Jan. 16, 1968 N. G. LONG 3,364,469

SIGNAL RATIO ALARM SYSTEM

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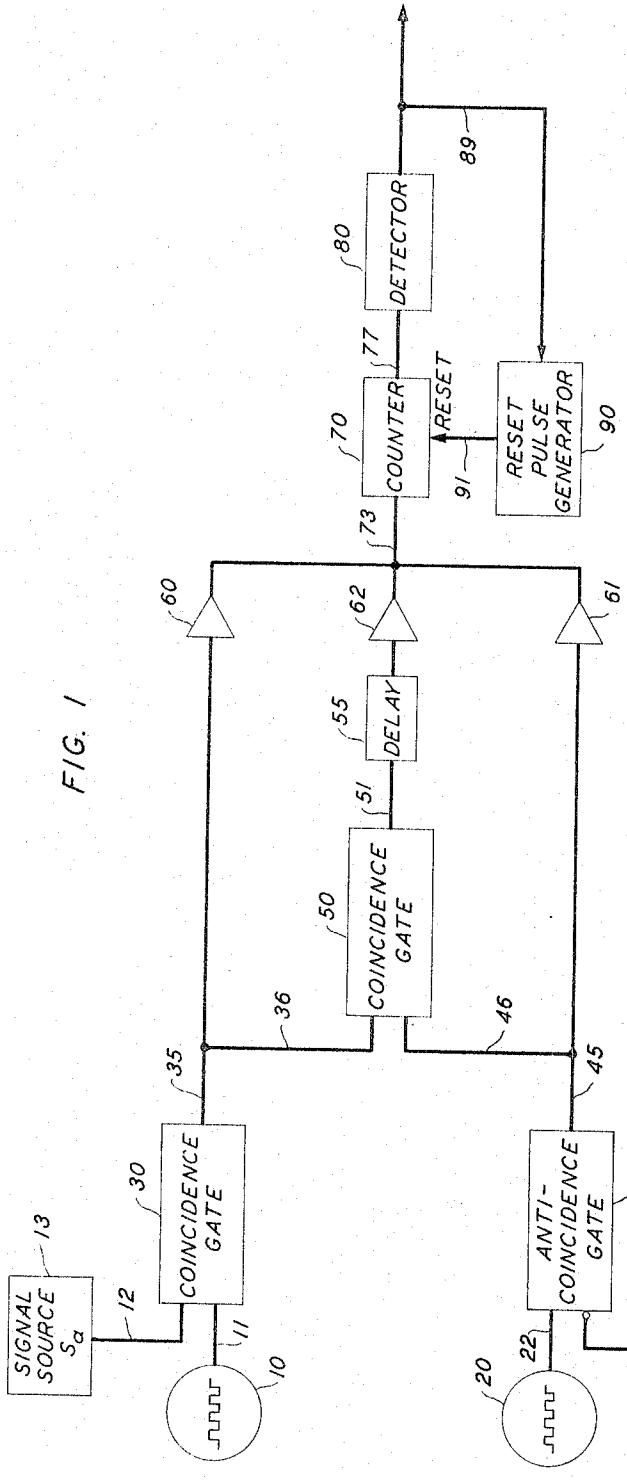


