

Oct. 17, 1967

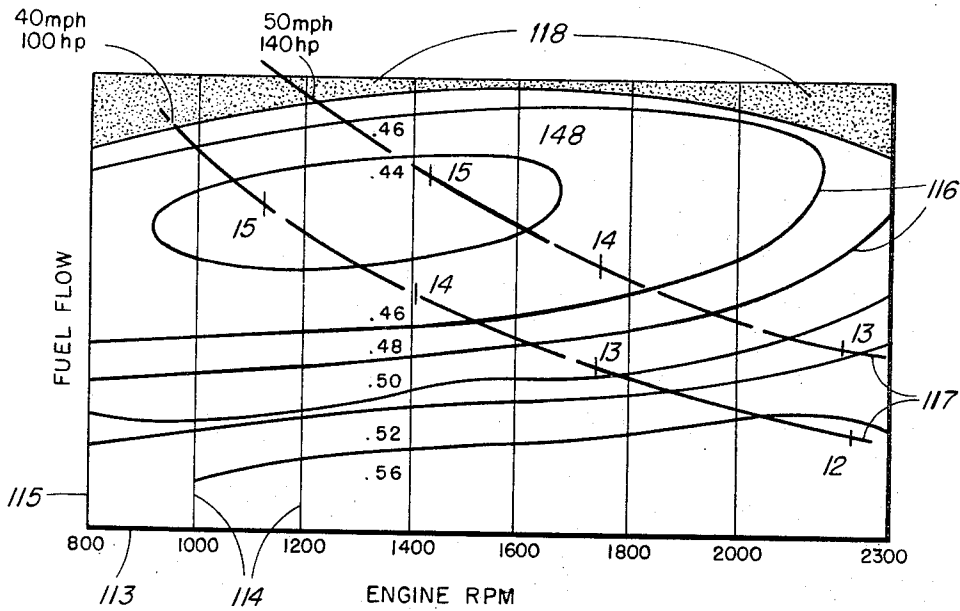
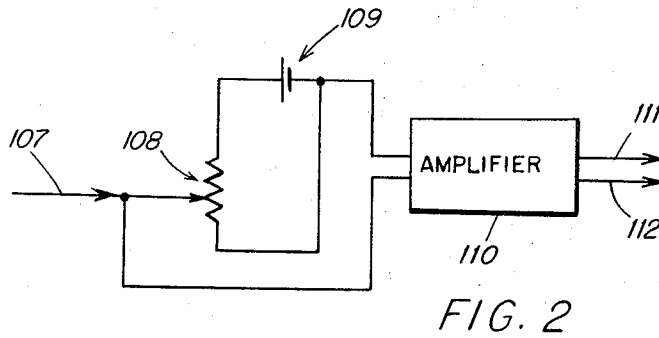
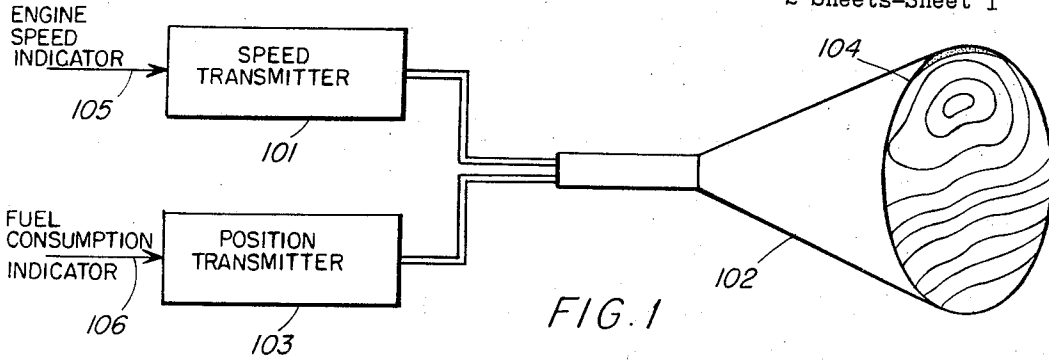
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3,347,092

