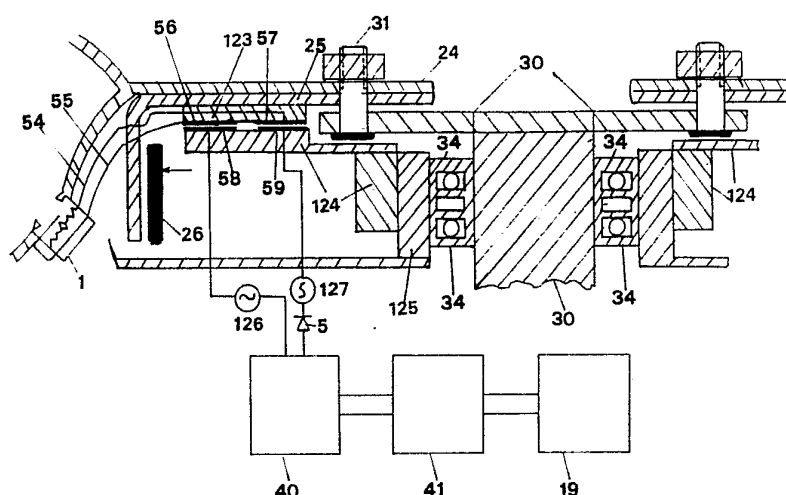


## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

<b>(51) International Patent Classification <sup>5</sup> :</b>  <b>B60C 23/04</b>	<b>A1</b>	<b>(11) International Publication Number:</b> <b>WO 92/13730</b>  <b>(43) International Publication Date:</b> 20 August 1992 (20.08.92)
<b>(21) International Application Number:</b> PCT/GR92/00001 <b>(22) International Filing Date:</b> 6 February 1992 (06.02.92)  <b>(30) Priority data:</b> 910100069      8 February 1991 (08.02.91)      GR  <b>(71)(72) Applicant and Inventor:</b> TSAGAS, Nicolaos [GR/GR]; Terma Nees Ergatikies Katikies, GR-67 100 Xanthi (GR).  <b>(81) Designated States:</b> AT, AT (European patent), AU, BE (European patent), BF (OAPI patent), BG, BJ (OAPI patent), BR, CA, CF (OAPI patent), CG (OAPI patent), CH (European patent), CI (OAPI patent), CM (OAPI patent), DE (European patent), DK (European patent), ES (European patent), FI, FR (European patent), GA (OAPI patent), GB (European patent), GN (OAPI patent), GR (European patent), HU, IT (European patent), JP, KR, LU (European patent), MC (European patent), ML (OAPI patent), MR (OAPI patent), NL (European patent), NO, RU, SE (European patent), SN (OAPI patent), TD (OAPI patent), TG (OAPI patent), US.		<b>Published</b> <i>With international search report.</i> <i>With amended claims.</i>

**(54) Title:** AN INDICATOR OF THE ABNORMAL AND NORMAL PNEUMATIC TYRE PRESSURE DURING THE DRIVING OR STOPPING OF A VEHICLE

**(57) Abstract**

A device for monitoring tyre pressure whilst the vehicle is moving can operate with the help of: two complete circular metallic strips (56, 57) placed on an insulated surface of the internal side of a brake drum (25) or on an insulated surface of the disk brake; two metallic strips (58, 59) placed on a non-rotating part of the vehicle forming two complete circular strips (58, 59); a pressure gauge sensor (1) and electronic signal generating circuitry (19, 40, 41). The non-rotating strips (58, 59) are placed parallel to the rotating strips (56, 57) and very close to them so as to form a pair of air capacitors (56, 58) (57, 59). The electronic circuit (19, 40, 41) produces high frequency alternating voltages which are applied to the plates of the capacitors (56, 58) (57, 59). In case of dangerous tyre pressure the sensor (1) closes the circuit, an alternating current flows and a warning device is activated. The current thus flowing in the capacitor circuit does not pass through the wheel bearing (34).

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An indicator of the abnormal and normal pneumatic tyre pressure during driving or stopping of a vehicle.

The present invention relates to the apparatus for indicating to the driver the abnormal and normal pneumatic tyre pressure during driving or stopping of the vehicle. This apparatus consists of a special electronic circuit producing alternating voltages of definite frequency shape and amplitude which are applied to a special system of metallic strips placed on the rotating frame of the wheel and non-rotating part in a free space close to the brakes and to the axle of the wheel. These strips are operating as air capacitors of the circuit to transfer the signals from the rotating wheels to the vehicle's control panel, when a special pressure gauge sensor closes the circuit. This circuit operates with a battery (accumulator) which can be connected with the vehicle's battery. This device is not using a system of solid conducts (carbon brushes), where the flow of the alternating current from the rotating wheel to the non-rotating part of the vehicle, can take place by using either a capacitive coupling or an inductive coupling. This alternating current can also flow by applying either alternating high voltage or direct high voltage between two special electrodes placed on the rotating frame of the wheel and the non-rotating part of the vehicle, in a close distance between each other.

This device can operate as a safety apparatus indicating the dangerous limits of the pneumatic tyre pressure and therefore the damage of the tyres can be avoided. An USA patent No 3,930,223 DEC.30.1975 has been awarded to N.F.Tsagas and an E.P. Application No 0345 199. 30.3.89 has been published for another type of the present invention.

Indicators of the pneumatic tyre pressure of various types have been invented in the past, which have different disadvantages like, the use of solid conducts (carbon brushes) which were destroyed by the time, the use of small batteries placed on the rotating wheels was a problem for checking them, the use of pneumatic pressure gauges placed on the wheels as sensors were of big size and expensive and also the use of a system which was not working under bad weather conditions. The aim of the present invention, as it is described, is to get around and erase all these disadvantages which can be faced by using a number of metallic strips

of proper shape which are placed on the rotating frame of the wheel and on the non-rotating part near the brakes and the axle of the wheel and they form one or two plane capacitors or a combination of plane and cylindrical capacitors for each wheel. Also a pressure gauge sensor of a proper form can be used, so that its flexible membrane can have the ability to make displacements in an easy way in case it comes in contact with one of the two terminals of the sensor and closes the circuit. The pressure gauge sensor is of a simplest construction made by durable, light and not expensive material and can be applied to already existing valves of the wheels. The sensor can be applied in a permanent valve which can be added on the back side of the metallic rim of the wheel, especially made for those pressure gauges, in a hiding place which can not be seen by an outside observer. The sensor consists of one durable resilient rubber or metallic membrane of good elasticity which can be displaced along its axis and the amplitude of this displacement depends on the tyre pressure (conversion of pressure into mechanical displacements of membrane) and therefore the sensor can play the role of a switch which, in case of abnormal tyre pressure, connects electrically either the rotating metallic strip with the metallic rim of the wheel or the two rotating metallic strips each other. According to the present invention various other sensors could be used which consist of closed curved tubes or cylindrical tubes with very thin walls which form foldings of wavy shape like bellows or some special materials of which their ohmic resistance is varied according to the applied air pressure. The special electronic circuit can produce alternating voltages of certain characteristics which are applied between the rotating and non-rotating metallic strips, so that an alternating current is flowing in the circuit when the pressure gauge sensor closes the circuit in case of the abnormal tyre pressure. Then the alternating current can activate a light emitting diode or a loudspeaker on the driving control panel. It is possible, except for the indication of normal and abnormal tyre pressure, to have also an indication of the continuous air pressure in the tyres of the vehicle.

The advantage of this invention is mainly the transmission of the information of abnormal and normal tyre pressure from the rotating wheels to the cabinet of the driver, without using a solid contact and therefore to be worn out because of the friction. Hence the use of a conducting

system, as carbon brushes which must be substituted quite often, is avoided. The pressure gauge sensor and the circuit are simple and not costly. The vehicle's battery can be used for the operation of the circuit. From the above it is obvious that the present invention has many advantages.

A way of application of this invention is described below referring to the figures which accompany and explain it with clarity and technical detail so it can be understood and also any misunderstanding can be avoided.

10 Figure 1 is one view of a part of the device and a view of a part of the wheel and a part of the vehicle where a part of the device is placed. According to the invention the device consists of a system of metallic strips which are placed in a special way in a free space close to the brakes and to the rotating axle of the wheel, of a pressure gauge sensor and of an electronic circuit. The rotating metallic strip can cover

15 the round edge of a circular disk made by insulating material which is fastened on the metallic disc base of the axis of rotation, where the brake drum or brake disc and the metallic rim of the wheel are fastened. The non-rotating metallic strip, which surrounds circumferentially the first

20 strip is placed in the interior of a cavity of another insulating material which surrounds the first insulating material. The cavity has a shape of annular canal. The two strips are very close without making contact with each other and they form a combination of a cylindrical and two plane capacitors. The third metallic strip surrounds circumferentially the

25 second strip and it is the shielding of the second strip to avoid parasitic current. The electronic circuit is an oscillator with a current amplifier and a voltage transformer which can produce alternating voltages of definite form and frequency which are applied to the first and second metallic strip, so that an alternating electric current can flow when the sensor

30 closes the circuit.

Figure 2 gives the general principle of the device operation in block diagrams for the electronic circuit. A part of the annulus of the third metallic strip is also shown in this figure by the broken lines. The annuli of the first and second strip are not shown in figure 2.

35 also shows the way of connection of the first metallic strip with the circuit through the sensor which is earthed with the metallic rim of the wheel and how the third and second metallic strip are connected through a coaxial cable.

Figures 3a and 3b give another principle of the device operation, where two rotating metallic strips can form with two non-rotating strips either one cylindrical and one plane capacitor or two plane capacitors respectively. A main alternating current can flow in the electronic circuit presented by block diagrams, when a pin of the sensor is contacting any one of the two sensor's terminals and hence connecting electrically the two rotating metallic strips. The arrangement (setting) of the metallic strips, in figures 3a and 3b could be different depending on the free space available close to the drum and disk brakes for each type of the vehicle's wheels.

Figure 4 gives the simple principle of the device operation in block diagrams referring to figure 3b. The disadvantage of the appearance of the electrical resistances due to the lubricant covering the globules of the ball-bearing during the vehicle's motion can be avoided in the last two cases of operation with two capacitors. This electrical resistance appears in the cases referring to figures 1 and 2 where the metallic strips compose only one capacitor and the signal is transmitted through the ball-bearing.

Figures 5.1, 5.2, 5.3, 5.4, 5.5, 5.6, 5.7, 5.8, 5.9, 5.10, 5.11, 5.12, 5.13, 5.14, 5.15, 5.16, 5.17, 5.18, 5.19, give various views of pressure gauge sensors. One durable rubber membrane of certain thickness and elastic properties can close air-tightly a small volume which communicates with the interior of the tyre. The elastic membrane expands or contracts proportionally to the air pressure and therefore increasing or decreasing its curvature, where the sensitivity is depending on the area of the membrane surface. The rubber membrane can contain internally a thin steel wire with curvatures to strengthen (reinforce) the elasticity of the rubber. A thin electrode of good conductivity and special shape is fastened on the surface of the other side of the membrane. This electrode can be also connected with the steel wire for strengthening and conduction with one of the rotating metallic strips. The electrode can be displaced along the axis of the pressure gauge sensor according to the pressure and in between two other special electrodes which are in an adjustable distance. These electrodes can be connected to the metallic rim of the wheel in the case of using only one capacitor of the metallic strips. It is possible for the rubber membrane to be substituted by a metallic membrane with elastic properties. Also curved metallic tubes properly shaped

which have closed one of their ends and cylindrical tubes with very thin walls which form foldings of wavy shape like bellows can be used to device pressure gauge sensors. The elastic properties of a compressed gas which is contained in a little chamber can be also used for making pressure gauge sensors. The displacements of a small piston (with a flange on its perimeter pressed by a spring circumferentially all the way out) which is balanced by air pressure on one side and by a spring frame on the other side can be used as a pressure gauge sensor.

Finally some special materials of which their ohmic resistance varies according to the applied air pressure could be used as the base for making pressure gauge sensors.

Figure 6 gives various waveforms of the alternating voltages which are applied between the rotating and non-rotating strips which form the plates of the capacitors. It is important to use the proper frequency, amplitude and waveform of the alternating voltage in order to minimize the parasitic current. A way to eliminate the unwanted signals is to apply high frequency alternating voltages of different characteristics to the nonrotating strips and use bandstop filters.

Figure 7 gives a part of the electronic circuit of figure 1 in which a voltage comparator has been added in order to stop the parasitic currents to activate the LED of the circuit. Referring to the circuits of figures 3 and 4 a comparator can be used, after the high -Q notch filter and the stage of a half way rectifier which gives an output of square train whenever the input signal is falling below a certain level which is determined by one trimmer.

Figure 8 gives another arrangement of the invention where the metallic strips have been substituted by an electrode pin and one metallic annulus. In this case the capacity coupling has been substituted by a coupling which is performed by electric discharges between the electrode pin and the metallic annulus when a high voltage is applied.

Figure 9 shows the cross sections which can have the metallic annulus of figure 8. These cross sections can be: circular, triangular, rectangular and a combination of the above cross sections.

Figure 10 shows an arrangement which can be used to control more than one wheels. This can be achieved by the use of circuits of the previous figures and one sampler apparatus.

