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(54) PRESENCE DETECTOR APPARATUS

(71) We, REDLAND AUTOMATION LIMITED formerly known as Sarasota Engineering Company Limited, a British Company, of Chandler's Ford Industrial Estate, Eastleigh, Hampshire, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a presence detector apparatus.

Presence detector apparatus is used to detect the presence of a vehicle at a given location. In some cases it is desirable to detect only the arrival of a vehicle at the location but not to continue to detect the presence of the vehicle while it remains stationary at that location. The apparatus may then revert to a state at which it is capable of detecting the arrival of a further vehicle while the first vehicle is still present.

More particularly, the invention is concerned with a presence dedtector apparatus which operates in conjunction with an inductive sensing loop which is disposed at the location at which vehicle detection is required. The sensing loop is normally laid just below the carriageway and is of a size and shape appropriate to the application in question as is well known in the art. The arrival of a vehicle at the location changes the Q (quality factor) of the sensing loop and this change is detected to provide a presence-indicative signal.

The changes in Q can be detected by making the sensing loop the inductive part of a tuned circuit, preferably a parallel tuned circuit. If the tuned circuit is resonated at the frequency of an energising source, a maximum voltage can be developed by the tuned circuit, this maximum being dependent on the Q of the tuned circuit which is predominantly determined by the Q of the sensing loop. Changes in the Q of the loop are detectable by the resultant changes in amplitude of the voltage developed in the tuned circuit. However, in order to detect these last-mentioned changes other factors influencing the voltage developed have to be allowed for.

The sensing loop can have a shape and dimensions which lie within a wide range depending on the application to which the loop is put. This in turn means a wide range of possible loop inductance. A further and variable inductance is added by the feeder which connects the loop to the presence detector apparatus and the length of which may itself vary considerably from installation to installation. In a given installation the sensing loop in particular is sensitive to ambient changes such as temperature which affect the loop parameters. The loop inductance as well as Q will change in the presence of a vehicle. All these factors will thus affect the resonant frequency of the tuned circuit both as between different installations and for different operating conditions of a given installation. These factors affecting frequency would give rise to amplitude variations if the tuned circuit were fed from a fixed frequency source. It is desired therefore to track the frequency of the source with the resonant frequency of the tuned circuit which is done by combining the source and tuned circuit in an oscillator the frequency of which is essentially determined by the resonant frequency of the tuned circuit. Even so the voltage developed in the tuned circuit may still have some frequency dependence.

A more significant factor affecting the amplitude of the voltage developed by the tuned circuit is that the Q of an installed loop varies widely from installation to installation. In addition where an installation is required to detect the arrival of a second vehicle in the continued presence of a first, the effective quiescent Q of the loop is different in the two instances. Thus the quiescent voltage developed by the tuned circuit may lie within a wide range of values. To accommodate the range of possible quiescent voltage the circuitry which detects the Q change due to the arrival of a vehicle can be designed to have a wide dynamic range. The provision of a wide dynamic range may require a relatively high current drain by the detector circuitry. This may be undesirable if operation from batteries is required.

The present invention adopts a different approach to providing detector circuitry capable of use with a wide range of sensing loops which may be installed under a wide variety of conditions.

According to the present invention there is provided presence detector apparatus comprising:

an oscillator circuit having terminals for connection to an external inductive detector loop to complete the oscillator circuit for oscillation at a frequency dependent on the inductance of the loop;

a detector circuit coupled to said oscillator circuit to provide a first signal having an amplitude that varies in sympathy with a voltage at the oscillation frequency developed by the oscillator circuit;

means responsive to a change of one polarity and of sufficient magnitude in said first signal to provide a presence-indicative signal;

a circuit for processing said first signal to derive thereform a second signal; and

a regulator circuit connected to control the energisation of the oscillator circuit and responsive to said second signal to act to maintain said oscillation frequency voltage constant;

wherein said process circuit is sensitive to the polarity of changes in said first signal so as to derive said second signal with a slower response to changes of said one polarity of said first signal than to changes of the opposite polarity, and the derivation of the second signal continuing after the provision of a presence-indicative signal so that a further presence-indicative signal may be subsequently given notwithstanding the continuance of the circumstances that gave rise to the first-mentioned presence-indicative signal.

The apparatus defined above provides a negative feedback loop for regulating the oscillator voltage, the regulation loop having different responses in time in respect of the two polarity changes that may occur in the first signal.

