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PATENT SPECIFICATION

DRAWINGS ATTACHED

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Wheel unbalance detection and measuring.

COMPLETE SPECIFICATION

We, MOBIL OIL CORPORATION, formerly Socony Mobil Oil Company, Inc., a corporation organized and existing under the laws of the State of New York, United States of America, of 150 East 42nd Street, New York 17, New York, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to an apparatus for detecting and measuring wheel unbalance and more particlarly, to such apparatus especially suitable for use with a dynamometer in a vehicle diagnostic system.

The wheel unbalance measuring system of the present invention is designed to be used as part of a system for thoroughly testing and checking motor vehicles for any defects, malfunctionings and other conditions which may require correction. Time is of the essence in such a system and any feature which will save even a few seconds in the diagnostic process is important to the system, as it is only by these time-saving features that the diagnostic system becomes economically practical. The wheel unbalance detecting and measuring system of the present invention reduces the time required to determine wheel unbalance and thus saves valuable time.

Accordingly, a principal object of the present invention is to provide apparatus by which wheel unbalance may be quickly and effectively detected and measured.

Another object of this invention is the provision of an apparatus for detecting wheel unbalance which may be expeditiously employed in the dynamometer of a vehicle diagnostic system to provide an indication of wheel unbalance either simultaneously with the test function served by the dynamometer or which may be employed either before or after carrying out the dynamometer test function but without requiring movement of the vehicle in the bay.

A further object of this invention is to provide a wheel unbalance detecting apparatus which is readily adaptable without substantial adjustment to all sizes of automotive vehicle wheels and as well, to wheels on such vehicles having widely varying weight.

Still another object of the present invention is the provision of an apparatus of the type referred to which is extemely sensitive to wheel unbalance and which provides an accurate indication of the amplitude of vibration caused by unbalance in a wheel rotated at the desired test speed.

According to the present invention apparatus for detecting the unbalance of a tyre-bearing automotive vehicle wheel positioned on a dynamometer roller which is adapted to rotate the wheel and which supports the wheel with its full normal share of the weight of the vehicle, comprising a detecting device adapted to measure oscillatory movement of the wheel towards or away from the roller caused by the unbalance of the wheel and to deliver a corresponding output signal and a measuring circuit to indicate the amplitude of the frequency component of the signal which is proportional to the amplitude of the vibrations due to wheel unbalance. The invention also embraces a method of measuring wheel unbalance of an automotive vehicle wheel supported on a dynamometer roller while bearing its full share of the normal weight of the vehicle, by means of said apparatus.

The foregoing objects are accomplished in an embodiment of the present invention by providing a light source and a light-sensitive element on opposite sides of a wheel

(*Price 4s. 6d.*)

to be tested such that upon rotation of the wheel and resulting vibration caused by unbalance, the light passing from the source about the periphery of the wheel operates, by means of ~~a light sensitive~~ element, to produce a modulated output signal corresponding in amplitude to the amplitude of vibration brought about by rotation of the wheel and thus corresponding to the magnitude of unbalance in the wheel. Preferably, the light source and light-sensitive element are positioned between spaced rollers of a dynamometer on which the wheel is supported by which the desired amount of angular velocity or rotation is imparted to the wheel for testing.

Alternatively the wheel unbalance measuring system of the present invention comprises a vibration detector which is connected to the wheel suspension assembly of the vehicle wheel, the unbalance of which is being measured. The output from the vibration detector is fed to a low pass filter which removes all components in the output signal of the vibration detector above a predetermined frequency. The remaining components below this predetermined frequency comprising the output signal of the low pass filter are fed to a meter which measures the amplitude of the applied signal. To take the wheel unbalance measurement, the wheel of the vehicle is positioned on a pair of rollers and the rollers are then operated to drive the wheel of the vehicle at a predetermined speed. The number of cycles per second in the cutoff frequency of the low pass filter is selected to be above the number of revolutions per second that the wheel is driven by the rollers. With this arrangement, the amplitude of the output signal of the low pass filter will be proportional to the wheel unbalance and the meter will provide an indication of the wheel unbalance. Because the wheel unbalance measurement using this system can be taken in a shorter period of time than the systems of the prior art, the wheel unbalance measuring system of the present invention saves valuable time in the diagnostic process and contributes substantially to the making of this diagnostic process economically practical.