FIG. 1

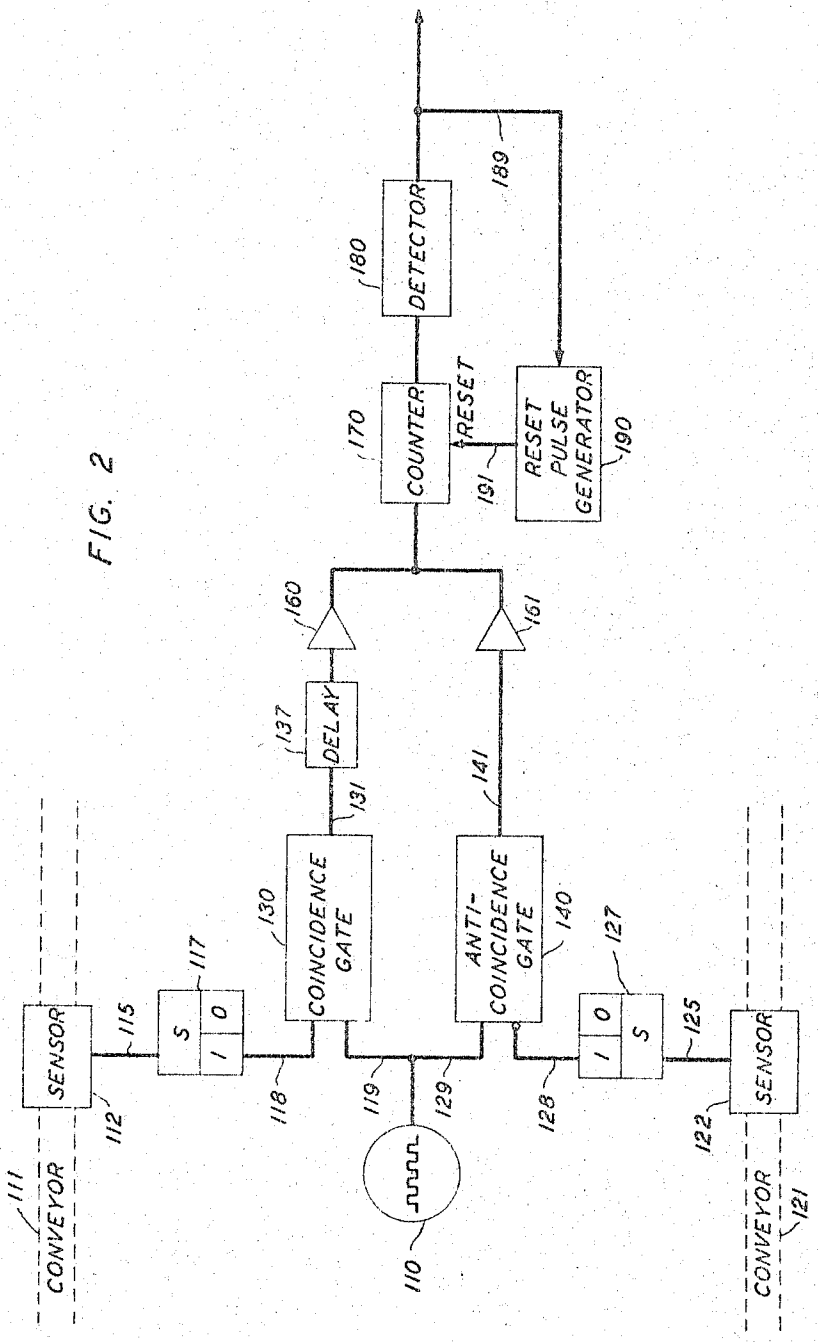
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FIG. 2



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SIGNAL RATIO ALARM SYSTEM

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This invention relates to a method of and apparatus for measuring the ratio of time durations of two independent signals and, more particularly, to a method and apparatus for monitoring the ratio of time durations of two independent signals to determine whether a particular ratio has been attained.

In many communication systems wherein a plurality of intelligence signals are transmitted on a lesser number of transmission channels, it is desirable to examine the fraction of time that the average signal source is active to provide an adequate number of transmission channels. An important figure of merit respecting the operation of such a system is the ratio of the duration of time for which no channel is available when required to the total duration of activity of the signal sources.

In known systems to measure the ratio of time durations of two independent signals, the use of two independent counters has been necessary to measure the ratio. Each signal to be measured is converted to a pulse train, the number of pulses being proportional to the duration of the signal.

The pulse train representing the denominator of the ratio to be measured is applied to a preset counter. This preset counter is designed to emit a signal following the receipt of a selected number of pulses. The pulse train representing the numerator of the ratio is applied to a second counter. The second pulse train is applied to the second counter through a disabling gate which is actuated by the designated signal pulse output of the preset counter. After disablement of the gate, the ratio of the two signals is represented by the ratio of count attained by the second counter with the selected count number assigned to the preset counter. The critical ratio is monitored by setting a particular threshold alarm ratio corresponding to a preselected count of the second counter.