In the above figures it is shown an apparatus capable to indicate via a light or audio signal inside the driving cabinet the unsafe limits of the pneuma-

matic tyre pressure during driving or stopping of a vehicle, where this apparatus basically consists of a pressure sensor (1), a system of metallic strips (2,3,4) or (50,51,52,53) or (56,57,58,59), high frequency oscillators with or without a frequency divider producing pulses (19), a current amplifier 5 (42), a transformer or an amplifier and properly tuned filters including a high-Q notch filter (41) which permits the fundamental frequency of the pulse train to pass in order to convert the square train to a sinusoidal waveform, a half wave rectifier and a voltage comparator (40) which converts the sinusoidal signal to the D.C. level and the comparator gives 10 an output of square train whenever the input signal falls below a certain level which is determined by a trimmer, an indicator like a LED (5) for each wheel or loudspeaker (11) or a microamperometer (8), two variable power resistors (9,21) a power resistor (12), cables (7,6) a shielding (13) and an isolated conductor (22) which absorbs parasitic current.

15

According to the present invention the apparatus can indicate the unsafe limits of the tyre pressure via a light (5) or an audio signal (11) using a different voltage comparator circuit (105,106,107). The pressure gauge sensor (1) which works as a circuit's switch can connect electrically either 20 the metallic strip (2) with the ground (10) that is the metallic frame of the wheel (24) or it can connect also electrically the two rotating metallic strips (56,57). The metallic frame of the wheel is connected electrically with the metallic frame of the vehicle through the ball bearing and axle of rotation (34,30). The metallic strip (2) which is a circular annulus with a cross section of shape "Π" is applied circumferentially on the 25 insulating disc (29) which is fastened by the screws (32) on the metallic disk of the axle (30) where the drum or disc brake (25) and the metallic frame of the wheel (24) are fixed. The centre of the disc (29) coincides with the axle of rotation (30) of the wheel. The metallic strip (2) must 30 cover enough area of the disc (29) so as to give sufficient capacitance of the capacitor (2,3). The non-rotating metallic strip (3), which surrounds the metallic strip (2) circumferentially, is mounted inside the "Π" shaped annular channel of an insulating circular annulus (28) which is fastened on the base (33). The metallic strips (2,3) form a capacitor 35 which is a combination of a cylindrical and two plane capacitors. The metallic strips (2) and (3) must not make contact between each other and their distance between them must be very small so that the capaci-

tance can be sufficiently bigger than the parasitic capacitances. The third metallic strip(4) surrounds with a larger area the second metallic strip (3) circumferentially and in between them a thin layer of insulating material is inserted. The strip (4) constitutes the shielding of the strip (3) for minimizing the parasitic capacitances during the normal tyre pressure when the sensor does not close the circuit to connect the strip (2) with the rim (24) or to connect the strips (56) and (57) electrically. The connection wires are very thin and covered by insulating material of very low dielectric constant. The centre wire (7) of a coaxial cable (7,6) connects the strip(3) and the LED(5) which is connected in parallel with the resistor (12) and in series with a loudspeaker (11), a digital or analog indicator (8), a variable power resistor (9) and with the one end of the secondary coil (14) of the high frequency and high voltage transformer (13,15,16). The indicators (8) and (11) are not necessary while the LED(5) can be driven by the comparator (106). The metallic strip (4), the conductor(6) and the thin metallic surface (13) constitute the shielding of all surrounded by them parts of the apparatus, for reducing the currents due to the parasitic capacitances. The isolated conductor (22) absorbs a big percentage of the parasitic currents which depends on the variable resistance (21) and the size of the conductor (22). In order to reduce the parasitic capacitances furthermore, all parts of the apparatus must not be close to the metallic frame of the vehicle. The coils (14,16) must not be close to each other. The core of the transformer (15) is a ferrite of special permeability. The other end of the coil (14) can be connected with the ground through a diode or a resistor or a capacitor.

The transformer (14,15,16) can be substituted by a set of properly tuned filters (41) including a high-Q notch filter in order to convert the square train to a sinusoidal wave form.

Between the rim of the wheel and the chassis of the vehicle there is an electric resistance due to the lubricant in the ball bearings(34) and this resistance obtains high values during the motion which can be counterbalanced automatically by the variable resistance (9). Another way to solve the problem is the automatic increase of the alternating voltage and frequency produced by the oscillator (19). A current flows in the circuit (1,3,2,7,5,9,14, 10) when the sensor(1) closes this circuit and this current depends on the capacitance between the metallic strips.

A different way to solve the problem of the ball bearing resistance is to divide the metallic strip (2) into two strips, one with a cylindrical shape (50) and another with a plane annular shape (51). The strip (3) is also divided into two similar strips (52) and (53) which together with the above strips (50) and (51) respectively can form two capacitors a cylindrical capacitor (50,52) and a plane one (51,53). The area and the position of these strips are chosen properly to have sufficient capacitance and minimize the parasitic current.

Another additional way similar to the above to solve the problem of the ball bearing resistance is to divide the strip (2) into two concentric plane annular strips (56) and (57). The strip (3) is also divided into two concentric plane annular strips (58) and (59) which can form two plane capacitors (56,58) and (57,59) with the strips (56) and (57). In order to reduce the parasitic capacitance of the above capacitors a proper area and position of the above strips (56,58,57,59) must be chosen. The strips must not be very close to the metallic parts of the wheel, the distance between the plates of the capacitors must be as small as possible and the area of the plates must be as larger as possible. For example the strips (56,57) and (58,59) are based on thick insulating layers with small dielectric constant (123) and (124) which are fixed on the brake drum (25) and on the non rotating base (125) respectively.

According to the present invention when the air pressure in one of the tyres exceeds the safety limits then the sensor (1) which operates as an electric switch connects electrically the strip (50) with the strip (51) or the strip (56) with the strip (57) and alternating current flows in the circuit (53,51,54,1,55,50,52,40,41,19,20) which activates the stage (40) so as to give light or sound. The stage (40) can or can not have an arrangement with the circuit of the comparator (105,106,107). A transformer (41) which is not necessary can increase the alternating voltage of the oscillator (19). Proper waveforms, frequencies and amplitudes must be found in order to avoid parasitic capacitances. The gap between the capacitors (52,50) and (51,53) or between (58,56) and (57,59) must be longer than the distance between the capacitors' plates. The capacitance of the capacitors (50,52) and (51,53) or (56,58) and (57,59) can obtain two different values which depend on the position of the switch sensor (1) if it is open or closed. The system of metallic strips is used as a timing capacitor in an oscillator (first stage of the circuit) which can produce a proper frequency in each case (on-off). The high frequency oscillator and the frequency divider (19) produce square train which can pass from

an amplifier and properly tuned filters including a high -Q notch filter (41) which permits the fundamental frequency of the train to pass in order to convert the square train to a sinusoidal wave form. The filter is designed in such a way so that one of the two frequencies falls in the gap of the notch filter while the second frequency falls outside. The result is in the output of the filter that a necessary distinction (discrimination) between the two frequencies takes place since the first frequency which falls in the gap, passes with very high attenuation. The next stages (40) is a half wave rectifier, a voltage comparator and a monostable multivibrator in which the rectifier converts the sinusoidal signal to the D.C. level, the comparator gives an output of square train whenever the input signal falls below a certain level determined by a trimmer and the monostable multivibrator increases the amplitude of the pulses train of the comparator output. This multivibrator is implemented by using a proper timing circuit and its output drives an indicating LED.

According to the present invention the capacity coupling can be substituted by another coupling which is an induction coupling or an electric discharge coupling.

In the case of induction coupling the metallic strips (2,3) or (50,51,52, 53) or (56,57,58,59) are substituted by one couple or more couples of coils. A higher current flows in the circuit when the rotating coil makes contact with the chassis of the vehicle through the pressure gauge sensor, the rim and the axle of the wheel.

In the case of electric discharge coupling the metallic strips (3,2) are substituted by an electrode pin (111) and an electrode metallic annulus (112) or by reverse way. A current can flow in the circuit only in the case of abnormal pressure in which the metallic annulus (112) is earthed to the chassis and there is an electric discharge between the electrodes (111,112) due to the applied voltage. The flowing current in the circuit can activate a light or audio indicator. In the above cases the rest of the operation of the electric circuit is the same as in the case of the capacity coupling.

In order to control more than one wheels by only one oscillator and one amplifier, a sampling frequency regulator (122) and a sampler apparatus (121) can be used so that all the wheels one after the other can be

controlled continuously many times per minute.

Alternatively a separate independent circuit for each tyre can be used to reduce parasitic currents. Each one of these independent circuits can be placed in a non-rotating position near to each wheel for reducing parasitic currents. All the cables must be not close to the metallic frame of the vehicle and must be covered by a thick insulating material with very low dielectric constant so that their capacitance with the chassis to be as small as possible. Any one of the independent circuits, when is activated, produces a signal which can be transferred to the vehicle's control panel through cables to activate its own corresponded LED. The signals can be amplified if there is a significant drop of voltage due to the distance of the wheels and the above independent circuits from the vehicle's control panel where all the corresponded indicating Light Emission Diodes are positioned.

There is a range of high frequency (kHz~MHz) where the parasitic currents are reduced significantly and this is due possibly to some characteristics of the surrounding metallic frame of the wheel which can not follow the fast changes of high frequency oscillations.

An additional way to reduce the parasitic capacitance and increase the main current which flows through the capacitors (59,57) and (58,56), when the pressure gauge sensor (1) closes the circuit (56,55,1,54,57), is to apply to the strips (58), (59) two different or same high frequency (kHz~MHz) oscillations (126), (127) with common earth and different or same voltage. Two separate oscillations with common earth can also be produced by (19) and compared by (40) so that the oscillation (126) which is applied to the strip (58) can be of a different or same high frequency (kHz~MHz) of different or same waveform and of different or same amplitude than the oscillation (127) which is applied to the strip (59). The separation gap between the strips (58) and (59) must be long enough for reducing the parasitic capacity coupling between these strips. The gap between the strips (56) and (57) must also be large. The insulating materials (123) and (124) which are the base of the strips (58,59,56,57) must have very small dielectric constant and sufficient thickness so that these strips must be in a long distance from the adjacent metallic frame.

## CLAIMS

1. A device for indicating to the driver of a vehicle the abnormal and normal pneumatic tyre pressure during driving or stopping of the vehicle consists of a special system of metallic strips (2,3,4) or (50,52,51,53) or (56,58,57,59) placed on the rotating frame of the wheel and on the non-rotating  
5 part in a free space close to the brakes and to the axle of the wheel forming either a capacitor (2,3) which is a combination of a cylindrical capacitor and two plane capacitors of cross section "II" or two capacitors either one cylindrical (50,52) and one plane capacitor (51,53) of cross section "I" or two plane capacitors (56,58) and (57,59), of an oscillator and a  
10 frequency divider (19), of an amplifier (42), of a set of properly tuned filters (41) or a transformer with ferrite core of special permeability (15), of an isolated conductor (22) big enough to absorb the alternating current due to the parasitic capacitances, of a LED (5), a loudspeaker (11) an analog or digital microamperometer (8) which can be activated by a circuit  
15 of two variable resistors (105,107) and a comparator (106), of a variable resistor (9) to counterbalance the electric resistance due to the lubricant of the ballbearing which is increased during the rotation of the wheel, of a variable resistance (21) to minimize the current due to parasitic capacitance so that the LED (5) shouldn't be activated by the parasitic  
20 current but only by the main current, of a shielding system (4,6,13) to minimize the parasitic capacitances, of a system of three stages as a half wave rectifier, a voltage comparator and a monostable multivibrator (40) or two high frequency (kHz, MHz) oscillator (19) with common earth, comparators (40) and finally the apparatus consists of a pressure gauge sensor (1) to convert the variations of the type air pressure into displacements of an elastic membrane or two rubber surfaces containing a curved steel  
25 wire in a sandwich and also other pressure gauge sensors can use curved metallic tubes of different shape which are closed at one of their ends or cylindrical tubes with thin folding walls of wavy shape like bellows and additionally the elastic properties of a spring or a special gas closed by a  
30 membrane in a small chamber can be used as pressure gauge sensors and eventually in all the above cases the result is the displacement of a pin electrode to connect electrically either the strip (2) of the capacitor (2,3) with the metallic rim of the wheel or the strips (50,51) of the capacitors (50,52) and (51,53) or the strips (56,57) of the capacitors  
35 (58,56) and (59,57) and it is still possible to use some special materials for pressure gauge sensors of which their ohmic resistance varies

according to the applied air pressure, therefore the current which flows through the system of capacitors (2,3) or (53,51,50,52) or (56,58,57,59) is converted according to the tyre pressure and finally obtains a continuous indication of the tyre pressure by a properly calibrated instrument (8).

2. The device for indicating to the driver of a vehicle the abnormal and normal pneumatic tyre pressure during driving or stopping of the vehicle according to claim 1, is characterized by a system of metallic strips (2,3) which are placed in a special way in the free space close to the brakes and the rotation axle of the wheel. The metallic strip (2) which is a circular annulus with a cross section of shape "Π" can cover the round edge of the insulating disc (29) circumferentially which is fastened by the screws (32) on the metallic disc base of the axle of rotation (30) where the drum or disc brake (25) and the metallic frame of the wheel (24) are fixed, so that the centre of the disc (29) coincides with the axle of rotation (30) of the wheel. The cylindrical annulus of the strip (2) which is the middle line of "Π" covers the total thickness of the external circumference of the annulus (29) and the height of the cylindrical annulus is equal to the thickness of the insulating disk (29). The other two circular annuli of the strip (2) which are the two parallel lines of "Π" can cover the two annular sides of the insulating disc (29) circumferentially in such an area so as to give sufficient capacitance to the capacitor which is formed by the metallic strips (2,3). These two circular annuli of strip(2) are not always necessary if the capacitance which is achieved by the cylindrical annulus of the middle line of "Π" has a sufficient area so as to give the required main current in the circuit. Also a sufficient capacitance could be achieved by using only the two or one of the extreme parallel lines of "Π" of the strip (2).