In a practical installation with the oscillator circuit completed by having an inductive sensing loop connected to its terminals, the said one polarity of the first signal would normally correspond to a decrease in the oscillation frequency voltage due to the arrival of a vehicle in the vicinity of the loop. Furthermore, the change in voltage will be relatively abrupt so that due to the slow response of the regulation loop, a sufficient magnitude of signal change of the one polarity occurs to result in a presence-indicative signal being given. If the vehicle soon departs, the signal changes are of opposite polarity to which the circuit more rapidly accommodates itself. Should the vehicle remain stationary in the vicinity of the sensing loop, the adjustment of the circuit regulation loop to this circumstance continues so that the circuit is again in a state in which a further presence-indicative signal can be given.

Although for the one polarity of change of the first signal, the regulation response is relatively slow, it can be designed to meet the requirements of adjusting the apparatus to the effects of ambient changes which take place relatively slowly.

In one embodiment of the invention described hereinafter, the processing circuit includes a capacitor the voltage across which provides the second signal; first means connected to the capacitor to charge it in one sense that acts to produce a change in the first signal of the opposite polarity (as defined above); and second means responsive to a change of the opposite polarity of the first signal to charge the capacitor in the opposite sense and responsive to a change of the one polarity in the first signal to act to isolate the capacitor from this change so as to allow the capacitor to charge in the aforementioned one sense.

The procesing circuit effectively achieves a balance at the capacitor. The first means attempts to charge it in one sense to produce a change in the first signal of the opposite polarity that is readily effective through the polarity-sensitive element to charge the capacitor in the opposite sense. Thus the circuit achieves a quiescent balance. On the one hand, an externally-induced opposite polarity change in the first signal, as when a vehicle leaves the sensing loop in the circumstances outlined above, produces a relative rapid adjustment to the balanced condition. On the other hand, the change of the abovementioned one polarity, as when a vehicle arrives at the sensing loop, causes the polarity-sensitive element to isolate the capacitor from charging in its opposite sense and balance is restored relatively slowly as it charges in its one sense.

For example, the one sense of charging the capacitor may be discharge of the capacitor through a parallel circuit connected across the capacitor. The capacitor charge is then increased by charging through the polarity-sensitive element (charging in the opposite sense) when a change of opposite polarity of the first signal occurs.

The invention and its practice will now be more particularly described with reference to the accompanying drawings, in which:

Figure 1 shows a block diagram of a

presence-detector apparatus embodying the invention forming part of a presence detector installation;

Figure 2 shows the variation with time of various voltages in the apparatus of Figure 1;

Figure 3 is a schematic diagram of one specific form of the apparatus; and

Figures 4 and 5 are partial circuit diagrams showing modifications of the circuit of Figure 3.

Referring to Figure 1, the apparatus comprises an oscillator 20 having an active device 21 and a frequency-determining parallel tuned circuit 22 (the full interconnections between device 21 and circuit 22 are not shown here). The tuned circuit comprises a capacitor Co fixed in the oscillator circuit and connected in parallel with an external sensing loop 24 which is connected to the apparatus through a feed line 23 of a length dependent on the requirements of the installation and which itself contributes some inductance. The predominant inductance is that of the loop diagrammatically shown as inductor L. A typical oscillator frequency is a few tens of kHz. The oscillator 20 is connected between power supply rails, designated +Vs and Ov respectively, through a regulator 25 having a control input 26 (power-supply connections to the remainder of the circuitry are not shown). The regulator 25 controls the D.C. power supplied to the oscillator 20 in dependence upon the voltage Vc applied at its control input 26. The regulator 25 may be regarded as controlling the proportion of the supply voltage Vs applied across the oscillator 20, this voltage being the voltage Vp appearing at the point P.

In operation the alternating voltage *vo* developed across the tuned circuit 22 is taken from the circuit point 0 and utilised. When working at low supply voltages, e.g. 6 volts, and with low oscillator current, e.g. 1mA, the magnitude of *vo* is likely to be around 300 mV peak. Such a voltage level is not adequate for detector diodes which typically require a peak voltage of at least 500mV to drive them into significant conduction. The voltage *vo* is thus amplified by an amplifier 27 of well-stabilised gain. The amplified signal is then applied to a peak detector circuit 28 (shown more fully in Figure 3) from which is obtained a direct voltage Vo proportion to the peak amplitude of the oscillator voltage *vo*. The voltage Vo is applied to a comparator amplifier 29 to which a reference voltage Vref is fed from a source 30. The comparator amplifier produces at its output an error voltage Ve which varies as the difference between Vo and Vref. This error voltage Ve appears at a circuit point Q.

From the point Q the voltage Ve is taken to the input of an analyser circuit 31 on the one hand and to a low-pass filter 32 on the other hand. The operation of circuit 31 will be described more fully below with reference to Figure 3. Suffice it to say that if this circuit is to detect a relatively rapid change in *vo* due to the arrival of a vehicle at loop 24, then this change must be reflected in the voltage Ve.

