United States Patent

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[54] **APPARATUS FOR CONTROLLING SONIC ENERGY DISTRIBUTION**

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[52] **U.S. Cl.**..........................**181/.5 R,** 179/115.5 H, 340/8, 333/95, 73/71.5

[51] **Int. Cl.**..........................**G01s 9/00,** H04r 1/28

[58] **Field of Search**..........................181/31 A, .5 R; 73/71.5 U; 340/8 RT, 8 L, 38; 179/115.5 H; 333/95, 98

[56] **References Cited**

UNITED STATES PATENTS

1,823,705	9/1931	Smith	181/31 A
1,845,768	2/1932	Stokes	181/31 A

FOREIGN PATENTS OR APPLICATIONS

821,371	7/1949	Germany	179/115.5

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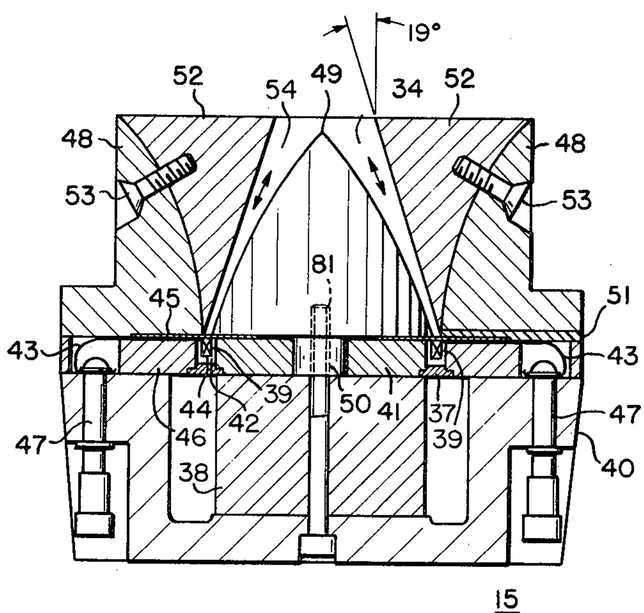
Assistant Examiner—J. V. Doramus
Attorney—Harold S. Wynn

[57] **ABSTRACT**

An electromechanical transducer is provided for producing pulses of sonic energy and respondingly generating electrical signals relative to received sonic energy wherein a driver generates the sonic pulses; and an improvement for projecting the sonic energy in a peculiar controlled pattern is a wave guide interposed at the output of the driver for controlling the propagation of the pulses by setting up substantially a line source of sonic energy which emanates the sonic energy in an operating pattern of at least a minimum intensity near the point of greatest breadth of the pattern.

There has been provided an electromechanical transducer for projecting sonic energy in a peculiar pattern including a head mounted at the output of the transducer and a wave guide having a transverse slot therethrough adapted to cooperate with the head for directing the propagation of the sonic energy to substantially complete sonic coverage within a limited range.

17 Claims, 14 Drawing Figures



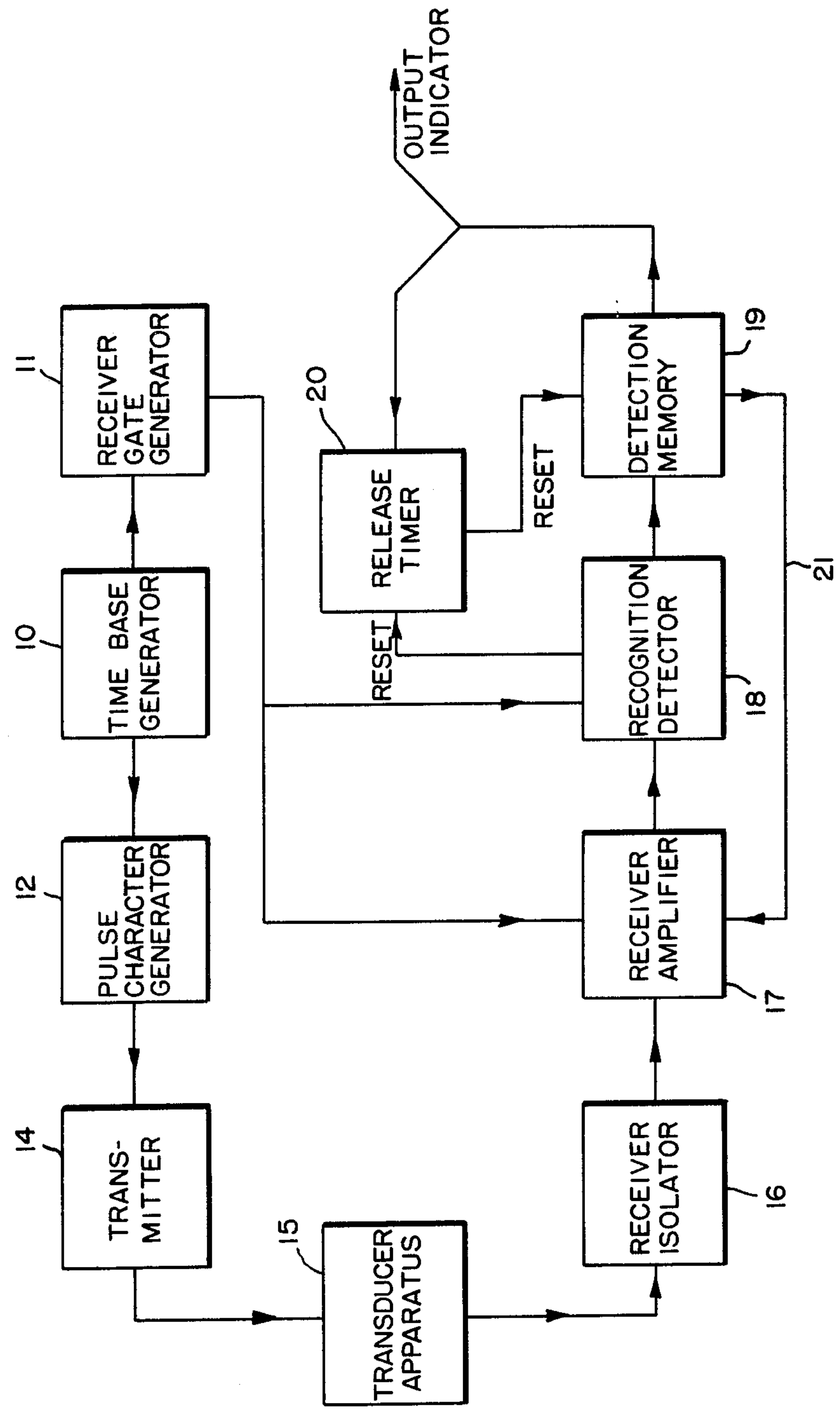

OUTPUT INDICATOR
RECEIVER GATE GENERATOR
11
TIME BASE GENERATOR
10
PULSE CHARACTER GENERATOR
12
TRANS-MITTER
14
TRANSDUCER APPARATUS
15
RELEASE TIMER
20
RESET
RESET
DETECTION MEMORY
19
RECOGNITION DETECTOR
18
RECEIVER AMPLIFIER
17
RECEIVER ISOLATOR
16
21

