THIS OPINION WAS NOT WRITTEN FOR PUBLICATION

The opinion in support of the decision being entered today (1) was not written for publication in a law journal and (2) is not binding precedent of the Board.

Paper No. 30

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE BOARD OF PATENT APPEALS
AND INTERFERENCES

Ex parte PIERO P. BONISSONE,
KENNETH HSIN-CHAO CHIANG,
MARK E. DAUSCH,
and JAMES B. COMLY

Appeal No. 96-4014
Application 08/192,939[1]

ON BRIEF

Before HAIRSTON, KRASS, and BARRETT, Administrative Patent Judges.

BARRETT, Administrative Patent Judge.

DECISION ON APPEAL

[1] Application for patent filed February 7, 1994, entitled "Fuzzy Hierarchical Controller For A Turboshaft Engine," which is a continuation of Application 07/909,290, filed July 6, 1992, now abandoned.

This is a decision on appeal under 35 U.S.C. § 134 from the final rejection of claims 7-16 and 18-20, all of the claims pending in the application. Claims 1-6 and 17 have been cancelled.

We affirm-in-part.

The disclosed invention is directed to a fuzzy logic control system for controlling a turboshaft engine as can be understood from claim 7 reproduced below.

> 7. A control system for controlling a turboshaft or an aircraft engine comprising:
>
> a plurality of low-level controllers adapted to receive engine signals, each of said low-level controllers operable to output a control variable value that is based upon said received engine signals; and
>
> a fuzzy logic hierarchical controller connected to said plurality of low-level controllers to receive each of said control variable values, said fuzzy logic hierarchical controller being adapted to generate a single output value for each control variable which is used for controlling said aircraft engine, the single output value is an aggregation of said control variable values received from said plurality of low-level controllers, wherein the aggregation is a weighted sum of said control values.

The examiner relies on the admitted prior art in the specification and the following reference:

Hisano	5,249,258	September 28, 1993 (effective filing date September 28, 1989)

Claims 7-16 and 18-20 stand rejected under 35 U.S.C. § 103 as being unpatentable over Hisano in view of the admitted prior art in the specification of a typical control scheme for a turboshaft engine.

The examiner's statement of the rejection is contained in the Final Rejection (Paper No. 21) and the Examiner's Answer (Paper No. 25). Appellants' position is set forth in the Brief (Paper No. 24).

OPINION

Grouping of claims

Appellants divide the claims into three main groups: (1) Group I - claims 7-13; (2) Group II - claims 14-16 and 18-19; and (3) Group III - claim 20. Within each group appellants argue some claims individually, i.e., claims 8, 12, and 13 in Group I (Brief, pages 11-12) and claims 18 and 19 in Group II (Brief, pages 17-18). These specifically mentioned claims cannot be said to fall with the broadest claim in the group. The examiner does not address claims 8, 12, 13, 18, and 19 in the Examiner's Answer. However, since the claims are addressed in the Final Rejection, we rely on the examiner's reasoning in the Final Rejection and will not remand to have the claims considered.

Obviousness

The independent claims are directed broadly to the concept of using a fuzzy logic controller for controlling a turboshaft engine. In our opinion, the issue is whether it would have been obvious to one of ordinary skill in the art to replace the mode selector in the prior art with a fuzzy logic controller.

The prior art of figure 2 shows a schematic diagram of a conventional turboshaft engine control system. A number of low level controllers are connected to a mode selector. The low level controllers are "designed to govern the engine when specific conditions or modes are sensed" (specification, page 3, lines 6-7). The low level controllers "examine various sensor readings from points within the engine and produce fuel flow and VATN angle derivatives" (specification, page 3, lines 8-10). "These rates then drop through a chain of minimums and maximums (min/max ladder) [in the mode selector] that selects one of those rates." Specification, page 3, lines 11-13. Fuel flow is the variable used to control the engine. Only one low level controller is active at a time. As shown in figure 3b, the fuel flow derivative can be clipped due to abrupt mode selection, which produces less than optimal performance (specification, page 3, line 24, to page 4, line 7).

Hisano is not the simplest reference to address because it contains complicated hardware implementation details that tend to

obscure the basic fuzzy logic principles and that are unnecessary to meeting the claim limitations. It will help simplify the analysis by noting Hisano is applied simply to show a fuzzy logic controller that takes sensor inputs, performs fuzzy logic operations on them, and outputs the results as a control signal. As a background of fuzzy logic for any judicial review, we cite the article Fuzzy set and systems, in McGraw-Hill Encyclopedia of Science & Technology (7th ed. 1992), pages 524-527. This article is not relied on to support the rejection and therefore does not raise a new ground of rejection. See In re Boon, 439 F.2d 724, 727-28, 169 USPQ 231, 234 (CCPA 1971) (standard work cited to support an officially noticed fact which plays a minor role does not raise a new ground of rejection).