The output of the low-pass filter appearing at the circuit point S is a smooth and thereby delayed voltage Vc which is applied to the input 26 of regulator 25 to counteract whatever change occurs in *vo*, that is the circuit described, with the exception of presence circuit 31, provides a negative feedback regulation loop acting to maintain the voltage *vo* at a constant level set by the value of Vref. Clearly the polarities of the changes in the various signals developed in this loop can be selected positive- or negative-going provided a nett negative feedback is achieved. The action of the feedback loop must not, however, be so rapid as to eradicate the changes in *vo* which are required for presence detection. This is the function of the low-pass filter 32, the characteristic of which to positive-going changes in Ve is determined by resistor R and capacitor C which provide a time constant of at least several minutes.

The operation of the circuit of Figure 1 may be better appreciated by reference to Figure 2 in which the voltages Vo, Ve, Vc and Vp are shown as functions of time, part A of the figure relating to a vehicle passing over loop 24 and part B of the figure relating to a vehicle arriving at the loop location and remaining stationary there for some time before moving off. The time scales in parts A and B are very different as will be explained. Some of the voltage changes are shown exaggerated relative to one another for clarity of illustration.

In part A the circuit is in a quiescent state until a vehicle arrives at time t_1. As the vehicle couples to the field of the loop, the loop Q reduces and as a result *vo* drops. The peak detected voltage Vo correspondingly drops relative to the reference voltage Vref and since the amplifier is connected in inverting mode as regards Vo, the error voltage Ve rises positively from its quiescent value. Due to the action of filter 32 effectively delaying the change in Ve, Vc barely changes, which is also true of Vp. Thus as the vehicle leaves the loop *vo* and Ve are restored to their previous values. The change in Ve passes to circuit 31 for detection therein. Obviously the duration of the voltage change in *vo* depends on the size of the loop in the direction of travel of the vehicle and vehicle speed. However, the changes would be expected to be completed in a time ranging from a few tens of milliseconds to say 1 or 2 seconds.

Part B of Figure 2 illustrates the arrival of a vehicle at the loop location at t_2 producing a drop in *v*o and a rise in Ve as described in the preceding paragraph. However, in this instance the vehicle remains stationary at the loop location and as indicated, the voltage Vc at point S begins to rise in response to the abrupt rise in Ve. Voltage Vp rises with Vc acting to increase *v*o and thereby decrease the error voltage Ve. Eventually, the feedback loop settles down after several minutes to a value of *v*o not far removed from the initial value.

The degree of constancy of *v*o achieved by the feedback loop depends on the gain of the feedback loop primarily determined by the gains A_1 and A_2 of amplifiers 27 and 29 respectively. The feedback loop is of a kind requiring an error voltage Ve to exist but the error voltage can be made arbitrarily small by having a sufficient loop gain. It is to be noted that the loop gain in the presence of a vehicle is somewhat less than when no vehicle is present due to the lower Q of the tuned circuit.

Assuming the sensing loop 24 is of a size where it can accommodate more than one vehicle it will be seen that after settling down, the arrival of a second vehicle can be detected with the present detector apparatus working at substantially the same voltage levels as before.

Additionally the loop will adjust to ambient variations acting to vary *v*o and which normally take place over periods considerably longer than the time constant of the low-pass filter 32.

Assume now that the stationary vehicle at the sensing loop 24 leaves the loop location at a time t_3. With the feedback circuit thus far described, the departure of the vehicle would cause a sequence of voltage changes like that caused by the vehicle's arrival at t_2 but with all the voltage changes being of opposite polarity. Vehicle departure is of no interest in this apparatus. What, therefore, is wanted is that the feedback loop act rapidly to stabilize *v*o as the vehicle leaves. The loop response time is quickened by making the low-pass filter act differently for negative-going changes of Ve than for positive-going changes. To this end diode D_1 is connected across resistor R_1 and poled to by-pass R_1 and allow the capacitor C_1 to discharge rapidly towards the negative-going Ve as the vehicle leaves. The oscillator voltage rapidly settles back to the initial condition obtaining before time t_1 but it will be noted that there is a negative-going overshoot of the voltage Ve. This is due to the effect of the forward drop across diode D_1 which in a high gain regulation loop and particularly in a circuit designed for low supply voltage may be comparable with changes in Ve. Thus here $Vc = Ve + V_{D1}$. The recovery time from this overshoot depends on the condution characteristic of diode D_1 and the time constant eventually depends on R_1 as the diode ceases to conduct. This overshoot is not detrimental provided that it does not cause analyser circuit 31 to give a false presence-indication. This is unlikely if recovery is slow.

Figure 3 shows a specific circuit embodying the invention. The circuit has a number of stages 20, 25, and 27, 28, 29, 30 to 32 corresponding to the stages shown in Figure 1.