FIG. 1

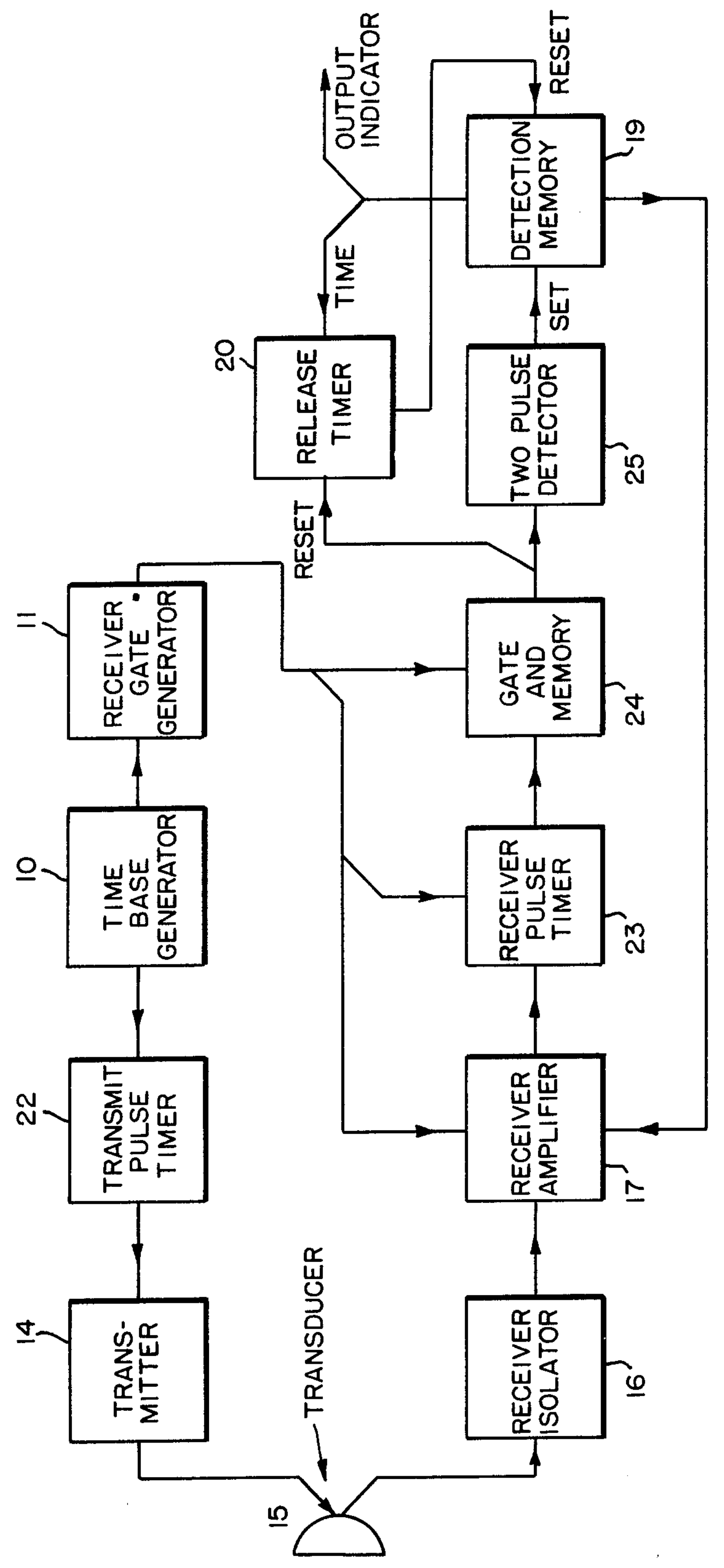
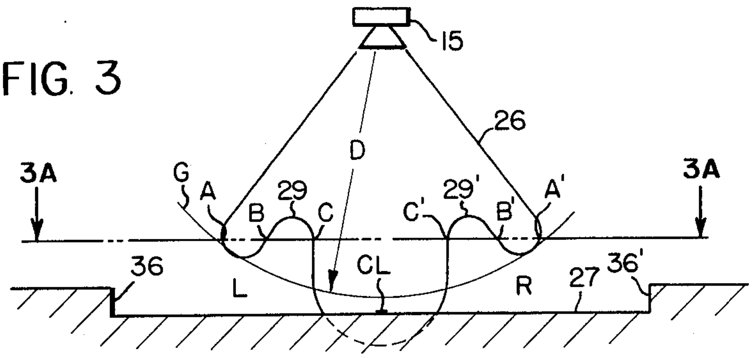

OUTPUT INDICATOR
RESET
DETECTION MEMORY
19
TIME
20
RELEASE TIMER
SET
TWO PULSE DETECTOR
25
RESET
11
RECEIVER GATE GENERATOR
GATE AND MEMORY
24
10
TIME BASE GENERATOR
RECEIVER PULSE TIMER
23
22
TRANSMIT PULSE TIMER
RECEIVER AMPLIFIER
17
14
TRANS-MITTER
TRANSDUCER
RECEIVER ISOLATOR
16
15

