The opinion in support of the decision being entered today was not written for publication and is not binding precedent of the Board.

Paper No. 14

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE BOARD OF PATENT APPEALS
AND INTERFERENCES

Ex parte ERIC D. THOMAS

Appeal No. 2002-0584
Application 09/321,028

ON BRIEF

Before STAAB, MCQUADE, and NASE, Administrative Patent Judges.

MCQUADE, Administrative Patent Judge.

DECISION ON APPEAL

Eric D. Thomas appeals from the final rejection of claims 1 through 29, all of the claims pending in the application.

THE INVENTION

The invention relates to "a system and method for controlling fuel injection of fuel injectors in an internal combustion engine" (specification, page 1). Representative claims 1 and 11 read as follows:

1. A method for controlling fuel delivery from a fuel injector, the method comprising:
determining a first desired engine torque output;
determining engine speed;

determining a first quantity of fuel to be delivered by the fuel injector based on the first desired engine torque output and the engine speed;

determining an injection pressure; and

determining a first amount of time for energizing the fuel injector in order to deliver the first quantity of fuel based on the injection pressure.

11. A system for controlling fuel delivery from a fuel injector having an electronic control valve, the fuel injector being in communication with a fuel rail, the system comprising:

a crankshaft sensor for sensing rotational speed of the crankshaft;

a fuel pressure sensor for measuring fuel pressure in the fuel rail;

a microprocessor in communication with the crankshaft sensor, the fuel pressure sensor and the electronic control valve, the microprocessor including instructions for determining a first desired engine torque output, instructions for determining engine speed based on the rotational speed of the crankshaft, instructions for determining a first quantity of fuel to be delivered by the fuel injector based on the first desired engine torque output and the engine speed, instructions for determining fuel pressure in the fuel rail using the fuel pressure sensor, instructions for determining a first amount of time for energizing the electronic control valve in order for the fuel injector to deliver the first quantity of fuel based on the fuel pressure and the first quantity of fuel, and instructions for generating an output signal for the electronic control valve corresponding to the first amount of time.

THE PRIOR ART

The references relied on by the examiner to support the final rejection are:

Takeuchi et al. (Takeuchi)	5,402,760	Apr. 4, 1995
Weisman, II et al. (Weisman)	5,647,317	Jul. 15, 1997

THE REJECTION

Claims 1 through 29 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Weisman in view of Takeuchi.

Attention is directed to the appellant's main and reply briefs (Paper Nos. 9 and 11) and to the examiner's first Office action and answer (Paper Nos. 3 and 10) for the respective positions of the appellant and the examiner with regard to the merits of this rejection.[1]

DISCUSSION

I. The references

Weisman, the examiner's primary reference, discloses a method and system for controlling an internal combustion diesel engine 22 composed of a plurality of electronic unit injectors 34 corresponding to respective engine cylinders and a plurality of sensors 36 for detecting various engine operating conditions (see column 6, lines 20 through 25). The control system includes an electronic control unit 20 comprising a microprocessor 24, volatile RAM 26, non-volatile ROM 28, and optionally other types of memory such as EPROM AND EEPROM, with the ROM containing

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[1] Although the examiner refers in the answer to the final rejection (Paper No. 7) for an explanation of the rejection, the explanation actually appears in the first Office action.

"instructions, which are executed to perform various control and information functions, as well as data tables, which contain calibration values and parameters which characterize normal engine operation" (column 6, lines 2 through 5).

Weisman's Figure 2 illustrates a representative processing sequence involving the determination of a desired engine torque for a particular engine cycle. As described by Weisman,

> [t]his typically involves a combination of retrieving values from tables stored in ROM 28 and determining an appropriate torque based on these values. The retrieved values are a function of engine operating parameters, such as engine RPM, throttle position, or coolant temperature, such that a particular parameter value, or combination of values, corresponds to a memory location which contains the table entry. The resulting, desired engine torque, determined by this function is an initial value which is then communicated to additional control functions for further processing as described below.
>
> In function 58, also shown in FIG. 2, the desired engine torque determined by function 56 is used to specify the quantity of fuel required to deliver that desired torque based on a plurality of engine operating conditions. In the preferred embodiment, the quantity of fuel is represented as an angular displacement of the crank required to energize a control solenoid associated with an EUI 34 for allowing fuel to be injected into the cylinder. Furthermore, as detailed below, the desired torque can be attained by allocating the quantity of fuel to be injected into a particular cylinder, to more than one discrete fuel injection. Thus, in any cylinder, during a single firing cycle, fuel is injected during at least one discrete fuel injection event. As is known, this method is effective in reducing combustion noise when near idle speed which is associated with ignition delay.

