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(72) Inventor: Grant, John Thomas
Reepham, Norfolk, NR10 4LD (GB)

(74) Representative: Jones, David Colin et al
Withers & Rogers,
Goldings House
2 Hays Lane
London SE1 2HW (GB)

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(71) Applicant: SECURITY ENCLOSURES LIMITED
Sutton, Surrey SM1 2UE (GB)

(54) Infra red intrusion detection system

(57) An infra red intrusion detection system employs a transmitter unit having a plurality of transmitters (A_t , B_t , C_t , D_t) arranged in a transmitter housing and a plurality of receivers (A_r , B_r , C_r , D_r) arranged in a receiver housing that is separate from the transmitter housing. A transmitter controller (2, 4, 6, 8) causes the transmitters to transmit in a predetermined sequence and at a pre-

determined transmit rate. A receiver controller (20, 22, 24, 26) is arranged to read the receiver inputs in a predetermined sequence and at a predetermined receive rate. By arranging for the transmit and receive rates to be different, the need for a synchronising link between the transmitters and the receivers is avoided, thus providing simplification.

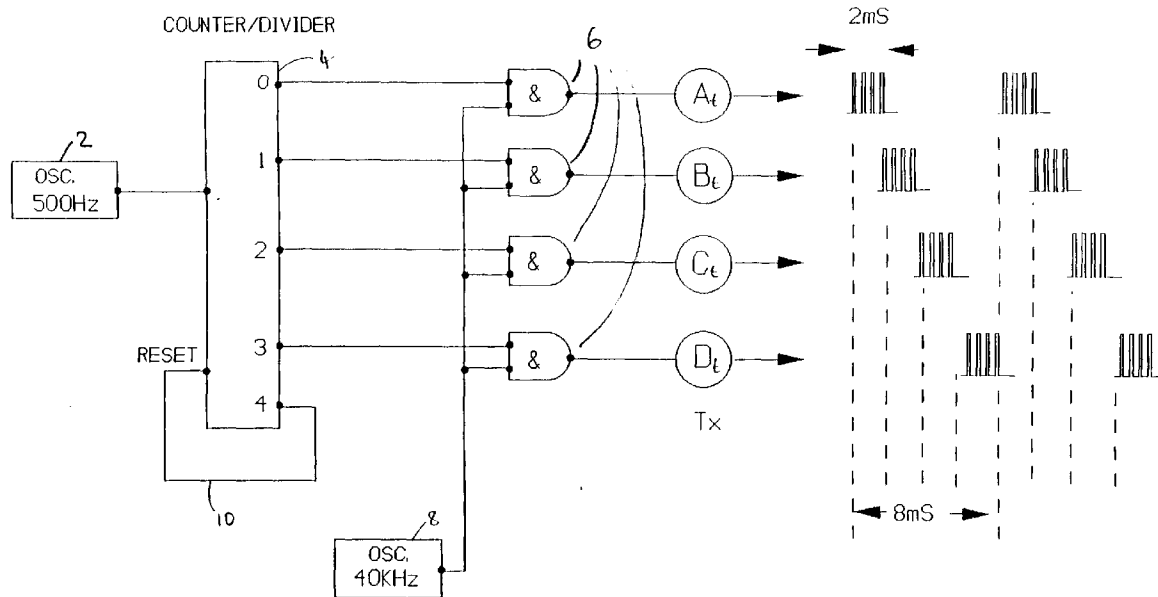


Fig. 1

Description

[0001] This invention relates to detection apparatus in which objects are detected by the interruption of one or more beams of radiation transmitted from a transmitter to a receiver. Such apparatus is used, for example, as an intruder detector and typically employs infra red radiation.

