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Seyfried

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[54] METHOD AND APPARATUS FOR ADJUSTING THE COUPLING BETWEEN AN INDUCTOR AND VALVE SEAT

[72] Inventor: **Richard F. Seyfried**, Parma Heights, Ohio

[73] Assignee: **Park-Ohio Industries, Inc.**, Cleveland, Ohio

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Primary Examiner—J. V. Truhe

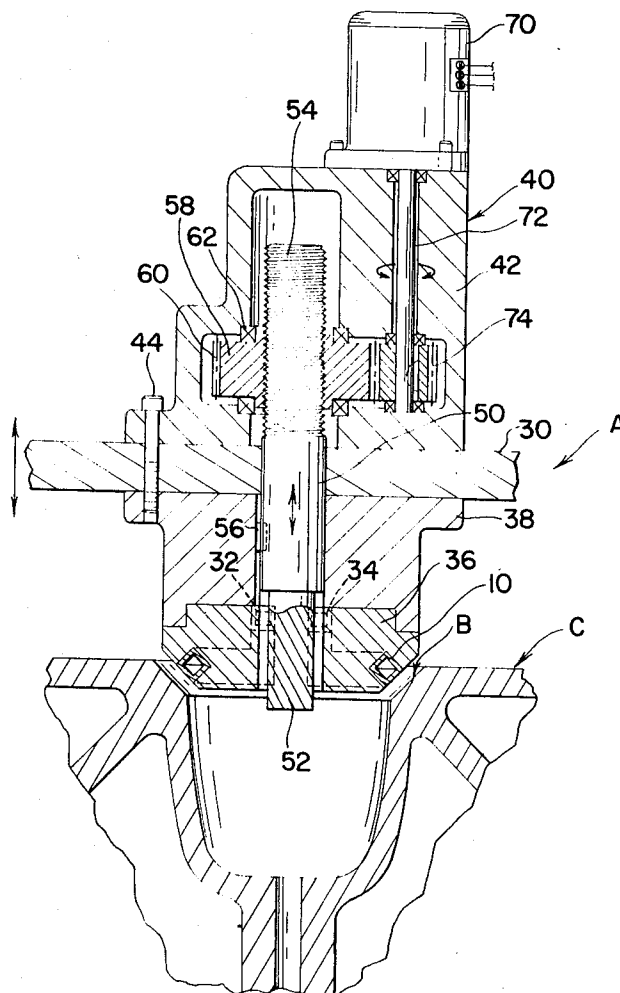
Assistant Examiner—B. A. Reynolds

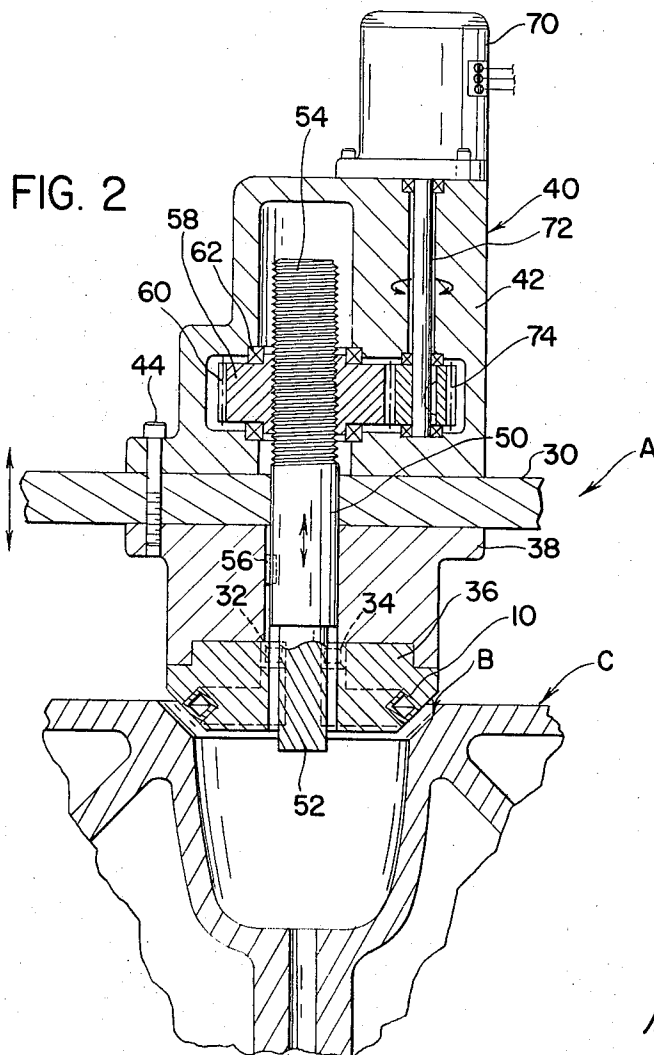
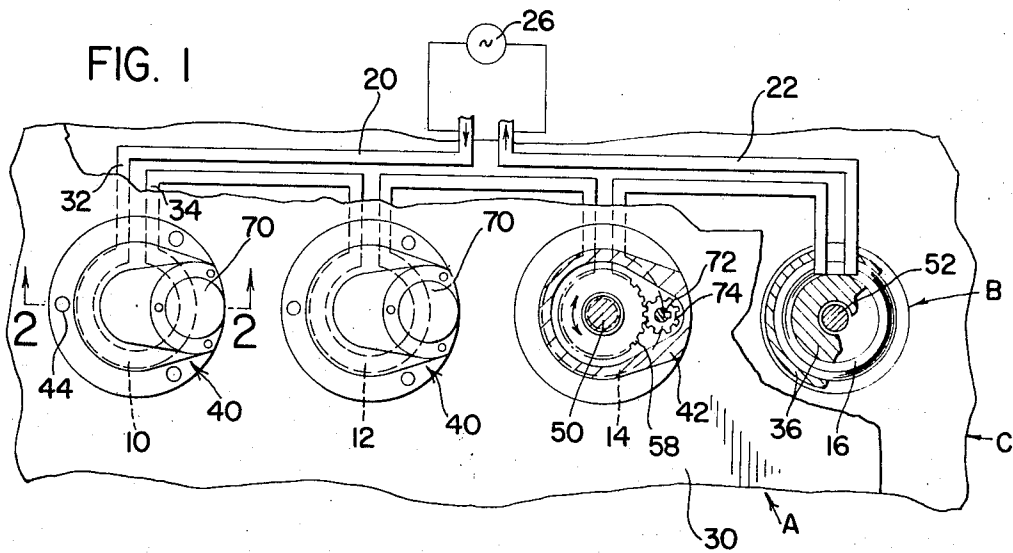
Attorney—Meyer, Tilberry & Body

[57] ABSTRACT

A method and apparatus for positioning an inductor with respect to a generally circular valve seat of an engine block which method and apparatus comprises applying a constant current across the inductor; measuring the voltage across the inductor to create a signal representative of the actual coupling of the inductor with the valve seat; comparing the signal with a reference signal to determine the difference between these signals; and, adjusting the coupling between the inductor and the seat in accordance with this difference.