In order that the disclosure will be more fully understood and readily carried into effect, the following detailed description is given with respect to the accompanying drawings in which:

Figure 1 is a fragmentary perspective view illustrating a vehicle diagnostic bay and particularly the portion thereof containing the dynamometer with which the present invention may be advantageously employed;

Figure 2 is an enlarged, schematic cross-section taken along the line 2—2 of Figure 1 and showing an automotive vehicle wheel in its test position;

Figure 3 is a schematic fragmentary cross-sectional view taken along line 3-3 of Figure 2; and

Figure 4 is a diagrammatic illustration of a measuring circuit adapted for use with the present invention.

Figure 5 is a diagrammatic illustration of a modifed measuring circuit.

Referring now to the drawings, and particularly Figures 1-3 thereof, the diagnostic bay in which the present invention is desirably incorporated is generally designated by the reference numeral 10. The bay constitutes an enclosure having walls 12, a floor 14, an entrance opening 16 at one end and an exit opening (not shown) at the other end. Also, a Maxwell dynamometer designated generally by the reference numeral 18 is positioned in a well 19 under the level of the floor 14 and toward the entrance end of the bay. The dynamometer itself is conventional and includes pairs of spaced rollers 20 between which the wheels 22 of the test vehicle are supported or cradled during performance of the dynamometer test function. The rollers 20 are suitably journaled in supporting beams 23 of the dynamometer frame structure and at least one roller in each pair is adapted to be ~~rotably~~ driven by a motor 24. It will be understood that both the diagnostic bay 10 and the Maxwell dynamometer 18, in practice, embody substantially more structural detail than is illustrated in the drawings or described above. Such details, however, are omitted to permit a clear disclosure of the present invention.

As shown in Figures 2 and 3 of the drawings, the wheel 22 is in position between the rollers 20 of the Maxwell dynamometer and thus in the proper position both for effecting the dynamometer test function and for employment of the wheel unbalance detecting apparatus of the present invention. This latter apparatus includes a light source 26 positioned on one side of the wheel 22 and suitably supported by mounting, for example, to the frame member 23. For reasons which will become more apparent from the description which follows below, the light 26 is preferably supplied with power from a DC source, such as a battery 28. On the opposite side of the wheel 22 from the light 24, a light sensitive element in the form of a photocell 30 is suitably supported such as by a bracket 32 connected to the frame member 23 on that side of the wheel. The photocell functions to provide a modulated signal corresponding in magnitude to the amplitude of wheel vibration due to unbalance therein upon rotation by sensing light passing from the light source 26 about the periphery of the wheel 22.

Accordingly, the light sensitive element is rendered elongated in a radial direction with respect to the wheel 22 by the provision of a slit 34 in the chassis within which the photocell 30 is contained. In this manner, the amount of light passing through the slit 34 and thus sensed by the photocell 30 will vary with movement of the wheel periphery due to vibrations caused by unbalance of the wheel. In the preferred form of the invention illustrated in the drawings, the slit 34 defining the operative position of the light sensitive element and the light source 26 are positioned in a vertical plane passing through the centre of the wheel 22 and also midway between the axis of the rollers 20. Further, it is preferred that both the photocell 30 and the light source 26 are positioned at the lowermost portion of the wheel or physically between the rollers 20 though it will be understood by those skilled in the art that the photocell 30 and light 26 could be positioned at other points about the periphery of the test wheel 22 for satisfactory operation of the wheel unbalance detecting apparatus of this invention.

The photocell 30 is connected with a measuring circuit 36 illustrated schematically in Figure 3. The measuring circuit 36 removes the DC component from the output signal of the photocell and filters out all the AC above 20 cps. After this filtering has been carried out, the measuring circuit measures the amplitude of the remaining AC signal by converting it to DC, amplifying the DC and applying it to a meter. In operation the rollers 20 are driven by the motor of the dynamometer. In turn, the rollers 20 drive the wheel 22 of the vehicle. The wheel 22 will then vibrate or oscillate with an amplitude proportional to the amount of unbalance in the wheel 22 and as the wheel 22 oscillates it will cut off a portion of the light from the source 26 irradiating the photocell 30 through the slit 34, and the amount of light that is cut off will increase and decrease with the oscillation of the wheel 22. Thus the amount of light that irradiates the photocell through the slit 34 will oscillate with the wheel 22 and with an amplitude equal to the amplitude of oscillation of the wheel 22. Therefore, the photocell 30 will generate an AC output signal proportional to the amplitude of oscillation of the wheel 22 and therefore proportional to the amount of unbalance in the wheel 22. The frequency of this AC signal will be equal in cycles per second to the revolutions per second of the wheel 22. The measuring circuit 36 is designed to measure and indicate the amplitude of this AC output signal generated by the photocell 30 and thus indicate the amount of unbalance of the wheel 22.