[0002] Known devices comprise one or more vertically spaced transmitters located in a housing and one or more receivers disposed at an appropriate distance (typically up to 150m) from the transmitters. When used in a security system an alarm output may be given when one or more beams are blocked. Systems using a plurality of beams have been used for many years both in the security industry and also in other industries where they may be used for example as machine safety guards. In some of these systems an array of transmitters is placed opposite a corresponding array of receivers and the transmitters are energised sequentially. The corresponding receivers are also enabled sequentially so that each receiver only responds to its corresponding transmitter and not to an adjacent transmitter. In the majority of these types of systems the receivers are synchronised with the transmitters by means of a hard-wired connection. Some systems achieve synchronism by the use of a 'sync' pulse applied to one or more of the transmitter beams.

[0003] Where a system is located outdoors in say, a security system, there is always a potential for false alarms caused by birds flying through the beams. One known solution to this problem is to provide two parallel-connected transmitter heads and two parallel-connected receiver heads for each beam spaced apart so that a bird would be unlikely to block both beams simultaneously whereas an intruder would. An alarm indication is given when both beams are blocked.

[0004] Prior art systems are also known which provide separate responses if one beam or more than one beam is blocked. In a machine guard system a single beam break caused by thin material may allow a machine to operate but two or more beam breaks caused by an operator's hand may prevent operation.

[0005] One object of the present invention is to overcome the requirement for a synchronising link (either hard-wired or via a transmitter signal) between the transmitter array and the receiver array.

[0006] According to the present invention there is provided intrusion detection apparatus comprising a transmitter unit having a plurality of transmitters arranged in a transmitter housing and a transmitter controller operable to cause the transmitters to transmit in a predetermined sequence at a predetermined transmit rate, and a receiver unit having a plurality of receivers arranged in a receiver housing separate from the transmitter housing and a receiver controller operable to read the receiver outputs in a predetermined sequence at a predetermined receive rate, the transmit and receive rates

being different rates.

[0007] Preferably the invention provides n squared beams where n is the number of transmitter/receiver pairs. For example: the embodiment described herein employs 4 transmitter/receiver pairs arranged vertically to provide 16 beam paths. The number of transmitters and receivers need not be the same.

[0008] Thus, the present invention does away with the need for a synchronising connection between transmitter and receiver units and allows each unit to have a simple free-wheeling oscillator which need not have highly accurate frequency characteristics. Having provided a solution to the inconvenience of synchronisation, a surprising advantage is that information in the received pulse train is available about the size or lateral location of an obstruction between the transmit and receive units.

[0009] By introducing (either by identifying a particular transmitter or with a hard-wired link) a synchronising means, it is then possible additionally to obtain information about the height of an obstruction.

[0010] Advantageously the invention may provide an alarm signal if one beam is blocked for a user controlled period of say, 0.5 to 1.5 seconds, and also an alarm signal if two adjacent beams are blocked for a shorter period of say, 40mS. This feature provides high false alarm immunity to beam blockages caused by small objects such as flying birds or falling leaves, yet retains the ability to detect an intruder running through the beam network.

[0011] Optionally the invention may provide an indication as to the position of the blockage or intrusion within the protective network. This indication may be in the form of positional information signalled separately from the alarm signal, or may be used as an alarm signal itself. For example: a security system having CCTV monitoring would benefit from having positional information sent separately from the alarm signal so that the positional information could be used by the operator to pan or zoom a camera to the area in question. In another example, an unmanned site having CCTV monitoring may use the positional information to automatically pan or zoom a camera to the area and that action alone may be used to initiate an alarm condition.

[0012] The positional information may also be used selectively to activate security lighting, either covert or visible types, thus saving energy and maintenance costs.

[0013] One particular advantage of the invention is that additional transmitter/receiver pairs may be added with little extra complexity or cost. The system also allows the use of different numbers of transmitter and receiver heads with minor changes to the timing circuits. For example: a system may include say 4 transmitter heads and 6 receiver heads giving 24 possible beam paths. This may be advantageous to protect undulating ground or to dip below bridges or other obstructions.

[0014] Other preferred features are set out in the de-

pendent claims appended hereto.

[0015] The invention will now be described by way of example with reference to the accompanying drawings in which:-

Figure 1 is a schematic block diagram of a transmitter in accordance with the invention;

Figure 2 is a schematic block diagram of a receiver in accordance with the invention; and

Figures 3A to 3H are schematic diagrams showing blockages and received pulse trains in accordance with the invention.