FIG. 2

FIG. 3



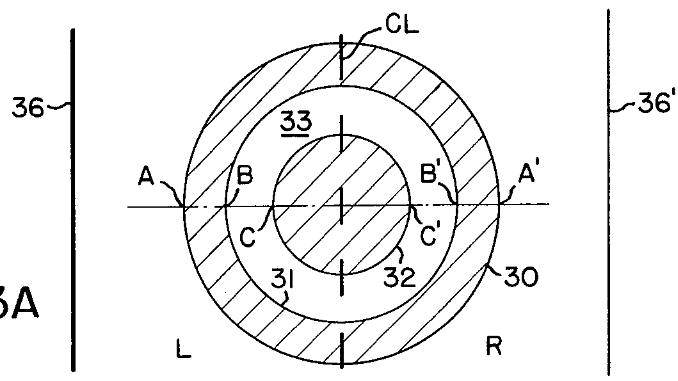


FIG. 3A

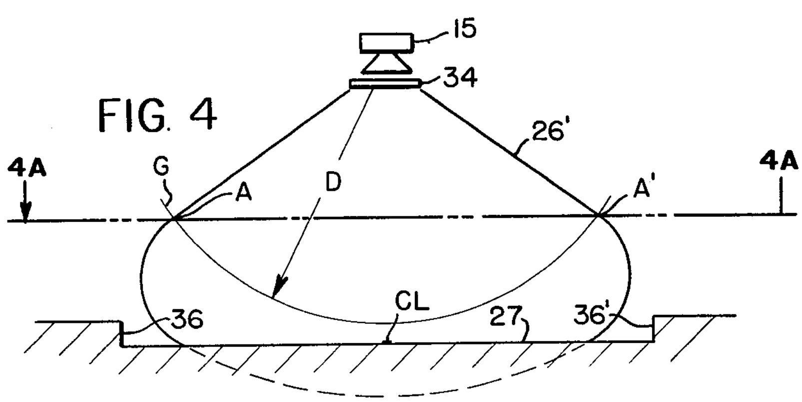


FIG. 4

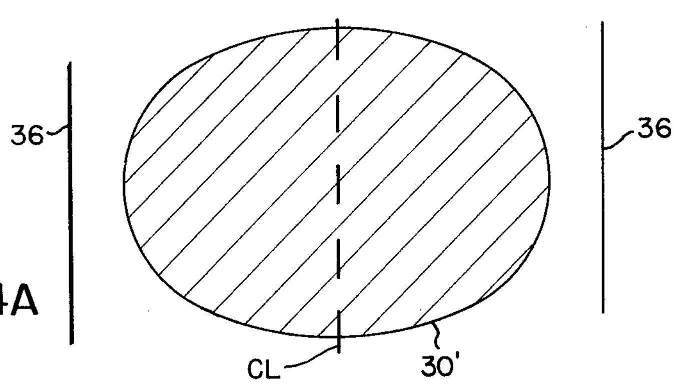


FIG. 4A

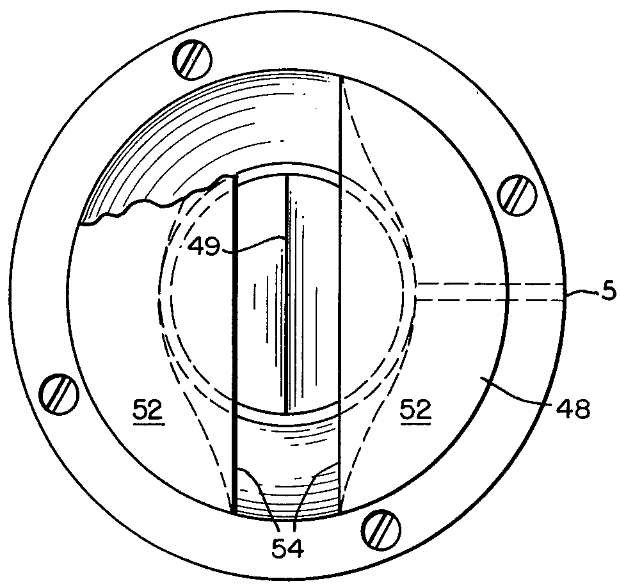


FIG. 6

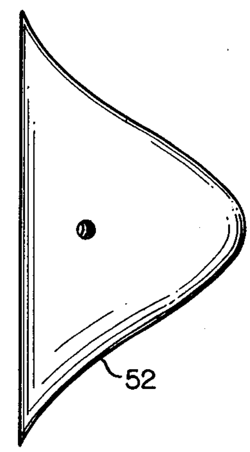


FIG. 7

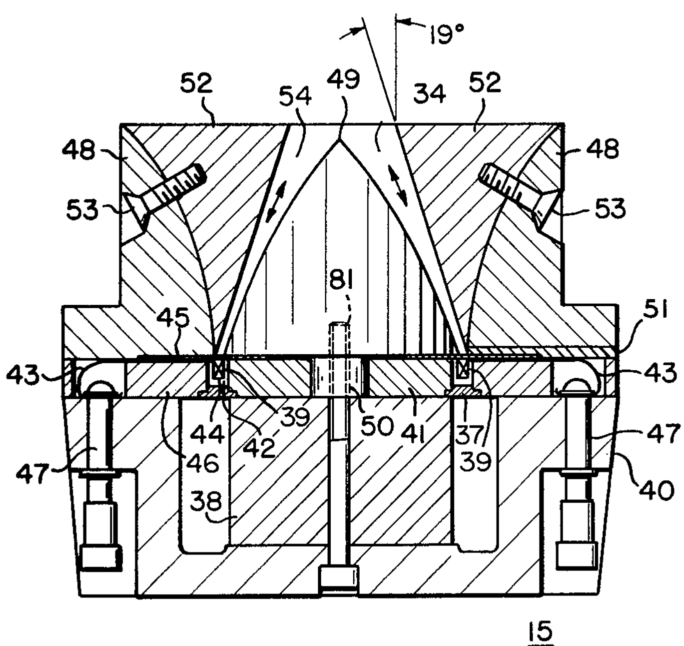


FIG. 5

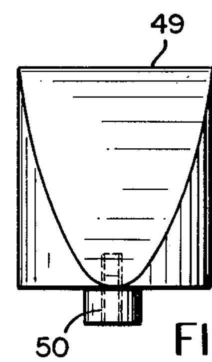


FIG. 8

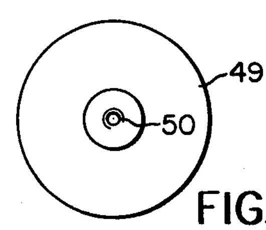
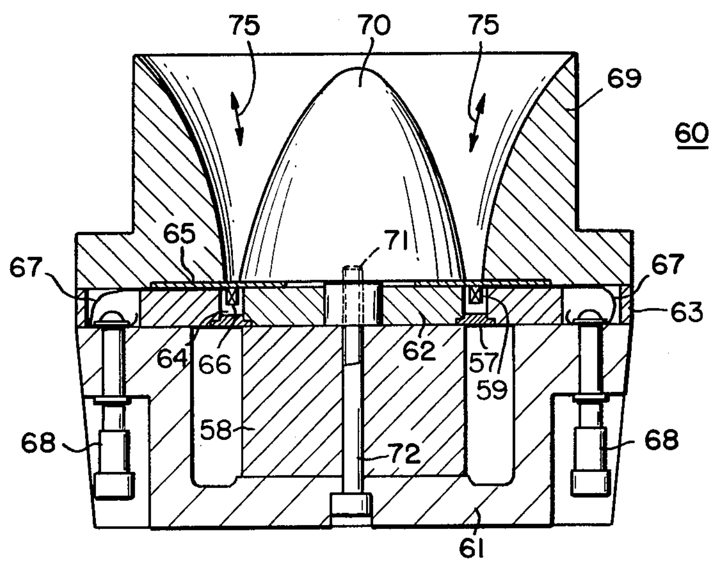


FIG. 9

FIG. 11



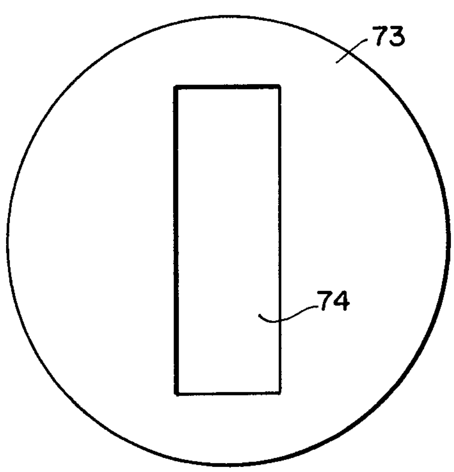


FIG. 12 FIG. 10

APPARATUS FOR CONTROLLING SONIC ENERGY DISTRIBUTION

BACKGROUND OF INVENTION

The present invention relates to sonic detector systems and more particularly to systems capable of distinguishing vehicle reflected signals in a defined zone.

Sonic detection systems find utilization in a number of applications, for example, traffic control and garage supervision. This invention describes a system primarily intended for the detection and indication of vehicle presence for traffic control.

In a typical application, detection systems transmit short duration pulses of vibration energy, preferably within the ultrasonic frequency region. These pulses are directed toward the vehicles by transducer apparatus which also produces electrical signals by responding to reflected energy from the roadway and vehicle surfaces. The roadway reflections are gated out of the system and have no effect upon its operation. Those signals reflected from the vehicle or object are recognized and produce a distinctive indication of vehicle or object presence. Thus, presence of a vehicle or object on the roadway is indicated whenever sufficiently strong reflections of sonic energy are received by the transducer apparatus within the vehicle gate interval.

In practice, systems using ultrasonic techniques have proven substantially successful and adaptable to various environments and targets. However, due to the nature and design of those presently deployed systems, all in varying degrees are limited by certain operation deficiencies. Primarily these deficiencies may be related to the inability of the system to adequately distinguish false signals, either generated within the system or present in the environment, from signals actually reflected from the surface of the vehicle or object under scrutiny. Noise or false signals mainly result from electrical coupling within the system and ringing or continued vibration of the sonic transducer after transmission of each sonic pulse. The latter source of noise is the use of a single sonic transducer for both transmitting and receiving. Another noteworthy problem concerns vibrations in reflected signal strength due to differences in shapes and sizes and materials of the vehicle or objects. Variation occurs in reflected signals also because the initial pulses are projected in "lobes" of high and low intensity patterns. That is, over a desired zone of detection, the intensity of the pattern of pulses projected by the transducer varies significantly to cause sensitivity problems. When a wide detection zone is desired, apparatus necessary for detection in a large zone is multiplied because the so-called low intensity areas must be covered with at least a minimum intensity pattern before a significant reflected signal can be utilized.