FUEL ECONOMY METER

Filed Aug. 19, 1964

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

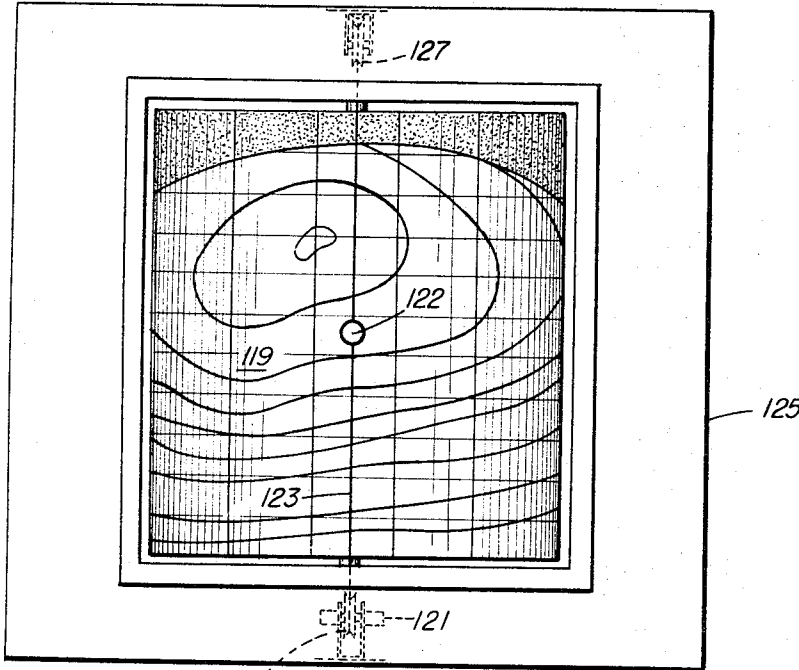


FIG. 4

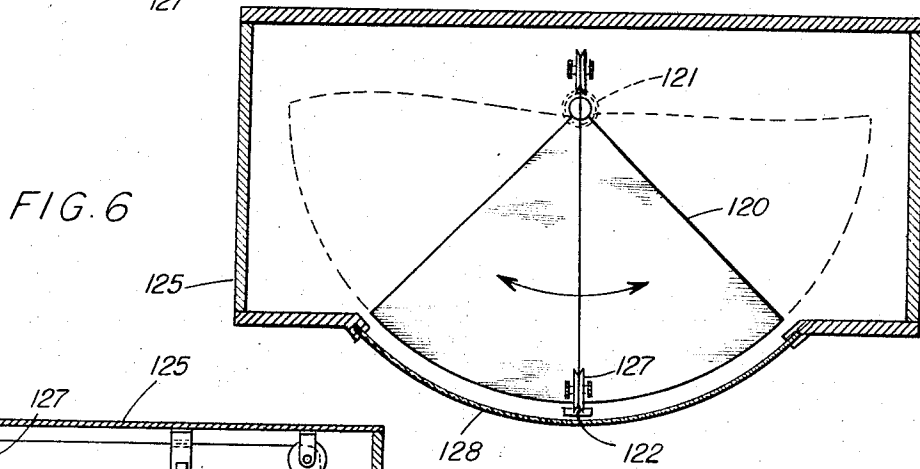


FIG. 6

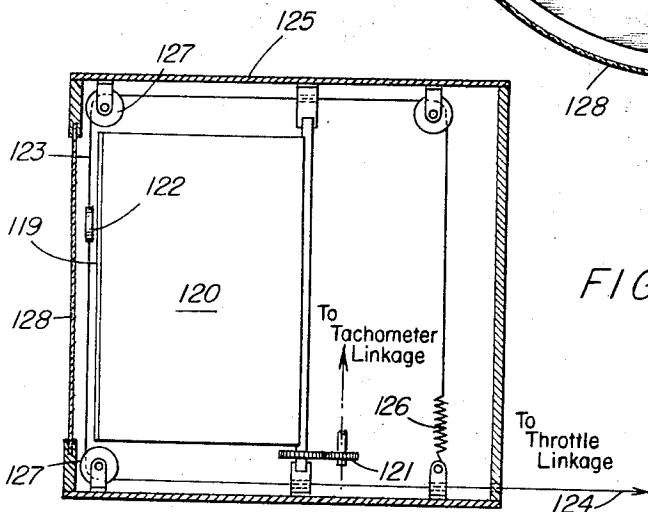


FIG. 5

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**FUEL ECONOMY METER**

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 4 Claims. (Cl. 73—114)