[0016] With reference to Figure 1 the transmitter heads A_t , B_t , C_t , D_t each contain a light emitting diode (LED) radiating energy in the near infra red region at typically 900nm wavelength. To reduce average power consumption and improve peak transmission energy, the diode is pulsed with mark/space ratio of typically 1:50 or more. The transmitting heads A_t , B_t , C_t , D_t preferably contain an optical focusing means (not shown) to concentrate the energy towards the remote receivers.

[0017] The plurality of transmitter heads A_t , B_t , C_t , D_t are typically located vertically within a housing and spaced apart typically 300-400 cm.

[0018] The corresponding receivers A_r , B_r , C_r , D_r , may similarly be located within a separate housing.

[0019] For the system to operate optimally, the transmitters and receivers should be positioned such that all transmitters illuminate all receivers and all receivers have all transmitters within their fields of view.

[0020] The receiver heads A_r , B_r , C_r , D_r , normally contain an infra red receiver chip (not shown) which converts modulated infra red light to an electrical logic output. These receiver chips are commonly used in infra red remote control systems as found in vehicle locking systems or consumer products. They usually contain modulation frequency filters to allow discrete channeling and normally produce a logic level output voltage on receipt of an infra red data stream of the required frequency. Thus they can convert modulated pulses of infra red to digital logic output signals. They do not generally provide analogue outputs.

[0021] The optical components of the receiver head A_r , B_r , C_r , D_r , typically include a positive focusing lens to provide a relatively narrow field of view. In some practical arrangements an additional cylindrical optical element may be employed in order to provide a vertically asymmetrical field of view or transmitter beam. This is advantageous when transmitter and receiver arrays are located close to each other such that there might not otherwise be a line of sight between all the opposing heads. Similar arrangements are possible where the transmitter and/or receiver heads are not arranged in a vertical line.

[0022] With reference to Figure 1, a free-running os-

cillator 2 drives a counter/divider 4 which provides a repeating sequence of discrete outputs. The transmitter heads A_t , B_t , C_t , D_t are connected to 4 adjacent output ports of the counter/divider 4 via 'AND' gates 6. A second free-running oscillator 8 is connected to the other input of each gate 6. The first oscillator 2 typically runs at 500Hz. The second oscillator 8 typically runs at 40KHz and outputs a pulse stream having an on/off ratio of some 1:50 or more.

[0023] Modulated drive signals are relayed to the heads A_t , B_t , C_t , D_t when there is a signal at the corresponding counter output port. Thus, the transmitter heads are sequentially driven with, for example, 2mS wide pulses modulated at 40KHz.

[0024] Because the 'AND' gates 6 are connected to adjacent count outputs, each head transmits sequentially without gaps. Typically, the sequence would run 'A' 'B' 'C' 'D' but could run 'D' 'C' 'B' 'A' but as will be described later, it is ideal (but not essential) that the receiver array is sequenced in the same direction. Transmission from consecutive transmitters which are not adjacent (e.g. 'A', 'C', 'B', 'D') is also possible but also not ideal for the reasons described below.

[0025] More heads may be added by connecting additional 'AND' gates to the next adjacent count output and moving the reset connection 10 up one count. The system as illustrated could provide drive for 10 heads if extra 'AND' gates were added.

[0026] With reference to Figure 2, to the remotely located receiver heads A_r , B_r , C_r , D_r , the transmitter array will appear to be producing a continuous modulated stream of infra red energy. Only when one or more beams are blocked will gaps appear at the repetition frequency, in this example 125Hz (i.e. 500/4Hz). These gaps will vary in width depending upon how many adjacent transmitters are blocked. In the unlikely event of say ' A_t ' and ' C_t ' heads being blocked and assuming the ' A_t ' and ' C_t ' heads are not energised consecutively, the receivers would 'see' 250Hz.