To simplify the analysis we consider a single fuzzy computer (FC) in Hisano, e.g., FC 2 in figures 1 and 3. FC 2 is attached to MPU 1 and to a plurality of sensors 6a and to FC 3. FC 2 accepts the values of input variables (x1, y1 in the equation for figure 2, col. 3, lines 55-56; x, y, and z in equation (1), col. 5, line 26), via input controller 12. Figure 2 illustrates that the values of some fuzzy input variables (e.g., x3, y3) are obtained directly from sensors 6 (in dotted box 7), while the values of other fuzzy input variables (the antecedents to the rule, e.g., x1, y1) are obtained from the results of the

execution of a lower level fuzzy computer (FCb, FCc). FC 2 applies a plurality of fuzzy rules stored in fuzzy rule storage 9 (figure 4; col. 4, lines 9-14) to a waveform produce unit 50 in fuzzy rule register 11 which generates fuzzy membership functions (col. 6, lines 13-33). The fuzzy reasoning unit 14 generates a belongings degree and the reasoning is converted into an affirmed value in the defuzzifier 69 (cols. 6-8). While the hardware is complex, Hisano is seen to perform a typical fuzzy logic operation of applying a plurality of fuzzy logic rules to a plurality of input variable values, to get an affirmed or decided value which is an aggregation of weighted values.

Contrary to appellants' arguments that "Hisano has nothing to do with control but only to an improved reasoning computer system" (Brief, pages 10 and 16), Hisano does teach that the system can be used for control. See col. 3, lines 3-6: "Thus executed final reasoning results are displayed by a display included in the higher rank computer 1 or applied to other system associated therewith as control signal" (emphasis added).

The level of ordinary skill is not argued, so we find Hisano to be representative of the level of ordinary skill in the art in fuzzy logic computers and the admitted prior art to be representative of the level of ordinary skill in the art of control systems for turboshaft engines. See In re Oelrich,

579 F.2d 86, 91, 198 USPQ 210, 214 (CCPA 1978) ("the PTO usually must evaluate both the scope and content of the prior art and the level of ordinary skill solely on the cold words of the literature"); In re GPAC Inc., 57 F.3d 1573, 1579, 35 USPQ2d 1116, 1121 (Fed. Cir. 1995) (the Board did not err in adopting the approach that the level of skill in the art was best determined by the references of record). In addition, those of ordinary skill in the art must be presumed to know something about the art apart from what the references expressly disclose. In re Jacoby, 309 F.2d 513, 516, 135 USPQ 317, 319 (CCPA 1962).

In our opinion, it would have been obvious to one of ordinary skill in the art to replace the mode selector of the admitted prior art turboshaft engine control scheme in appellants' figure 2 with a fuzzy logic controller as taught in Hisano because Hisano discloses that the fuzzy control system can be applied in a control environment. Based on the record before us, we find additional motivation in that fact that it was well known in the control art to apply fuzzy logic controllers to a wide variety of control applications because fuzzy logic is often capable of better performance than traditional mathematical algorithms. (In arguing this additional finding involving the level of skill in the art in any judicial review, appellants should admit or deny the finding, and not avoid the issue by

arguing that the finding is not expressly supported in Hisano.) The fuzzy logic controller would take the same inputs from the low level controllers in figure 2 and provide the same single fuel flow output control value as the mode selector in figure 2. Fuzzy logic control inherently involves using a weighted sum of values as claimed. Although appellants disclose using specific engine parameters to define the modes of engine operation (specification, page 7) (i.e., as state variables), these specific variables are not argued. It is noted that while Hisano does not disclose any specific membership functions, neither do appellants. The fuzzy logic controller substituted in place of the mode selector would be a "fuzzy logic hierarchical controller" because it is in a hierarchical relationship to the low level controllers. Appellants' arguments have been considered, as discussed infra, but are not deemed persuasive. The rejection of claim 1 is sustained.

Hisano includes a memory 9 (figure 3) which stores a plurality of fuzzy rules which are fired (in the fuzzy rule register 11 and fuzzy reasoning unit 14) to assign predetermined weights, as recited in claims 8 and 14. The elements of FC 2 in Hisano assign predetermined weights to variable values, create a weighted distribution of output values, and aggregate the output values as recited in claim 20. The admitted prior art mode

selector of figure 2 teaches taking a plurality of input variable values from the low level controllers and computing the single output variable value of fuel flow (or fuel flow derivative as shown in appellants' figure 3b). It would have been obvious to one of ordinary skill in the art, seeking to substitute a fuzzy logic controller for the mode selector in the admitted prior art, to aggregate the control variable values from the low level controllers in the prior art into the single output value taught by the prior art. For the reasons stated with respect to claim 1, and the reasons further set forth in this paragraph, we sustain the rejection of claims 8-11, 14-16, and 20.