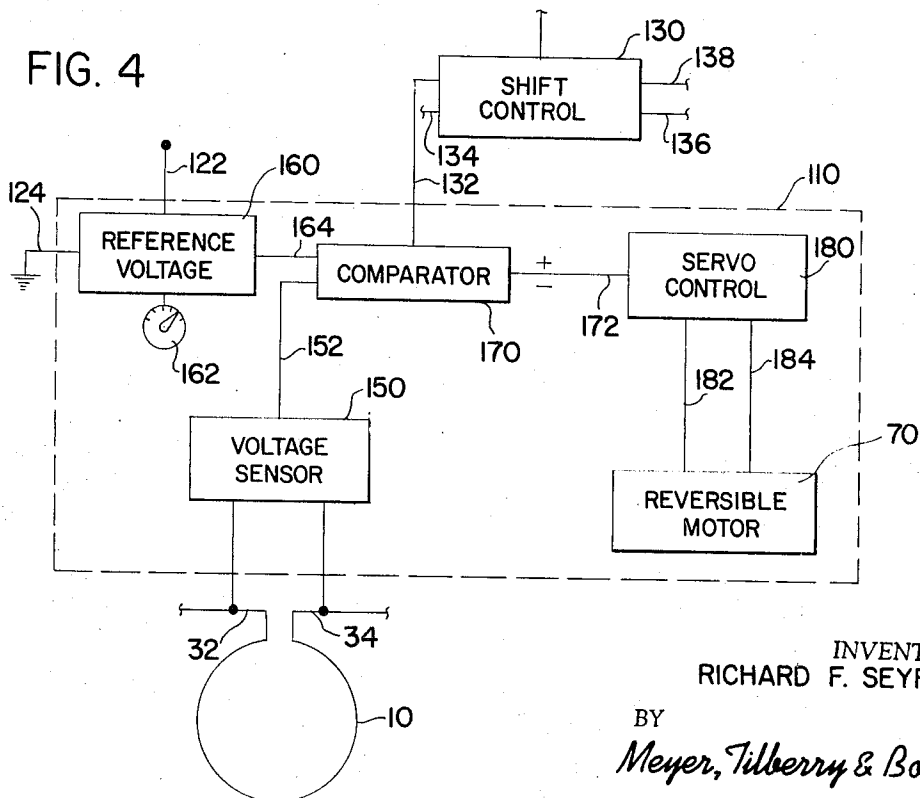
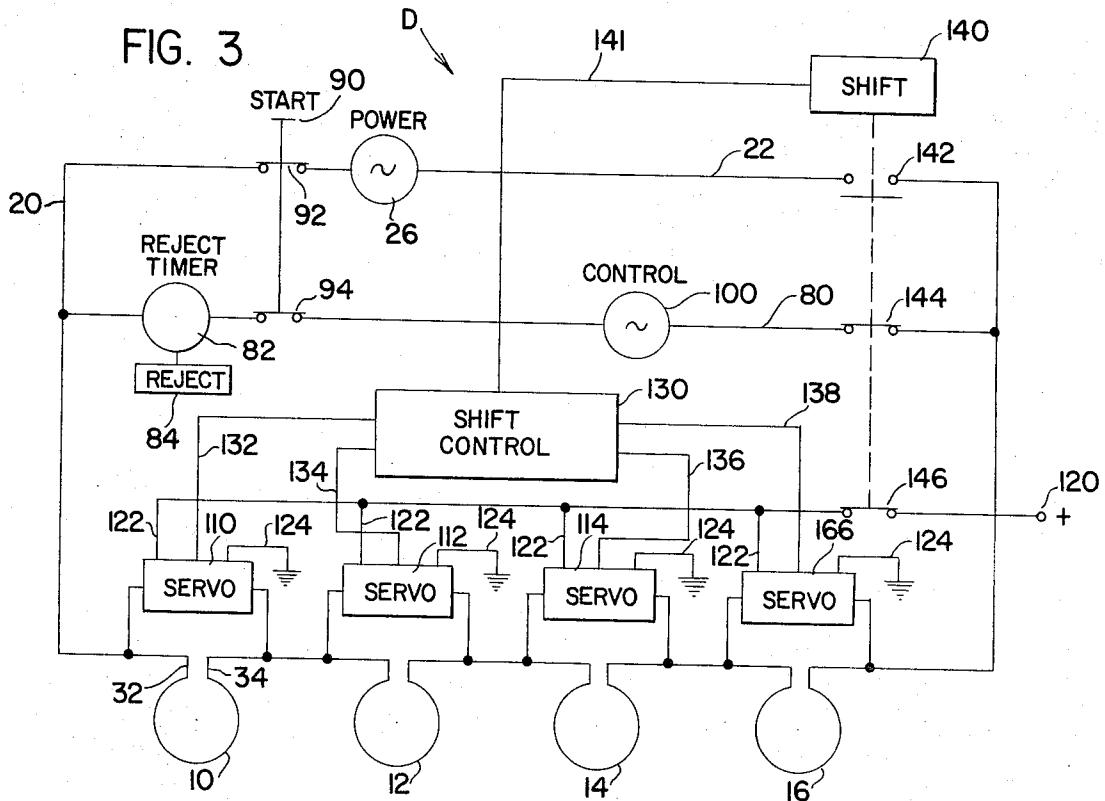
4 Claims, 4 Drawing Figures





INVENTOR.
RICHARD F. SEYFRIED

BY
Meyer, Tilberry & Body
ATTORNEYS



INVENTOR.
RICHARD F. SEYFRIED

BY
Meyer, Tilberry & Body

ATTORNEYS

METHOD AND APPARATUS FOR ADJUSTING THE COUPLING BETWEEN AN INDUCTOR AND VALVE SEAT

This invention pertains to the art of induction heating and more particularly to the method and apparatus for adjusting the coupling between an induction heating inductor and a valve seat of an engine block.

