data for each particular lane.

In FIG. **2**, the details of construction of one embodiment of strip **12** are illustrated. In this embodiment, segment **12***a* is illustrated enclosed in a sealed envelope **25** formed by a pair of strips of polyethylene material **26** and **28**. Strips **26** and **28** extend the length of strip **12** and are sealed at their edges **30** and **32**. Segment **12a** is constructed from a commercially available resilient envelope **34** defining a chamber **36** in which are mounted a pair of parallel spaced conducting plates **38** and **40**. Plates **38** and **40** are normally resiliently held in the position illustrated in FIG. **2** by a pair of compressible spacers **42** integrally moulded into the interior of envelope **34** to extend from the sides thereof. Upon compression of envelope **34**, plates **38** and **40** will contact. Suitable electrical conductors are connected to plates **38** and **40** and are connected through cable **20** to assembly **21**. To assist in the compression of envelope **34**, an extending portion **44** protrudes from the upper surface thereof.

Positioned on either side of segment **12***a* are six conductors **45–50**. Conductors **45–50** can be appropriately

connected to the plates of segments 12*b*, 12*c* and 12*d*. More or less conductors can be provided as required by the number of lanes in a given roadway to be monitored.

A pair of plates 52 are bonded between strips 26 and 28 adjacent to sealed edges 30 and 32. To anchor strip 12 to roadway 16, suitable fasteners 54 can be driven through plates 52 at spaced locations along the length of strip 12.

In addition to edges 30 and 32, strip 12 is completely sealed at its ends. A connector may be provided in the end of strip 12 adjacent to segment 12a to attach cable 20 to the conductors for the pressure-sensitive elements of segments 12*a*, 12*b*, 12*c* and 12*d*. Alternatively, cable 20 could be fixed to strip 12 and a connector provided at assembly 21.

Assembly 21 is provided with means for sensing and recording contact between the plates of segments 12*a*, 12*b*, 12*c* and 12*d*, caused by the passage of an automobile thereover.

An alternate embodiment of the invention is illustrated in FIG. 3. This alternate embodiment 58 is identical to strip 12 illustrated in FIG. 2 except that a coaxial cable 60 replaces envelope 34.

Coaxial cable 60 is a compression-friction responsive cable. Preferably, it is of the type manufactured and sold by Microdot Inc., Cable Division, South Pasadena, California, as Product Code No. 918, Dwg. No. 250–4262–0000 dated July 9, 1973. RG/U-316 CABLE is also acceptable but has a short life. The microdot cable has a double wrap of metal shielding and has been found to produce a distinct and identifiable signal upon passage of a vehicle thereover.

In the embodiment illustrated in FIG. 3, cable 60 is divided into a plurality of segments corresponding to the lanes to be monitored. These individual segments are connected through conductors in cable 20 to unit 21 as previously described with respect to strip 12. Cable 60 has central conductor 62 which is surrounded by dielectric insulation 64. Shield element 66 surrounds insulation 64 and shield element 66 is surrounded by a second layer of high wear resistant insulation 68.

In use, central conductor 62 and shield element 66 are connected to unit 22 through cable 20. An electrical effect in the form of voltage is generated between the conductor and shield when a vehicle passes over and compresses cable 60.

In FIG. 4, a time history of a tire patch presence on the cable is graphically illustrated. At t_1 the tire first touches the sensor. During period "A" (from t_1 to t_2), the maximum acceleration of the tire rubber occurs and therefore, the greatest change in forces on the cable occur. During the "B" period (t_2 to t_3) the force on the cable is relatively constant and is approximately proportional to the pressure in the tire and the acceleration of the rubber away from the road at the sensor. In the "C" period (t_3 to t_4), the tire is leaving the sensor with complex dynamics occuring in the tire.

In FIG. 5, a graphic illustration of the voltage generated in an 80-foot length of cable is shown as plot 70. The ordinate of the graph is voltage and the abscissa is time. The amplitude A is believed to be proportional to the weight of the vehicle or pressure exerted on the cable. The period B is believed to be proportional to the vehicle speed and patch length.

The operation of the coaxial cable when generating the electrical effect is not completely understood. It is believed that the voltage in the conductor is created either through friction generated by shield element 66 rubbing on the adjacent dielectric as cable 60 produces a static charge or by an effect similar to a piezoelectric device caused by the molecular arrangement when the dielectric is extruded.

By using the cable as a variable current generator, recording electronics can be used with a low input impedance. These electronics can be what is generally known as a charge amplifier, which partially integrates the cable signal which is differentiated to some degree by the cable. This output of this amplifier can be used in systems to measure dynamic local road loading. In addition, the output can be connected to a threshold detector to produce signals from only those vehicles which exceed a desired road loading. This system minimizes the effects of environmental factors such as temperature and moisture.

It may also be desirable to detect just the leading or trailing edge of the patch. This can be accomplished by differentiating the signal produced by the cable. An example of the resultant signal from this differentiation is illustrated in FIG. 6. The leading and trailing edges of the patch produce sharp indications on the graph.

In FIG. 7, a third embodiment is illustrated using coaxial cable as a transducer providing lane segregation. On this embodiment two closely spaced cables 80 and 82 are placed across a roadway 84. In this illustration, roadway 84 has traffic lanes 84*a* and 84*b*. Cable 80 extends completely across lanes 84*a* and 84*b* while cable 82 extends only across lane 84*a*.