This invention relates to a novel method and means which aid in increasing the operating efficiency of an engine. More particularly, this invention relates to an engine efficiency indicator, which presents a correlation of fuel flow and engine speed to the fuel consumption efficiency of the engine in a manner easily understood by the vehicle driver. Additionally, this invention relates to a method wherein the fuel consumption efficiency is improved by varying the operating conditions of the engine in accordance with the indicator means referred to above.

Briefly, the engine efficiency indicator of this invention comprises an indicator means, such as a cathode ray tube, an engine performance map superimposed upon the face of the indicator means and associated actuating means. The input, for example, to the cathode ray tube is from electrical means which are indicators of the operating variables of the engine. In particular, the invention may comprise a cathode ray tube with an input from an engine speed transmitter and from a measured fuel feed transmitter wherein the integrated signal from these two variables is displayed upon an engine performance map.

This invention provides a solution to a long-standing problem in the automotive field. It is widely appreciated that engines—and especially commercially employed automotive engines—are operated at substantially below optimum obtainable fuel consumption efficiency. This is a particular problem for long-haul diesel truckers. Automotive engineers and manufacturers have been continually engaged in the design and production of more efficient engines. A great deal of time and effort has been expended in providing proper gear ratio trains in transmission systems. The introduction of increasingly refined gearing systems now has made the economical transmission of power practical. A compromise between engine efficiency and convenience has been reached in the passenger vehicle field wherein 3- and 4-position gear boxes are now common. Long-haul diesel trucks often are now equipped with 15-position gear shifts in their transmission systems. However, no matter how sophisticated gear transmissions become, and, in fact, because transmission systems now are so highly sophisticated, the human factor is most important. Improper operation of a vehicle by a driver is the greatest cause of inefficient fuel consumption. In view of the complexity of present transmission systems, the problem of fuel consumption efficiency is not entirely solved merely by adequately training the vehicle operator. The need exists for an indicator system that provides motivation and information for the driver by a simple means, yet one that is sufficiently sophisticated to increase operating efficiency.

Many devices have been employed to increase operational efficiency, including a number of engine indicator meters. The simplest systems comprise indicator markings on the vehicle's speedometer or tachometer which show the preferred gear position. However, these systems are not truly accurate since they indicate the same gear position for a standard number of engine r.p.m., regardless of the load carried by the vehicle. Yet it has been esti-

2

ated that a truck engine pulling half its maximum rated load can reduce fuel consumption by over 10% by a judicious selection of gears not always appreciated by the driver.

5 Nor have systems of greater complexity been entirely satisfactory. For example, an indicating and recording instrument which attempts to give direct readings of means effective brake pressure has proved to be impractical in view of the difficulty of tapping and maintaining a sensing device in the engine cylinders. Mechanical devices of this sort have proved especially unwieldy and have not given reliable readings.

15 A device which has been suggested is a fuel efficiency indicator which directly reads fuel consumption from the contents of the fuel tank and compares actual consumption against "normal" or desired fuel consumption. Although this device provides aid in approximating fuel efficiency and engine performance, it totally lacks any guide lines which would direct the driver. This is especially true since the time response of said device is quite slow and only is helpful in averaging a performance over an appreciable span of time.

20 A particular drawback of prior art devices has been the difficulty in providing a system which can be easily read by the vehicle operator. Complex graphs and tables obvious are not suitable outside of the laboratory. In fact, any device which the driver must study creates difficulties and hazards in actual operation. These, and other difficulties, have been overcome by the present invention of a fuel economy meter which provides an accurate continuous indication of engine operation in relation to fuel consumption efficiency and provides ready information which instructs the driver to change the operating variables of his vehicle to achieve maximum efficiency.