30 The non-rotating metallic strip (3) which surrounds the metallic annuli of the first strip (2) circumferentially is applied on the internal side of an annular channel made on the smaller radius circumference of the insulating circular annulus (28) which is fastened on the non rotating base (33) by the screws (27). Inside this channel (28) which is of rectangular shape "Π" enters the bigger radius circumference of the insulating circular annulus (29) of rectangular shape "Π" without making contact internally with the channel of the insulating annulus (28). The metallic strips (2,3) form an air capacitor which is a combi-

nation of a cylindrical and two plane capacitors. The metallic strips (2) and (3) must not make contact between each other but their distance in between them must be small and their common area must be sufficiently large in order to give a capacitance which is sufficiently bigger than the 5 parasitic capacitances so that the alternating current which flows in the circuit (10,3,2,7,5,14,10) can activate the LED(5) or the electric circuit (105,106,107) which activates the LED (5) and the loudspeaker (11). The shape, the size and the position of the metallic strips (2,3) and their distance in between them are specified according to the available 10 free space close to the brakes and to the axle of the wheel and they vary according to the size of the wheels and also to the type of the brake system used. The above description shows the way to achieve the best exploitation of the available space so that the capacitance of the system (2,3) can obtain the maximum value and at the same time can have the mini- 15 mum parasitic capacitances which are due to the capacitive coupling between the metallic strips (2,3) and the adjacent metallic frame of the wheel brake system and axle of the wheel. Dielectric materials of special composition and high dielectric constant can be inserted in between the strips (2,3) to increase their capacitance. The alternating current flows from the rotating wheel to the non-rotating part of the vehicle through the ball-bearing 20 ing and the axle of the wheel rotation. In the case of the disc brake only one circular metallic strip (2) can be used on the rotating part and another one circular metallic strip on the non-rotating part to form a circular annular plate capacitor (2,3). The non-rotating metallic strip 25 (3) could also be a part of the complete circular strip. The material (29) inserted in between the strip (2) and the metallic frame of the wheel is of sufficient thickness and low dielectric constant. The material (28) inserted in between the metallic strip (3) and the adjacent non-rotating part of the vehicle must also be of the same characteristics. An electric resistance 30 due to the lubricant in the ball-bearings(34) obtains high values during the rotation of the wheel, which can be counterbalanced automatically by the variable resistance (9) and the automatic variation of the alternating voltage, frequency and waveform produced by the oscillator (19). The parasitic currents could be minimized by a suitable shielding and an automatic 35 cal regulation of the variable resistor (9) which during the motion of the vehicle must take small values when the light of LED (5) begins to dim. An automatical regulation of the resistor (9) can be implemented by a feed back electronic circuit which will control the current intensity flowing through the circuit. A current flows in the circuit (1,3,2,7,5,9,12,10) when the

sensor (1) which works as a switch closes the circuit and this current depends on the capacitance between the metallic strips (2,3).

3. The device for indicating to the driver of a vehicle the abnormal and  
5 normal pneumatic tyre pressure during driving or stopping of the vehicle according to the claims 1 and 2 is characterized by the metallic strip (2) which can be divided into two metallic strips, one in a cylindrical shape (50) and another of a plane annular shape (51). The strip (3) is also divided into two similar strips (52) and (53) which together with the  
10 above strips (50) and (51) respectively can form two capacitors as a cylindrical capacitor (50,52) and a plane one (51,53).

An alternating way is to divide strip (2) into two concentric plane annular strips (56) and (57). The strip (3) is also divided into two similar concentric plane annular strips (58) and (59) which can form two plane capacitors  
15 (56,58) and (57,59) with the strips (56) and (57) respectively.

In order to reduce the parasitic capacitances of the above capacitors, a suitable area of the strips (50,52,51,53) or (56,58,57,59), must be found. Also the separation distance between the capacitors (56,58) and (57,59) or (50,52) and (51,53) and their position in the available empty space  
20 close to the brakes must be properly chosen so that a parasitic capacitive coupling between each other and the adjacent metallic parts of the vehicle could be minimized. Therefore the strips should not be very close to the adjacent metallic parts of the wheel, the distance between the plates of the capacitors must be as small as possible, the area of the plates  
25 must be as large as possible and the separation gap between the capacitors must not be very small.

According to the present invention, when the air tyre pressure exceeds the safety limits then the sensor (1) which operates as an electric switch connects strip (56) with strip (57) electrically so that an alternating current flows in the circuit (58,56,1,57,59,40,41,19,20) which can  
30 activate a light or sound indicator. The capacitance of the capacitors (56,58) and (57,59) can take two different values which depend on the switch pressure gauge sensor (1) if it is open or closed. The system of metallic strips is used as a timing capacitor in an oscillator which can produce a  
35 suitable frequency in each case (on-off). The high frequency oscillator and the frequency divider (19) produce square train which passes from the stages (41) consisting of an amplifier and properly tuned filters including a high-Q notch filter. This filter permits the fundamental frequency of the

train to pass in order to convert the square train to a sinusoidal wave form. The filter is designed in such way so that one of the two frequencies falls outside the gap of the notch filter, while the second one which falls in the gap, passes with very high attenuation. The next three stages (40) consist of a half wave rectifier which converts the sinusoidal signal to the D.C. level, of a voltage comparator that gives an output of square train whenever the input signal falls below a certain level determined by a trimmer and of a monostable multivibrator which increases the amplitude of the pulses train of the comparator output by using a proper timing circuit and its output drives a LED. In the above circuit using the two capacitors the alternating current does not flow through the ball bearing and the axle of the rotating wheel where there is an electrical resistance due to the lubricant in the ball bearing. In the case of a disc brake the metallic strips (56) and (57) are placed on the disc or on the metallic rim of the wheel in the available free space close to the brakes where an insulating material of low dielectric constant is inserted between the strips and the metallic brake disk or rim of the wheel. The non-rotating strips (58,59) sometimes are not complete circles but they can be a part of circles and they are placed very close to the strips (56,57) on a steady part of the chassis which is isolated by a material of small dielectric constant.

According to the characteristics of the system, that is main and parasitic capacities, type of cables and type of shielding, the range of frequencies depends on the operation alternating voltage, which can be from 20V AC to 1000 V AC and the frequencies from 10kHz to 3 MHz. The above ranges can be enlarged whenever it is necessary to achieve a sufficient operation of the device.

There is a range of high frequency (kHz~MHz) where the parasitic currents are reduced significantly and this is due possibly to some characteristics of the surrounding metallic frame of the wheel which can not follow the fast changes of high frequency oscillations.

An additional way to reduce the parasitic capacitance and increase the main current which flows through the capacitors (59,57) and (58,56), when the pressure gauge sensor (1) closes the circuit (56,55,1,54,57), is to apply to the strips (58), (59) two different or same high frequency (kHz~MHz) oscillations (126), (127) with common earth and different or same voltage. Two separate oscillations with common earth can also be produ-

ced by (19) and compared by (40) so that the oscillation (126) which is applied to the strip (58) can be of a different or same high frequency (kHz~MHz) of different or same waveform and of different or same amplitude than the oscillation (127) which is applied to the strip (59). The separation gap between the strips (58) and (59) must be long enough for reducing the parasitic capacity coupling between these strips. The gap between the strips (56) and (57) must also be large. The insulating materials (123) and (124) which are the base of the strips (58,59,56,57) must have very small dielectric constant and sufficient thickness so that these strips must be in a long distance from the adjacent metallic frame.

4. The device for indicating to the driver of a vehicle the abnormal and normal pneumatic tyre pressure during driving or stopping of the vehicle according to claims 1,2 and 3 is characterized by a third metallic strip (4), which is isolated from the metallic strip (3) by a thin layer of insulating material to minimize the parasitic currents flowing in the circuit when the switch sensor is not closed. The strips (51, 50) or (56,57) or (2) are connected to the sensor (1) by a very thin conductor (35) which is covered by a thick insulating layer of a small dielectric constant. The central conductor (7) of the coaxial cable (7,6) connects the strip (3) and the LED(5) which is connected in parallel to resistor (12) and in series to loud speaker (11), a digital or analog indicator (8), a variable power resistor (9) and to one end of the secondary coil (14) of a high alternating voltage transformer (14,15,16). The LED (5) can also be activated by using the electronic circuit of comparator (106). The indicators(8) and (11) are not necessary. Attention must be paid to the coil winding so as to limit the high number of turns which must not be very close to each other to avoid an electrical breakdown on the insulating material covering the wire. The external conductor (6) connects the strip (4) to the same end of the coil (14) which is connected to the resistor (9). The strip (4) can also be connected with a middle point of the coil (14) which is different than the final turn that is connected to the resistors (9,21). The central conductor (7) and the strip (3) are shielded by conductor (6) and strip (4) to reduce parasitic current (noise). The system of electrostatic shielding (13), which is a thin metallic surface, can shield all the sections (5,8,9,11,12) surrounded by this system to

reduce parasitic currents. The insulating conductor (22) absorbs a high percentage of parasitic current which depends on the value of variable resistor (21) and on the size of the conductor (22). The current due to the parasitic capacitance in the wheel is reduced proportionally to the distance of the strip (2), the wire (35) and the metallic sections of the sensor (1) from section of the wheel's metallic frame. The strip (4) plays also a significant role which has a larger area than the strips (3) and (2) and covers them from the back side. The capacitors (58,56), (59,57), (50,52), (53,51) and (2,3) are shielded by the use of a metallic strip which is placed in a small distance behind the strips (3) or (52,53) or (58,59). The distance between the coils (14) and (16) should be sufficiently enough. The core (15) is a ferrite of special permeability to follow the high frequency oscillations. The end of the (14) can also be connected with the ground (10) through a diode or a resistor or a capacitor. The transformer (14,15,16) or (41) and the amplifier (10, 16,17,18) or (42) are not necessary if the oscillator (19) is sufficiently powerfull.

In order to control more than one wheels by only one oscillator and one amplifier, a sampling frequency regulator (122) and a sampler apparatus (121) can be used so that all the wheels one after the other can be controlled continuously many times per minute.

Alternatively a separate independent circuit for each tyre can be used to reduce parasitic currents. Each one of these independent circuits can be placed in a non-rotating position near to each wheel so that to reduce parasitic currents. All the cables must be not close to the metallic frame of the vehicle and must be covered by a thick insulating material with very low dielectric constant so that their capacitance with the chassis to be as small as possible. Any one of the independent circuits, when is activated, produces a signal which can be transferred to the vehicle's control panel through cables to activate its own corresponded LED. The signals can be amplified if there is a significant drop of voltage due to the distance of the wheels and the above independent circuits from the vehicle's control panel where all the corresponded indicating Light Emission Diodes are positioned.

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5. The device for indicating to the driver of a vehicle the abnormal and normal pneumatic tyre pressure during driving or stopping of the vehicle according to claims 1,2,3 and 4 is characterized by contacts of special substances (ceramic, carbon, etc) which have electrical conducting properties and they are hardly worn out. In this case the circuit is simple,

that is, it consists of one pressure gauge sensor (1), a contact system, an electric bulb and the vehicle's accumulator. The contact system consists of an electrically isolated metallic ring, which is placed on the wheel's rim or on the rubber of the tyre and of the substance which is continuously in contact with the metallic ring making electrical conduct between the rotating ring and non-rotating substance. The metallic ring is connected electrically, through the sensor, to the rim of the wheel which is connected to the chassis of the vehicle through the wheel's rotation axle. The vehicle's metallic chassis is connected with the negative electrode of the accumulator while the positive electrode is connected through the electric bulb to the substance which makes contact to the metallic ring.

6. The device for indicating to the driver of a vehicle the abnormal and normal pneumatic tyre pressure during driving or stopping of the vehicle according to the claims 1,2,3,4 and 5 is characterized by various pressure gauge sensors which are based on different operation principles as the elastic properties of a durable rubber membrane of certain thickness (61) containing internally a curved steel thinwire (60) in sandwich and the membrane (61) closes air-tightly a volume (66) which communicates with the interior of the tyre (69). The curvature of the membrane (61) increases or decreases proportionally to the air pressure and the sensitivity depends on the area of the membrane surface. A thin electrode (63) of good conductivity and special shape is fastened on the other side of the membrane. The electrode (63) can be also connected with the steel wire (60). The electrode (63) can be displaced along the axis of the sensor proportionally to the air pressure and in between two other special electrodes of good conductivity (65,64) which are in an adjustable distance and are connected either to the metallic rim (24,10) or to the strips (56,57) or (51, 52) respectively so that in case of abnormal air pressure the electrode (63) makes a contact with one of the two electrodes (65,64) and connects electrically either the strip (2) with the metallic rim (24) or strip (56) with strip (57) or strip (51) with strip (52). Curved metallic tubes properly shaped which have closed one of their ends and cylindrical tubes with very thin walls which form foldings of wavy shape as bellows can also be used to device pressure gauge sensors. The elastic properties of a compressed gas, which is contained in a little volume (78) and is closed by membrane (90), could be used to device pressure gauge

sensors. The displacement of a small piston (with a flange on its perimeter pressed by a spring circumferentially all the way out) where the air pressure is balanced by a spring can be used as pressure sensor. Finally, some special materials of which their ohmic resistance varies proportionally to the applied air pressure could be used as the base for making pressure sensors. Principles of the above sensors are given in figures 5.1, 5.2, 5.3, 5.4, ..., 5.19.