The above-described critical ratio monitoring system has several inherent disadvantages. The chief disadvantage is that the average time period over which the ratio is determined is not a constant but is completely dependent upon the duration of one of the signals and is independent of the other. This means that a critical ratio could possibly be exceeded for a considerable time before one of the signals was of sufficient duration to enable the alarm. Another disadvantage is that two counters are necessary to determine one threshold alarm count. A third disadvantage is that, as the ratio to be checked is altered, the pulse output of the second counter necessary to attain the alarm threshold changes. This means that certain ratios will require much more time to attain the same threshold count than others, seriously limiting the time selection of periods over which the ratio can be monitored.

It is therefore an object of the present invention to monitor the time duration ratio of two independent signals for any preselected period of time independent of the ratio to be monitored.

It is another object of the present invention to monitor the time duration ratio of two independent signals with a simpler method than hitherto used, requiring only one counter.

In accordance with the present invention, the two independent signals, whose duration ratio is to be monitored, are used to control the outputs of two pulse generators. The ratio of the repetition rates of the two generators is inversely proportional to the value of the critical signal ratio to be monitored. The one independent signal is used to enable the output of one pulse generator. The other independent signal is used to inhibit the output of the other pulse generator. A counter is provided to record the total number of pulses transmitted from both generators. An alarm indicates the attainment of a predetermined count, representing the attainment of the critical ratio.

These and other objects, the nature of the present invention and its various advantages, will appear more fully upon consideration of the attached drawings and of the following detailed description of the drawings wherein:

FIG. 1 is a schematic diagram of one illustrative embodiment utilizing the ratio monitoring method of the present invention to monitor the ratio of time durations of two signals; and

FIG. 2 is a schematic diagram of an alternative embodiment of the present invention designed to monitor the critical ratio of the number of two sets of discrete physical objects passing particular reference points.

Referring more particularly to FIG. 1, an illustrative embodiment of the invention is shown which may be used to monitor ratios of the respective time durations of two separate, intermittent signals. A first signal source 13 of intermittent signals is connected to the input 12 of the coincidence gate 30. A second signal source 23 of intermittent signals is connected to the input 21 of the anti-coincidence gate 40. The signal sources 13 and 23 may comprise any signal sources whose ratio of durations it is desirable to monitor.

A particular illustrative example of such signal generating means may be found in a communication system, where it is desirable to monitor the ratio of two separate communication signals. Such a system is described in A. R. Kolding Patent 2,957,946, issued Oct. 25, 1960. Described therein is a Time Assignment Speech Interpolation (TASI) system that permits a particular number of parties to speak with each other through a lesser number of communication channels. Basically, the communication system therein described performs its function by assigning a party to an idler communication channel during the time he is speaking. When the party is silent, he is disconnected from the channel so that the speech of another active party may be interpolated on the same channel between the active speech segments of the first party.

If more parties seek access to the communication channels than there are channels available, part of the speech of some of the parties is lost ("frozen out") because there is no available communication channel.

To determine the number of channels necessary to handle a certain number of parties, the ratio of the total activity time of the parties' speech to the time it is "frozen out" must be monitored. It is assumed that the signal source 23 generates signals proportional in duration to the parties' speech. Similarly, the signal source 13 generates signals proportional to the freezeout time.

A first pulse generator 10, having a predetermined characteristic output repetition rate, is connected, via lead 11, to the coincidence gate 30. A second pulse generator 20, also having a predetermined but different characteristic output repetition rate, is connected, via lead 22, to the anti-coincidence gate 40. The two pulse generators 10 and 20 may comprise blocking oscillators or any other means for producing pulse trains at predetermined output repetition rates.

The two pulse generators 10 and 20 are each individually preset at some predetermined repetition rate; the quotient of the two repetition rates being equal to some selected ratio. The selected ratio of the repetition rate of

the pulse generator 10 to the repetition rate of the pulse generator 20 is equal to the inverse of the critical value of the ratio of the duration of the signal output of the signal source 13 to the duration of the signal output of the signal source 23.