35 It is therefore an object of this invention to provide an improved fuel economy meter which overcomes the disadvantages of the systems referred to above.

It is a further object of this invention to provide a fuel economy meter which is both accurate and reliable and which is satisfactory for use on commercial vehicles.

40 Yet a further object of this invention is to provide a meter which shows the vehicle driver his rate of fuel consumption and guides him to the throttle or fuel rack position, engine speed, and gear position which yields the maximum economy for his load and road speed.

45 An object of this invention is to provide a fuel economy meter which contains a performance map which indicates fuel efficiency and also guides the driver to the proper throttle or fuel rack and gear shift position which results in maximum efficiency.

Another object of this invention is to provide a method wherein an improved fuel economy meter is meaningfully employed by commercial vehicle drivers.

50 Other objects and advantages of the present invention are apparent from the following description and drawings:

The invention in a specific embodiment is illustrated in the accompanying drawings wherein like characters of reference indicate like parts in the drawings.

60 FIGURE 1 is a schematic representation of an improved fuel economy meter.

FIGURE 2 is a specific embodiment of a motion transmitter for the fuel economy meter.

65 FIGURE 3 is a drawing of a fuel performance map which may be used in this invention.

FIGURE 4 is a front elevation of a mechanical version of an improved fuel economy meter.

FIGURE 5 is a side elevation of the device of FIGURE 4.

FIGURE 6 is a top view of the device of FIGURE 4. A more detailed description of this invention follows.

In FIGURE 1, 101 represents an engine speed transmitter, of conventional design and manufacture, which transmits an electrical signal of a magnitude proportional to the speed of the engine. The output of this transmitter leads, for example, to the horizontal sweep of an oscilloscope 102.

The position transmitter 103 in such case is then connected to the vertical sweep of the oscilloscope 102. The position transmitter, of conventional design and manufacture, transmits a signal indicative of the position of a mechanical linkage to the throttle, the fuel rack, the injector feed or of some other indicator of fuel quantity and consumption.

The output from the speed transmitter and the motion (position) transmitter is integrated to produce a signal upon the face of the cathode ray tube. Superimposed upon the cathode ray tube is a transparent fuel performance map, 104, through which the integrated signal from the cathode ray tube appears. The fuel performance may be shaded to indicate the area of maximum fuel efficiency.

The speed transmitter, 101, referred to above, is, for example, a variable speed, variable voltage, DC generator (not shown) which leads to an amplifier (not shown) prior to transmission to the cathode ray tube. The input to the speed transmitter may be a flexible shaft or other type of linkage 105 from the engine shaft. The input to the motion transmitter is indicated by 106, which represents a fuel consumption indicator, derived from throttle position or fuel rack or fuel metering valve.

A simplified version of a motion transmitter is shown in FIGURE 2. A mechanical linkage, 107, from the throttle or fuel rack is connected to the arm of a potentiometer, 108. The leads from the potentiometer extend to a power supply, 109, and to an amplifier 110. Leads 111 and 112 carry the output of the amplifier to the cathode ray tube. The auxiliary circuit of FIGURE 2 is not necessary when the cathode ray tube contains a built-in amplifier for horizontal and vertical sweep.

FIGURE 3 is a detailed example of a fuel performance map, 104. The horizontal axis, 113, represents engine speed in r.p.m. In the example shown, vertical lines, 114, extend from the horizontal axis and subdivide it into engine speeds from about 800 to 2300 r.p.m. The vertical axis, 115, represents throttle or fuel rack position, or fuel injected per cycle, but is not calibrated in any particular system. The contour lines 116, represent brake specific fuel consumption. For example, the lowermost line represents 0.56 lb. per brake horsepower hour (lb./BHP-hr.). Lines 117 represent the output of the vehicle in speed and horsepower and are subdivided into various gear ratios. For example, the lowermost line represents a vehicle speed of 40 miles per hour at 100 horsepower. Numerals 12, 13, 14, and 15 represent various gear positions. The shaded area 118 at the uppermost portion of the map represents the smoke area which indicates an operating condition where the vehicle exhaust emits smoke. This area, of course, represents a deposit forming engine condition and an operating condition which may also be a violation of local ordinances.