7. The device for indicating to the driver of a vehicle the abnormal and normal pneumatic tyre pressure during driving or stopping of the vehicle according to the claims 1, 2, 3, 4, 5 and 6 is characterized by the strip (2) which has the form of a very thin circular metallic annulus embodied in the rubber of the lateral vertical side of the tyres in a small depth from the outside surface of the rubber (special manufacturing of tyres). The thin layer of material which covers the strip (2) on the surface of the tyre must be of high dielectric constant while the rubber under the strip (2) must be of small dielectric constant if possible. The wire guard netting, which is embodied in the tyre rubber for strengthening the tyre, can be substituted by a special plastic guard netting (Kevlar) in order to reduce the parasitic capacity between the strip (2) and the rim of the wheel. The metallic strip (3), which is a segment of a complete circular annulus of equal radius with strip (2), is placed (fixed) in a proper non-rotating part of the vehicle very close and parallel to the strip (2). The strips (2, 3), which are in a hiding place of the vehicle, form a plane capacitor where in between the plates there is a thin insulating layer of high dielectric constant and a thin layer of air.

8. The device for indicating to the driver of a vehicle the abnormal and normal pneumatic tyre pressure during driving or stopping of the vehicle according to the claims 1, 2, 3, 4, 5, 6 and 7 is characterized by coils, which can be placed on the rotating wheel and non-rotating part of the vehicle, instead of the strips (2, 3) or (50, 51, 52, 53) or (56, 57, 58, 59) so that the capacity coupling of the strips can be substituted by the electromagnetic induction coupling of the coils and normal pressure can be shown by an analog or digital micro amperometer. The abnormal and normal tyre pressure can be shown by an analog or digital microamperometer where the indication of parasitic currents is marked as normal pressure while the

indication of the main current is marked as abnormal pressure. The main current which is higher than the parasitic current flows in the circuit when the sensor (1) closes the circuit. A special relay in the circuit can be used in order to avoid activation of the LED by parasitic current.

- 5 The relay in the circuit is adjusted to be activated only by a flowing current of a certain value in the range of the main current and therefore it can close a separate circuit (105,106,107) with an electric lamp connected to the vehicle's battery. The relay can also be substituted by a different voltage comparator circuit (105,106,107) with comparator (106) or a microprocessor. The LED (5) can be driven by the comparator (106).

9. The device for indicating to the driver of a vehicle the abnormal and normal pneumatic tyre pressure during driving or stopping of the vehicle according to the claims 1,2,3,4,5,6,7 and 8 is characterized by the infusible electrode pin (111) which can substitute the strip (2 or 3) and the metallic annulus (112) can substitute the strip (3 or 2). The surface of the annulus (112) is covered by a material which has a coefficient of secondary electrons emission of high value, as  $\text{MgO}$ ,  $\text{Ag}$ ,  $\text{Pt}$  etc, while the cross section of the annulus (112) can be of circular, parallelogram or triangular form or a combination of them with their vertex close to the pin. In addition the pin can be covered by a small quantity of B-rays radioisotope. A current can flow in the circuit only in the case of an abnormal pressure in which the metallic annulus (112) is grounded to the rim of the wheel and through the axle to the chassis of the vehicle so there is an electric discharge between the electrodes (111,112) due to the applied high voltage and therefore there is a spark discharge coupling. The flowing current in the circuit can activate the LED (5) or an audio indicator. Therefore by the above method the parasitic current can be avoided and there is a significant reduce of the metallic strips size. The strips (56,57) or (58,59) can also be substituted by two infusible metallic pins and the strips (58,59) or (56,57) can be substituted by a metallic annulus which has the same characteristics with the annulus (112). The applied high voltage between the electrodes (111,112) can be AC or DC voltage and in this case it can be produced by high voltage generator (19,41,40).

## AMENDED CLAIMS

[received by the International Bureau on 13 July 1992 (13.07.92);  
original claims 1-9 replaced by the amended claims 1-8 (11 pages)]

1. A device for indicating to the driver of a vehicle the abnormal and normal pneumatic tyre pressure during driving or stop-  
5 ping of the vehicle consists of a special system of metallic strips (56,58,57,59) or (50,52,51,53) placed on the rotating frame of the wheel as two complete circular annuli (56,57) on an insulated surface of the internal side of the drum brake or two complete annuli (50,51) on a proper place of the disk brake  
10 and on the non-rotating part as two complete circular annuli (58,59) facing the annuli (56,57) respectively or two annuli (52,53) facing the annuli (50,51) respectively forming two capacitors (56,58) and (57,59) or (50,52) and (51,53), of a high frequency oscillator and a frequency divider (19), of an amplifier  
15 (42), of a set of properly tuned filters (41), of a LED (5), a loudspeaker (11), an analog or digital microamperometer (8) which can be activated by a circuit of two variable resistors (105,107) and a comparator (106), of a system of three stages such as a half wave rectifier, a voltage comparator and a monostable multi-  
20 vibrator(40), of a DC to DC converter (21) and finally the apparatus consists of a pressure gauge sensor ((1) to convert the variations of the tyre air pressure into displacements of a rubber layer which separates air-tightly the interior of the tyre chamber from the sensors' chamber (1) filled by an elastic sponge fo-  
25 amy material or a heavy compressed gas under the same pressure as the normal air tyre pressure or a spring, or some little elastic balls and eventually in all the above cases the result is the displacement of a pin electrode (63,73,83,93) inside the chamber of the sensor (1) to connect electrically, as an on-off  
30 microswitch, the strips (56,57) of the capacitors (58,56) and (59,57) or the strips (50,51) of the capacitors (50,52) and (51,53) and using some special materials for pressure gauge sensors of which their ohmic resistance varies according to the applied air pressure, therefore the current which flows through the sys-  
35 tem of capacitors (56,58),(57,59) or (51,53),(50,52) is converted according to the tyre pressure and obtains a continuous indication of the tyre pressure by a properly calibrated instrument(8).

2. The device for indicating to the driver of a vehicle the abnormal and normal pneumatic tyre pressure during driving or stopping of the vehicle according to claim 1, is characterized by the rotating complete annulus metallic strip (2) which is placed on the insulated surface of the internal side of the drum brake and disk brake and the non-rotating annulus metallic strip (3) facing the strip (2) forms an air capacitor (2, 3). A main alternating current flows in the circuit (1, 2, 3, 105, 106, 107, 5) when the sensor (1) connects the strip (3) with the metallic frame of the wheel which is the earth of the circuit through the ballbearing (34). A thin layer of dielectric material of special composition and high dielectric constant is inserted in between the strips (2, 3) to increase their capacitance and therefore to increase the main current which activates the LED (5). The insulating material inserted in between the strips (2) and the metallic parts of the wheel and in between the strip (3) and the chassis of the vehicle is of sufficient thickness and low dielectric constant to minimize the parasitic current which is due to the capacitive coupling between the metallic strips (2, 3) and the adjacent metallic frame of the wheel brake system and axle of the wheel. An automatic regulation of the resistor (9) can be implemented by a feed back electronic circuit which will control the current intensity flowing through the circuit.

25

3. The device for indicating to the driver of a vehicle the abnormal and normal pneumatic tyre pressure during driving or stopping of the vehicle according to the claims 1 and 2 is characterized by two metallic complete annular strips, one in a complete cylindrical shape (50) and another of a plane complete annular shape (51). Two similar annular strips (52) and (53) facing the above strips (50) and (51) respectively form two air capacitors as a cylindrical capacitor (50, 52) and a plane one (51, 53).

35 An alternating way is that two concentric plane complete annular strips (56) and (57) facing another two similar concentric plane complete annular strips (58) and (59) form two plane

- capacitors (56,58) and (57,59) respectively. The operation efficiency of the device increases with the area of the strips (56,58,57,59,50,52,51,53) and with the separation distance between the capacitors (50,52) and (51,53) or (56,58) and (57,59).
- 5 The position of these capacitors in the available empty space close to the brakes is properly chosen so that a parasitic capacitive coupling between the plates (56) and (57), (58) and (59), (56) and (59), (57) and (58) and between the capacitors' plates and the adjacent metallic parts of the vehicle, is minimized.
- 10 Therefore the strips are not very close to the adjacent metallic parts of the wheel, the distance between the plates of the capacitors must be as small as possible, the area of the plates must be as large as possible and the separation gap between the capacitors must not be very small.
- 15 The complete circular annuli (56,57) are placed on the internal side of the drum brake and the complete annuli (50,51) are placed on a proper position of the disk brake. The non-rotating complete circular annuli (58,59) facing the rotating annuli (56, 57) respectively form two capacitors (56,58) and (57,59) and the
- 20 non-rotating annuli (52,53) facing the rotating annuli (50,51) form two capacitors (50,52) and (51,53). A thin layer of dielectric material of special composition and high dielectric constant is inserted in between the above capacitors' plates strips to increase their main capacitance and therefore to increase the
- 25 main current which activates the LED(5). A paste of high dielectric constant is mixed with an epoxy resin and covers those surfaces of the capacitors' plates which face each other. The insulating material, inserted as a basis under the strips (56), (57), (58), (59), (50), (51), (52), (53) is of sufficient thickness and low
- 30 dielectric constant to reduce the parasitic capacitance between these metallic strips and the adjacent metallic parts, brake system and axle of the wheel. A minimum thickness is not less than 2 mm and as thicker as better provided there is enough space.
- 35 The pressure gauge sensor (1) and the rotating metallic complete annuli (56), (57), (50), (51) are the only parts of the present device which are placed on the rotating wheel and nothing

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else like electronic circuits, batteries and other parts which are sensitive and need often changes.

According to the present invention, when the air tyre pressure exceeds the safety limits then the sensor (1) which operates as  
5 an electric switch connects strip (56) with strip (57) electrically so that an alternating current can flow in the circuit (58,56,1,57,59,40,41,19,20) which activates a light or sound indicator. The capacitance of the capacitors (56,58) and (57,59) is taking two different values which depend on the switch pressure gauge sensor (1) if it is open or closed.  
10

4. The device for indicating to the driver of a vehicle the abnormal and normal pneumatic tyre pressure during driving or  
15 stopping of the vehicle according to the claims 1, 2 and 3 is characterized by the fact that the system of metallic strips forming two capacitors (56,58) and (57,59) takes two different values of capacitance, one value when the switch sensor (1) is closed and another one smaller than the first value when the  
20 switch sensor (1) is open. This system of metallic strips is used as a timing capacitor in an oscillator which produces a suitable frequency in each case (on-off). The high frequency oscillator and the frequency divider (19) produce square train which passes from the stage (41) consisting of an amplifier (42)  
25 and properly tuned filters including a high-Q notch filter. This filter permits the fundamental frequency of the train to pass in order to convert the square train to a sinusoidal wave form. The filter is designed in such a way so that one of the two frequencies falls outside the gap of the notch filter,  
30 while the second one which falls in the gap, passes with very high attenuation. The next three stages (40) consist of a half wave rectifier which converts the sinusoidal signal to the D.C. level, of a voltage comparator that gives an output of square train whenever the input signal falls below a certain level determined by a trimmer and of a monostable multivibrator which  
35 increases the amplitude of the pulses train of the comparator output by using a proper timing circuit and its output drives

a LED. In the above circuit using the two capacitors the alternating current does not flow through the ball bearing and the axle of the rotating wheel where there is an electrical resistance due to the lubricant in the ball bearing. In the case of  
5 a disk brake the metallic strips (56) and (57) are placed on the disk or on the metallic rim of the wheel in the available free space close to the brakes where an insulating material of low dielectric constant is inserted between the strips and the metallic brake disk or rim of the wheel. The non-rotating strips  
10 (58,59) are placed very close to the strips (56,57) on a steady part of the chassis which is isolated by a material of small dielectric constant.

According to the characteristics of the system, that is main and parasitic capacities, type of cables and type of shielding,  
15 the range of frequencies depends on the operation alternating voltage, which is from 20V AC to 1000 V AC and the frequencies from 10kHz to 3 MHz. The above ranges are enlarged whenever it is necessary to achieve a sufficient operation of the device. There is a range of high frequency (kHz~MHz) where the parasitic  
20 currents are reduced significantly and this is due possibly to some characteristics of the surrounding metallic frame of the wheel which does not follow the fast changes of high frequency oscillations.