[0027] A free running oscillator 20 drives a counter/divider 22 which provides a repeating sequence of discrete outputs. Each receiving head A_r , B_r , C_r , D_r is connected to one input of a respective AND gate 24. The other AND gate inputs are connected to adjacent count outputs.

[0028] The outputs from all the AND gates 24 are fed via an 'OR' gate (preferably implemented as shown with diodes 26) to the inputs of two pulse-width detectors 28, 30. These detectors provide an output if a zero voltage appears at the input for longer than 1.5mS or 3.5mS respectively.

[0029] The output from the 3.5mS pulse-width detector 28 drives a delay timer having a short (typically 40mS) delay. This provides an output if outputs from the pulse-width detector are received for a period of 40mS or more and effectively provides an integrating function. The output from the 1.5mS pulse-width detector drives a delay timer 32 having a longer variable delay. This tim-

er operates in the same way as the other timer but with a different time constant. The outputs from these delay circuits provide an alarm signal. Note that the sequencing oscillator does not operate at the same frequency as the transmitter sequencing oscillator.

[0030] The operation is as follows:

[0031] Under normal un-blocked conditions, all receivers A_r , B_r , C_r , D_r 'see' a continuous infra red signal from the sequenced transmitters A_t , B_t , C_t , D_t and all present a logic high signal to their respective AND gates 24. As each AND gate is sequenced by the counter outputs, it will produce a logic high for that duration (3mS for a 333Hz counter clock frequency) at its output and this is repeated for each receive head in sequence. It will be appreciated that because the AND gates 24 are connected to adjacent counter outputs, there will substantially be no gaps between the successive gate outputs. Thus, there will be a permanent logic high at the common diode cathode outputs.

[0032] If a blockage occurs close to a transmitter, a negative-going pulse will appear at this common point. The pulse width will be 2mS and have a repetition rate of 125Hz. If two adjacent transmitter heads are blocked the pulse will be 4mS wide and so on.

[0033] Similarly, if a receiver head is blocked, a negative-going pulse will appear having a width of 3mS and a repetition rate of 83Hz (333Hz/4 heads). If two adjacent receivers are blocked the pulse will be 6mS wide and so on.

[0034] Thus, blockage of any one receiver or transmitter head will produce pulses no wider than 3mS or narrower than 2mS and blockage of any two adjacent receiver or transmitter heads will produce pulses no wider than 6mS or narrower than 4mS and so on. The 1.5mS or more pulse-width detector 30 will therefore provide an output if any one receiver or transmitter head is blocked. The 3.5mS or more pulse-width detector 28 will provide an output if any two adjacent transmitters or receivers are blocked.

[0035] Provided that the 1.5mS detector 30 presents a signal to the variable timer 34 for a period longer than the variable delay setting, an alarm will be signalled. Provided that the 3.5mS detector 28 presents a signal to the 40mS timer 32 lasting longer than 40mS, an alarm will be signalled.

[0036] This arrangement allows the system to accept single beam blockages for many times longer than multi-beam blockages and thus provide immunity to false alarms from bird or falling leaves blockages but still detect a fast moving intruder.

[0037] Beam blockages at points between the transmitter and receiver units will produce additional pulse patterns depending upon the size and location within the beam network. This is described in more detail below.

[0038] It was mentioned earlier that the sequencing rates of the transmitter unit and receiver unit differ. This is unlike any previously known system which normally require synchronism. To understand the reason, consid-

er a case where the sequencing rates are identical so that both transmitter pulses and receiver gate periods are exactly the same. In this case each receiver would always see the same transmitter but because there is no synchronising means, it could be any one of the four possible transmitters. Thus, there would only be 4 beam paths; and these paths would not necessarily be parallel with the ground. (Receiver ' A_r ' might only see transmission from say, transmitter ' D_t '). This type of condition would not provide useful detection of smaller objects at mid way points between transmitters and receivers.

[0039] Consider now a condition where there is a small difference between the sequencing oscillators of say, 4 cycles per second. In this case each receiver would see a different transmitter every 1 second so all sixteen possible beam paths would be covered after 4 seconds.