The oscillator 20 comprises a standard Colpitts circuit, the active device 21 of which is a transistor Tr10 and the tank circuit of which has the resonating capacitance Co made of two series capacitors in a capacitance divider in the usual fashion. The external sensing loop 24 and feeder 23 of Figure 1 are represented by their combined inductance L.

The regulator device 25 comprises a transistor Tr11 operated as an emitter follower and to the base 26 of which the feedback control voltage Vc is applied. Preferably the transistor Tr11 is of the Darlington type.

The amplifier 27 comprises a transistor Tr12 connected in common emitter with an undecoupled emitter resistor R_{12} providing a considerable amount of local feedback to stabilise the amplifier gain to a value of five, say.

The peak detector circuit is preferably of the diode pump type acting as a voltage doubler and providing the voltage Vo as a positive polarity voltage across capacitor C_{12}.

The comparator amplifier 29 is realised as a simple common emitter amplifier using transistor Tr13, preferably of the Darlington type. The reference voltage source 30 is a diode D_{12}, the relatively constant forward voltage drop across which provides the reference. Strictly, to this voltage should be added the base-emitter voltage drop of Tr13. The voltage Vo at the base of Tr13 should be sufficiently large to maintain transistor Tr13 conductive under all circumstances.

The low pass RC filter 32 is as previously described with reference to Figure 1 and the smoothed or delayed voltage Vc appearing at point S is returned to the base of regulator transistor 26 to complete the negative feedback loop controlling the voltage applied to the oscillator 20 at point P. The forward time constant R_1C_1 is typically 1000 seconds ($R_1 = 1M\Omega$, $C_1 = 1000\ \mu F$).

The illustrated analyser circuit 31, which is connected externally of the voltage regulation loop, has characteristics relating to the criteria by which the presence of a vehicle is decided that make it particularly well suited for use with the regulator circuitry described thus far.

The analyser or presence-indicative circuit comprises a differential amplifier comprising transistors Tr14 and Tr15 having a common emitter resistor R_{17} and an output load resistor R_{16} in the collector of Tr14. A common emitter amplifier comprising transistors Tr16 is driven from the collector of transistor Tr14 and its collector output connected to the base of transistor Tr15 by a diode D_{13}. The base circuit of Tr15 also includes a large value capacitor C_{13} the voltage across which is applied to the base of this transistor. The collector circuit of tranistor Tr16 has its collector load made up of series resistors R_{19}, R_{20} from the junction point of which an output transistor Tr17 is driven to control an indication and/or utilisation circuit (not shown).

Firstly assume diode D_{13} is replaced by a short circuit. It will readily be seen that, in response to a change of voltage at the base of transistor Tr14, transistor Tr16 drives the base of Tr15 in the same polarity sense acting to maintain the differential amplifier in a balanced condition so that little output voltage could be developed. In fact the gain of the differential amplifier from the base of transistor Tr14 to the collector of transistor Tr16 is unity.

Now assume the connection through D_{13} is made an open circuit, the capacitor C_{13} acts as a slow changing, reference voltage source at whatever voltage currently exists across it. Under these conditions the balance of the differential amplifier is not automatically maintained and a rapid voltage change at the base of Tr14 apperas duly amplified at the collector of Tr16. In addition the capacitor C_{13} tends to discharge mainly through the base-emitter of Tr15 tending to turn the latter off and Tr14 on.

The effect of D_{13} is two-fold. It provides a short circuit condition maintaining balance of the amplifier for negative-going voltage changes, whether fast or slow, on the base of Tr14. For such changes capacitor C_{13} rapidly charges through D_{13} and Tr16 and the unity gain condition applies so that only a small collector output is developed by Tr16 which is not sufficient to turn the output transistor Tr17 off.

For rapidly positive-going signals at the base of transistor Tr14, diode D_{13} provides an open circuit allowing the amplified change to appear in the collector circuit of transistor Tr16 and turn off the transistor Tr17 if the input signal Ve is of sufficient magnitude. If, however, the positive change at the base of transistor Tr14 is slow, the base of Tr15, which is continually being pulled positive by the attempted discharge of capacitor C_{13}, is clamped by diode D13 to the collector of transistor Tr16 so that the balance condition is just maintained.

Furthermore when a rapidly positive-going signal is applied to the base of Tr14, although diode D_{13} is immediately reversed biased to let the amplified signal through, if the signal is then maintained, C_{13} will discharge through the base-emitter of transistor Tr15 until the base voltage of the latter reaches a value corresponding to that now existing at the base of Tr14, further positive-going change being prevented by the clamping action of diode D_{13}.