An additional way to reduce the parasitic capacitance and increase the main current which flows through the capacitors (59,  
25 57) and (58,56), when the pressure gauge sensor (1) closes the circuit (56,55,1,54,57), is to apply to the strips (58), (59) two different or same high frequency (kHz~MHz) oscillations (126), (127) with common earth and different or same voltage.  
30 Two separate oscillations with common earth are also produced by (19) and compared with (40) so that the oscillation (126) which is applied to the strip (58) is of a different or same high frequency (kHz~MHz) of different or same waveform and of different or same amplitude than the oscillation (127) which  
35 is applied to the strip (59). The separation gap between the strips (58) and (59) must be large enough to reduce the parasitic capacity coupling between these strips. The gap between

the strips (56) and (57) must also be large. These gaps are filled by a material of very low dielectric constant like the air. The insulating materials (123) and (124) which are the base of the strips (58,59,56,57) have very small dielectric constant and sufficient thickness so that these strips must be in some distance from the adjacent metallic frame.

Two D.C. power supplies of the same voltage are needed for the operation of the electronic circuit (19,42,41,40,5,59,57,1,56,58) of the device and in order to use only the vehicle's battery (20) a D.C. to D.C converter (21) is used to supply the above circuit with the two necessary power supplies. The technology of VLSI is used to make an integrated circuit which contains the electronic parts (19,42,41,40) of the above circuit.

A furthermore reduction of parasitic capacitances is achieved by using one integrated circuit for each tyre and placing these circuits on some suitable nonrotating positions of the vehicle close to each tyre.

In order to control the air pressure of more than one tyres by only one oscillator and one amplifier, a sampling frequency regulator (122) and a sampler apparatus (121) are used so that all the wheels one after the other are controlled continuously many times per minute.

Alternatively a separate independent circuit for each tyre can be used to reduce parasitic currents. Each one of these independent circuits can be placed in a non-rotating position close to each wheel so as to reduce parasitic currents. All the cables are not near the metallic frame of the vehicle and they are covered by a thick insulating material with very low dielectric constant so that their capacitance with the chassis is as small as possible.

Any one of the independent circuits, when it is activated, produces a signal which can be transferred to the vehicle's control panel through cables to activate its own corresponding LED. The signals will be amplified if there is a significant drop of voltage due to the long distance between the above independent circuits and the vehicle's control panel where all the corresponding indicating Light Emission Diodes are positioned.

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5. The device for indicating to the driver of a vehicle the abnormal and normal pneumatic tyre pressure during driving or stopping of the vehicle according to claims 1,2,3 and 4 is characterized by contacts of special substances (stainless steel, steel alloy, steel tungsten, ceramic, carbon, etc) which have electrical conducting properties and they are hardly worn out. In this case the circuit is simple, that is, it consists of one pressure gauge sensor (1), a contact system, an electric bulb and the vehicle's accumulator. The contact system consists of an electrically isolated metallic ring, stainless steel band, which is placed on the wheel's rim and of the substance which is continuously in contact with the metallic ring making electrical conduct between the rotating ring and non-rotating substance.

The metallic ring is connected electrically through the sensor, to the rim of the wheel which is connected to the chassis of the vehicle through the wheel's rotation axle. The vehicle's metallic chassis is connected with the negative electrode of the accumulator while the positive electrode is connected through the electric bulb to the substance which makes contact to the metallic ring. A continuous indication of the tyre pressure is obtained by gauge sensors using some materials of which their ohmic resistance varies according to the applied pressure and the current flowing in the circuit activates a properly calibrated instrument (8)

6. The device for indicating to the driver of a vehicle the abnormal and normal pneumatic tyre pressure during driving or stopping of the vehicle according to the claims 1,2,3,4 and 5 is characterized by various pressure gauge sensors which are based on different operation principles as the elastic properties of a rubber layer or a metallic membrane (61,71,81) closing airtightly the sensor's small chamber which is filled up either by many small elastic balls or an elastic sponge foamy material (78) or by a heavy gas (88) compressed under the same pressure as the normal air tyre pressure. The springs (60,70,80) are used to reinforce the elasticity of the rubber layers (61,71,81) the heavy gas (88) and the elastic balls or the sponge foamy material (78). Durable rubber layers of certain thickness (61), containing internally a thin curved zig-zag steel wire (60) in a sandwich closed airtightly volume (68) which communicates

through the tube (69) with the interior of the tyre (23). The curvature of the rubber layer (61) increases or decreases proportionally to the air tyre pressure and the magnitude of the displacement of the electrode's edge (63) to the points (66) depends on the area of the rubber layer surface. When the air pressure in the tyre is abnormal the end of the electrode (63) is able to press one of the contacts' points (66) of the sensitive microswitch (62) to connect electrically the strips (56, 57) or (51,52) so that a main alternative current flows in the circuit (1,57,59,5,19,41,40,58,56,1) to activate the LED(5). The other edge of the electrode (63) is fastened on the middle point of the rubber layer (61) and is connected with the steel wire (60). The position of the electrode's edge (63) depends on the air tyre pressure which is balanced by the elastic properties of the rubber-spring sandwich (61,60). The proper position of the microswitch (62) is adjusted by the screw (67) or similar means from any convenient side of the pressure gauge (1) so that under normal tyre pressure the round edge of the electrode (63) is in the middle of the distance between the contact points (66).

The elastic properties of many small balls made by material like rubber or the properties of a sponge foamy material filling up a small chamber (78) are used to devise another pressure sensor. The rubber layer (71) closes the chamber (78) so that it separates air-tightly the other side chamber which communicates with the interior of the tyre (23). One edge of the electrode (73) is fastened on the middle point of the rubber layer (71) and the other edge of the electrode (73) is moving between the contact points (76) of the microswitch (72). The screw (77) regulates the position of the microswitch (72) and the use of soft springs (70) supports the elastic properties of the sponge foamy material or small elastic balls. Also the elastic properties of a heavy compressed gas filling up a little volume (88) closed by a rubber layer (81) are used to make another similar pressure gauge sensor (1). The electrode (83) is fastened on the middle point of the rubber layer (81) and the springs (80) support the elasticity of the rubber layer (81). The screw (87) controls the correct position of the microswitch (82).

All the types of the above described pressure gauge sensors are applied either on some air inlet valves which are fixed externally on the metallic rims (36) of the wheels or they are placed on the internal side of the metallic rims (36).

5 Another type of a sensor which is fixed on the internal surface of the wheel's metallic rim (36) consists of a small chamber (98) which is closed around by walls (90,91, 103) made either by rubber or by very thin metallic layers which form folding of wavy shape as bellows. One edge of the electrode (93) is fast-  
10 tened on the wall (90) and the other edge moves between the contact points (96) of the microswitch (92). Only the wall (103) is fixed steady on the internal walls of the metallic box (104, 109) while the wall (90) moves freely along the axis which is parallel to the cylindrical wall (91). The base (109) of the  
15 metallic box (104,109) is fixed steadily on the internal side of the wheel's rim (36) and the interior of the tyre (23) communicates with the interior of the box (104,109) through the opening (108) of the wall (104). The chamber (98) is filled up either permanently by a heavy gas with same pressure as  
20 the normal tyre pressure or by air through the inlet valve (99) which is fixed on the wall (103) and comes out through the rim (36). The inlet valve (99) is useful for calibration purposes instead of screw (97), to adjust the correct position of electrode edge (93) between the contact points (96). Provided the  
25 air pressure in the tyre is normal, then a pressurized air is admitted in the chamber (98) until the electrode edge (93), which is moving away from the contact points (96), reaches the middle point of the distance between the contact points (96). The average value of the two air pressures in the chamber (98)  
30 when the LED (5) turns on-off-on gives an indication of the correct position of the electrode edge (93). In order to obtain a continuous indication of the air tyre pressure the electrode edge (93) is rotated by an attached small metallic wheel or slips with very small friction on a special material with  
35 high electrical resistance along its moving distance so that there is a continuous electrical contact between the electrode (93) and this material. The electrical resistance between

the points (96) depends on the position of the electrode edge (93). Finally, some special materials of which their ohmic resistance varies proportionally to the applied air pressure are used as the base for making pressure sensors.

5

7. The device for indicating to the driver of a vehicle the abnormal and normal pneumatic tyre pressure during driving or stopping of the vehicle according to the claims 1,2,3,4,5 and 6 is characterized by a different voltage comparator circuit (105, 10 106,107) with a comparator (106) or a microprocessor which are used in order to avoid activation of the LED (5) by parasitic currents. The LED (5) which is driven by the comparator (106) is activated only by the main current. The third isolated metallic strip (4) is connected with a middle point of the coil 15 (14) which is different than the final turn that is connected to the resistors (9,21). The LED (5) is activated by using the electronic circuit of comparator (106). Attention must be paid to the coil winding (14) so as to limit the high number of turns which are not very close to each other to avoid an electrical breakdown of the insulating material covering the wire. 20 The end of the coil (14) is connected with the ground (10) through a diode or a resistor or a capacitor.

The rotating strips (2) or (50,51) or (56,57) are replaced by one or more rotating coils of thin wire in a spiral plane form 25 and the non-rotating strips (3) or (52,53) or (58,59) are replaced by one or more non-rotating coils of the same spiral plane shape. One end of the wire of the rotating coil is connected with any one of the terminals (64,74,84,94) of the sensor (1) and the other end of the wire of the rotating coil is connected 30 with any one of the other terminals (65,75,85,95) of the same sensor (1). The alternating current which flows in the non rotating coil is reduced when the ends of the rotating coil are shorted out by the sensor (1) in case of abnormal tyre pressure. The reduction of the current depends on the number and 35 ratio of turns of the rotating and non-rotating coils, on the frequency of the applied voltage, on the separation distance between the rotating and non-rotating coils and on the magnetic properties of the coils' cores.

Especially the cores of the coils should be very close to each other so that the rotating core almost touches the non-rotating core. The voltage reduction in the non-rotating coil is detected by a voltage comparator circuit (105,106,107).

5

8. The device for indicating to the driver of a vehicle the abnormal and the normal pneumatic tyre pressure driving or stopping of the vehicle according to the claims 1,2,3,4,5,6 and 7 is characterized by the infusible electrode pin (111) which  
10 substitutes the strip (2) or (3) and the complete metallic annulus (112) which substitutes the strip (3) or (2). The surface of the annulus (112) is covered by a material which has a secondary electrons emission coefficient of high value, as  $\text{MaO}$ ,  $\text{Ag}$ ,  $\text{Pt}$  etc, while the cross section of the annulus (112) can be  
15 of circular, parallelogram or triangular shape or a combination of them with their vertex close to the pin (111). In addition the pin is covered by a small quantity of  $\beta$ -rays radioisotope. A current can flow in the circuit only in the case of an abnormal pressure in which the metallic annulus (112) is grounded  
20 to the rim of the wheel and through the axle to the chassis of the vehicle so there is an electric discharge between the electrodes (111,112) due to the applied high voltage and therefore there is a spark discharge coupling. The flowing current in the circuit activates the LED (5) or an audio indicator. There-  
25 fore by the above method the parasitic current is avoided and there is a significant reduce of the metallic strips size. The strips (56,57) or (58,59) can also be substituted by two infusible metallic pins and the strips (58,59) or (56,57) can be substituted by a metallic annulus which has the same characteristics  
30 with the annulus (112). The applied high voltage between the electrodes (111,112) can be AC or DC voltage and in this case it can be produced by high voltage generator (19, 41,40).