[0040] In the embodiment described herein there is a difference of 167Hz between both sequencing oscillators producing sequence repetition rates of 125Hz and 83Hz respectively. This means that all combinations of beam paths are repeated 42 times per second.

[0041] Both sequences preferably should be in the same direction (A-D or D-A). If they are in opposite directions it is possible that a small object at the exact mid crossover point of two or more beams may produce two adjacent blockage signals. (This also applies if consecutive transmitters/receivers are not adjacent). To illustrate this, consider a small object located at the exact mid point of the beam network where $Tx'A$ sees $Rx'D$, and $Tx'B$ sees $Rx'C$ etc. and all these paths cross; then if the transmitters are sequencing 'A'-D' but the receivers are sequencing 'D'-A' there would appear to be a continuous blockage if the repetition rate were the same. Even where the sequence rates are different, a mid-point blockage may cause a wider blockage pulse when the sequences are not in the same direction.

[0042] Figure 3 illustrates some of the signal patterns appearing at the common diode cathode point for various blockage conditions.

[0043] Figures 3A to 3D illustrate the waveforms to be expected for single or double blockages at either end (near the transmitter or receiver respectively) of the system.

[0044] Figure 3 E illustrates the signal pattern to be expected for a small blockage in the 'D' beam path. This shows the 2mS gap; caused by the blockage of the $Tx'D$ as received when receiver ' D_r ' is gated open. Note that narrower pulses may be apparent as the receiver time slot 'scans' through the $Tx'D$ time slot producing a group of pulses having a maximum pulse width of 2mS, spaced 8mS apart with a group repetition rate of 42 kHz (the difference between the sequence rates). Since no pulse is wider than 2mS, the system will have a slow alarm response.

[0045] Figure 3F illustrates a small blockage at a beam crossing point of two adjacent transmitters. This results in a 3mS pulse and not a 4mS pulse as may be

expected because receiver 'C_r' or 'D_r' can only receive for a 3mS period. (This would not be the case if the two sequences were in opposite directions). Since no pulse is wider than 3.5mS the system will have a slow alarm response.

[0046] Figure 3G illustrates the same small blockage at the mid-crossing point of all four transmitters and again the widest pulse is only 3mS wide to give a slow alarm response.

[0047] Figure 3H illustrates a blockage wider than the distance between any two heads. In this case two adjacent receiver time slots of 6mS allow two blockage signals from adjacent transmitters to produce a group of pulses having a maximum width of 4mS. Thus, the 3mS or longer pulse-width detector and following delay circuit will give a fast alarm response.

[0048] Referring again to Figure 2 there are shown in dotted outline three band pass filters. These may be arranged to respond to the frequencies of pulses or groups of pulses that appear at the common point. For example: a blockage of one, two or three (but not four) transmitters will produce a pulse stream having a frequency of 125Hz, the transmitter repetition rate. A blockage of one, two or three (but not four) receivers will produce a pulse stream having a frequency of 83Hz, the receiver repetition rate. A blockage at a mid-way point within the network will produce pulse groups of 125Hz or 83Hz or combinations of both, at repetition rates of 42Hz.

[0049] By feeding these signals to frequency selective filters 36, 38, 40, it is possible to signal whether the blockage is at either end or somewhere between. Further signal analysis using microcontrollers to store and compare individual receiver head pulse streams allows more precise location and sizing of blocking objects by means of triangulation.

[0050] The embodiments described herein produce far more information about position and size than any known prior art and with further digital signal processing can provide even more precise information allowing improved intruder detection and false alarm rejection. All without the need for synchronization between transmitter and receiver.

[0051] It will be appreciated that if one or more of the transmitter heads' transmissions is identifiable (for example by transmitting at a different power, frequency or after a brief gap), then signal processing of the received pulses allows the height of a blockage to be determined (i.e. its vertical position - for a vertically aligned array of transmitters/receivers).