Power is applied to the measuring circuit 36, in the form of the DC voltage applied between the line 40 and the line 42, which is grounded. The positive side of the DC voltage is applied to line 40. A voltage divider comprising resistors 44 and 46 are connected in series between the lines 40 and 42 and the anode of the photocell 30 is connected to the junction between the resistors 44 and 46. The cathode of the photocell 30 is connected to the grounded line 42 over a load resistor 48. Thus a portion of the DC voltage between lines 40 and 42 will be applied across the photocell 30 and the variation in current in the photocell 30 caused by variations in the irradiating light will cause a corresponding variaton in the voltage across the load resistor 48. This signal voltage is applied through a capacitor 50 to the grid of a triode 52, which grid is connected to the ground through a resistor 54. The capacitor 50 removes the DC component in the signal voltage produced across the load resistor 48 and only applies to the grid of the tube 52 the AC voltage caused by variations in the light irradiating the photocell 30. The plate of the tub 52 is connected to the line 40 over a load resistor 56 and the cathode of the tube 52 is connected to the grounded line 42 over a resistor 58. The triode 52 will amplify the signal voltage applied to its grid and apply the amplified signal voltage through a capacitor 60 to a low pass filter 62. A resistor 64 connects the junction between the capacitors 60 and the filter 62 to the grounded line 42. The filter 62 removes all components in the applied signal voltage from the plate of the tube 52 over 20 cycles per second and applies the remaining signal across the resistance of a potentiometer 66. The junction between the filter 62 and the potentiometer 66 is connected to the grounded line 42 over a resistor 68. The moveable contact of the potentiometer 66 is connected through a capacitor 70 to the grid of a triode 72. Thus the potentiometer 66 attenuates the output signal from the filter 62 a selectively variable amount and applies it to the grid of the triode 72. The grid of the triode 72 is connected to the grounded line of 42 over a resistor 74. The cathode of the triode 72 is connected to the line 42 over a resistor 76 and the plate of the triode 72 is connected to the line 40 over a load resistor 77. The triode 72 amplifies the attenuated output voltage produced at the moveable contact of the potentiometer 66 and applies it through a capacitor 78 to the anode of a diode rectifier 80 and the cathode of a diode rectifier 82, the anode of which is connected to the grounded line 42. The junction between the capacitor 78 and

the diode rectifiers 80 and 82 is connected to ground through a load resistor 84. The diode rectifiers 80 and 82 convert the AC signal voltage applied thereto from the plate of the triode 72 to a DC signal voltage, which is produced across a load resistor 86. The load resistor 86, which is connected between the cathode of the diode rectifier 80 and the grounded line 42, is connected in parallel with a capacitor 88, which removes the ripple from the rectified DC voltage. The DC voltage signal produced across the resistor 86 and the capacitor 88 is applied through a resistor 90 to the grid of a triode 92. The plate of the triode 92 is connected through a load resistor 94 to one side of a potentiometer 96, the other side of which is connected through a load resistor 98 to the plate of a triode 100. The moveable contact of the potentiometer 96 is connected directly to the line 40. The cathodes of the triodes 92 and 100 are connected through resistors 102 and 104, respectively, to a junction 106, which is connected to the grounded line 42 through a resistor 108. The grid of the anode 100 is connected to the grounded line 42 through a resistor 109. The triodes 92 and 100 together with the resistors 94, 98, 102, 104, 108, and 109 and the potentiometer 96 comprise a differential amplifier connected to amplify the DC voltage produced across the resistor 86 and the capacitor 88. The amplified DC output voltage of the differential amplifier is produced between the plates of the triodes 92 and 100. A meter 110 is connected between the plates of the triodes 92 and 100 to provide an indication of this output voltage.

Thus the signal generated by the photocell 30, after having the DC component removed therefrom by the capacitor 50 will be amplified by the triode 52, and then be filtered by the filter 62 to remove all components above 20 cps. Thus the output signal from the filter 62 will be an AC signal proportional to the AC components generated in the photocell 30 below 20 cps. This AC signal is attenuated a selectively variable amount by the potentiometer 66 and then amplified again by the triode 72. After being amplified by the triode 72 the AC signal is converted to a DC signal voltage by the diode rectifiers 80 and 82 and applied across the parallel circuit of the resistor 86 and the capacitor 88. Thus the DC voltage produced across the resistor 86 and the capacitor 88 will be proportional to the AC components generated in the photocell 30 below 20 cycles per second. The DC signal voltage produced across the resistor 86 and the capacitor 88 will be amplified by the differential amplifier comprising the triodes 92 and 100 and then be indicated by the meter 110. Thus the meter 110 will provide an indication of the amplitude of the AC components produced in the photocell 30 below 20 cycles per second.