The specific chart shown is for a diesel engine of conventional manufacture. Maps of this nature are readily available from the manufacturers of all types of engines.

In actual practice, the fuel performance map need only contain contour lines indicating brake specific fuel consumption and need not be marked to indicate specific quantities. The map is shaded to indicate the smoke area and the areas of greater or less fuel consumption. Thus, the operator is not required to read any figures, but merely

operates his vehicle to bring the signal from the cathode ray tube within a specific shaded area upon the map.

The following table lists data obtained from the specific map in FIGURE 3.

TABLE  
[Fuel consumption—BSFC]

	Gears	BSFC	Percent Increase Above Minimum	Percent Increase per Step
40 m.p.h., 100 HP-----	15th-----	.44	-----	-----
	14th-----	.45	2	2
	13th-----	.49	11	9
	12th-----	.56	27	14
15 50 m.p.h., 140 HP-----	15th-----	.44	-----	-----
	14th-----	.45	2	2
	13th-----	.51	15	13

From the preceding table, it may be seen that, at 40 m.p.h., when the operator is drawing 100 HP, he has a choice of at least four gear positions. In position 15, his brake specific fuel consumption (BSFC) is 0.44. In the 14th gear position, his BSFC is 0.45, an increase of 2% above maximum fuel consumption efficiency. Such a slight difference in fuel consumption efficiency, which is indicated upon the fuel performance map, would otherwise ordinarily not be appreciated by many drivers. In the 13th gear position, the BSFC is 0.49, an 11% increase in fuel consumption over the gear position of maximum efficiency. In view of the different operating characteristics of commercial engines, a driver might not appreciate that he should shift gears from this position. Even when a driver considers that he might not be operating at maximum efficiency an appreciable length of time may pass before he shifts gears, especially when a further shift in gear position would soon be necessary. However, by the use of the fuel performance map in this invention, such a glaring waste of fuel is so apparent to the driver that he will more readily adjust the operating conditions of his vehicle to conform to those indicated on the fuel performance map. Of course, an even greater waste of fuel results from the use of the 12th gear position, where the BSFC is 0.56, or a 27% decrease in fuel consumption efficiency when compared with the 15th position. It is emphasized that lines 117 in FIGURE 3 are not shown upon the fuel consumption map when in actual use. They are merely illustrative of the data compiled in the table. The remaining data are self-explanatory.

The throttle position or fuel consumption represented by the vertical axis, 115, is indicative of the throttle linkage which adjusts the potentiometer, 108. The throttle position is taken from the fuel pump rack, or the linkage to the foot pedal, or any measuring device for the fuel feed per engine cycle depending upon the size and type of device which is used. A linkage to the foot pedal is quite simple and accurate, up to the speed or load where an overspeed or horsepower limiting governor takes effect. Such sensing devices are proportional to, or directly measure, fuel per cycle per cylinder and provide a ready signal for amplification to the cathode ray tube. The calibration of these devices is easily made by an automobile mechanic. Diesel engines usually have a fuel rack maximum stop to prevent excessive smoke, cylinder deposits and excessive load damaging to the engine, and a minimum idling stop set upon the engines. These stops define the maximum and minimum positions on the performance charts. An adjustment device for calibrating the fuel economy meter to different performance charts is guided by these maximum and minimum settings.

The horizontal axis, 113, of FIGURE 3 is indicative of engine speed, which is obtained from a linkage to the engine. Practically all engines are built with a connection for installing a tachometer. When a tachometer has not been previously installed in the vehicle, the fuel economy meter is connected to the available linkage

which, for example, drives a variable voltage generator. When there is a recording tachometer already installed, a lead-in to the existing device is practical. The same adaptation and adjustment with regard to calibration for the throttle position is applicable to the use of the tachometer linkage.