Hisano does not disclose or suggest proportional-integral controllers as recited in claims 12 and 18, or fuzzy proportional-integral controllers as recited in claims 13 and 19. The examiner states that the admitted prior art discloses that the low level controllers can be proportional-integral controllers (Final Rejection, page 4). Appellants argue in response (Brief, page 12) (emphasis added):

> Appellant agrees that this feature is disclosed in the specification at page 10, lines 1-5. However, this feature is not disclosed as prior art. Instead, this section provides a description of a function describing a conventional proportional-integral controller. <u>There is no statement disclosing that conventional proportional-integral controllers are currently being used or can be used with the prior art control system disclosed in Fig. 2 of Appellant's specification.</u> Therefore, it is submitted that the

description of the proportional-integral controller in Appellant's specification is not prior art.

The examiner does not address appellants' arguments. In our opinion, it would be misleading to argue that "[t]here is no statement disclosing that conventional proportional-integral controllers are currently being used or can be used with the prior art control system disclosed in Fig. 2 of Appellant's specification" (Brief, page 12), if appellants were in fact aware that proportional-integral controllers were used or can be used in the prior art control system. Thus, on this record, we have no evidence establishing a prima facie case of obviousness with respect to the proportional-integral controllers of claims 12 and 18 or the fuzzy proportional-integral controllers of claims 13 and 19. The rejection of claims 12, 13, 18, and 19 is reversed.

Appellants' arguments

1.

Appellants argue that Hisano does not disclose the claimed limitations of: (1) a plurality of low-level controllers; (2) a fuzzy logic hierarchical controller connected to the low-level controllers; and (3) the fuzzy logic hierarchical controller generating a single output value derived from an aggregation of control variable values. These three limitations are common to all three independent claims 7, 14, and 20.

(1) low-level controllers

Appellants argue (Brief, page 8):

> Hisano shows a multi-stage computer system which includes the MPU and the plurality of fuzzy reasoning computers (i.e., FC_a, FC_b, FC_c). Neither the MPU nor the fuzzy reasoning computers are considered to be analogous to the claimed low-level controllers. Instead of controlling engine signals like the claimed low level controllers, the MPU and the fuzzy reasoning computers analyze or reason large and complicated propositions.

The examiner states (Examiner's Answer, page 6):

> [A] plurality of low-level controllers is taught by Hisano on figures 2 and 4 and column 3, lines 50-68, his lower controllers, z1 ... zn and his all rules having at their consequent x1 or y1 executed in a particular FC and the synthetic reasoning result gained from results by the execution is applied to FCa from FCb or FCc as a decided value, thus a low-level controllers is taught by Hisano.

It is not clear from this explanation what structure in Hisano the examiner considers to be the controllers. A better statement of the examiner's position is that "[t]he multistage computers are fuzzy controllers" (Final Rejection, page 5), that is, the fuzzy computers FC are fuzzy controllers.

We find that the only control disclosed in Hisano is at the top level where the final reasoning can be applied as control signals (col. 3, lines 3-6). The lower level computers in Hisano do not control. However, the low level controllers are not claimed as performing any control. The "low-level controllers" are claimed as "operable to output a control variable value that

is based upon said received engine signals" (claims 7 and 14) or as "outputting a control variable value that is based upon the received engine signals" (claim 20). That is, the low level controllers are sensors. Hisano discloses a fuzzy computer performing fuzzy logic operations on input values from sensors and, in our opinion, this would have suggested to the artisan that the fuzzy computer could operate on the outputs from the low level controllers in the admitted prior art. Further, it is not necessary that Hisano disclose low level controllers because these are already present in the prior art.

(2) a fuzzy logic hierarchical controller

The examiner states that Hisano's MPU is analogous to the claimed fuzzy logic hierarchical controller (e.g., Examiner's Answer, pages 3 and 6). Appellants argue (Brief, page 8):

> Hisano's MPU does not disclose or suggest the fuzzy logic hierarchical controller. In particular, the MPU is the highest ranked computer in Hisano's multi-stage construction and does not utilize fuzzy logic.