The properties of the analyser circuit 31 thus accommodate themselves very well to those of the regulator circuit previously described. It will be recalled that when a vehicle arrives at the loop there is a relatively rapid positive-going rise in Ve (Figure 2) which is applied to the base of Tr14 to cause activation of the output transistor Tr17. The circuit 31 itself compensates for slow ambient changes and it will be apparent that it will set itself to balance in response to a change in Ve due to a vehicle remaining stationary in the field of a sensing loop as indicated in Part B of Figure 2, quite apart from the reduction in the quiescent fluctuations of Ve achieved by the regulator loop itself. The time constant of the discharge circuit of C_{13} is chosne in accordance with these requirements, *i.e.* at least several minutes.

When starting the circuit of Figure 3 as described thus far, there would be a delay in bringing the circuit into operation while capacitor C1 charges to working voltage through R1 and R15. This would mean a delay of some minutes in the oscillator starting and reaching a stable operating condition. This delay is avoided by using a switching device 33 to temporarily connect the capacitor directly to the positive supply line to quickly charge the capacitor. Device 33 can be a mechanical switch, e.g. a push-button switch, or a transistor switch. A resistor R_{23} acts a current limiter and, in conjunction with a pair of back-to-back diodes D_{14} and D_{15}, to prevent the positive terminal of capacitor C1 rising excessively above the voltage at the base of Tr15, which voltages are substantially equal in the quiescent operating condition of the circuit. Resistor R_{24} in parallel with these diodes is of high value.

Figure 4 shows two independent modifications of the circuit of Figure 3, one being concerned with substituting the diode D_{13} by a different asymmetrically-conductive device, and the other being concerned wih the low-pass filter 32. Only those parts of the circuit relevant to understanding the modifications are shown.

In Figure 4 the diode D13 between the collector of transistor Tr16 and the base of transistor Tr15 is substituted by a PNP transistor Tr18 the base-collector junction of which is connected between Tr15 and Tr16 with the same polarity as the diode D_{13} and the emitter of which is taken to the positive rail through resistor R_{22}.

The transistor Tr18 is normally in a saturated condition. A vehicle leaving the loop L causes the collector of the transistor Tr16 to go more negative, as previously described, in which case the capacitor C_{13} charges rapidly through the collector-base junction of transistor Tr18 to maintain the balance of the differential amplifier.

For a presence-indicative signal to be given upon a vehicle arriving over the loop L, the positive rise in the collector voltage of Tr16 must be sufficient to take the transistor Tr18 out of saturation and must proceed at a rate greater than that which the differential amplifier accommodates by virtue of the charging of capacitor C_{13} through the collector-emitter path of transistor Tr18. The charging rate is controlled by emitter resistor R_{22}. If the rate of rise of transistor Tr16's collector voltage is great enough, transistor Tr18 comes out of saturation progressively isolating the capacitor C_{13} from the collector of transistor Tr16 to unbalance the differential amplifier leading to transistor Tr1 cutting-off and giving a presence-indicative signal. As transistor Tr18 becomes less conductive it effectively introduces in series with resistor R_{22} an increasing resistance to the discharge of capacitor C_{13}. Resistor R_{21} can be omitted here; alternatively it can be retained to limit the time-constant achieved by the increasing resistance of transistor Tr18.

Also in Figure 4 the input of filter 32 is disconnected from the point Q at the collector of transistor Tr13 and is now connected to the base of transistor Tr15 in the presence-indicative circuit 31. It will be recalled that in Figure 3 in response to a rapid positive-going surge of the error voltage Ve, diode D_{13} is cut off and the base of transistor Tr15 will only slowly go positive as capacitor C_{13} discharges. Thus there is a delay here similar to that required for delaying the control voltage Vc relative to the error voltage Ve. Consequently the time delay arrangement of the analyser circuit can be used for both purposes by connecting the whole differential amplifier in the voltage regulating feedback loop to provide a time delay in addition to that provided by filter 32 or, as will be later described, to provide all the required time delay in the voltage regulation loop.

Because the time constant associated with capacitor C_{13} in the analyser circuit 31 is already chosen to allow response to vehicle presence signals and to allow adjustment to other voltage variations, it is possible to use the analyser time constant alone to control the forward delay in the regulation loop. Thus in Figure 4 the filter 32 can be omitted and replaced by a direct connection of the base of regulator transistor Tr11 to the base of transistor Tr15. Such a modification of Figure 4 also has the advantage of immediate starting without the use of switch 33 (Figure 3). Upon applying the supply voltage, the base of transistor Tr15 will start from +Vs and go negative to its working voltage as C_{13} charges. This advantage also can bring a disadvantage if the supply line is subject to transients or other rapid voltage fluctuations. These will be transmitted straight through capacitor C_{13} to the regulator transistor and in turn will cause variations in the oscillator v_o quite probably leading to false presence indications being given.

In Figure 4 the filter 32 removes such transients and, if desirable, its time constant can be modified to serve this purpose alone.

