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DETONATION METER FOR COMBUSTION MOTORS

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Fig. 1.

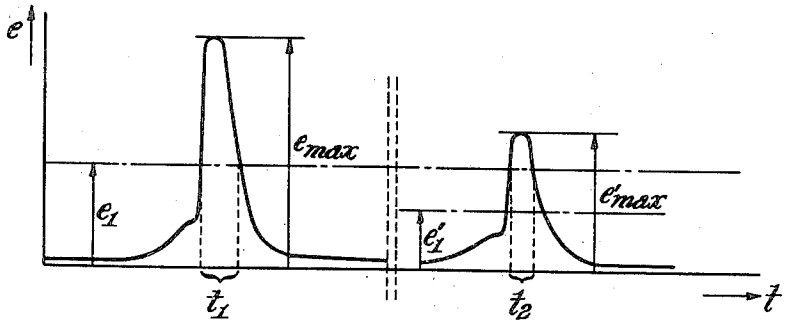
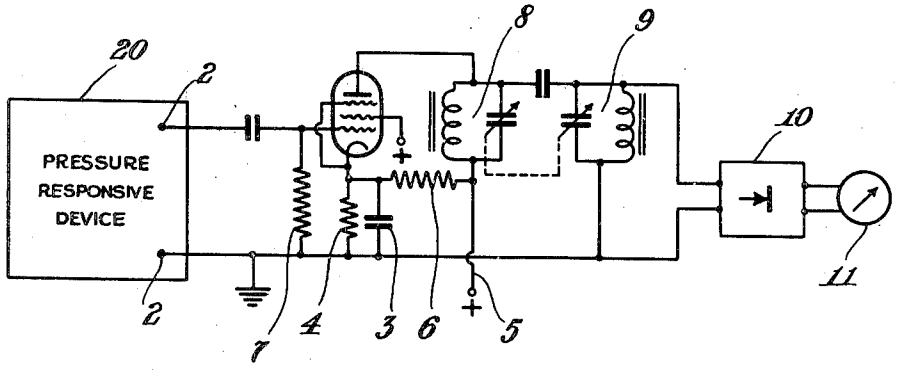


Fig. 2.



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DETONATION METER FOR COMBUSTION MOTORS

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5 Claims. (Cl. 73—35)

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For the indication of detonation in combustion motors it is known to translate the vibrations produced in the cylinder into electrical oscillations by means of a pressure responsive device provided in the cylinder, and to supply the oscillations, having frequencies that are characteristic of detonation (2000 to 5000 cycles per second) to an indicating device.

In order to eliminate the spurious vibrations having a corresponding frequency but not caused by detonation which may result from closure of the inlet or outlet valves of the motor and bring about a response it is known to resort to expedients which permit the vibrations acting upon the pressure responsive device to bring about a response only during a limited part of the cycle of the motor.

Therefore, in a known device of this kind the indicating device is connected to the pressure responsive device only during the combustion period, for instance by means of a contact moved by the motor or by means of a relay contact which is controlled in accordance with the ignition voltage of a cylinder other than that connected to the pressure responsive device.

In both cases, however, control of the contact, by means of which the pressure responsive device and the indicating device are intermittently coupled, entails difficulties of a practical nature.

In the first-mentioned case the contact moved by the motor requires a special mechanical coupling between the shaft of the motor and the contact, which coupling can often not be provided without the need for additional means.

In the second case, in which the pressure responsive device and the indicating device are connected in accordance with a voltage for igniting the gaseous mixture in a cylinder other than that connected to the pressure responsive device one cannot be sure that the indicating device is made operative at the most favourable moment for the avoidance of parasitic vibrations acting on the pressure responsive device. This last-mentioned method of controlling the contact can be used only with motors having ignition means.

Again it is known to establish the intermittent coupling between a pressure responsive device and indicating device by connecting an amplitude filter between the pressure responsive device and indicating device which filter consists, for instance, of an amplifier having such a non-linear dynamic characteristic that solely the oscillations set up at high pressures corresponding to combustion pressures reach the indicating device after having been amplified.

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We have found, however, that in this case the drawback occurs that no reliable indication is obtained with a modified composition of the gaseous-mixture when the combustion pressures are materially lower than normal, such as occur in aircraft motors at a great height. Although with such an adjustment of the amplitude filter and a normal composition of the gaseous-mixture in the cylinder a reliable indication is obtained of the detonation taking place in the cylinder.

According to the invention the said drawbacks are avoided in a detonation meter of the kind referred to above by controlling the means, which only during a limited part of the motor cycle permit the vibrations acting upon the pressure responsive device to bring about an indication, in accordance with the pressure produced in the cylinder in such manner that solely the vibrations produced at a pressure exceeding a pressure proportional to the maximum pressure produced in the cylinder are capable of bringing about an indication. This may be achieved, for instance, by supplying the oscillations taken from the pressure responsive device to an amplifier, whose amplification factor is controlled in a manner known e. g. in the radio technique under the name automatic gain control in such manner in accordance with the supplied oscillations having a frequency characteristic of the cycle of the motor that the amplitude of the amplified oscillations appearing at the output of the amplifier is substantially constant and consequently independent of the amplitude of the oscillations taken from the pressure responsive device, and by supplying the oscillations thus amplified to the indicating device through an amplitude filter having a constant threshold value.