> The quantity of fuel determined by function 58 may be adjusted by function 60, which performs cylinder balancing, to enhance qualitative attributes such as noise and vibration. For example, in the preferred embodiment, if the engine speed is at or close to idle speed, the pulse width signal to the integral fuel pump injectors may be adjusted to more evenly distribute the power contribution of each cylinder. . . .
> . . .
> Continuing now, with reference to FIG. 2, function 64 controls fuel delivery to the engine cylinders by energizing the control solenoid of the appropriate EUI 34, at the appropriate time, for the period of time determined by function 62 [column 7, line 11, through column 8, line 11].

The delivery of fuel to a cylinder in two discrete injections is known as split injection and consists of a first pilot injection followed by a delay and then a second main injection (see column 14, lines 50 through 63). In Weisman's words,

> [a]s also shown in FIG. 6b, the Final Torque 214 is divided into a Pilot Torque (PTQ) 220 and a Main Torque (MTQ) 222. The value of PTQ 220 is the lesser of the Final Torque 214 and a pilot torque limiting value, EPIPTQ, not shown. The value of MTQ 222 is simply PTQ 220 subtracted from the Final Torque 214. If split injection is disabled, then Final Torque 214 equals PTQ 220 and MTQ 222 equals zero.
> The quantity of fuel to be delivered is represented by the amount of angular displacement of the crank, preferably measured in degrees, during which a control solenoid of an appropriate EUI 34 is energized. This signal is referred to as the fuel pulse width. Two Provisional Pulse Width (PROVPW) values are calculated, subject to further adjustment by other functions such as Cylinder Balancing 230, and limited by a maximum pulse width parameter, MAXPW. The value of PROVPW is found in a look-up table referenced

> by engine operating parameters, such as engine speed and desired torque. In the preferred embodiment, the desired torque used for this look-up function will be either MTQ 222 or PTQ 220 such that two PROVPW values are obtained. The Provisional Pilot Pulse Width (PPP) 224 corresponds to the value of PTQ 220 while the Provisional Main Pulse Width (PMP) 228 corresponds to the value of MTQ 222. The values of PPP 224 and PMP 228 are the lesser of PROVPW and MAXPW, with PROVPW corresponding to MTQ 222 or PTQ 220 as noted immediately above [column 14, line 64, through column 15, line 22].

Takeuchi discloses a fuel injection control apparatus and method for an internal combustion diesel engine 2 having a fuel pump 5, a common fuel rail 4, a plurality of injectors 3 and an ECU (electronic control unit) 6. The ECU 6 controls fuel injection pressure in the common rail 4, and uses the fuel injection pressure to determine fuel injection timings and periods.

With respect to fuel injection pressure control, Takeuchi teaches that

> [t]he ECU 6 is associated with a rotational speed sensor 7 and an accelerator sensor 8 each serving as a driving condition detecting means. The rotational speed sensor 7 detects an engine rotational speed Ne, and the accelerator sensor 8 detects an accelerator opening degree Acc representing an engine load. Although not shown in the drawing, some other sensors such as a cooling water temperature sensor, an intake air temperature sensor, and an intake air pressure sensor are provided as one of a driving condition detecting means.

> The ECU 6 receives the information detected by the driving condition detecting sensors (7, 8,-) and performs a feedback control of the common rail pressure to obtain an optimum fuel injection pressure, so that the combustion condition of the diesel engine 2 can be optimized in accordance with the detected driving condition [column 6, lines 52 through 68].

The ECU 6 also controls fuel injection based on a number of sensed parameters such as engine rotational speed Ne, accelerator opening degree Acc, cooling water temperature Tw, intake air temperature Ta, intake air pressure Pa and common rail fuel pressure Pc (see column 7, line 1 et seq.). Of particular interest is the role common rail fuel pressure Pc plays in determining injection timings and periods (see column 8, lines 58 through 68; column 10, lines 33 through 42; and column 14, lines 41 through 50). As explained by Takeuchi (see column 15, lines 1 through 5), a positive correlation exists between the common rail pressure and the amount of fuel injected per unit time.