Also in Figure 4, it should be noted that the cathode of diode D_1 can be equally well left connected to the collector of transistor Tr13 (Figure 3) because for negative-going change in Ve, the collector of transistor Tr13 is at the same voltage as the base of transistor Tr15. The diode still has the same by-passing effect in the low pass filter.

Figure 5 shows an alternative solution achieved by a further modification of Figure 4. (In Figure 5 the diode D_{13} is retained also). The base of regulator transistor Tr11 is directly connected to the base of transistor Tr15 as suggested above but the positive ends of resistors R17 and R18 in the differential amplifier Tr14, Tr15 are removed from the +Vs supply line and taken to a separate stabilized and smoothed supply point provided by the zener diode D_{14}, resistor R_{22} and capacitor C_{15}. Where low current drain is important, the modification of Figure 5 carries a penalty in requiring extra current for the zener diode.

Of couser, if the main supply +Vs is well regulated, the direct connection between transistors Tr15 and Tr11 is possible without the extra modification of a separate stabilized line shown in Figure 5.

In operation of the circuit of Figure 5, the capacitor C13 is operated in the balance condition described earlier in respect of the analyser circuit 31 of Fig. 3. The parallel circuit through the base-emitter of transistor Tr15 is continually attempting to discharge the capacitor and act via the regulator Tr11 to increase the oscillator voltage v_o. The polarity of this charge, which is opposite to that obtained when a vehicle arrives at the sensing loop, acts to lower the collector voltage of transistor Tr16 which is readily applied by virtue of the poling of diode D13 to increase the charge on the capacitor. Thus a balance is achieved. An abrupt drop in the collector voltage of transistor Tr16, as wen a vehicle leaves the sensing loop, is readily applied through diode D13 to rapidly charge the capacitor C13 and restore the circuit to a balanced condition. On the other hand, when a vehicle arrives at the sensing loop, the collector of transistor Tr16 abruptly rises (goes positive) in voltage, reverse biasing diode D13 to isolate the capacitor C13 from the detector circuitry. Balance is then eventually restored as the capacitor slowly discharges to increase *vo* as well as becoming more positive at the plate connected to the base of transistor Tr11, putting the circuit in condition to detect the arrival of a second vehicle at the loop while the first is still present.

WHAT WE CLAIM IS:—

1. A presence-detector apparatus comprising:

an oscillator circuit having terminals for connection to an external inductive detector loop to complete the oscillator circuit for oscillation at a frequency dependent on the inductance of the loop;

a detector circuit coupled to said oscillator circuit to provide a first signal having an amplitude that varies in sympathy with a voltage at the oscillation frequency developed by the oscillator circuit;

means responsive to a change of one polarity and of sufficient magnitude in said first signal to provide a presence-indicative signal;

a circuit for processing said first signal to derive thereform a second signal; and

a regulator circuit connected to control the energisation of the oscillator circuit and responsive to said second signal to act to maintain said oscillation frequency voltage constant;

wherein said process circuit is sensitive to the polarity of changes in said first signal so as to derive said second signal with a slower response to changes of said one polarity of said first signal than to changes of the opposite polarity, and the derivation of the second signal continuing after the provision of a presence-indicative signal so that a further presence-indicative signal may be subsequently given notwithstanding the continuance of the circumstances that gave rise to the first-mentioned presence-indicative signal.

2. Apparatus as claimed in Claim 1 in which said processing circuit includes;

a capacitor the voltage across which provides said second signal;

first means connected to the capacitor to charge it in one sense that acts to produce a change in said first signal of said opposite polarity; and

scond means including a polarity-sensitive element connecting the capacitor to said detector circuit and responsive to a change of said opposite polarity in said first signal to charge the capacitor in the opposite sense and responsive to a change of said one polarity in said first signal to act to isolate the capacitor from said change so as to allow the capacitor to charge in said one sense.

3. Apparatus as claimed in Claim 2 in which said first means comprises a parallel circuit connected across said capacitor to discharge same and said polarity-sensitive element is connected so as to increase the charge on the capacitor in response to changes of said opposite polarity in said first signal.

4. Apparatus as claimed in Claim 3 in which a change of said one polarity of said first signal corresponds to a decrease in said oscillation frequency voltage.

5. A presence-detector installation comprising apparatus which is as claimed in any one of Claims 1 to 4 and an inductive loop for sensing the presence of a vehicle connected to said oscillator circuit to complete same for oscillation.

6. In or for a presence-detector installation, a presence-detector apparatus substantially as hereinbefore described with reference to Figures 1 to 3, or to Figures 1 to 3 as modified by Figure 4 and/or Figure 5 of the accompanying drawings.