As pointed out above, the photocell 30 when the wheel 22 is being driven by the rollers 20 will generate an AC signal voltage proportional to the amount of unbalance in the wheel 22. This AC signal generated by the photocell 30 will have a frequency equal to the revolutions per second that the wheel 22 is driven by the rollers 20. In the preferred embodiment of the invention, the rollers 20 drive the wheel 22 at a peripheral speed of 57 to 60 miles per hour. When the wheel 22 is being driven by the rollers 20 at 57 to 60 miles per hour, it will be rotating at less than 20 revolutions per second, This is true for all sizes of vehicle wheels. The photocell 30, in addition to generating the AC signal at the frequency equal to the revolutions per second of the wheel 22, also generates a substantial amount of higher frequency signals. However, substantially no AC signals other than the one caused by and proportional to the unbalance of the wheel 22 will be generated by the photocell 30 below 20 cycles per second. Thus the output signal produced by the filter 62 will be directly proportional to the amount of unbalance in the wheel 22 and the meter 110 will directly indicate the amount of unbalance in the wheel 22.

The modified arrangement illustrated in Figure 5 is adapted to measure the unbalance of a vehicle wheel by a vibration detector fastened to the wheel suspension assembly of an automotive vehicle. The vehicle wheel is positioned on a pair of rollers without removing the wheel from the vehicle. The vibration detector is then fastened to the suspension assembly of the vehicle wheel and preferably to the lower control arm thereof. This vibration detector is designated by the reference number 11 in Figure 5 of the drawings. As shown in the drawings, the output from the vibration detector 11 is fed to a low pass filter 13, which removes all the components in the output signal of the vibration detector above its cutoff frequency. The remaining components in the output signal of the low pass filter are fed to a meter 15, which measures the amplitude of the output signal of the low pass filter 13. The vehicle wheel is then driven by the rollers at a predetermined speed. The number of cycles per second in the cutoff frequency in the low pass filter is selected to be above the number of revolutions per second that the vehicle wheel is driven. When the vehicle wheel is rotated in this manner, the vibration detector 11 attached to the wheel suspension assembly will generate a signal pro-

portional to the amount of unbalance of the vehicle wheel at a frequency having a number of cycles per second equal to the number of revolutions per second that the wheel is rotating. The low pass filter 13 serves to remove noise and other extraneous signals not caused by wheel unbalance from the output signal of the vibration detector 11. There will be substantially no extraneous signals or noise at frequencies below the number of revolutions per second that the wheel is rotating. As a result, the output signal from the low pass filter 13 will have an amplitude proportional to the wheel unbalance of the vehicle wheel, and the meter 15, which measures and indicates the amplitude of the output signal of the low pass filter, will indicate the amount of wheel unbalance. In this manner the low pass filter 13 and the meter 15 detect the component of the output signal of the vibration detector at the frequency equal in cycles per second to the speed of the vehicle wheel in revolutions per second, or in other words detects the component caused by wheel unbalance.

WHAT WE CLAIM IS:

1. Apparatus for detecting the unbalance of a tyre-bearing automotive vehicle wheel positioned on a dynamometer roller which is adapted to rotate the wheel and which supports the wheel with its full normal share of the weight of the vehicle, comprising a detecting device adapted to measure oscillatory movement of the wheel towards or away from the roller caused by the unbalance of the wheel and to deliver a corresponding output signal and a measuring circuit to indicate the amplitude of the frequency component of the signal which is proportional to the amplitude of the vibrations due to wheel unbalance.

2. An apparatus for determining wheel unbalance according to Claim 1 wherein said dynamometer has a pair of spaced rollers for rotatably engaging the periphery of said wheel.

3. An apparatus according to Claim 2 wherein said detecting device detects the amplitude of deflection of the periphery of said wheel between said rollers.

4. An apparatus according to Claim 1, 2 or 3 wherein said detecting device comprises a light source positioned on one side of said wheel, and instrument means responsive to the light passing from said source about the peripheral edge of the wheel during rotation thereof for producing a modulated signal corresponding in amplitude to the amplitude of vibrations due to the wheel unbalance.

5. The apparatus according to any one of the preceding apparatus claims which includes filter means to filter out all components in said signal above a predetermined frequency.

6. The apparatus according to Claim 5 which includes an indicator to display the amplitude of the resulting filtered signal.

7. Apparatus according to Claim 1 comprising a vibration detector adapted to be mounted on the wheel suspension assembly of a vehicle wheel, a low pass filter connected to receive at its input the output signal from said vibration detector, and means to indicate the amplitude of the output signal of said low pass filter.