1-12

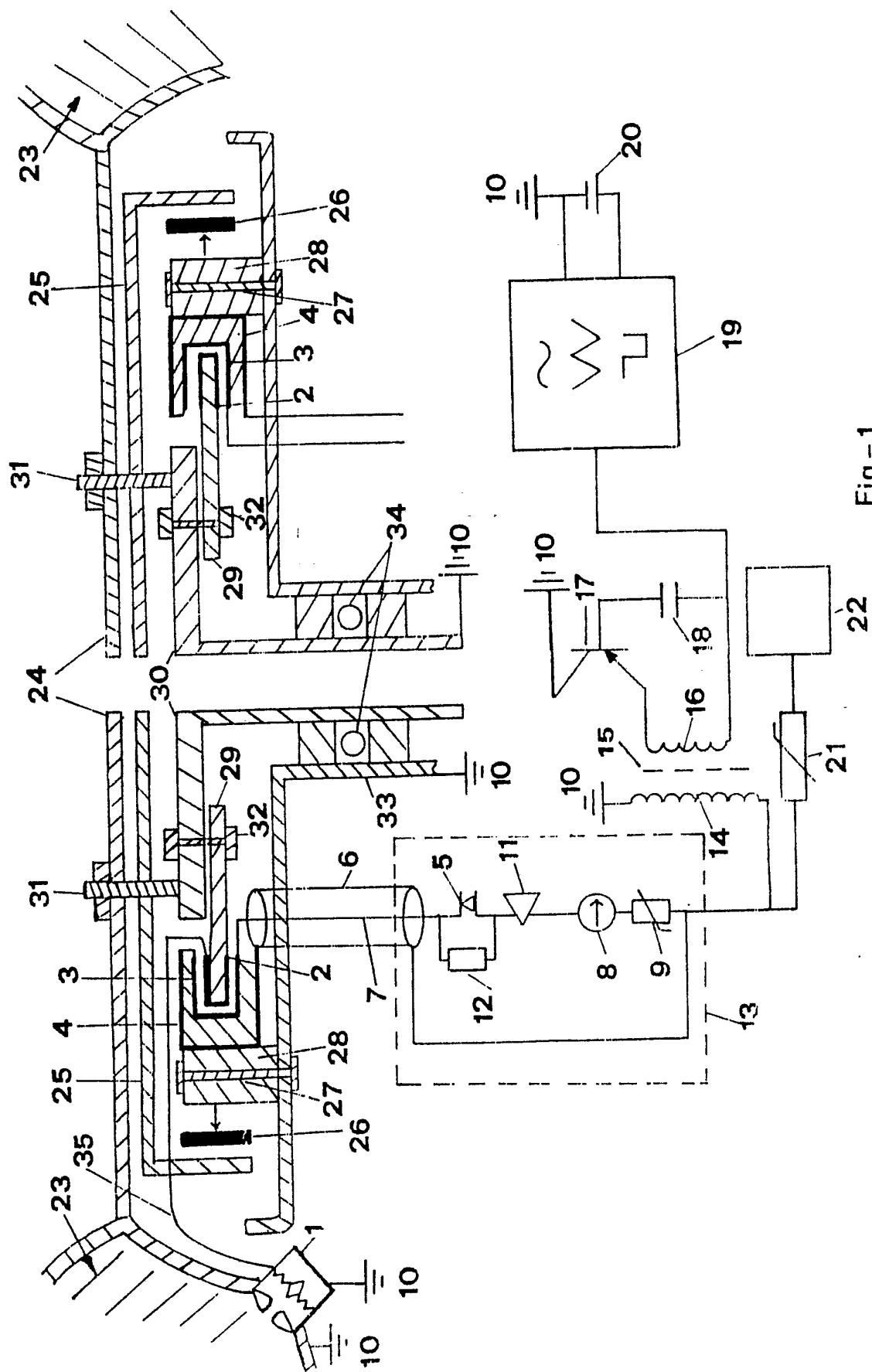


Fig-1

2-12

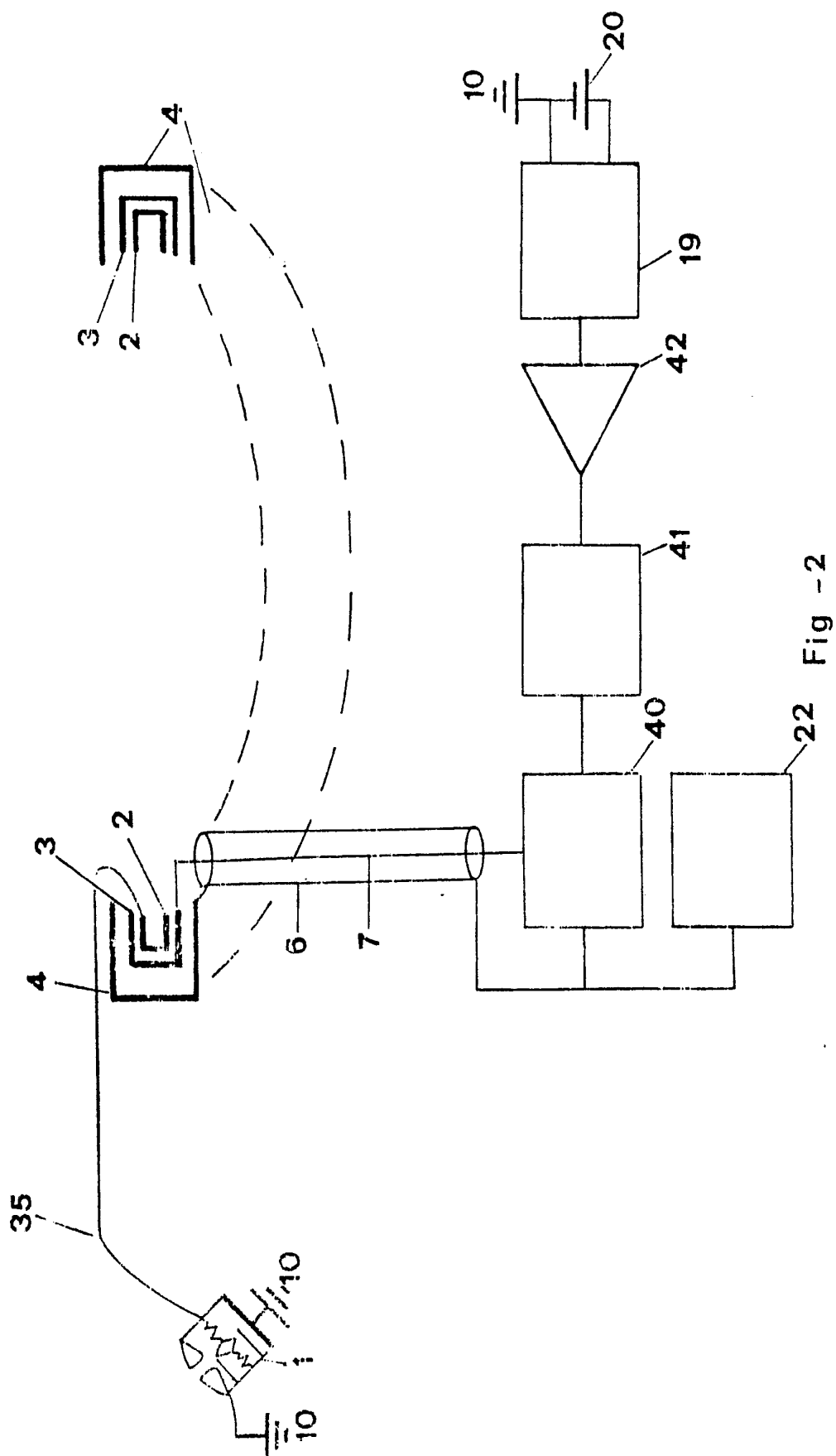


Fig -2

SUBSTITUTE SHEET

3-12

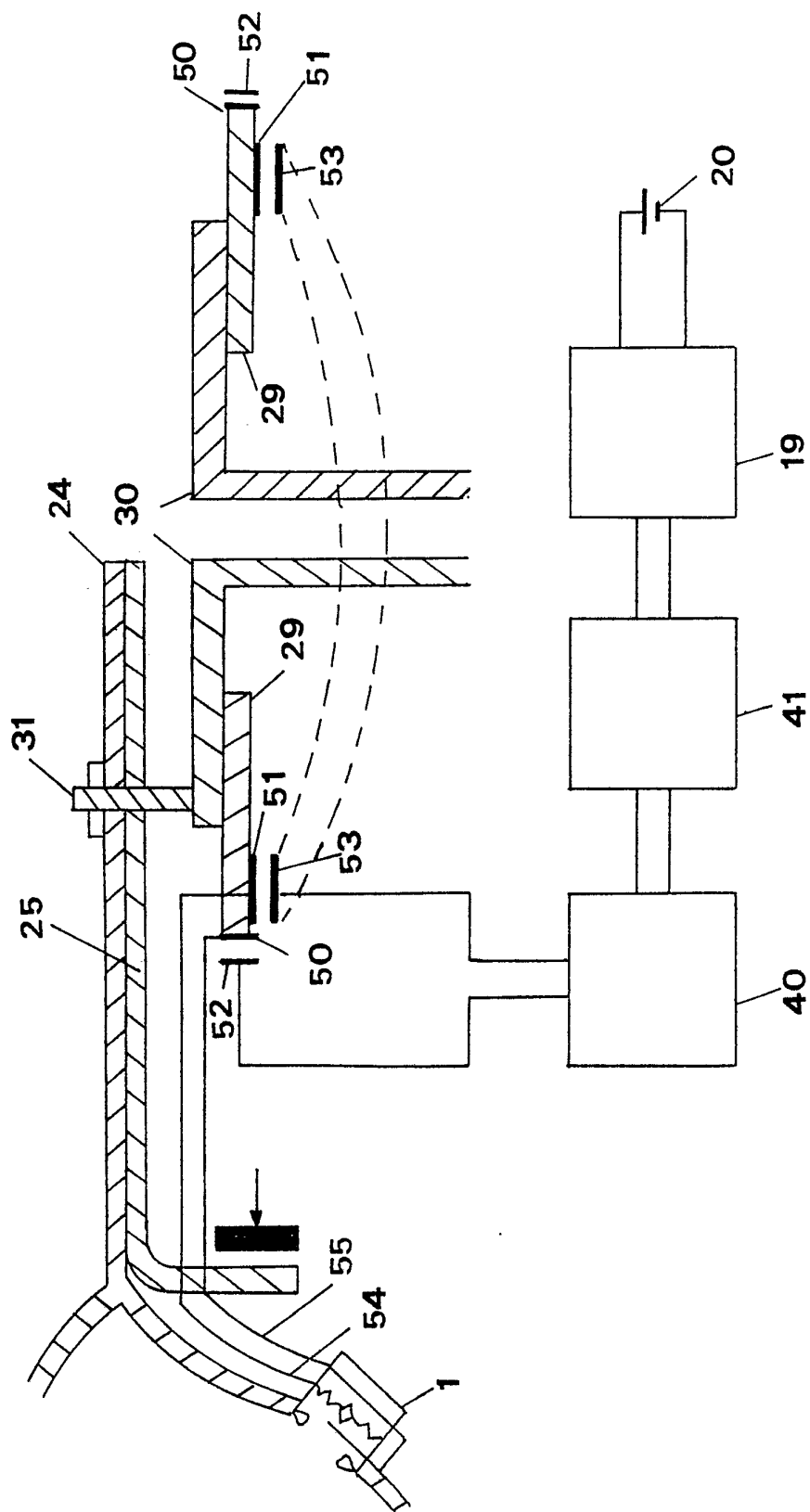


Fig - 3a

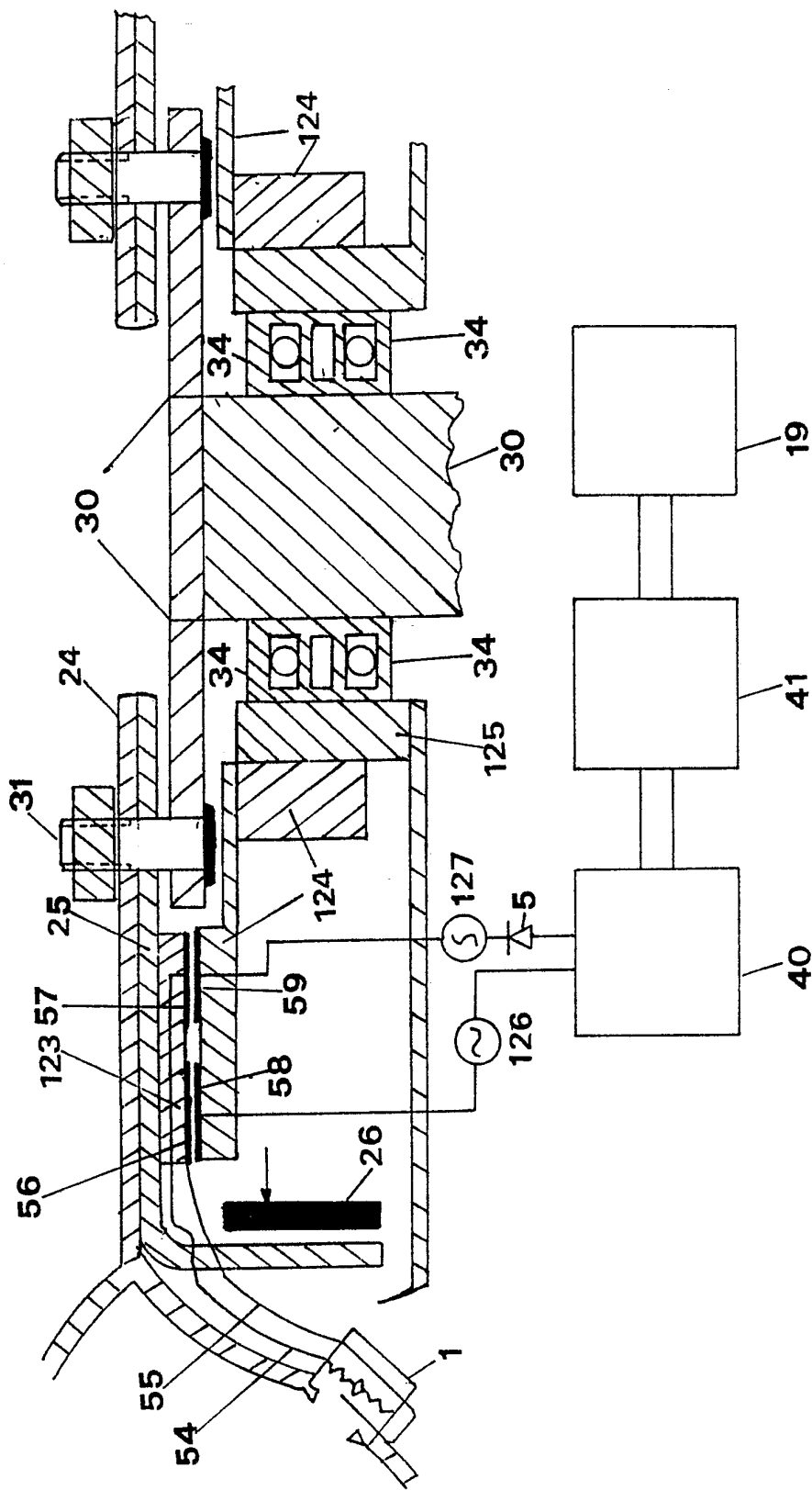


Fig - 3 b



6-12

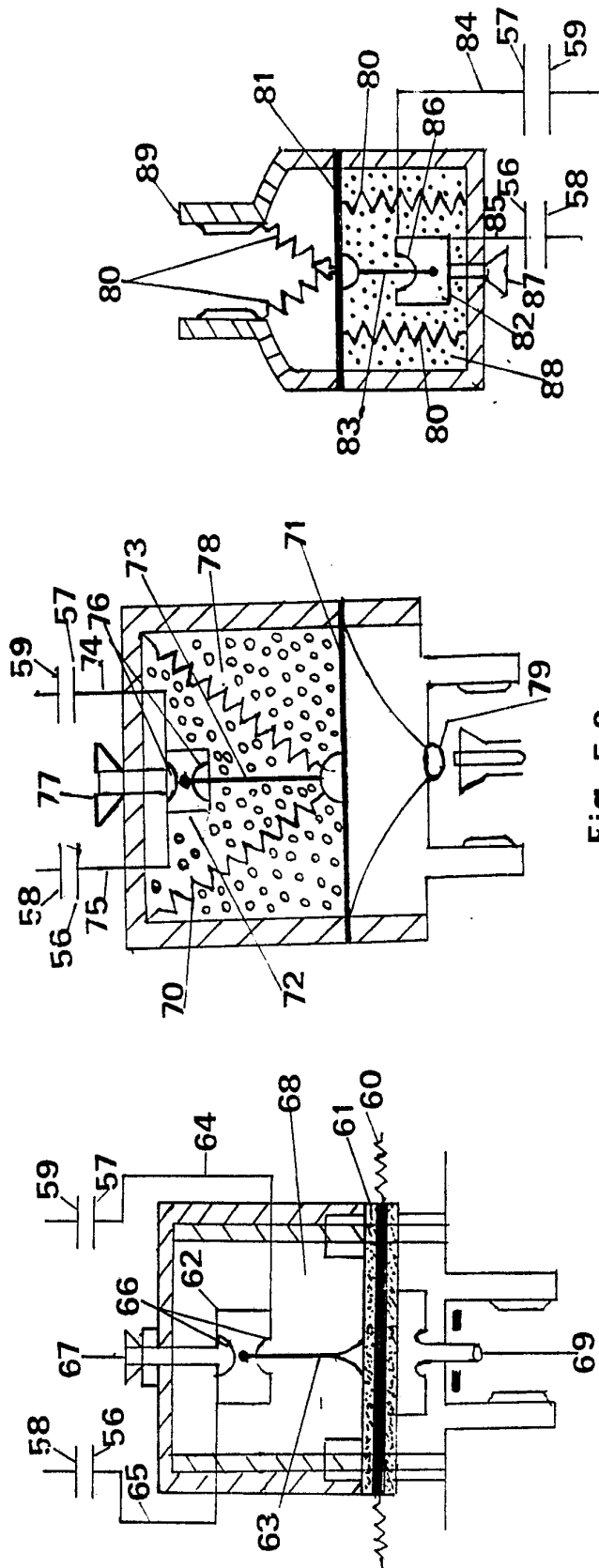


Fig-5-3

Fig-5-2

Fig-5-1

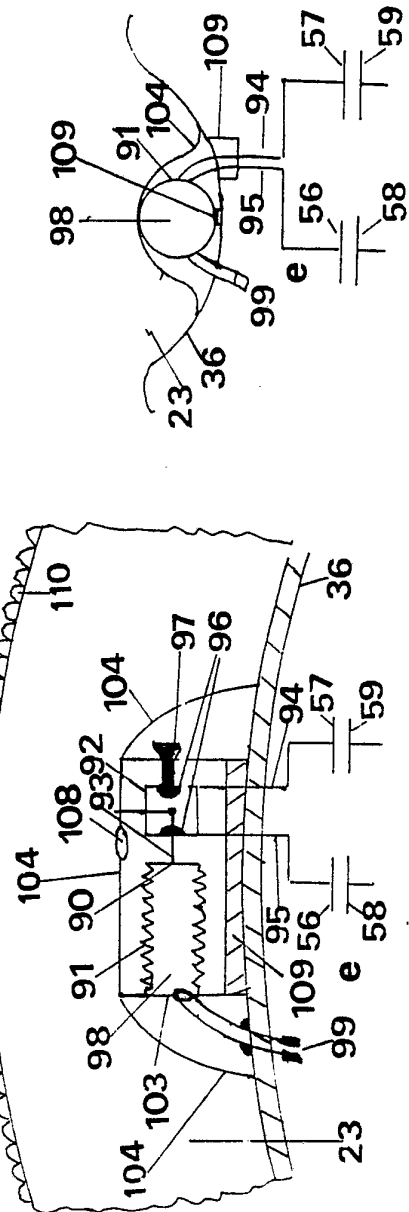


Fig-5-4

Fig-5-5

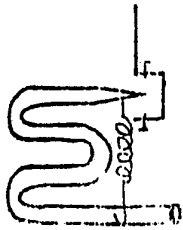