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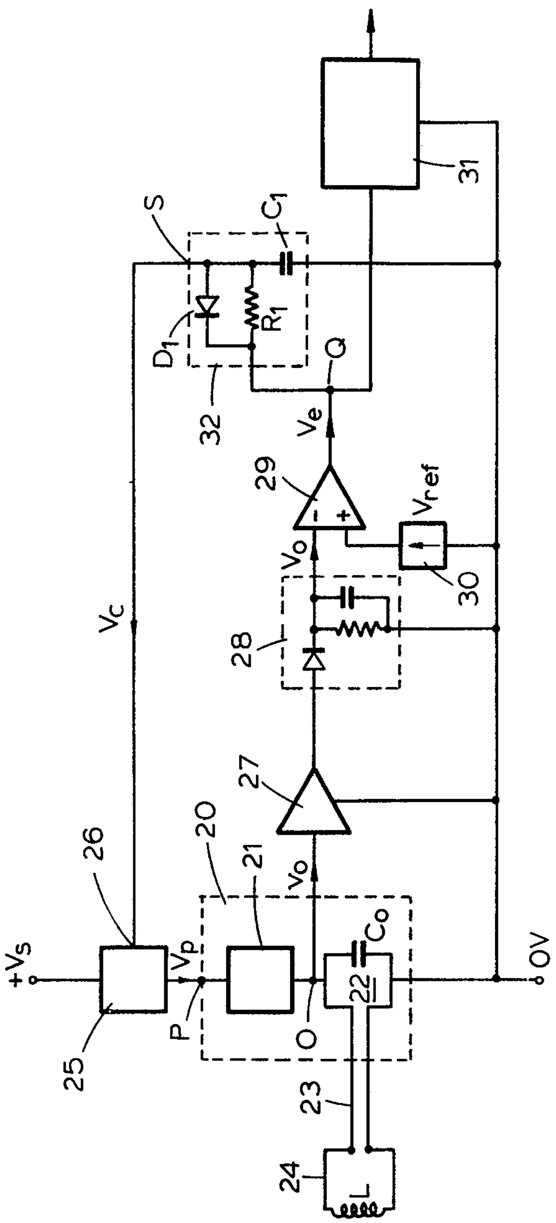
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Fig. 1

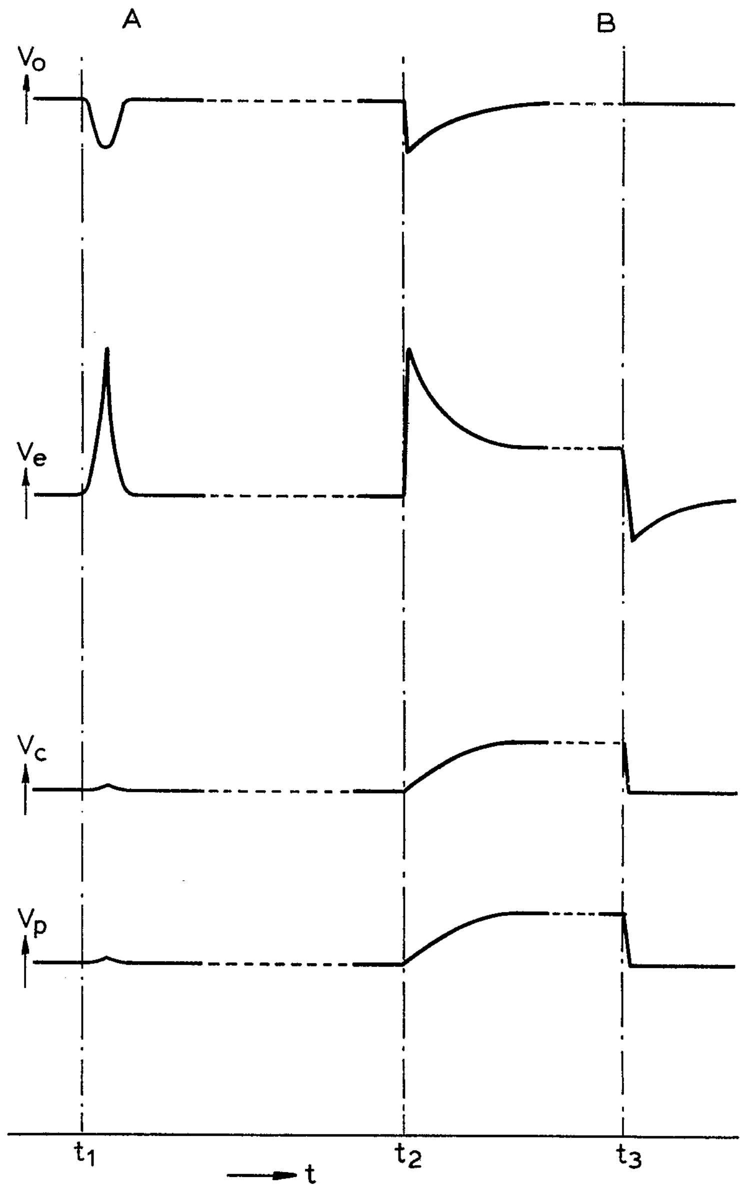
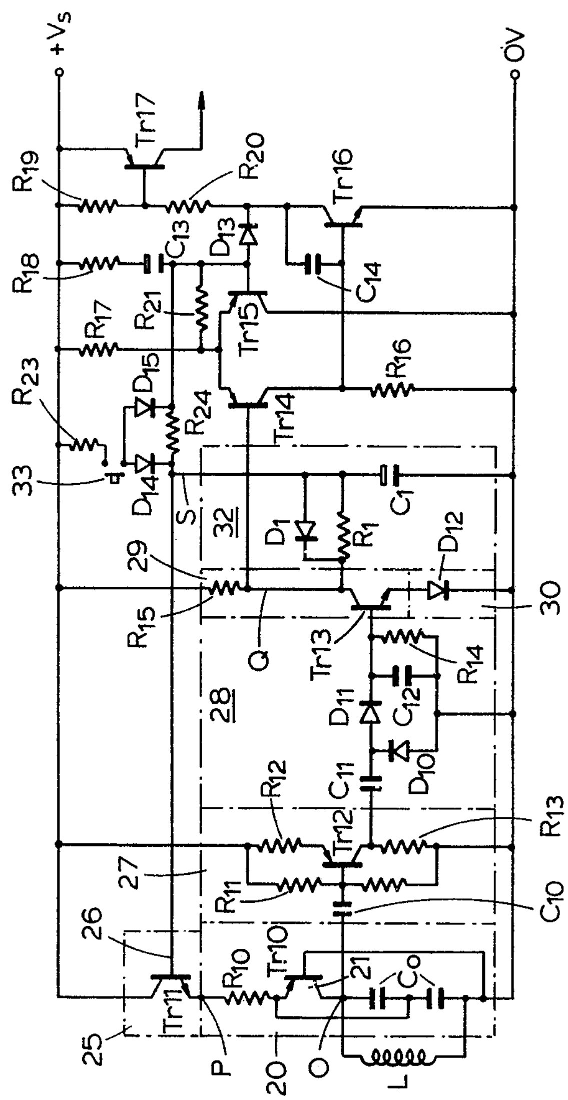