The output lead 35 from coincidence gate 30 is connected to an isolating amplifier 60 and, via lead 36, to a coincidence gate 50. The coincidence gate 30 may comprise any circuit arrangement that will permit the transmission of a pulse train applied to one of its input leads when the other of its input leads is energized.

The output lead 45 of the anti-coincidence gate 40 is connected to an isolating amplifier 61 and, via lead 46, to a coincidence gate 50. The anti-coincidence gate 40 may comprise any circuit arrangement that will prevent the transmission of a pulse train applied to one of its input leads when the other of its input leads is energized. Coincidence and anti-coincidence circuits are well known in the art and will not be further described here.

The output lead 51 of the coincidence gate 50 is connected, via a delay line 55, to the isolating amplifier 62. The coincidence gate 50 may be identical to the coincidence gate 30. The delay line 55 is designed to delay a pulse signal transmitted through it a length of time at least equal to the pulse width of the pulses from sources 10 and 20.

The outputs of the three isolating amplifiers 60, 61, and 62 are connected, via lead 73, to a pulse counting circuit 70. The pulse counting circuit 70 may comprise any type of counting circuit which provides a distinctive output when a particular count is reached.

The output lead 77 of the counter 70 is connected to a detector circuit 80. The detector circuit 80 may comprise a blocking oscillator or some other circuit responsive to the distinctive output from counter 70.

The output of the detector 80 may be used to operate an alarm or other control or indicating circuit, and is also applied via lead 89 to reset pulse generator 90. The reset pulse generator 90 is connected, via the reset input lead 91, to the counter 70. The reset pulse generator 90 may be any circuit arrangement designed to generate a reset pulse whenever triggered by a signal on input lead 89, and at regular intervals thereafter.

Briefly, the operation of the circuit is as follows:

The two separate signals from the signal sources 13 and 23 are applied, respectively, to the input 11 of the coincidence gate 30 and the input 21 of the anti-coincidence gate 40. A pulse train generated by the pulse generator 10 at a preselected repetition rate is applied to the input 12 of the coincidence gate 30. During the period that the signal source 13 is active, the coincidence gate 30 is enabled by signals on input 12 to transmit this pulse train to output lead 35, the isolating amplifier 60, and the pulse counter 70.

A pulse train generated by the pulse generator 20 at some other preselected repetition rate is applied to the input 22 of the anti-coincidence gate 40. The ratio of the repetition rate of pulse generator 20 and the repetition rate of pulse generator 10 is selected, as indicated above, to be equal to some preselected value.

During the period that the signal source 23 is active, the anti-coincidence gate 40 prevents the transmission of the pulse train on input 22 to the output lead 45. During the period that the signal source 23 is inactive, the pulse train on input 22 is transmitted to output lead 45, the isolating amplifier 61, and the pulse counting circuit 70.

The pulse trains on leads 35 and 45 are also applied, via leads 36 and 46, respectively, to the coincidence gate 50. The coincidence of pulses of the two respective pulse trains applied thereto permits the transmission of a pulse to the output lead 51. This pulse output is applied, via the delay line 55 and the isolating amplifier 62, to the pulse counting circuit 70. In this way, the loss of a pulse count when individual pulses of the pulse train on leads 35 and 45 coincide is prevented. The delay line 55 delays the pulse transmitted by the coincidence gate 50 a sufficient length of time to prevent overlap with the coincident pulses.

In summation, if signal source 13 is active, the pulse train output of the pulse generator 10 is transmitted to the pulse counter 70. Similarly, if the signal source 23 is inactive, the pulse train output of the pulse generator 20 is transmitted to the pulse counter 70. The attainment of a preselected count in the pulse counter 70 within some predetermined period of time indicates that some preselected ratio being monitored has been attained or exceeded.

After the predetermined time for monitoring has passed, or after the detector has been activated, the counter is reset by generator 90 to initiate the monitoring of the critical ratio for a subsequent time period. The predetermined period of time for which the ratio is monitored is selected by adjusting the time period of the reset pulse generator 90 to generate a reset pulse at the end of the selected time period. Should the ratio be attained before the time period has expired, the output signal of the detector circuit 80, applied to the generator 90 via lead 89, immediately resets the counter circuit.