SUMMARY OF INVENTION

There has been provided an electromechanical transducer for projecting sonic energy in a peculiar pattern including a head mounted at the output of the transducer and a wave guide in the form of a cap having a transverse slot therethrough adapted to cooperate with the head for directing the propagation of the sonic energy to substantially complete sonic coverage within a limited range.

An electromechanical transducer apparatus for producing pulses of sonic energy and respondingly generating electrical signals relative to received sonic energy has been provided. A driver generates the sonic pulses and an improvement for projecting the sonic energy in a peculiar controlled pattern is a wave guide interposed at the output of the driver for controlling the propagation of the emitted sonic pulses. The wave guide means sets up substantially a line source of sonic energy. The line source eminates the energy in an operating pattern of at least a minimum intensity near the point of greatest breadth of the pattern.

There has been provided an improved object detection system wherein a transmitter produces periodic pulses of sonic frequency and peculiar time duration. A transducer converts these pulses into emitted sonic energy pulses and respondingly generates electrical signals relative to received sonic energy including energy reflected from the object. A detector manifests an indication of object presence when actuated and a receiver is rendered responsive for a selected interval to the signals for actuating the detector only when signals having a peculiar characteristic correlative to the pulses of sonic energy are received during the selected interval. The improvement provides for projecting the emitted sonic energy in a peculiar pattern wherein a wave guide means interposed at the output of the transducer modifies the propagation of the emitted sonic energy pulses to control the pattern. The wave guide means sets up substantially a line source of emitted sonic energy for spreading the emitted sonic energy pulses in a direction perpendicular to the line source such that an elliptical pattern of sonic energy is produced and said line source provides an operating pattern of at least a minimum intensity over the elliptical pattern.

It is another object of the invention to provide an improved object detection system with a controlled detection zone.

It is yet another object of the invention to provide a vehicle detection system wherein a transducer produces a peculiar pattern of at least a minimum intensity.

It is still another object of this invention to provide a controlled pattern of sonic energy in a controlled area.

It is another object to provide an enlarged pattern of sonic energy distribution.

It is yet another object of the invention to adapt wave guide techniques to sonic detector systems for increasing the reliability of such systems.

The foregoing objects and features of the present invention are clearly outlined and explained in the drawings and detailed description.