Cable 80 is connected to an AND gate 86 while cable 82 is connected to gate 86 and amplifier 88. The output of amplifier 88 will represent the traffic in lane 84*a* while the output of AND gate 86 will represent the traffic lane 84*b*.

By designing the sensor in this manner the traffic in more than two lanes can be separated and recorded. In addition, the lanes can be segregated by placing a small rigid tubular member around the cable in the lanes in which a signal is not desired.

In FIG. 8, another embodiment is illustrated using coaxial cable as a transducer providing lane segregation. In this embodiment lanes 84*a* and 84*b* have three cables 90, 91 and 92 extending completely thereacross. Cables 90 and 91 intersect at a point between the lanes. Cables 91 and 92 are positioned transverse to the traffic flow. By differentiating the signal from the cables 90, 91 and 92 as described above, lane segregation and speed can be determined. Vehicles in lane 84*a* would be indicated by signals in order from cables 90, 91 and 92. Vehicles in lane 84*b* would be indicated by signals in order from 91, 90 and 92. In both instances the time lapse between cables 91 and 92 would be proportional to speed.

In FIG. 9, an embodiment using cables 94, 95 and 96 is shown which prevents coincidence at the cable crossover of cables 94 and 95. In this embodiment, cable 94 is protected by a rigid metal tube 97 or the like to prevent a coincident signal at the crossover point. By using the logic of the FIG. 8, embodiment lane segregation and speed can be determined.

In FIG. 10, an embodiment for installing a cable 100 on a road bed 102 is shown. In this embodiment tempo-

rary mounting of cable **100** is accomplished by use of an adhesive tape **104.**

In FIG. **11,** cable **100** is permanently attached by means of an adhesive compound **106** which is shaped to cover cable **100** and adhere to roadway **102.** A suitable adhesive compound **106** has been found to be Miracle Seal Mfg. by Revere Chemical Corp., 12407 Woodland Ave., Cleveland, Ohio 44120.

In FIG. **12,** an additional embodiment is illustrated wherein the cable **100** is inserted into a groove **108** in the roadbed **102.** This groove extends completely across the lane to be monitored. A suitable adhesive compound **110** can be used to adhere the cable to the roadway.

Thus, it can be seen that the present invention provides a traffic sensor element which is portable and easy to install with lane isolation. In addition, the profile of the sensor has a gradual buildup for smooth transition making the sensor practically invisible to the motorists. The sensor is sealed to reduce the possibility of damage from dirt and moisture, and flanges are provided to easily attach the sensor to the road.

In addition, the strip **58** can provide an inexpensive element which functions even through the near lane is compressed. It is believed that by use of strip **58,** speeds, weights, patch lengths and axle counting can be accomplished. In addition, the strip **58** can be utilized to sense compression by other than the passage of vehicles thereover.

Having thus described the invention, it is to be understood, of course, that the present invention may be practiced otherwise than as described and that numerous modifications and alterations may be made therein without departing from the spirit and scope of the invention as set forth in the appended claims.

In the claims:

1. A traffic sensor which comprises:

a. an elongated element which produces an electrical effect when compressed;

b. a pair of insulating strips enveloping said element with faces of said strips confronting;

c. a plurality of parallel insulated electrical conductors positioned between said strips and alongside said element, and

d. a pair of rigid metallic strips bonded to said insulating strips at each edge thereof.

2. The sensor of claim **1** in which said element comprises a pair of conductive plates normally spaced apart which make electrical contact when compressed.

3. The sensor of claim **1** wherein said element comprises a coaxial cable having a central insulated conductor, a shield around said insulator and a second insulator around said shield.

4. The sensor of claim **1** wherein said element is segmented along its length.

5. A traffic sensor which comprises:

a. an elongated element which produces an electrical effect when compressed;

b. an elongated insulating envelope housing said element centrally thereof;

c. a pair of rigid metallic strips of thickness substantially less than the thickness of said element and bonded to the inner faces of opposite sides of said insulating envelope, and

d. a plurality of insulated electrical conductors positioned between said strips and extending parallel alongside said element.

6. The sensor of claim **5** in which said strips have holes therethrough at spaced points along the length for receiving hold down anchors.

7. The sensor of claim **6** wherein said element comprises a compression friction responsive coaxial cable having a central insulated conductor, a shield around said insulator and a second insulator around said shield forming an elongated cylinder, bodies of filler material on opposite sides of said cable having sides which slope from a thickness of said cable to a thickness of said strips.

8. A traffic sensor which comprises:

a. an elongated compression-friction responsive coaxial cable which produces an electrical effect when compressed,

b. a wide thin insulating body enveloping and intimately adhered to said cable forming a profile of gradual buildup for smooth transition of an automobile tire thereover, and

c. a pair of metallic members bonded to said insulating body at opposite sides of said cable for securing said body to a roadway.

9. A traffic sensor which comprises:

a. an elongated compression-friction responsive coaxial cable having a central conductor, an insulator surrounding said conductor, and a coaxial conductive shield element intimately secured to and surrounding said insulator over its length wherein said cable produces an electrical signal when compressed, and

b. a wide thin insulating body enveloping and adhering said cable to a vehicle path and forming a profile of gradual buildup for smooth transition of an automobile tire thereover.

10. The sensor of claim **9** in which said body is adhered to said path by adhesive material.

* * * * *