Fig. 5.6

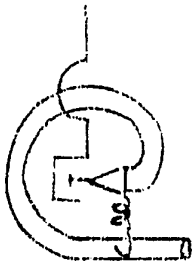


Fig. 5.7

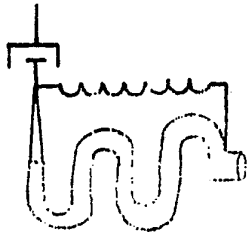


Fig. 5.8

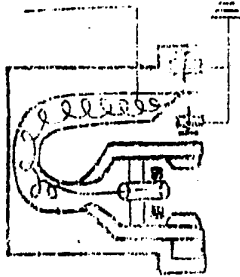


Fig. 5.9

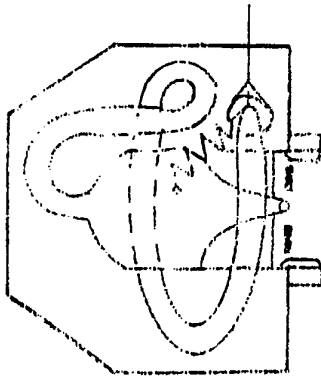


Fig. 5.10

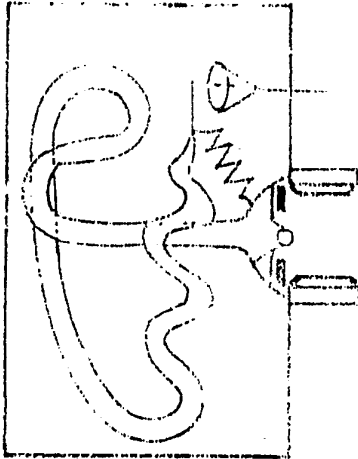


Fig. 5.11

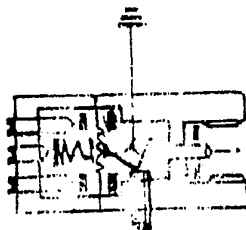


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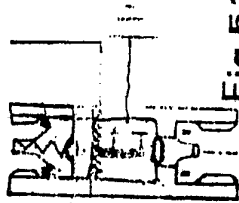