DESCRIPTION OF DRAWINGS

The drawings contain the following:

FIG. 1 shows one embodiment of the object detection system of the present invention.

FIG. 2 shows another embodiment of the object detection system of the present invention using two-pulse recognition.

FIG. 3 shows a pattern of emitted sonic energy of a transducer without the improvement of the present invention.

FIG. 3A shows a projection of the emitted sonic energy of FIG. 3 along 3A—3A.

FIG. 4 shows a pattern of emitted sonic energy of the transducer of the present invention.

FIG. 4A shows a projection of the emitted sonic energy of FIG. 4 along line 4A—4A.

FIG. 5 shows a side section elevation of the transducer of the present invention.

FIG. 6 is a top elevation of the transducer of the present invention.

FIG. 7 is a portion of the preferred wave guide means.

FIGS. 8 and 9 are side and bottom elevations of the preferred insert, respectively.

FIG. 10 is a side view of a modified wave guide.

FIG. 11 is a side section elevation of the prior art transducer.

FIG. 12 is a front elevation of the modified wave guide of FIG. 10.

DESCRIPTION OF THE EMBODIMENT

FIG. 1 shows a detection system incorporating pulse recognition and detection in which a time base generator **10** containing a free-running oscillator of the multivibrator or other similar type generates pulses of desired repetition rate. The time base generator **10** has two outputs alternately producing pulses. The alternate pulses are used to control a receiver gate generator unit **11** and a transmitter pulse character generator **12** respectively.

The pulse character generator 12 produces a pulse having an identification characteristic different from the noise signals either generated or received by the system. A transmitter 14 is controlled to transmit an electrical signal of substantially a single sonic frequency possessing the same identification characteristic. The transducer apparatus 15 responds to the transmitter 14 by converting the transmitter 14 electrical signals into a vibratory output of substantially the same frequency and characteristic. It also responds to reflected or environmental sonic energy by generating electrical signals. Thus the transducer apparatus 15 respondingly produces electrical signals corresponding to environmental sonic noise and reflected sonic signals.

The receiver gate generator 11 when keyed by the time base generator 10 provides a system gate signal activating the receiver circuitry for periods of time relative to the anticipated receipt of reflected signals from the targets. The receiver isolator unit 16 conducts the electrical signals to the receiver amplifier 17 and provides the desired impedance levels for the transducer apparatus. It is primarily needed in applications where a single transducer for both transmitting and receiving is utilized. The receiver amplifier 17 is tuned to the sonic frequency of the transmitted pulse and thus is primarily responsive to only those signals containing energy within its band. The gate signal supplies bias voltage to the first stage of the receiver amplifier 17, and thus controls its response. When no gate signal is present, the gain of the receiver amplifier 17 is essentially zero while during the gate signal interval it reaches a value determined by the parameters of the circuit. This gain control prevents the amplifier from responding to signals received at times other than those anticipated for reflected target signals. Amplifier gain is also modified during the gate interval by other circuitry to further control the response of the system to ringing signals and variations in signal strength. These controls will be more fully described in ensuing detailed descriptions.

The recognition detector 18 responds only to those amplified signals having the peculiar identification characteristic of the transmitted pulse. If the received electrical signal is coincident with the gate signal and has a characteristic correlative to the peculiar character of the transmitted pulse, the recognition detector 18 circuitry will respond. The recognition detector 18 circuitry may be conditioned to respond only to a plurality of reflected signals received within a particular selected interval ranging over a number of transmission cycles. Should the requirements of the recognition detector 18 be met, it initiates an alteration in the detection memory 19.

The detection memory 19 when altered to a second stable state, produces a distinctive indication of vehicle presence and also causes a release timer 20 to be activated. Should signals be produced by the recognition detector 18 at a rate greater than a predetermined minimum, the release timer 20 once actuated, is prevented from producing an output signal. At such time, however, as recognition detector 18 signals cease, relative to the removal of the object or vehicle from the detection zone, the release timer 20 times out and extinguishes the presence indication in the detection memory 19, thus conditioning the system for detection of succeeding vehicles or object. The detection memory 19 contains a feedback feature represented by line 21 which increases the gain of the receiver amplifier after detection is accomplished. The increased gain prevents loss of recognition due to reductions in reflected signal strengths.

An embodiment using multiple pulse detection is also detailed. It must therefore be kept in mind that the various forms shown are intended to show equipment organizations conforming to the exigencies of practical applications and not necessarily providing the maximum security available for any given situation.

FIG. 2 shows a system embodiment, containing both pulse recognition and plural pulse detection, wherein a time base generator 10 comprising any suitable free-running oscillator of required pretition rate, creates repetitive pulses used to key the transmission of sonic energy and receiver gate signals. The time base generator 10 output is conducted to the transmit pulse timer 22, which apparatus provides a pulse output of approximately 5 millisecond duration to drive transmitter 14. The transmitter output, a substantially monotonic energy pulse of 5 millisecond duration, supplies power to the sonic transducer 15. The sonic transducer 15, through electromechanical conversion, directs compressional wave front signals, commensurate to the frequency of the transmitter signal, to intercept the predetermined path of moving vehicles or objects.

The time base generator output 10 determines the repetition rate of receiver gate signals by triggering the receiver gate generator 11. In response to each pulse from the time base generator 10; the receiver gate generator 11 produces an output signal of sufficient duration so as to encompass an interval of time commencing shortly after the cessation of transducer 15 transmission and ending shortly before the time required for acquisition of the sonic energy reflected from the pavement. If the system is used where no pavement reflection exists, then a different time may be selected. The receiver gate generator 11 output is utilized by various parts of the system, viz., the receiver amplifier 17, receiver pulse timer 23 and gate and memory 24 in the recognition of reflected vehicle signals.

The sonic transducer 15 in addition to being capable of converting electrical energy into mechanical motion, is also sensitive to the receipt of pressure variations. Pressure variations are caused by ambient noise conditions prese nt in the environment of the transducer and energy reflections in response to its own transmitted pulses. Thus, as a transmitted sonic pulse is reflected either from the roadway or a passing vehicle, it is sensed by the transducer 15 and results in generation of a voltage output. The voltage output is coupled to the receiving portion of the system through receiver isolator 16 which allows the receiver portion of the system to sense reflected signals while rejecting excessively large signals produced when voltage or power is supplied to the transducer 15. Also prevented is the loading of the transmitter 14 during pulse transmission periods and the transducer 15 during energy reflection periods.