II. Claim 1

Weisman teaches, or would have suggested, a method meeting all of the limitations in independent claim 1 (reproduced above) except for those relating to injection pressure. The appellant's contention that Weisman also lacks response to the limitation in the claim requiring the step of determining a first quantity of fuel to be delivered by the fuel injector based on the first desired engine torque output and engine speed (see pages 5 and 6 in the main brief) is not persuasive. As indicated above, Weisman expressly discloses that the quantity of fuel to be injected is based on desired engine torque and engine speed (see Weisman at column 7, lines 8 through 54; and at column 15, lines 4 through 22). The limitation in question does not, as implied by the appellant, exclude Weisman's representation of the fuel amount in terms of an angular displacement of the crank or a pulse width value.

As for the injection pressure limitations in claim 1, Takeuchi's disclosure of the relationship between common rail pressure (i.e., injection pressure) and the amount of fuel injected per unit time, and the use of this relationship in a engine control method to determine fuel injection periods based on sensed common rail pressure, would have suggested modifying the method disclosed by Weisman by incorporating such steps, thereby arriving at the subject matter recited in claim 1. The requisite motivation for the modification stems from the self-evident benefit of attaining accurate injection periods (i.e., accurate fuel injector energizing times). Contrary to the position taken by the appellant (see page 6 in the main brief and pages 1 and 2 in the reply brief), the reference combination does not involve any undesirable redundancies.

Accordingly, we shall sustain the standing 35 U.S.C. § 103(a) rejection of claim 1 as being unpatentable over Weisman in view of Takeuchi.

III. Claim 10

Independent claim 10 recites a method of controlling fuel delivery to a cylinder of an internal combustion engine comprising, inter alia, the steps of determining pilot and main quantities of fuel to be delivered by a fuel injector and determining pilot and main amounts of time for energizing the fuel injector to deliver these quantities of fuel, "wherein determining the pilot amount of time and determining the main amount of time are performed independently of angular measurements associated with an engine crankshaft." As indicated above, angular displacement of the crankshaft constitutes a factor in Weisman's determination of pilot and main amounts of time for energizing a fuel injector. There is nothing in the combined teachings of Weisman and Takeuchi which would have suggested making this determination independent of the angular displacement of the crankshaft.

Therefore, we shall not sustain the standing 35 U.S.C. § 103(a) rejection of claim 10 as being unpatentable over Weisman in view of Takeuchi.

IV. Claim 11

Weisman teaches, or would have suggested, a system meeting all of the limitations in independent claim 11 (reproduced above) except for those relating to the fuel pressure sensor and the instructions pertaining to the fuel pressure. The appellant's arguments that Weisman also lacks response to the limitations relating to the quantity of fuel are similar to those advanced with respect to claim 1, and are unpersuasive for the same reasons. As for the fuel pressure sensor and instruction limitations in the claim, Takeuchi would have suggested the incorporation of such features into the Weisman system for the reasons discussed above in connection with claim 1.

Thus, we shall sustain the standing 35 U.S.C. § 103(a) rejection of claim 11 as being unpatentable over Weisman in view of Takeuchi.

V. Claim 12

Independent claim 12 recites a computer readable storage medium having information stored thereon representing instructions executable by an engine controller to control fuel delivery from a fuel injector having an electronic control valve, with the fuel injector being in communication with a fuel rail. The claim further requires the computer readable storage medium to comprise instructions for determining (1) a first desired engine torque output, (2) engine speed, (3) a first quantity of fuel to be delivered by the fuel injector based on the first desired engine torque output and the engine speed, (4) fuel pressure in the fuel rail and (5) a first amount of time for energizing the control valve in order for the fuel injector to deliver the first quantity of fuel based on the fuel pressure in the fuel rail. For reasons essentially similar to those expressed above in connection with claims 1 and 11, the combined teachings of Weisman and Takeuchi, with focus on Weisman’s disclosure of an electronic control unit comprising a microprocessor and ROM containing instructions for executing various control functions, would have suggested the computer readable storage medium set forth in claim 12 to one of ordinary skill in the art.

Consequently, we shall sustain the standing 35 U.S.C. § 103(a) rejection of claim 12 as being unpatentable over Weisman in view of Takeuchi.