The invention is particularly applicable for adjusting the coupling between an inductor and a generally circular valve seat of an engine block and it will be described with particular reference thereto; however, it should be appreciated that the invention has much broader applications and may be used for adjusting the coupling between an inductor and a generally circular surface to be inductively heated thereby.

In the manufacture of engine blocks for internal combustion engines, it is common practice to heat inductively the generally conical valve seats of the block. Thereafter, the heated seats are quench hardened to increase the hardness of the seats to reduce wear as poppet valves are operated against the valve seats. Generally, this induction heating process is accomplished by a generally circular inductor which is positioned directly opposite the conical surface of the valve seat and energized by an appropriate high frequency power source. In the past, the magnetic coupling between the inductor and the valve seat could vary substantially. Consequently, various relatively fixed arrangements were used to adjust the magnetic coupling between the valve seat and the induction heating inductor. The actual magnetic coupling between the inductor and valve seat could be adjusted by changing the position of the inductor with respect to the valve seat or by moving an electrically conductive plug or core with respect to the central opening of the inductor. These adjustments were accomplished in advance of the heating operation. Consequently, the magnetic coupling was maintained within a substantially wide range.

With the advent of engines capable of using gasoline with reduced lead content, it has been found that the valve seat hardening operation must be held within a more limited range. Prior apparatus for inductively heating these valve seats do not provide the mechanism for accomplishing this type of induction heating operation. Consequently, substantial effort has been devoted to the problem of reducing the number of valve seats which must be rejected as an engine block progresses through an automated operation for inductively heating and quench hardening the valve seats. The present invention relates to a method and apparatus which effectively causes a more uniform induction heating of the valve seats in an engine block than was heretofore possible.

In accordance with the present invention, there is provided an apparatus for positioning an inductor with respect to a generally circular valve seat of an engine block. This apparatus includes an electrical circuit for measuring the actual magnetic coupling between the inductor and the valve seat and for creating a first signal representative of this actual magnetic coupling; a circuit for providing a reference signal representative of a desired magnetic coupling between the inductor and the valve seat; a circuit for comparing the first signal and the reference signal and providing a different signal representative of the difference between the actual magnetic coupling and the desired magnetic

coupling; and, means responsive to the different signal for adjusting the coupling between the inductor and the valve seat from the actual coupling toward the desired coupling.

In accordance with another aspect of the present invention, there is provided a method of positioning an inductor with respect to a generally circular valve seat of an engine block, the method comprises the steps of generating a first electrical signal representative of the actual magnetic coupling between the inductor and the valve seat; comparing the first signal with a reference signal representative of a desired coupling between the inductor and the valve seat; and, adjusting the coupling between the inductor and the valve seat in response to this comparison.

The primary object of the present invention is the provision of a method and apparatus for inductively heating valve seats of an engine block, which method and apparatus automatically adjusts the magnetic coupling between an inductor and a generally circular valve seat of the engine block.

Another object of the present invention is the provision of a method and apparatus for inductively heating valve seats of an engine block, which method and apparatus provides a more uniform quality of heating at the valve seat and prior to quench hardening.

Still another object of the present invention is the provision of a method and apparatus for inductively heating valve seats of an engine block, which method and apparatus senses the actual coupling between the heating inductor and the valve seat and changes this coupling to the desired magnetic coupling to obtain the desired heating effect.

These and other objects and advantages will become apparent from the following description taken together with the accompanying drawings in which:

FIG. 1 is a partial top elevational view showing the preferred embodiment of the present invention;

FIG. 2 is an enlarged cross-sectional view taken generally along line 2—2 of FIG. 1;

FIG. 3 is a schematic wiring diagram illustrating the preferred embodiment of the present invention; and,

FIG. 4 is an enlarged schematic wiring diagram showing, in more detail, the servo-mechanism illustrated in FIG. 3.

Referring now to the drawings wherein the showings are for the purpose of illustrating a preferred embodiment of the invention only and not for the purpose of limiting same, FIGS. 1 and 2 illustrate an induction heating apparatus A for inductively heating a series of conical valve seats B in an engine block C. Any number of these valve seats may be present; however, only four of them are shown for purpose of illustrating the present invention. Associated with each valve seat is inductor 10, 12, 14 and 16 connected in series with lines 20, 22, which are the output lines of an R.F. oscillator 26.