In an advantageous form of construction of the detonation meter according to the invention the purpose aimed at can be attained in a particularly simple manner by interposing between the pressure responsive device and the indicating device an amplitude filter, whose threshold value is proportional to the maximum amplitude of the electrical oscillations taken from the pressure responsive device.

The invention will be more fully explained by reference to the accompanying drawing in which

Fig. 1 illustrates the form, as a function of time of electrical oscillations taken from the pressure responsive device, and

Fig. 2 schematically represents an extremely advantageous form of construction of a detonation meter according to the invention.

Fig. 1 shows two diagrams of voltages (e) as a function of time (t) which are taken from the

pressure responsive device. Each diagram represents one cycle of the motor, the first diagram illustrating the pressure variation in the cylinder with a normal gaseous-mixture, in which case the voltage corresponding to the maximum pressure occurring in the cylinder amounts to e_{max}, whereas the second diagram illustrates the pressure variation occurring with a modified gaseous mixture when the maximum voltage taken from the pressure responsive device amounts to e'_{max}. For the sake of clearness it is pointed out that the oscillations characteristic of detonation together with spurious oscillations having the same frequency have not been indicated in the diagrams.

If, as with the device referred to above as being known, an amplitude filter is connected between the pressure responsive device and indicating device, whose threshold value, which is represented by e_1 in Fig. 1, is so chosen that the pressure responsive device and indicating device are interconnected for a time t_1, whilst avoiding as much as possible the disturbing influence of spurious vibrations, so that a reliable indication is obtained about the intensity of the detonation phenomena occurring in the cylinder, no reliable indication will be obtained in the circumstances illustrated in the second diagram, since in this case the pressure responsive device and indicating device are coupled at a later moment and are interconnected only for a time t_2, which is much smaller than t_1, so that if the intensity of the detonation phenomena be equal in both cases the indicating device, more particularly if it indicates the average intensity of the detonation phenomena, will indicate a smaller detonation in the last-mentioned case. This results in that if in the last-mentioned case the combustion process in the cylinder is so controlled that the detonation meter indicates an intensity just not exceeding the highest permissible detonation, the detonation actually produced in the cylinder will have an intensity highly exceeding the permissible intensity which, of course, is very undesirable.

According to the invention this drawback is avoided by rendering the threshold value of the amplitude filter dependent on the maximum amplitude of the electrical oscillations taken from the pressure responsive device.

Thus it is achieved that independently of the value of the maximum pressure produced in the cylinder a reliable indication of the detonation can be obtained at any instant and at the same time the action upon the indication by spurious vibrations can be avoided as much as possible.

It has been found to be advantageous that the threshold value of the amplitude filter amounts to about ⅓ to ½ of the maximum amplitude of the oscillations taken from the pressure responsive device. In the diagrams represented in Fig. 1 the threshold value then amounts, for instance, to e_1 under a stationary condition illustrated in the first degree, whereas under a stationary condition illustrated by the second diagram it amounts to e'_1 as shown in the figure, where $e_1/e_{max.}$ is approximately equal to $e'_1/e'_{max.}$

In Fig. 2, which schematically represents an advantageous form of construction of the detonation meter according to the invention, the reference numeral 1 designates an amplifying tube to whose control grid is supplied the voltages applied to the junction terminals 2 and taken from the pressure responsive device 20. The cathode lead of the tube 1 comprises a resistance 4 which is

shunted by a condenser 3. The resistance 4 forms part of a potentiometer 6, 4 which is connected between the positive supply conductor 5 and earth and through which such a constant negative grid bias is supplied through a grid resistance 7 to the control grid of the tube that the anode current of the tube is substantially suppressed. At the same time, however, the anode current produced on supplying electrical oscillations to the control grid produces a grid bias which depends on the amplitude of the supplied oscillations. The value of the resistance 4 and condenser 3 are so chosen that the variable negative bias supplied to the control grid is proportional to the average value of the anode current of the tube if the control grid receives oscillations having a frequency which is characteristic of the cycle of the motor. The generated variable negative grid bias, which corresponds to the threshold value (e_1 and e'_1 respectively in Fig. 1) of the amplitude filter constituted by the tube 1, has a value which amounts to an approximately constant fraction of the maximum amplitude of the oscillations supplied to the grid.

Thus solely the oscillations occurring for a limited part of the cycle of the motor can be taken from the anode circuit of the tube 1 after having been amplified. These oscillations are supplied to a band-pass filter 8, 9 which transmits the frequencies characteristic of detonation and which is preferably adjustable in view of determining detonation with various motors. The oscillations taken from the circuit 9 are supplied to an indicating device 11, if required after further amplification, rectification 10 and smoothing.