VI. Claims 2 and 13

Claims 2 and 13 depend from independent claims 1 and 12, respectively, and contain limitations similar to those in independent claim 10 relating to the determination of valve energizing time independently of angular measurements associated with an engine crankshaft. For the reasons expressed above in connection with claim 10, the combined teachings of Weisman and Takeuchi would not have suggested this subject matter.

Accordingly, we shall not sustain the standing 35 U.S.C. § 103(a) rejection of claims 2 and 13 as being unpatentable over Weisman in view of Takeuchi.

VII. Claims 5, 15 and 23

Claims 5, 15 and 23 depend ultimately from independent claims 1, 12 and 11, respectively, and pertain to the determination of a desired injection pressure based on desired engine torque and engine speed. As indicated above, Takeuchi discloses the determination of a desired injection pressure based on, among other parameters, engine speed. Given the importance placed by Weisman on desired engine torque as an engine operating parameter, the combined teachings of these references, applied as above, would have suggested the determination of a desired injection pressure based on desired engine torque as well as engine speed, and hence would have rendered the subject matter recited in claims 5, 15 and 23 obvious to one of ordinary skill in the art.

Accordingly, we shall sustain the standing 35 U.S.C. § 103(a) rejection of claims 5, 15 and 23 as being unpatentable over Weisman in view of Takeuchi.

VIII. Claims 7, 16 and 24

Claims 7, 16 and 24 depend ultimately from claims 1, 12 and 11, respectively, and pertain to the determination of a desired acceleration mode, and the modification of the desired injection pressure based on the desired acceleration mode. Takeuchi's disclosure of controlling injection pressure based on, among other parameters, accelerator opening degree (see column 6, lines 52 through 68), considered within the context of the combined teachings of Weisman and Takeuchi as applied above, would have suggested this subject matter.

Therefore, we shall sustain the standing 35 U.S.C. § 103(a) rejection of claims 7, 16 and 24 as being unpatentable over Weisman in view of Takeuchi.

IX. Claims 8, 17 and 25

Claims 8, 17 and 25 depend ultimately from claims 1, 12 and 11, respectively, and pertain to the determination of engine temperature and the modification of the desired injection pressure based the engine temperature. Takeuchi's disclosure of controlling injection pressure based on, among other parameters, cooling water temperature (see column 6, lines 52 through 68), considered within the context of the combined teachings of Weisman and Takeuchi as applied above, would have suggested this subject matter.

Thus, we shall sustain the standing 35 U.S.C. § 103(a) rejection of claims 8, 17 and 25 as being unpatentable over Weisman in view of Takeuchi.

X. Claim 21

Claim 21 depends ultimately from claim 1 and pertains to the determination of rail pressure in a fuel rail connected to the fuel injector, and the generation of an output signal for controlling the fuel pump system based on the difference between the desired injection pressure and the rail pressure. Takeuchi's disclosure of the feedback control of rail pressure to obtain an optimum fuel injection pressure (see Figure 4 and column 6, lines 52 through 68), considered within the context of the combined teachings of Weisman and Takeuchi as applied above, would have suggested this subject matter.

Hence, we shall sustain the standing 35 U.S.C. § 103(a) rejection of claim 21 as being unpatentable over Weisman in view of Takeuchi.

XI. Claims 3, 4, 6, 9, 14, 18 through 20, 22 and 26 through 29

Finally, we shall sustain the standing 35 U.S.C. § 103(a) rejection of dependent claims 3, 4, 6, 9, 14, 18 through 20, 22 and 26 through 29 as being unpatentable over Weisman in view of Takeuchi since the appellant has not challenged such with any reasonable specificity, thereby allowing these claims to stand or fall with independent claims 1, 11 and 12 from which they variously depend (see In re Nielson, 816 F.2d 1567, 1572, 2 USPQ2d 1525, 1528 (Fed. Cir. 1987)).

SUMMARY

The decision of the examiner to reject claims 1 through 29 is affirmed with respect to claims 1, 3 through 9, 11, 12 and 14 through 29, and reversed with respect to claims 2, 10 and 13.

No time period for taking any subsequent action in connection with this appeal may be extended under 37 CFR § 1.136(a).

AFFIRMED-IN-PART

LAWRENCE J. STAAB Administrative Patent Judge	) BOARD OF PATENT
JOHN P. MCQUADE Administrative Patent Judge	) APPEALS AND) INTERFERENCES
JEFFREY V. NASE Administrative Patent Judge	)

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