Claims

1. Intrusion detection apparatus comprising a transmitter unit having a plurality of transmitters, a transmitter controller operable to cause the transmitters to transmit in a predetermined sequence at a predetermined transmit rate, a receiver having a plu-

rality of receivers spaced apart from the transmitters, and a receiver controller operable to read the receiver outputs in a predetermined sequence at a predetermined receive rate, the transmit and receive rates being different rates.

2. Apparatus according to Claim 1, wherein said transmitters are arranged in a transmitter housing, and said receivers are arranged in a receiver housing separate from the transmitter housing.

3. Apparatus according to Claim 2, wherein the transmitter and receiver housings are not electrically coupled together.

4. Apparatus according to any one of the preceding claims, wherein the transmitter controller is arranged such that the predetermined transmit sequence causes transmitters located adjacent one another to be activated consecutively.

5. Apparatus according to any preceding claim, wherein the receiver controller is arranged such that the predetermined receive sequence causes receivers located adjacent one another to be read consecutively.

6. Apparatus according to any preceding claim wherein the transmitter controller is arranged such that in use, each respective transmitter transmits for substantially the same period.

7. Apparatus according to any preceding claim wherein the transmitter controller is arranged such that there are substantially no gaps between transmissions from consecutive transmitters.

8. Apparatus according to any one of claims 1 to 5, wherein the transmitter controller is arranged such that transmissions from one of the transmitters are transmitted at a different power level and/or before or after a gap in the transmit sequence such that the transmission from the transmitter is identifiable by the receiver controller.

9. Apparatus according to any preceding claim wherein the outputs of the receivers are ORed together and the receiver controller is operable to detect a change in the logic level of the ORed output of the receivers of substantially a predetermined duration.

10. Apparatus according to Claim 9, wherein an alarm condition is given after a predetermined number of changed logic levels of the predetermined duration have been detected.

11. Apparatus according to any preceding claim, comprising means for indicating the position of an ob-

struction lying within the field view of said transmitters.

12. Apparatus according to any preceding claim wherein the outputs of the receivers are ORed together and the receiver controller is operable to detect a change in the logic level of the ORed output of the receivers occurring substantially at a predetermined repetition rate.

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13. Apparatus according to claim 12, wherein an indication of the lateral position of an obstruction between the transmitter and receiver is given according to the said repetition rate.

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14. Apparatus according to any preceding claim wherein the transmitters and receivers are operable to transmit and receive respectively in the infra-red spectrum.