Fig. 2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Tr14
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D1
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C12
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C11
R12
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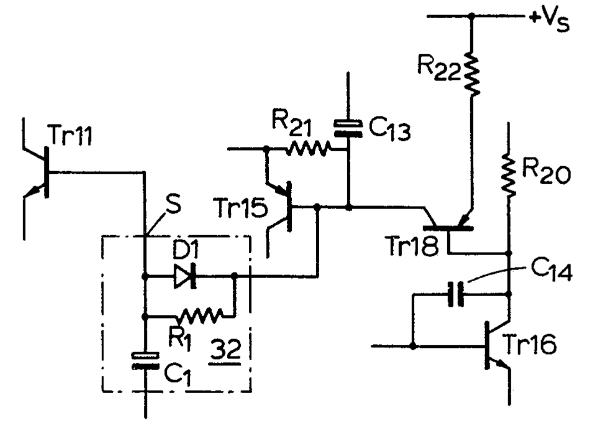
Fig. 3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R22
R21
C13
Tr11
R20
S
Tr15
D1
Tr18
C14
R1
32
Tr16
C1

Fig. 4

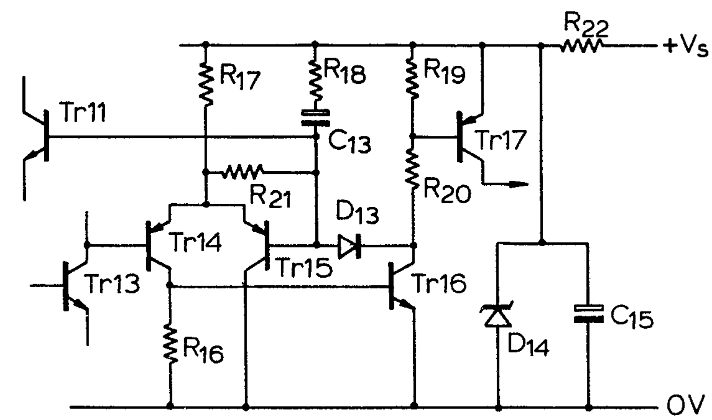
R22
+Vs
R17
R18
R19
Tr11
C13
Tr17
R20
R21
D13
Tr14
Tr15
Tr13
Tr16
C15
R16
D14
OV

Fig. 5