The operation of the above-described monitoring method may be briefly analyzed as follows:

S is the number of pulses transmitted to counter 70;
A is the number of pulses corresponding to the alarm limit;
F_a is the pulse repetition rate of the pulse generator 10;
F_b is the pulse repetition rate of the pulse generator 20;
T_a is the time duration of the signal applied to the gate input 12 by the signal source 13;
T_b is the time duration of the signal applied to the gate input 21 by the signal source 23;
R is the critical ratio to be detected where $R=F_b/F_a$; and
T is a preselected time period over which the ratio is to be checked.

The total number of pulses S transmitted to the counter 70 for the fixed measuring period T may be expressed as

$$S=F_aT_a+F_b(T-T_b) \quad (1)$$

When the ratio of the two time durations T_a and T_b is exactly equal to the critical ratio R, the number of pulses A transmitted is sufficient to actuate the detector circuit 80. That is,

$$R=T_a/T_b=F_b/F_a \quad (2)$$

and

$$T_aF_a=T_bF_b$$

By substituting Equations 2 into 1 we obtain the number of pulses A at which detector 80 must respond as

$$A=F_aT_a+F_bT-F_aT_a=F_bT \quad (3)$$

As Equations 2 and 3 indicate, the present monitoring method requires that the ratio of the frequency of the two pulse generators must be set inversely proportional to the critical signal duration ratio to be monitored. The number of pulses necessary to indicate the attainment of this ratio is equal to the quantity of (TF_b) pulses and is independent of the time T_b. The adjustment of the repetition rate F_b permits selection of any suitable time duration during which the ratio is monitored.

Referring more particularly to FIG. 2, an embodiment of the invention is shown for the purpose of monitoring the ratio of the number of physical objects traveling on two separate paths. A useful application of this embodiment would be at a statistical quality inspection station situated at some point in a manufacturing process to compare the ratio of the number of parts rejected by the inspection process to the total number of parts inspected.

Statistical quality inspection is used as a substitute for total inspection of all parts in many modern industrial processes because of the expense involved in inspecting

all parts individually. Generally, out of each commercial lot of goods to be investigated a smaller number of parts is selected at random to form a sublot. All parts of the sublot are inspected. Statistical quality inspection dictates that an entire lot size of goods be rejected if a certain threshold percentage of a sublot size of units is found to be defective.

Normally the inspector must resort to computation and graph paper to ascertain if this threshold percentage has been attained. A particularly effective method of measuring this threshold percentage is to measure the ratio of the units rejected to the total number of units inspected in the sublot size. An illustrative embodiment of the present invention, as subsequently presented, can monitor such a ratio.

A single pulse generator **110** is connected, via leads **119** and **129**, to a coincidence gate **130** and an anti-coincidence gate **140**, respectively. These gates may be identical to the gates **30** and **40** shown in the illustrative embodiment of FIG. 1. The discrete objects that have been rejected by the inspector at some inspection station pass through a sensor **112**, on the conveyor path **111**. The sensor **112** may comprise any device which will detect objects passing by on the conveyor and emit a pulse signal output for each object so detected.

The sensor **112** is connected, via lead **115**, to the input of a monostable multivibrator **117**. The monostable multivibrator **117** is designed to respond to a signal applied to its input by switching to its unstable state for a specific predetermined time period. The unstable output terminal of the multivibrator **117** is connected, via lead **118**, to the input of the coincidence gate **130**.

The total number of discrete objects of the sublot to be inspected pass through the sensor **122**, on the conveyor **121**. The sensor **122** is identical in function to the sensor **112**. The sensor **122** is connected, via lead **125**, to the input of the monostable multivibrator **127**. The monostable multivibrator **127** is designed to respond to a signal applied to its input by switching to its unstable state for a specific predetermined time period.

The ratio of the respective durations of the unstable states of the two monostable multivibrators **117** and **127** is selected to represent some critical value. This preselected ratio represents the inverse of the critical ratio of the rejected units on conveyor **111** to the total number of units of the sublot inspected on the conveyor **121**.