Output from the receiver isolator 16 is conducted to the receiver amplifier 17. The amplifier is tuned to the tonal frequency of the transmitter-transducer combination and is relatively unresponsive to any received signals not primarily containing that single basic frequency; this results in rejection of a certain amount of noise received from environmental effects on the transducer itself. The receiver amplifier 17 is rendered responsive by the receiver gate generator 11 signal, thus avoiding responding to energy pulses indicative of transmitted rather than reflected signals.

The received signals of specified tonal frequency after amplification are received by the receiver pulse timer 23 which is arranged to produce a signal output upon its recognition of pulses having a time duration in excess of 3 milliseconds. Further, the received pulses of required duration must be coincident with the gate signal provided by receiver gate generator 11. If these two conditions are met, a signal output lasting for the remaining duration of the gate signal period is produced by the gate and memory unit 24.

The gate and memory unit 24 is only enabled during the gate period provided by receiver gate generator 11. Its memory feature is provided by the bistable character of its circuitry; once energized during the gate interval, it can be only deenergized upon cessation of the gate signal. Thus, the receipt of reflected signals during the gating period produce only a single output from the gate and memory unit 24.

The two-pulse detector unit 25 is actuated if more than a single output signal is derived from the gate and memory unit 24 during a predetermined span of time. This interval is selected to encompass one or more energy transmission cycles, a single cycle consisting of the time between successive transmission of energy from the sonic transducer 15 as determined by the time base generator 10. System parameters are chosen to demand two received pulses before producing an output from the two-pulse detector 25 to indicate the presence of a passing vehicle or object of this condition ultimately distates the cycle time of the system dependent upon the transducer 15 coverage and the maximum speed of the vehicles.

The two-pulse detector 25 output then effects a change of state in the detection memory unit 19. Once the detection memory unit 19 is altered, it remains so until output signals from the gate and memory unit 24 cease for longer than a certain maximum period. The desired period, before resetting of the detection memory unit 19, is determined by specified operational requirements and implemented by a release timer unit 20. The release timer unit 20 starts to time out whenever a signal is produced by the detection memory unit 19 and is reset to start upon each receipt of an output signal from the gate and memory unit 24. Thus, as long as signals are being received from the gate and memory unit 24 at a certain minimum rate, the release timer unit 20 is not permitted to time out. At such time as these, signals cease for a period commensurate with the minimum rate, the release timer 20 goes through its time cycle and produces an output signal which in turn resets or clears the detection memory unit 19.

In addition to the problems described in the previous discussion, difficulties associated with acoustical patterns set up by the transducer must be discussed. These problems when solved provide for reliability relative to the detection zone pattern and thus increase the efficiency of the electronic improvements previously discussed.

Referring to FIG. 3 of the drawings, the transducer unit 15 without the improvement of the present invention and its normal sonic pattern is shown. The curve G at a radius D from transducer 15 represents the gate interval set up by gate generator 11. This wave pattern is of a uniform intensity along line 26. This intensity represents the minimum signal which must be transmitted by the transducer unit 15 in order to receive a reflected signal from an object within the detection zone of any usable intensity. The pattern of FIG. 3 has a major lobe in the center and two minor lobes to either side of center. This pattern presents certain difficulties in vehicle traffic detection. The pavement 27 is divided into two lanes at center lane marker CL; L and R representing left and right. It is sometimes desirable to be able to detect vehicles in both lanes L and R. For this reason, transducer 15 is placed above the center CL of the highway as shown. Vehicles coming within the detection zone of the unit 15 reflect sonic pulses from the surface of the vehicle to the unit 15 and a suitable electrical signal is generated for controlling the associated apparatus. Certain of the reflected signals to the transducer 15 are gated out by the timing of the various circuits of the system. Generally all signals below one or two feet from the pavement 27, represented by curve G, are gated out so that there is no pavement reflection to the transducer 15. However, it can be seen from the drawing that the areas 29 and 29′ indicate that the minimum intensity sonic energy varies along curve G. With this difference in intensity shown merely by way of example in FIG. 3, it is possible to miss or lose sight of a vehicle in the detection zone. To alleviate this problem, it has sometimes been necessary to use separate transducers and place one over each of the lanes L and R to be certain of positive detection. This, when multiplied by as many intersections that are usually controlled by systems of this sort, requires additional equipment which is quite costly.

FIG. 3A is a projection of the pattern provided by transducer 15 upon a plane parallel to the highway containing line 3—3′. The outer circle 30 shows the extremity of the system or widest range of points A—A′. Circles 31 and 32 define an annular shaped area 33 (unshaded) produced by the rotation of points B—B′ and C—C′ by 180° about the center CL of the highway 27, wherein a substantially less intense signal is received or available in the detection zone. A vehicle may be present in area 33 and yet be missed by the detection system. Line 32, the innermost circle, shows again a high intensity area possibly the width of one lane of traffic which would be used in single lane occupancy detection.

FIG. 4 shows the transducer 15 of the present invention with wave guide 34 adapted to the output of the transducer 15. This wave guide 34 modifies the sonic pulses emitted from transducer 15 by setting up a line source at the output of wave guide 34 and produces a pattern having at least a minimum intensity signal over the detection zone. The curve G similar to FIG. 3 at a radius D from the transducer 15 represents the gate interval set up by gate generator 11. From this all signals below line G are gated out by the system and transducer 15 is not responsive to reflected signal from any objects beyond curve G. Comparing FIGS. 3 and 4, it is apparent that empty areas 29—29′ of FIG. 3 are not present within curve G and therefore the whole detection zone is filled.

FIG. 4A is a pattern 30′ of the sonic energy in a plane including line 4A—4A parallel to the highway. The pattern in FIG. 4A shows an elliptical shape 30′ covering more of an area than the pattern in FIG. 3A. The curbs 36—36′ shown in FIGS. 3A and 4A define the width of the highway 27. It is clear that the projection 30 in FIG. 3A does not extend as widely as the projection 30′ of FIG. 4A. The elliptical pattern may be arranged to either be longitudinal with the direction of the highway or across the two lanes L and R as shown in FIG. 4A. It has also been found useful to use the arrangement of the present invention with sidefire operation when across the highway detection is desired for three lane detection. That is, the transducer 15 is mounted off to the side of a highway, projecting sonic energy across the highway rather than down upon it. The same gating techniques are used as previously described, but for particular applications, side-fire may be more useful.