Referring now more particularly to FIG. 2, the details of the inductor 10 are shown. The other inductors have basically the same structure; therefore, the description of inductor 10 applies equally to these other inductors. Inductor 10 is moved with respect to the valve seat B by a movable support plate 30. After the engine block C is located, the support plate 30 moves downwardly to position all of the inductors ad-

jacent their respective valve seats. Input leads 32, 34 are connected onto the inductor 10 for energizing the inductor by the oscillator 26. Insulated support element 36 fixes the inductor 10 with respect to the support block 38 which is secured to the underside of movable support plate 30. In this manner, the inductor 10 is held in a preselected position with respect to the valve seat, and a certain actual magnetic coupling between the inductor and the valve seat is established. Because of manufacturing tolerances, this magnetic coupling often is not proper for the most desirable induction heating of the valve seat. Consequently, in accordance with the present invention, there is provided a mechanism 40 for changing the magnetic coupling between the inductor 10 and the valve seat B. Mechanism 40 includes a housing 42 having a plurality of bolts 44 for securing the housing onto the upper surface of movable support plate 30.

A movable core 50 is provided with a tip 52 formed from an electrically conductive material. This material may have a high permeability, such as soft iron or ferrite, or a low permeability, such as copper. By moving the core with respect to the conductor 10, the magnetic coupling between the inductor and the valve may be varied in accordance with common knowledge, as illustrated in U.S. Pat. No. 3,109,909. As distinguished from that prior patent, the inductor 10 from the illustrated embodiment of the present invention is positioned within the conical valve seat B and not above this valve seat. This provides closer control of the induction heating. Core 50 includes an upper threaded shank 54 and a key 56 which allows only reciprocal movement of the core. A nut 58 having an outer gear portion 60 is journaled within bearings 62 and is used to drive core 50 in a vertical direction through the use of a reversible motor 70 having drive shaft 72 and a pinion 74 which drivingly connects the reversible motor with the gear portion 60 of nut 58.

In operation, the reversible motor shifts the core tip 52 with respect to inductor 10 to change the magnetic coupling between the inductor and valve seat. If the inductor is too tightly coupled with the valve seat, core 52 will be moved according to the type of core being used. If a high permeability core were used, the core would be moved out. On the other hand, if a low permeability core were used, the core would be moved in. Each of these operations loosens the coupling between the inductor and the valve seat. The remaining description relates to the preferred embodiment of the present invention for controlling the individual reversible motors 70 for the inductors 10-16.

Referring now to FIGS. 3 and 4, a system D is provided for automatically controlling the reversible motors 70 for the individual inductors to adjust, in this manner, the actual magnetic coupling between these inductors and their valve seats to a preselected value. Basically, the control system includes arrangement for applying a low power of known current in series across the several inductors. This low power can be accomplished by reducing the output of the oscillator 26 or providing a second low power source. The voltage is then measured across the individual inductors to determine the actual coupling. As is well known, the coupling affects the effective resistance of the conductor; therefore, if a known constant current source is

used, the voltage across the inductors will indicate the magnetic coupling between the inductors and the respective valve seats. After determining the voltages across the inductors, these voltages are used as control signals for comparison with a reference voltage corresponding to the desired coupling. Thereafter, the reversible motors 70 are actuated in accordance with the difference between the reference voltage and the signals from the individual inductors to adjust the coupling of the individual inductors in accordance with these comparisons.

Several systems could be used for this purpose; however, FIGS. 3 and 4 illustrate one such system.

Referring now to FIGS. 3 and 4, control line 80 is provided with a reject timer 82 having a reject mechanism 84. The purpose of these elements will be explained later. The start button 90 includes switches 92, 94 for connecting the oscillator 26 across the inductors or a low power source, such as oscillator 100, across the inductors. The use of a second oscillator is only schematic in nature. In fact, appropriate switching is provided for reducing the output of the basic heating oscillator. The use of a second oscillator 100 is illustrated because it more clearly depicts the present invention.

Servo-mechanisms 110, 112, 114 and 116 are substantially identical and each is connected to a known voltage source 120 by leads 122 and to a ground potential by lines 124. The status of the respective servo-mechanisms is directed to a shift control 130 through lines 132, 134, 136 and 138, respectively. This shift control actuates shift relays 140 to close power switch 142 and open adjusting switch 144 and reference switch 146, after all servo-mechanisms have indicated that the magnetic coupling of the respective inductors is within the desired range.