The output of the coincidence gate **130** is connected, via lead **131**, to a delay line **137**. This delay line **137** is designed to delay a pulse passing through it for a period of time at least as great as the time duration of that pulse. The pulse is delayed to prevent possible coincidence with pulses transmitted by the anti-coincidence gate **140**.

The delay line **137** is connected, via the isolating amplifier **160**, to the pulse counter **170**. The pulse counter **170** may be identical to the pulse counter **70** used in the illustrative embodiment of FIG. 1. The output of the pulse counter **170** is connected to a detector circuit **180**. The detector circuit **180** is designed to be triggered by a certain threshold count signal attained by the counter **170**, which signal indicates that a particular critical ratio has been attained or exceeded.

A reset pulse generator **190** is connected to the reset input **191** of the counting circuit **170**. The generator **190** may be identical to the reset pulse generator **90** shown in FIG. 1. The output of the detector circuit **180** is connected, via lead **189**, to the reset pulse generator **190**.

The operation of the above-described embodiment is as follows:

An object passing the sensor **112**, on the conveyor **111**, causes the sensor **112** to apply a signal, via lead **115**, to the input of the monostable multivibrator **117**. The monostable multivibrator **117**, so activated, switches to its unstable state. During the period of its unstable output state, the multivibrator **117** applies a signal, via lead **118**, to the coincidence gate **130**. This signal enables the coincidence gate **130** to transmit the pulse train from pulse generator **110** to the output lead **131**.

Similarly, objects passing the sensor **122**, on conveyor **121**, cause the sensor **122** to apply a signal, via lead **125**, to the input of the monostable multivibrator **127**. The monostable multivibrator **127** switches to its unstable state and applies a signal, for the duration of that state, to the input lead **128** of the anti-coincidence gate **140**. The input lead **128** is connected to the inhibiting terminal of the anti-coincidence gate **140**. During the period that the signal is applied to input lead **128**, the anti-coincidence gate **140** is prevented from transmitting the pulse train output of the pulse generator **110** to the output lead **141**.

The transmitted pulse trains on leads **131** and **141** are applied, via the isolating amplifiers **160** and **161**, respectively, to the pulse counter **170**. The pulse train on lead **131** is delayed by the delay line **137** to prevent coincidence with the pulse train on lead **141**. The total number of pulses in both pulse trains is summed by the pulse counter **170**. The attainment of a certain sum within a preselected time period indicates that a particular ratio has been attained or exceeded.

In summation, every object on conveyor **111** passing the sensor **112** permits a preselected number of pulses to be applied to the pulse counter **170**. Every object on conveyor **121** passing the sensor **122** subtracts a preselected number of pulses from a continuous train of pulses directed to the pulse counter **170**. The attainment of a certain sum in the pulse counter **170** activates the detector circuit **180**. The ratio of the time duration of the unstable state of the two monostable multivibrators **17** and **27** determines the particular critical ratio to be monitored. In the preceding illustrative embodiment the critical ratio was determined by the respective ratio of the pulse repetition rates of the two generators **10** and **20**.

The detector circuit **180**, when activated, applies a signal, via lead **189**, to reset pulse generator **190**. Counter **170** is thereby reset, enabling the system to continue monitoring the ratio for a subsequent time period. If the ratio has not been attained within the time period of the reset pulse generator **190**, the regular pulse output from that generator is applied, via the reset input **191**, to the counter **170**.

It is to be understood that the method of the present invention is not limited to the enumerated illustrative embodiments. An alternative embodiment may comprise two separate pulse generators having the quotient of their respective repetition rates equal to a certain ratio as above and each pulse generator being enabled by a signal whose time duration is to be monitored. The resultant pulse trains might be applied, respectively, to the advance and reverse inputs of a reversible counter. The counter, upon the attainment of a balance count condition, triggers a connected alarm circuit. A system of this design is capable of monitoring a particular ratio for an indefinite period of time. It has the disadvantage, however, of requiring far more sophisticated counter circuits.