The two impulses received through the throttle position and engine speed are integrated and projected as a spot of light upon the face of the cathode ray tube. The fuel performance map is, of course, transparent and is positioned upon the face of the tube to show the fuel being burned and the engine speed. Since fuel performance maps differ for each type of engine, the cathode ray tube is built to receive such maps interchangeably.

A further embodiment of the fuel economy meter is shown in FIGURES 4 through 6. A fuel performance map 119 is mounted upon an oscillating sector 120 which is driven in response to the speed of the engine—for example by a tachometer linkage 121. A target indicator 122 is mounted upon a guide wire 123 which is driven by a throttle linkage 124. The other end of the guide wire is anchored to the casing 125 for the fuel economy meter through a spring 126. The guide wire travels over rollers 127 to position the target indicator 122 along the vertical axis of the fuel performance map. The front of the casing 125 comprises a transparent window 128. The operation of this device is similar to its electrical counterpart described above. The oscillating sector travels in a horizontal direction in proportion to the r.p.m. of the engine. The guide wire moves the target indicator in a vertical direction in proportion to the throttle position or fuel feed per cycle per cylinder. The fuel performance map is shaded to indicate the area of maximum fuel efficiency and the area in which smoking occurs. The operator of the vehicle merely adjusts his throttle position and gear shift to align the target indicator 122 with the area of maximum efficiency on the fuel performance map. This mechanical meter is quite simple in its construction, yet it accurately transmits the necessary data on fuel consumption and engine speed to permit control of such in order to yield increased fuel consumption efficiency.

From the foregoing description, the nature and operation of this invention are apparent. A simple and sturdy device has been provided to indicate fuel consumption efficiency of an engine. The device shown is easily understood by the vehicle driver and leads to increased fuel consumption efficiency. This novel combination of sensing devices, wherein an instantaneous signal related to engine speed and fuel consumption is displayed upon an indicator means, such as a cathode ray tube, in combination with a fuel performance map, is highly effective. The device is quite accurate and yet is easily employed by the driver of the vehicle. It is clear that the process of employing the fuel economy meter to indicate changes in the operating condition of the vehicle leads to great savings. The devices of this invention permit the driver, by controlling the throttle and by shifting the transmission gears, to operate in the lowest fuel consumption range possible under variations in road speed, grade, and cargo

weight. Thus, this invention provides a novel method and means for increasing the operating efficiency of an engine.

It is obvious that certain changes may be made in the above device, without departing from the spirit and scope of the invention, and it is intended that all matter contained in the foregoing description shall be interpreted as illustrative and not a limiting sense. It is also understood that other modifications may be made without departing from the spirit and scope of the appended claims.

I claim:

1. In combination with an internal combustion engine, a device for indicating fuel consumption efficiency of said internal combustion engine comprising a graphical representation relating said efficiency to a range of engine speed and a range of engine fuel consumption rate, speed signal means to generate a function representative of instantaneous engine speed, fuel signal means to generate a function representative of instantaneous rate of engine fuel consumption, indicator means including a cathode ray tube responsive to said respective signal means adapted and arranged to designate on said graphical representation a signal point corresponding to said engine speed signal and said fuel consumption signal, and hence representative of engine efficiency.
2. In combination with an internal combustion engine, a device for indicating fuel consumption efficiency of said internal combustion engine comprising a graphical means indicating brake specific fuel consumption related to a range of engine speed and a range of engine fuel consumption rate, speed signal means to generate a function representative of instantaneous engine speed, fuel signal means connected to a fuel throttle means of said engine to generate a function representative of instantaneous rate of engine fuel consumption, indicator means responsive to said respective signal means adapted and arranged to designate on said graphical representation a point corresponding to said engine speed signal and said fuel consumption signal, and hence representative of engine efficiency.
3. The device of claim 2, wherein said speed signal means comprises a variable-speed variable-voltage generator driven by said engine and said fuel signal means comprises a potentiometer connected to said engine through a throttle linkage means wherein the output from said voltage generator and potentiometer produce a signal upon said indicator means.
4. The device of claim 2 wherein said graphical means indicates operating conditions where the engine exhaust emits smoke.

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