Because of the shape of walls 48 and inserts 52, if the device is used for side-fire operation, it is possible for water to collect in the wave guide 34. Slot 51 extending through wall 48 provides for adequate water drainage under such circumstances.

As will be explained later, the elliptical shape of the pattern is a direct result of the wave guide 34 being interposed after output of the transducer 15. A vehicle anywhere within the range of the device across the highway 27 will be detected whether it is in the left or right lane.

The transducer 15 and certain components shown in FIGS. 5–9 includes a ferro-magnetic base 40 in which is mounted magnet 38 and ferro-magnet circular pole piece 41 and an outer pole piece 46 located about pole piece 41 leaving an annular air gap 42 for the flux of magnet 38. Non-ferromagnetic annular member 37 maintains the alignment of the air gap 42 between outer pole piece 46 and inner pole piece 41 without shunting the field in the air gap 42. The magnet 38 provides magnetic flux through inner pole piece 41 across the air gap 42 through outer pole piece 46, base 40 and back to the bottom of magnet 38. Diaphragm 45 having an annular shape for mounting over slot 42 includes ring 44 which fits into slot 42 and is capable of movement therein. The ring 44 has a wire coil 39 built therein, wrapped around, circularly, with the inner pole piece 41 and the wire coil 39 is attached by leads 43 to terminal points 47 for actuation by electrical energy. The diaphragm 45 is driven by ring 44 and coil 39 where it interacts with the magnetic field of the magnet 41 and produces emitted sonic energy pulses in response to electrical signals impressed in leads 43, and diaphragm 45 drives coil 39 which generates electrical signals from reflected pulses. An outer wall 48 is mounted on top of the outer member 46 and extends downwardly and inwardly from the top about the outer edge of diaphragm 45. Head 49 is a conoidal wedge having a defined shape mounted in the center of the transducer through a shank hole 50 through inner pole piece 41, magnet 38 and base 40 by screw 81. Wave guide 34 is formed by two wedge shaped inserts 52 mounted in the walls 48 of transducer 45 by screws 53. The wedges 52 in combination with the walls 48 provide a passage way forming a wave guide cap having a slot 54 for guiding pulses of sonic energy for transmission and reception by the driver of a transducer.

FIG. 11 shows a cross section of a typical transducer 60 of the prior art which includes a ferro-magnetic base 61, a magnet 58 mounted in the base 61, a circular inner pole piece 62 mounted above the magnet 58 and outer pole piece 63 which is mounted to the base 61, forming an annular air gap slot 64 between the inner pole piece 62 and outer pole piece 63. Non-ferro-magnetic annular member 57 maintains alignment of air gap 64 between outer pole piece 63 and inner pole piece 65 without shunting the field in the air gap 64. Magnet 58 provides the flux through inner pole piece 62 across air gap 64 through outer pole piece 63 through the base 61 to the bottom of magnet 58. A diaphragm 65 having an annular shape is mounted over the air gap 64. The diaphragm 65 has a ring 66 attached thereto with a wire coil 59 built in about the ring 66, circularly of the magnet 62 with leads 67 attached to terminals 68. When an electrical signal is impressed on terminals 68, a current flows through ring 66 and coil 59 and interacts with the field established by magnet 62 and a reflected pulse vibrates diaphragm 65 causing pulses of electrical energy to be generated in ring 66 and coil 59 and transmitted to terminals 68. Outer walls 69 are mounted to the base 61 over outer pole piece 63 about diaphragm 65 and bullet 70 is mounted to base 61 through shank hole 71 in base 61, magnet 58 and inner pole piece 62.

The wave guide 34 of transducer 15 shown in FIG. 6 provides a slot 54 at the output of the transducer 15. This slot 54 interfers somewhat with the propagation of the sonic pulses emitted from the transducer at the diaphragm 45. A line source of sonic energy is set up along slot 54 and the line source produces a uniformly projected pattern of sonic energy along the slot 54 which projects the energy in the desired pattern. The intensity is spread somewhat in a direction perpendicular to the direction of the slot. In this way, the transducer 15 can be placed above two lanes of traffic as shown in FIG. 4 and the slot can be aligned with the direction of traffic flow such that the line source of sonic energy aligned along slot 54 radiates sonic energy tending to spread perpendicular to the direction of slot 54 which generally is aligned with the traffic flow so that the pattern is spread across the lanes as shown in FIG. 4A.

The wave guide 34 is composed of two removable wedge shaped inserts 52—52. Screw 53 fastens the wave guide inserts 52 to wall 48 and allows for the removal of wave guide to permit theuse of the transducer 15 as a single lane occupancy detector.

The use of wave guide 34 also suppresses secondary oscillations which may arise by insertion of the wave guide 34 initially. With reference to FIGS. 10 and 12, it is possible to obtain a pattern similar to that shown in FIG. 4 by placing a plate 73 over the output of transducer 60. Plate 73 has a slot 74 therein. There would be an air space 75 between the diaphragm 66 of the transducer 60 and the outer wall 69 such that sonic pulses emitted from the diaphragm 65 may bounce against plate 73 and cause ringing which would actuate the system improperly.

Bullet 49 shown in side and bottom elevations in FIGS. 8 and 9 respectively is incorporated in transducer 15 and provides for a smooth exit path for sonic energy. It fills a gap between the diaphragm 45 and slot 54 and inserts 52—52 so that secondary oscillations will not be reflected back into the transducer 15 while it is transmitting sonic pulses. The conoidal wedge-like shape of bullet 49 and the width of slot 54 as shown has been determined by experimentation to obtain the most efficient configuration for the particular frequencies being used in this application. Typically the frequencies range in the area of 20 kilohertz.

The present disclosure describes a system combining sonic energy gating with a controlled beam of pulses. The gating the timing of the various pulses as they are transmitted and reflected back as previously described are to a degree dependent upon an accurate zone of detection. It is possible to get such an accurate zone by using more than one transducer. However, this requires additional equipment which often is very expensive. The present system provides for a controlled detection zone by using one transducer having a wider area of detection than has heretofore been advisable to use. A higher input to the transducer 15 does not necessarily increase the effectiveness of the system because the wave patterns are substantially the same whether there are high or low intensity inputs. The wave guide means 34 is the device which modifies the pulse transmission such that a uniform pattern of sonic energy is distributed over a desired area. In this case, an elliptical pattern such that two lanes of traffic may be detected at the same time.