While the inventor has shown and described only one embodiment of his invention it is to be understood that his concept is not to be limited thereby. For instance, the anode detection part of his circuit may be replaced by a grid detection or diode detection circuit and other possibilities are within the realm of this invention.

What I claim is:

1. Apparatus for indicating detonating pressures in a combustion motor, comprising a pressure-responsive device for converting pressure variations in said motor into voltage impulses having corresponding amplitude variations, an input circuit connected to the pressure-responsive device, an output circuit including an electrically-responsive indicating device, and a voltage transmission circuit interposed between the input circuit and the output circuit, said voltage transmission circuit having a variable threshold value proportional to the maximum amplitude of the voltage impulses applied thereto by the pressure-responsive device and transmitting to said output circuit solely that portion of the voltage impulses having an amplitude greater than the threshold value.

2. Apparatus for indicating detonating pressures in a combustion motor, comprising a pressure-responsive device for converting pressure variations in said motor into voltage impulses having corresponding amplitude variations, an input circuit connected to the pressure-responsive device, an output circuit including an electrically responsive indicating device, and a voltage transmission circuit interposed between the input circuit and the output circuit, said voltage transmission circuit having a variable threshold value proportional to and within the range of about one-third to one-half of the maximum amplitude of the voltage impulses applied thereto

by the pressure-responsive device and transmitting to said output circuit solely that portion of the voltage impulses having an amplitude greater than the threshold value.

3. Apparatus for indicating detonating pressures in a combustion motor, comprising a pressure-responsive device for converting pressure variations in said motor into voltage impulses having corresponding amplitude variations, an input circuit connected to the pressure-responsive device, an output circuit including an electrically-responsive indicating device, and a voltage transmitting circuit interposed between the input circuit and the output circuit, said transmitting circuit comprising a discharge tube having a cathode, a control grid coupled to said input circuit, and an anode coupled to the output circuit, and means for applying to the control grid a negative bias voltage having a substantially fixed component having a value at which the anode current is substantially suppressed in the absence of voltage impulses from the pressure-responsive device and a supplementary variable negative bias voltage component proportional to the average value of the anode current occurring in the presence of voltage impulses from the pressure-responsive device, said means comprising a resistor element common to the cathode-control grid and cathode-anode circuits and a condenser element connected in shunt with said resistor element, said supplementary bias voltage component having a value at which the voltage transmission circuit has a variable threshold value proportional to the maximum amplitude of the voltage impulses applied to the control-grid by the pressure-responsive device and transmits to the said output circuit solely that portion of the voltage impulses having an amplitude greater than the threshold value.

4. Apparatus for indicating detonating pressures in a combustion motor, comprising a pressure-responsive device for converting pressure variations in said motor into voltage impulses having corresponding amplitude variations, an input circuit connected to the pressure-responsive device, an output circuit including an electrically-responsive indicating device, and a voltage transmitting circuit interposed between the input circuit and the output circuit, said transmitting circuit comprising a discharge tube having a cathode, a control grid coupled to said input circuit, and an anode coupled to the output circuit, and means to apply to the control grid a negative bias voltage having a substantially fixed component and a variable component serving as a supplementary bias voltage, said means comprising a voltage source having its negative pole coupled to the control grid, a resistor element common to the cathode-control grid and cathode-anode circuits, a condenser element connected in shunt with said resistor element, and another resistor element connected in series with said first resistor element and interconnecting the cathode and the positive pole of said voltage source, said series connected resistors and said voltage source having values at which the fixed negative bias voltage component applied to the control grid substantially suppresses the anode current in the absence of voltage impulses, and said first resistor and shunting condenser having values at which the supplementary bias voltage component applied to the control grid is proportional to the average value of the anode current occurring in the presence of voltage impulses from the pressure-responsive device and has a value at which the voltage transmission circuit has a variable threshold value proportional to the maximum amplitude of the voltage impulses applied to the control grid and transmits to the said output circuit solely that portion of the voltage impulses having an amplitude greater than the threshold value.

5. Apparatus for indicating detonating pressures in a combustion motor, comprising a pressure-responsive device for converting pressure variations in said motor into voltage impulses having corresponding amplitude variations, an input circuit connected to the pressure-responsive device, an output circuit including an electrically-responsive indicating device, a voltage transmission circuit interposed between the input circuit and the output circuit, and a band-pass network interposed between said transmission circuit and said indicating device, said transmission circuit having a variable threshold value proportional to the maximum amplitude of the voltage impulses applied thereto by the pressure-responsive device and transmitting to said output circuit solely that portion of the voltage impulses having an amplitude greater than the threshold value, and said band-pass network being selective to voltage impulses having frequencies characteristic to the detonation being indicated.

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