8. Apparatus for detecting wheel unbalance according to Claim 1 substantially as hereinbefore described and illustrated in the accompanying drawings.

9. A method of measuring the wheel unbalance of an automotive vehicle wheel supported on a dynamometer roller while bearing its full normal share of the weight of said vehicle which comprises rotating said wheel by means of the dynamometer roller, and obtaining an indication of the amplitude of the oscillatory movement of said rotating wheel towards or away from said roller caused by unbalance of said wheel by means of the apparatus of any preceding claim.

10. A method according to Claim 9 comprising detecting the amplitude of the component of vibration of the wheel suspension assembly at a frequency having a number of cycles per second equal to the number of revolutions per second that the wheel is rotating.

11. A method according to Claim 4, comprising the step of filtering out all components in the output signal of said vibration detector above a predetermined frequency the number of cycles per second of which is greater than the number of revolutions per second that the wheel is rotating.

12. Method of measuring wheel unbalance according to Claim 9 of an automotive vehicle wheel substantially as hereinbefore described and illustrated in the accompanying drawings.

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portional to the amount of unbalance of the vehicle wheel at a frequency having a number of cycles per second equal to the number of revolutions per second that the wheel is rotating. The low pass filter 13 serves to remove noise and other extraneous signals not caused by wheel unbalance from the output signal of the vibration detector 11. There will be substantially no extraneous signals or noise at frequencies below the number of revolutions per second that the wheel is rotating. As a result, the output signal from the low pass filter 13 will have an amplitude proportional to the wheel unbalance of the vehicle wheel, and the meter 15, which measures and indicates the amplitude of the output signal of the low pass filter, will indicate the amount of wheel unbalance. In this manner the low pass filter 13 and the meter 15 detect the component of the output signal of the vibration detector at the frequency equal in cycles per second to the speed of the vehicle wheel in revolutions per second, or in other words detects the component caused by wheel unbalance.

WHAT WE CLAIM IS:

1. Apparatus for detecting the unbalance of a tyre-bearing automotive vehicle wheel positioned on a dynamometer roller which is adapted to rotate the wheel and which supports the wheel with its full normal share of the weight of the vehicle, comprising a detecting device adapted to measure oscillatory movement of the wheel towards or away from the roller caused by the unbalance of the wheel and to deliver a corresponding output signal and a measuring circuit to indicate the amplitude of the frequency component of the signal which is proportional to the amplitude of the vibrations due to wheel unbalance.

2. An apparatus for determining wheel unbalance according to Claim 1 wherein said dynamometer has a pair of spaced rollers for rotatably engaging the periphery of said wheel.

3. An apparatus according to Claim 2 wherein said detecting device detects the amplitude of deflection of the periphery of said wheel between said rollers.

4. An apparatus according to Claim 1, 2 or 3 wherein said detecting device comprises a light source positioned on one side of said wheel, and instrument means responsive to the light passing from said source about the peripheral edge of the wheel during rotation thereof for producing a modulated signal corresponding in amplitude to the amplitude of vibrations due to the wheel unbalance.

5. The apparatus according to any one of the preceding apparatus claims which includes filter means to filter out all components in said signal above a predetermined frequency.

6. The apparatus according to Claim 5 which includes an indicator to display the amplitude of the resulting filtered signal.

7. Apparatus according to Claim 1 comprising a vibration detector adapted to be mounted on the wheel suspension assembly of a vehicle wheel, a low pass filter connected to receive at its input the output signal from said vibration detector, and means to indicate the amplitude of the output signal of said low pass filter.

8. Apparatus for detecting wheel unbalance according to Claim 1 substantially as hereinbefore described and illustrated in the accompanying drawings.

9. A method of measuring the wheel unbalance of an automotive vehicle wheel supported on a dynamometer roller while bearing its full normal share of the weight of said vehicle which comprises rotating said wheel by means of the dynamometer roller, and obtaining an indication of the amplitude of the oscillatory movement of said rotating wheel towards or away from said roller caused by unbalance of said wheel by means of the apparatus of any preceding claim.

10. A method according to Claim 9 comprising detecting the amplitude of the component of vibration of the wheel suspension assembly at a frequency having a number of cycles per second equal to the number of revolutions per second that the wheel is rotating.

11. A method according to Claim 4, comprising the step of filtering out all components in the output signal of said vibration detector above a predetermined frequency the number of cycles per second of which is greater than the number of revolutions per second that the wheel is rotating.

12. Method of measuring wheel unbalance according to Claim 9 of an automotive vehicle wheel substantially as hereinbefore described and illustrated in the accompanying drawings.

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