The present invention also provides for a convertible feature to be incorporated into the wave guide 34. This convertible feature makes it possible to adapt the transducers presently being used to double lane occupancy detection and also provide for transducers of the present invention to be used as single lane occupancy detectors without substantial change in the cost of the overall detector.

That is it would be possible to substitute the conoidal wedge-like bullet 49 for the prior art bullet and mount inserts 52—52 in alignment with the bullet 69 to form the wave guide. In addition, the inserts 52—52 may be removed having a pattern adaptable to single lane detection without a substantial effect on the efficiency of the transducer 15 in other respects.

The removability of wave guide 51, i.e., by removal of wedges 52—52, provides transducers adaptable to systems which are already in operation. These devices when combined with the gating techniques described previously increase the efficiency of operation without a sacrifice of a substantial amount of expense and time in installation.

The use of the wave guide means of the present invention provides for an enhanced system wherein controlled beam propagation is provided. The invention provides a method of adapting present detectors to the more efficient operation of the present disclosure by the interposition of two inserts forming a wave guide at the output section of present vehicle detectors in use in addition to the wave guide, a new bullet is inserted for providing a smooth exit for sonic pulses. The use of the wave guide 34 in connection with sonic detectors has not heretofore been used as a method of controlling the sonic beam. While there are methods of controlling sound patterns into various directions including so-called sound lenses, the cost, size and excess of reflected secondary signals causing ringing is prohibitive in the applications for which these devices are contemplated. Wave guide 34 when used in conjunction with a highly efficient sonic transducer produces an energy pattern which is quite efficient and adaptable to the uses for which the invention was developed, without excess production, installation and maintenance expenses.

While there has been described what is at present considered to be the preferred embodiment of the invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein, without departing from the invention, and it is, therefore, aimed in the appending claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. An electromechanical transducer apparatus for producing pulses of sonic energy and respondingly generating electrical signals relative to received sonic energy wherein a driver generates the sonic pulses and the improvement for projecting the sonic energy in a peculiar controlled pattern comprises:

wave guide means interposed at the output of said driver and having a rectangular opening formed in such wave guide means for controlling the propagation of said pulses, the rectangular opening formed in said wave guide means setting up substantially a line source of sonic energy, said line source emanating the sonic energy in an operating pattern of at least a minimum intensity near the point of greatest breadth of the pattern.

2. The transducer apparatus of claim 1 wherein the wave guide means comprises:

a cap having a radial slot of rectangular shape, mounted over the output of said driver, for collecting and directing the energy towards the slot, said slot for modifying the propagation of said pulses to create the line source of pulsed sonic energy along the slot when said sonic energy is propagated therethrough by the driver.

3. The transducer apparatus of claim **2** wherein the wave guide means further includes:

a suppressor for eliminating secondary oscillations produced as a result of modification of the sonic energy pattern.

4. A transducer apparatus of claim **3** wherein the slotted cap for modifying the pulsed sonic energy and the suppressor further comprises:

two walls mounted at acute angles to the cap and each having a straight edge;

the walls with straight edges parallel to each other at a predetermined distance forming the slot, and

said angular positioning of the walls disposed inwardly towards the driver for suppressing the secondary oscillations.

5. The transducer apparatus of claim **4** including a heat mounted to the transducer between the output of the driver and the slotted cap for further directing said beam and for further decreasing secondary oscillations.

6. The transducer apparatus of claim **5** wherein the head comprises a conoidal wedge-like body aligned with said slot, interposed between said driver and wave guide.

7. The transducer apparatus of claim **6** wherein the conoidal wedge-like body has a circular bottom and arcuate surfaces extending from the bottom and meeting at the top of the body forming a wedge tip, said wedge tip aligned in and lateral with the slot.

8. An improved transducer wherein the improvement for projecting sonic energy in a peculiar controlled pattern comprises:

a head mounted at the output of the transducer and;

a wave guide having a transverse slot therethrough adapted to cooperate with the head for directing the propagation of the sonic energy to substantially complete sonic coverage within a limited range.

9. The improved transducer of claim **8** wherein the wave guide comprises a cup positioned for covering the output of the transducer and the head to capture the sonic energy and the slot is positioned in the cup over the head.

10. The improved transducer of claim **9** wherein the cup includes side walls at acute angles to the axis of the head projecting from the slot inwardly towards the transducer, said side walls for cooperating with the head for providing a relatively smooth unobstructed exit path for sonic energy to be conducted towards the slot whereby sonic energy is not reflected back into said transducer causing distortion of said energy.

11. The improved transducer of claim **10** wherein the head comprises a wedge-like conoidal body having arcuate sides oppositely disposed in said cup such that the arcuate sides are relatively parallel to the walls of the cup for further smoothing said exit path.

12. The improved transducer of claim **8** wherein said peculiar pattern of controlled energy comprises:

a substantially minimum intensity pattern of elliptical shape, said pattern in a plane substantially parallel to the output of the transducer and within the limited range.

13. The improved transducer of claim **12** wherein a line source of energy is set up along the slot of the wave guide and the elliptical pattern is widest in a direction perpendicular to said line source.

14. The improved transducer of claim **12** wherein the cup has a conduit slot therethrough providing a drainage for collected fluids in said cup.

15. A vehicle detection system comprising a transducer responsive to pulsed electrical energy for providing emitted sonic energy pulses and respondingly generating electrical signals relative to received sonic energy including:

a wave guide means interposed at the output of the transducer having a transverse opening formed therein for directing the propagation of the emitted sonic energy pulses to establish substantially complete sonic coverage within a limited area.

16. The vehicle detection system of claim **15** wherein said peculiar pattern of controlled energy is at least a minimum intensity of sonic energy pulses covering an elliptical pattern.

17. The vehicle detection system of claim **16** wherein the wave guide means includes a cap having a radial slot therein forming the transverse opening, a line source of sonic energy formed along said slot for providing the elliptical pattern of sonic energy in a plane parallel to the output of the transducer, said elliptical pattern widest in a direction perpendicular to the line source and having at least a minimum intensity in said pattern.

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