It would have aided the rejection if the examiner had addressed appellants' arguments instead of just reiterating that the MPU is the fuzzy logic hierarchical controller. The MPU alone is not a fuzzy logic controller because it does not contain the fuzzy logic rule storage and reasoning structure of a fuzzy computer. Nevertheless, Hisano states with respect to figure 3 (col. 3, lines 41-47):

> The result of the reasoning is applied to the fuzzy conclusion storage unit 13 and transferred to MPU 1 through a conclusion storage controller 15 and the higher rank bus 8.
>
> The MPU 1 can freely access the fuzzy rule storage 9, the rule controller 10 and the conclusion storage controller 15 to execute and complete a desired reasoning.

Because the MPU executes a fuzzy logic reasoning together with fuzzy computer 2, the MPU and FC 2 act together as a fuzzy logic controller. Therefore, we find that Hisano discloses a fuzzy logic hierarchical computer.

(3) generating a single output value derived from an aggregation of control variable values

Appellants further argue (Brief, page 9):

> [T]he role of the MPU [in Hisano] is to request execution about a proposition to the highest ranked child fuzzy reasoning computer FC_a. Hisano does not disclose or suggest that the MPU be used to aggregate control variable values as in the claimed invention.

The examiner states that "Hisano teaches on [sic] figure 1, an aggregation of output values from lower level controllers to generate a single output value in order to control a system" (Examiner's Answer, page 6).

As discussed, because the MPU executes a fuzzy logic reasoning together with fuzzy computer 2, the MPU and FC 2 act together as a fuzzy logic controller even if the MPU alone is not a fuzzy computer. FC 2 aggregates control variable values (e.g., figures 10, 11, and 16). Although the examiner's reliance on the MPU alone as a fuzzy controller is misplaced, we think that the fuzzy logic teachings of Hisano are apparent. Hisano teaches that the system can be used for control (col. 3, lines 3-6), which suggests that the fuzzy logic can be applied to aggregate control variables.

2.

Appellants argue that "the admitted prior art fails to disclose or suggest teachings directed to the claimed limitations

of the fuzzy logic hierarchical controller that generates a single output value derived from an aggregation of control variable values, wherein the aggregation is a weighted sum of the control values" (Brief, pages 9 and 15). The prior art is not relied on for these teachings. One cannot show nonobviousness by attacking the references individually where the rejection is based on a combination of references. In re Keller, 642 F.2d 413, 426, 208 USPQ 871, 882 (CCPA 1981). Hisano is relied on for the teaching of a fuzzy logic controller that generates an output value that is an aggregation of control variable values.

Appellants further argue that "neither the MPU nor the mode selector suggest generating a single output value derived from an aggregation of control variable values, wherein the aggregation is a weighted sum of the control values" (Brief, page 9). The test is what the combined teachings of the references would have suggested to those of ordinary skill in the art. Id. at 425, 208 USPQ at 881. The admitted prior art mode selector of figure 2 teaches taking a plurality of input variable values from the low level controllers and computing the single output variable value of fuel flow (or fuel flow derivative as shown in appellants' figure 3b). As demonstrated by Hisano, one skilled

in the art would have known how to apply fuzzy logic to aggregate the control variable values into the single output value.

3.

Appellants argue that there is no motive to combine Hisano with the admitted prior art because "Hisano is directed to an improved reasoning computer system and not to an improved approach to handling control for a system with a large number of sensors" (Brief, page 10). Hisano does teach that the system can be used for control. See col. 3, lines 3-6: "Thus executed final reasoning results are displayed by a display included in the higher rank computer 1 or applied to other system associated therewith as control signal" (emphasis added). Hisano manifestly does use a large number of sensors as shown in figure 1.

4.

Appellants argue, with respect to claims 8 and 14 (Brief, page 11 and 14-15):

> The MPU disclosed in Hisano, which the Examiner has submitted is analogous to the claimed fuzzy hierarchical controller, does not use fuzzy reasoning and therefore does not disclose using fuzzy rules which fire predetermined controller weights. There is no suggestion of replacing the MPU with a fuzzy computer.

As discussed, because the MPU executes a fuzzy logic reasoning together with fuzzy computer 2, the MPU and FC 2 act together as a fuzzy logic controller even if the MPU alone is not a fuzzy computer.

CONCLUSION

The rejection of claims 7-11, 14-16, and 20 is sustained.

The rejection of claims 12, 13, 18, and 19 is reversed.

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

KENNETH W. HAIRSTON Administrative Patent Judge	)
ERROL A. KRASS Administrative Patent Judge	) BOARD OF PATENT APPEALS AND INTERFERENCES
LEE E. BARRETT Administrative Patent Judge	)

GENERAL ELECTRIC COMPANY
CRD Patent Docket Rm 4A59
P.O. Box 8
Building K-1 - Salamone
Schenectady, NY 12301