Fig. 5.13

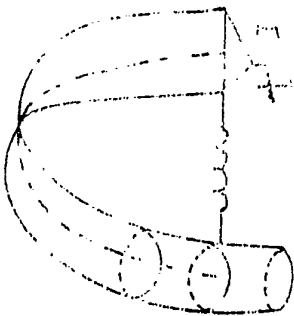


Fig. 5.14

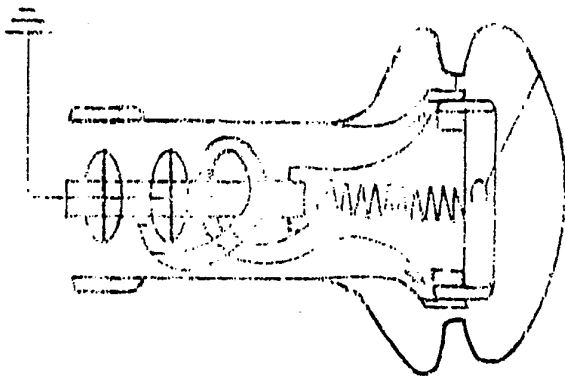


Fig. 5.15

8-12

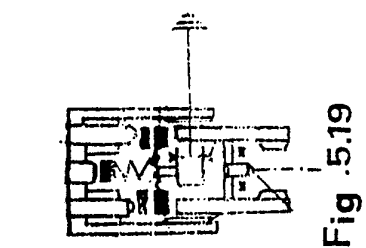


Fig. 5.19

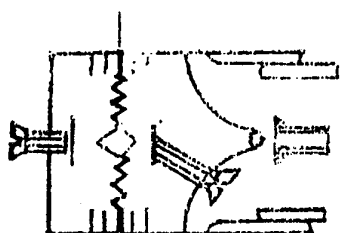


Fig. 5.18

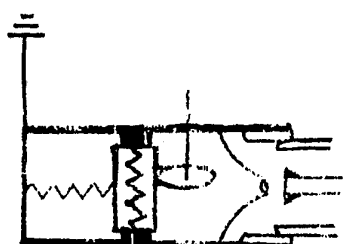


Fig. 5.17

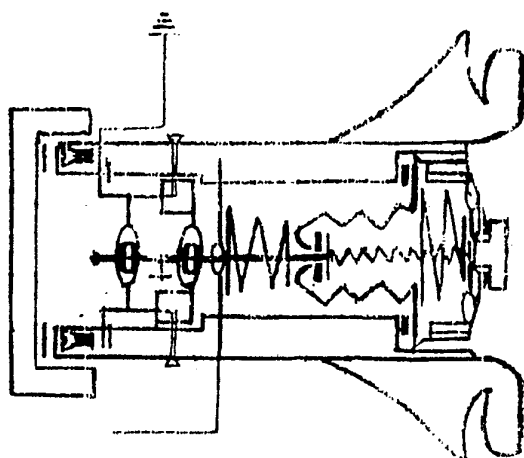


Fig. 5.16

9-12

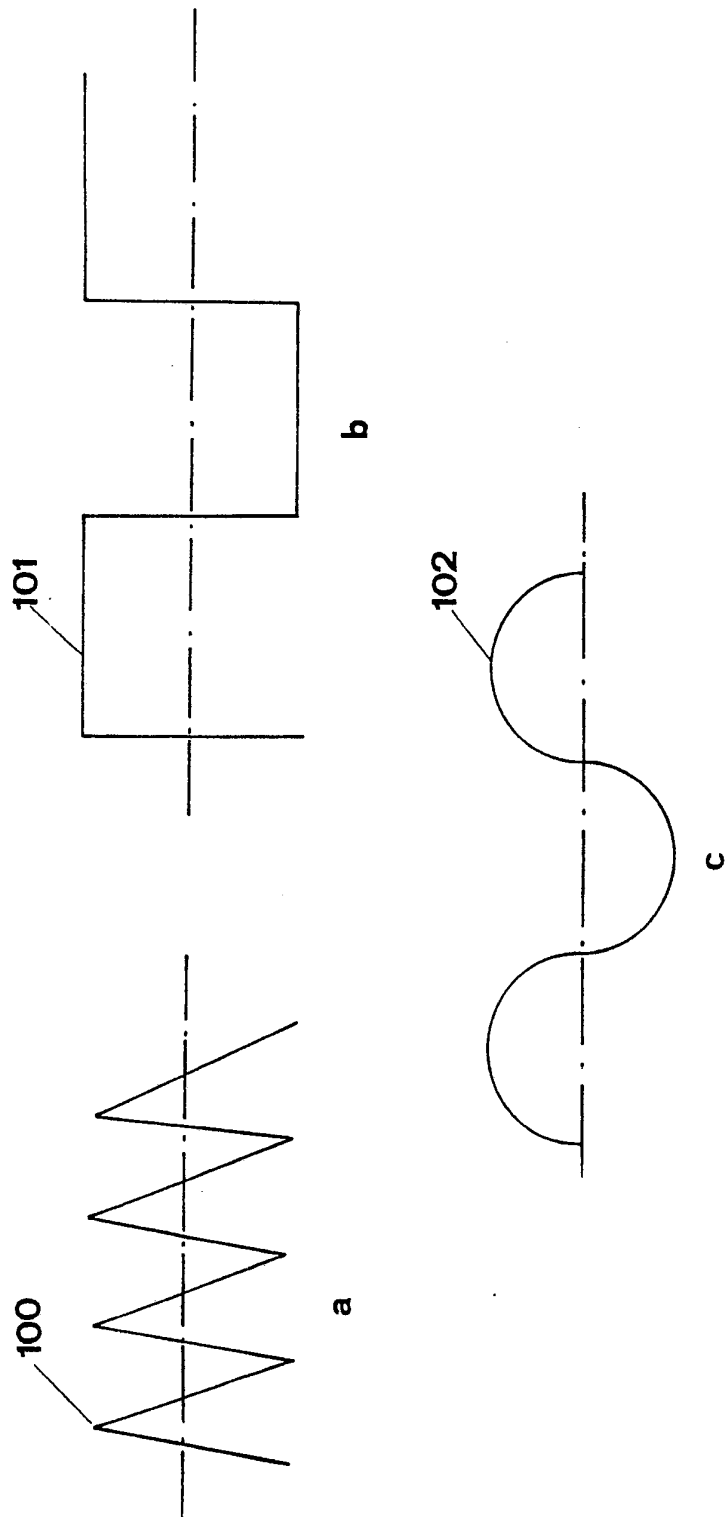


Fig - 6

10-12

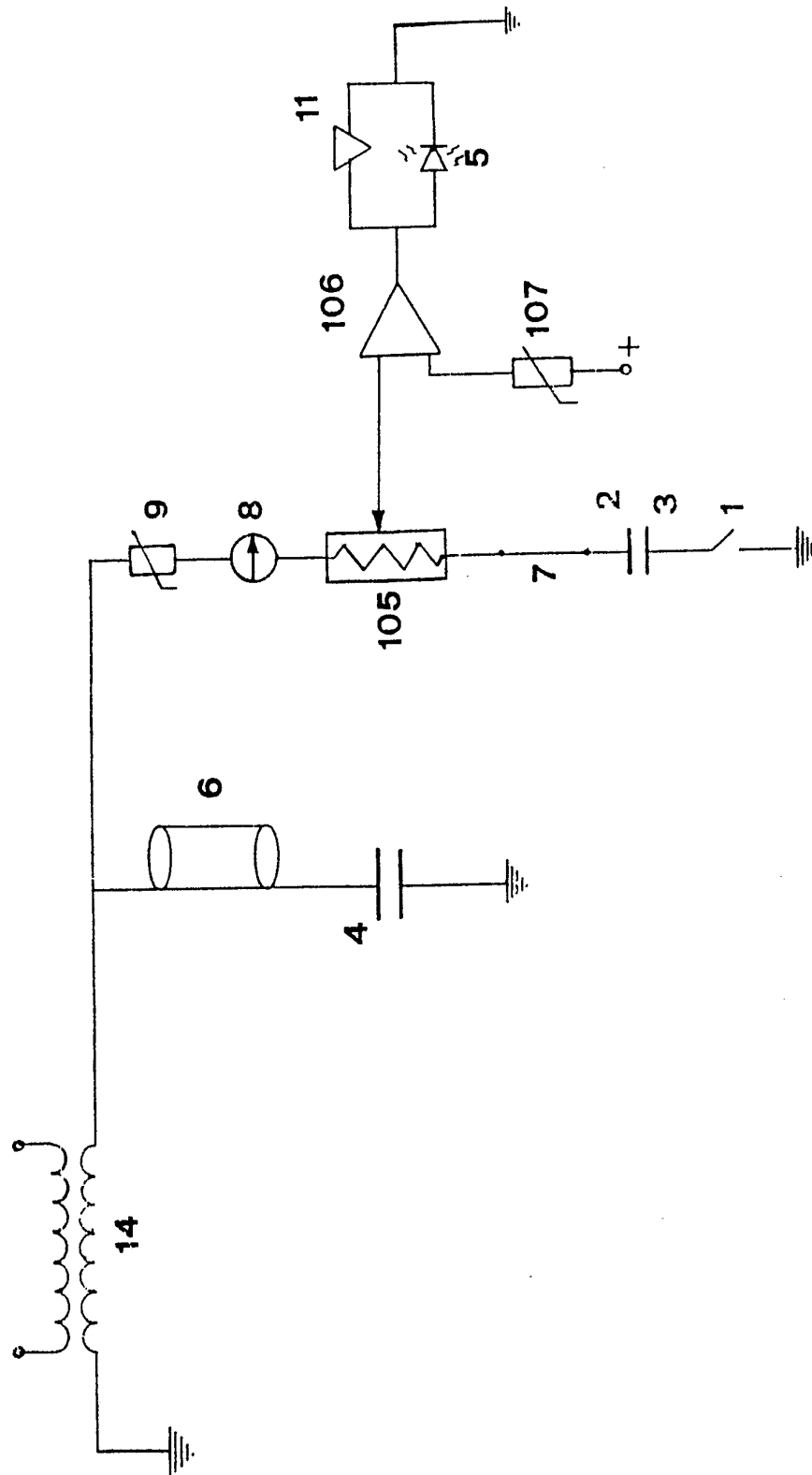


Fig - 7

11-12

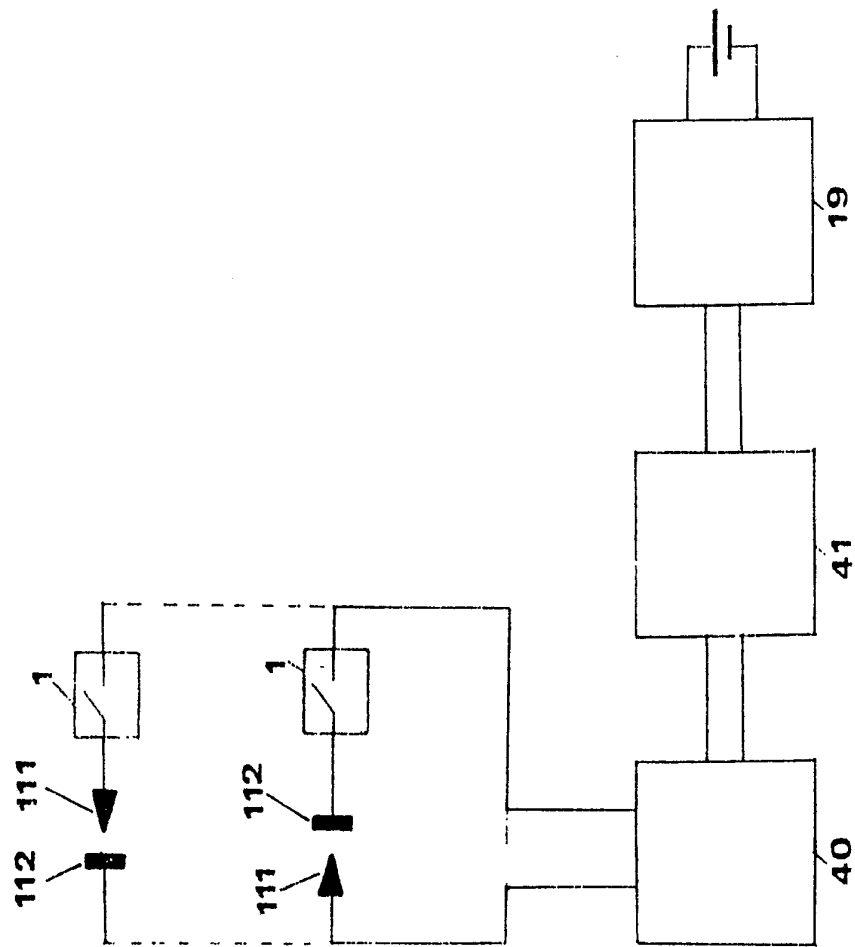
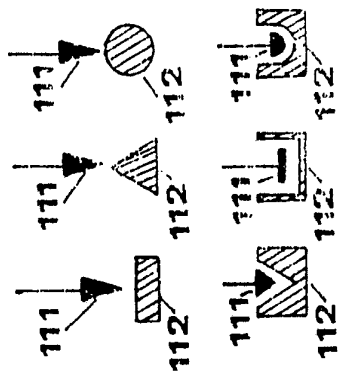


Fig - 8



Fig\_9

12-12

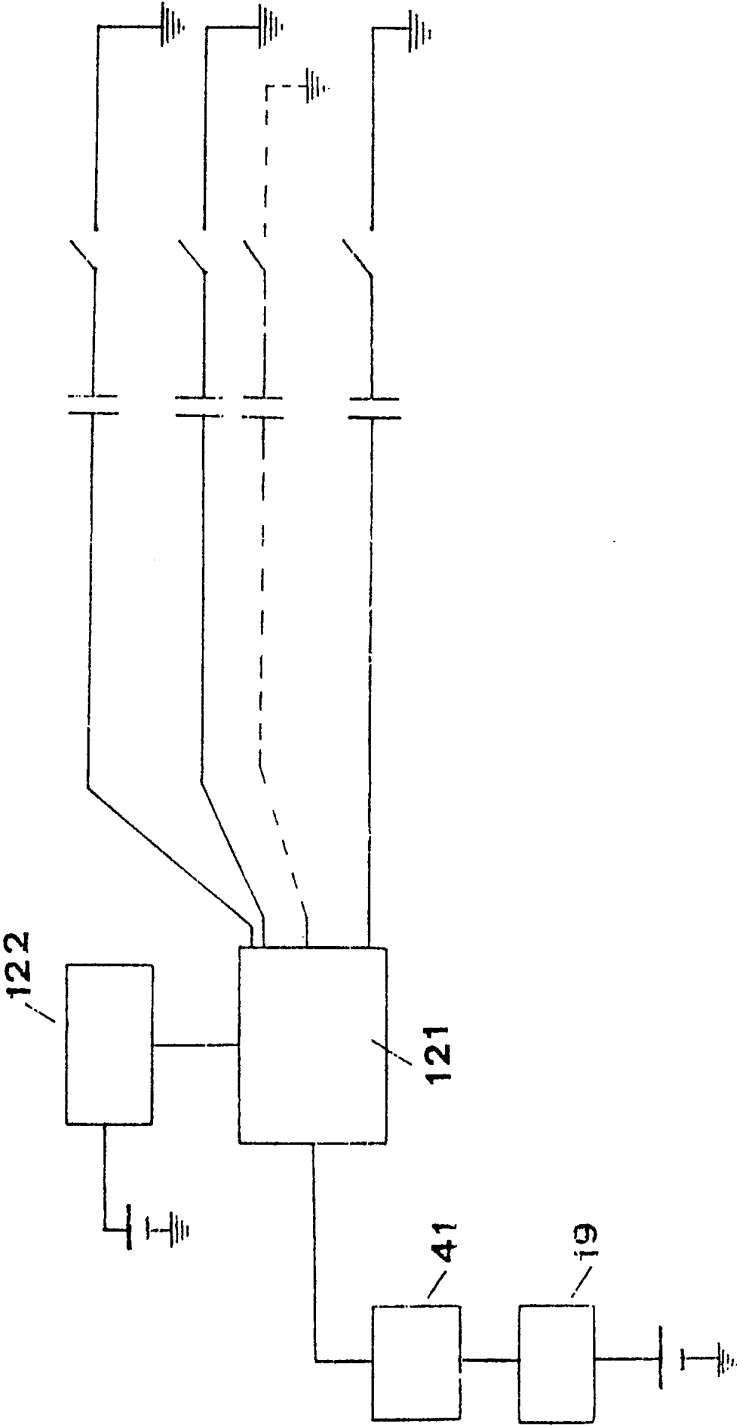
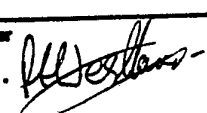


Fig - 10

## INTERNATIONAL SEARCH REPORT

PCT/GR 92/00001

International Application No

<b>I. CLASSIFICATION OF SUBJECT MATTER</b> (if several classification symbols apply, indicate all) <sup>6</sup>		
According to International Patent Classification (IPC) or to both National Classification and IPC		
Int.Cl. 5 B60C23/04		
<b>II. FIELDS SEARCHED</b>		
Minimum Documentation Searched <sup>7</sup>		
Classification System	Classification Symbols	
Int.Cl. 5	B60C	
Documentation Searched other than Minimum Documentation to the extent that such Documents are included in the Fields Searched <sup>8</sup>		
<b>III. DOCUMENTS CONSIDERED TO BE RELEVANT<sup>9</sup></b>		
Category <sup>10</sup>	Citation of Document, <sup>11</sup> with indication, where appropriate, of the relevant passages <sup>12</sup>	Relevant to Claim No. <sup>13</sup>
X	EP,A,0 345 199 (TSAGAS) 6 December 1989 cited in the application	1,2
Y	see the whole document	3,4,6,7
A	---	8
Y	GB,A,2 122 757 (PRECISION MECHANIQUE LABINAL) 18 January 1984 see abstract; claims; figures see page 1, line 1 - line 95 see page 2, line 10 - page 4, line 100	3,4,6,7
A	US,A,3 249 916 (GENERAL MOTORS) 3 May 1966 see column 1, line 70 - column 2, line 5 see figure 1	1
A	EP,A,0 087 138 (HITACHI) 31 August 1983 see abstract; claims; figures 3-5 see page 4, line 27 - page 8, line 2	1,8
	---	
	-/--	
<sup>10</sup> Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art. "A" document member of the same patent family		
<b>IV. CERTIFICATION</b>		
Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report	
28 APRIL 1992	14. 05. 92	
International Searching Authority	Signature of Authorized Officer	
EUROPEAN PATENT OFFICE	WESTLAND P.G. 	

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)		Relevant to Claim No.
Category *	Citation of Document, with indication, where appropriate, of the relevant passages	
A	US,A,4 283 707 (CHURCH) 11 August 1981 see the whole document ---	1,6,8

**ANNEX TO THE INTERNATIONAL SEARCH REPORT  
ON INTERNATIONAL PATENT APPLICATION NO.**

GR 9200001  
SA 55940

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on  
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information. 28/04/92

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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GB-A-2122757	18-01-84	FR-A- 2529513	06-01-84
		DE-A, C 3324041	05-01-84
		JP-A- 59047696	17-03-84
US-A-3249916		None	
EP-A-0087138	31-08-83	JP-A- 58142509	24-08-83
		CA-A- 1200294	04-02-86
		US-A- 4514645	30-04-85
US-A-4283707	11-08-81	None	