The above embodiments are merely illustrative of many possible arrangements which can represent applications of the principles of the present invention. These and other arrangements can readily be devised in accordance with the principles of the present invention by those skilled in the art without departing from the spirit and scope of the invention.

What is claimed is:

1. The method of monitoring the critical ratio of the respective time durations of a first and a second independent signal during a specified time period comprising the steps of generating a first pulse train at a first preselected frequency, generating a second pulse train at a second preselected frequency, the ratio of the frequency of said first and second pulse trains being inversely proportional to said critical ratio, transmitting the pulses in said first pulse train to a counting facility in the presence of said first independent signal, transmitting the pulses in

said second pulse train to said counting facility during the absence of said second signal, counting continuously with said counting facility the total number of pulses of both said first and second pulse trains transmitted to said counting facility within said specified time period, and detecting the attainment of a critical total count during said specified time period.

2. The method of monitoring the critical ratio of the respective time duration of a first and second signal as described in claim 1 further including the step of generating an auxiliary pulse whenever the individual transmitted pulses of said first and second pulse trains are coincident and counting said auxiliary pulses.

3. A critical ratio detector comprising, in combination, a first pulse generator having a predetermined pulse repetition rate, a second pulse generator having a predetermined pulse repetition rate, a first and a second signal, the critical ratio of the respective durations of said first and second signals being monitored for a predetermined measuring period, the ratio of the pulse repetition rates of said first and said second pulse generators being inversely proportional to said critical ratio, pulse counting means, enabling means to connect the output of said first pulse generator to said pulse counting means, said enabling means being responsive to said first signal, disabling means to disconnect the output of said second pulse generator from said pulse counting means, said disabling means being responsive to said second signal, and alarm means responsive to a predetermined count in said counter.

4. A critical ratio detector comprising in combination, pulse generation means, a first source of gating signals responsive to the passage of a first series of objects past a first sensory device, said first gating signals having a first predetermined time duration, a second source of gating signals responsive to the passage of a second series of objects past a second sensory device, said second gating signals having a second predetermined time duration, pulse counting means, first gating means to transmit the pulse output of said pulse generation means to said pulse counting means in response to the presence of said first gating signals, second gating means to transmit the output of said pulse generation means to said pulse counting means in response to the absence of said second gating signals, said first and second predetermined time durations being inversely proportional to some critical ratio to be detected, and means to respond to a count indicative of the attainment of said critical ratio within a specified time period.

5. A critical ratio detector comprising, in combination, a first pulse generator having a first predetermined pulse repetition rate, a second pulse generator having a second predetermined pulse repetition rate, a first and second signal whose critical ratio of respective durations is to be monitored, pulse counting means including means to advance and reduce the count in response to individual inputs, respectively, means to transmit the output of said first pulse generator to said advance means in response to the presence of said first signal, means to transmit the output of said second pulse generator to said reducing means in response to the absence of said second signal, means to disable the transmission of the output of said second pulse generator to said reducing means in response to the presence of said second signal, and alarm means to respond to the attainment of a specified threshold count within a specified time period to indicate the attainment of said critical ratio.

6. Apparatus to monitor the critical ratio of the respective time durations of a first and second signal comprising in combination a first pulse source freely running at a first preselected pulse repetition rate, a second pulse source freely running at a second preselected pulse repetition rate, the quotient of said first and second pulse repetition rates being equal to the inverse of said critical ratio, said first and second signals having independent durations, pulse counting means, first gating means, means to apply said first signal to said first gating means, said first gating means transmitting the pulse signals of said first pulse source to said pulse counting means in response to said first signal, second gating means, means to apply said second signal to said second gating means, said second gating means transmitting the pulse signals of said second pulse source to said counting means during the absence of said second signal and inhibiting the transmission of the pulse signals of said second pulse source in response to said second signal, and means coupled to said pulse counting means to detect a prescribed threshold level in said pulse counting means and means to generate an alarm signal in response thereto.

7. The apparatus in claim 6 further including means to generate a pulse in response to the coincidence of pulses from said first and second pulse sources, means to delay the transmission of said pulse for a period of time at least equal to the duration time of said coincident pulses, and means to apply said generated pulse to said pulse counting means.

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