Consequently, in general operation, the start button 90 is depressed to close switches 92, 94. This directs a low power from oscillator 100 across the inductors which are connected in series. The servo-mechanism measures the voltage across the inductors and compares it with a known voltage 120. In a manner to be described later, this then actuates the reversible motors 70 for changing the coupling at the respective inductors. After all servo-mechanisms inform the shift control that the magnetic couplings of each inductor are within the proper range, the shift control creates a signal through line 141 to actuate the shift relay 140. This closes switch 142 and opens switches 144 and 146. Consequently, the oscillator 26 is then connected across the inductors for inductively heating the respective valve seats. Thereafter, the heating cycle is terminated in accordance with normal practice and the valve seats are quench hardened, by a mechanism not shown. When switch 94 is closed, reject timer 82 is actuated. After a preselected time, the reject timer actuates a reject mechanism 84 to indicate that at least one valve seat in the engine block is defective and the inductor associated therewith can not be properly coupled. The timer can be set for a desired time, such as 5 seconds. In this manner, if the shift control 130 does not actuate shift relay 140 within 5 seconds, the reject mechanism 84 notifies the operator that the engine block being handled must be removed from the automatic line and handled separately.

Each of the servo-mechanisms 110, 112, 114 and 116 are identical; therefore, a description of one of

these mechanisms will apply equally to the others. Servo-mechanism 110, as shown in FIG. 4, includes a voltage sensor 150 connected across input leads 32, 34 of the inductor 10. The voltage across the inductor, creates a signal which is directed through line 152. At the same time, a reference voltage device 160 which is controlled by an appropriate dial 162 directs a reference signal through lines 164. This reference signal corresponds to the desired coupling for inductor 10 which has been determined experimentally. The signals through lines 152, 164 are directed to a comparator 170 which has an output line 172. Positive or negative signals are directed through line 172 to a servo-control 180 and output lines 182, 184 connected with the reversible motor 70. In accordance with the signal in line 172, the motor is operated to adjust the core tip 52 into the proper relationship with respect to the inductor 10. After the proper adjustment has been made, comparator 170 conducts a signal through line 132 to the shift control 130 indicating that inductor 10 is properly coupled. Of course, various arrangements can be used for accomplishing the adjustment. It can be done incrementally or continuously. When continuous operation is used, comparator 170 or servo-control 180 should be provided with an appropriate arrangement to prevent hunting as the difference between the actual coupling and the desired coupling is reduced. In practice, a range of desired coupling is provided to prevent hunting of the servo mechanism 110.

The power level of oscillator 100 or the reduced power level of oscillator 26, when used for the adjusting cycle, should be sufficient to prevent any heating of the valve seat. The reduction of the power level to 5-15 percent adequately prevents heating during the adjusting cycle. Of course, other reduced power levels could be used for this purpose.

Having thus defined my invention, I claim:

1. In a device for inductively heating several generally circular valve seats of an engine block simultaneously, said device comprising a plurality of inductors, means for positioning said inductors in heating

relationship with said valve seats with each of said inductors magnetically coupled with one of said seats,

and power means for energizing said inductors whereby said valve seats are inductively heated, the improvement comprising: means for generating a plurality of first electrical signals each proportional to the actual magnetic coupling between one of said inductors and its associated valve seat; means for comparing each of said first electrical signals with a second signal corresponding to a desired magnetic coupling of each inductor; and means responsive to the difference between said first and second signals for automatically and individually adjusting the magnetic coupling of each inductor from said actual sensed coupling toward said desired coupling, each of said first signal generating means includes means for connecting one of said inductors into an electrical circuit having a known current insufficient to cause heating of said seat associated with said one inductor and means for generating a signal representative of the voltage drop across said one inductor which signal is said first signal.

2. The improvement as defined in claim 1 wherein said adjusting means includes a core of electrically conductive material movable within each of said inductors and means for adjusting the position of each core with respect to its associated inductor.

3. The improvement as defined in claim 1 including timer means for stopping said adjusting means after a preselected time.

4. A method of positioning an inductor with respect to a generally circular valve seat of an engine block, said method comprising the steps of:

- positioning said inductor with respect to said valve seat;
- applying a constant current across said inductor;
- measuring the voltage across said inductor to create a signal representative of the actual coupling of said inductor with said seat;
- comparing said signal with a reference signal to determine the difference between said signals; and,
- adjusting the coupling between said inductor and said seat in accordance with said difference.

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