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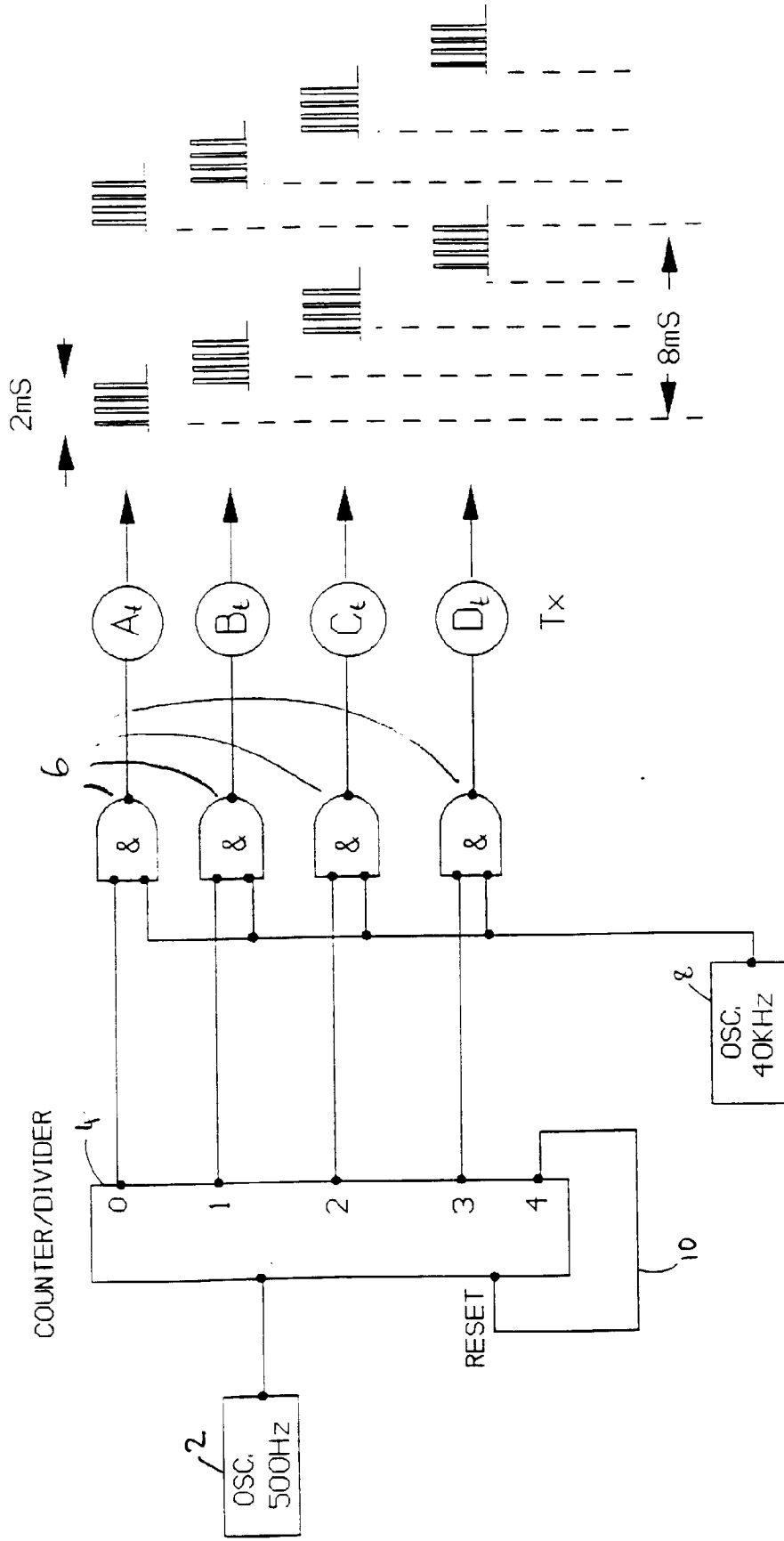


Fig. 1

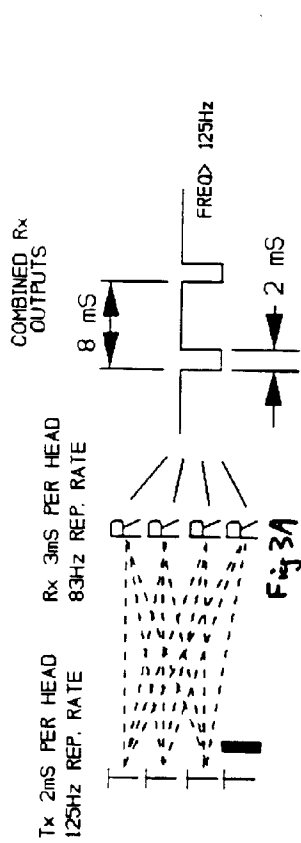


Fig. 3A

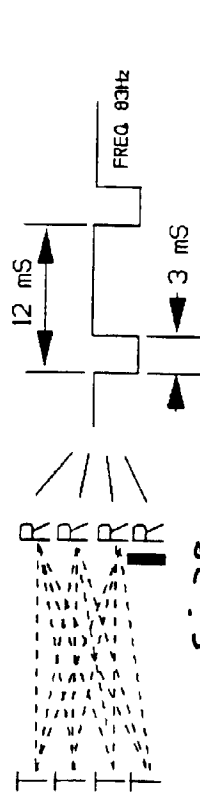


Fig. 3B

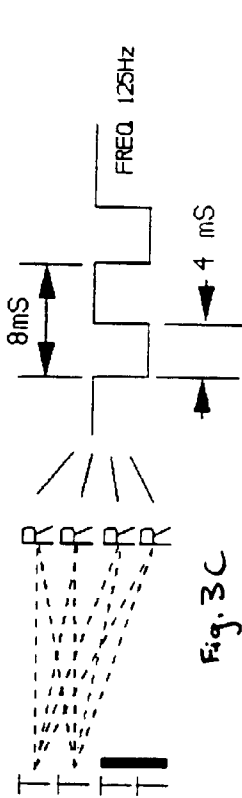


Fig. 3C

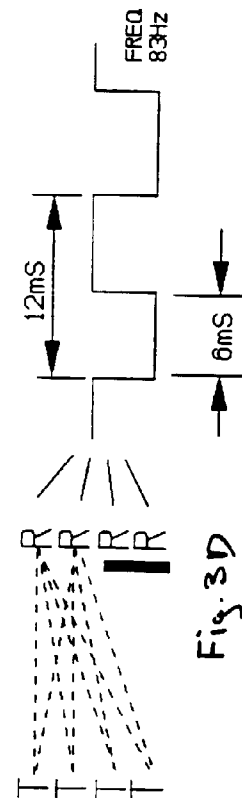


Fig. 3D

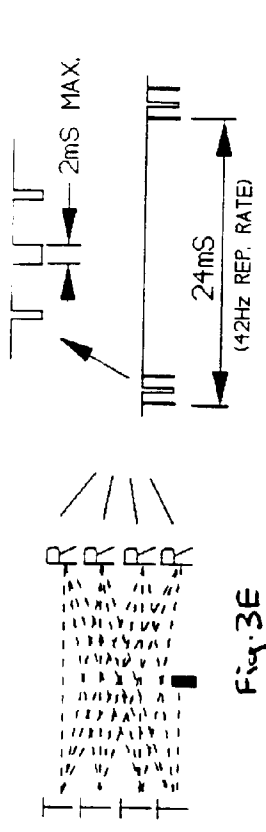


Fig. 3E

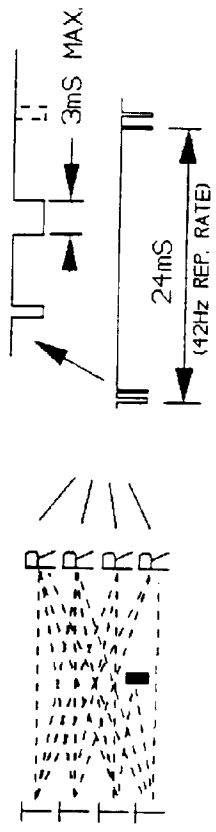


Fig. 3F

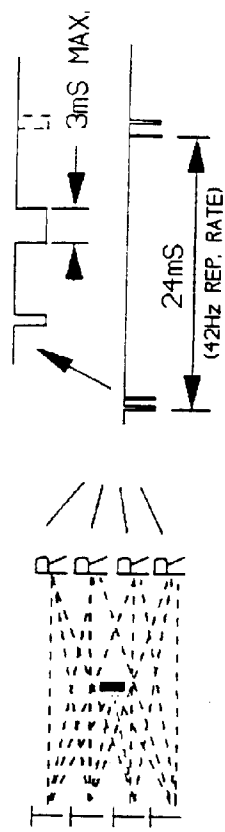


Fig. 3G

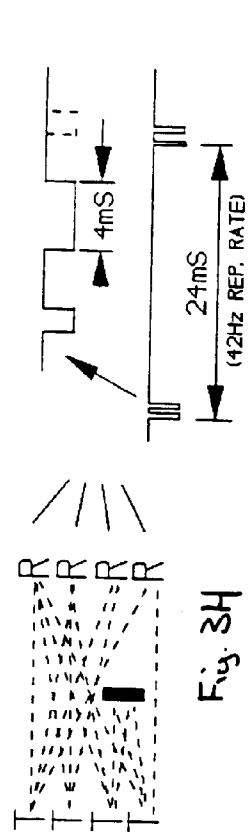


Fig. 3H