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UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

Ex parte SEAN S. STROUD
and MICHAEL J. PIOVOSO

Appeal 2015-002494
Application 12/777,508
Technology Center 3700

Before JAMES P. CALVE, LEE L. STEPINA, and SEAN P. O'HANLON, *Administrative Patent Judges*.

CALVE, *Administrative Patent Judge*.

DECISION ON APPEAL

STATEMENT OF THE CASE

Appellants appeal under 35 U.S.C. § 134 from the final rejection of claims 1–10 and 12–19. Appeal Br. 3. We have jurisdiction under 35 U.S.C. § 6(b).

We AFFIRM-IN-PART.

CLAIMED SUBJECT MATTER

Claim 1, 12, and 15 are independent. Claim 1 is reproduced below.

1. A method of controlling a rocket, the method comprising:
measuring a combustion chamber pressure within a combustion chamber of the rocket;
calculating a logarithm of the measured combustion chamber pressure;
calculating a difference between the logarithm of the measured combustion chamber pressure and a logarithm of a reference combustion chamber pressure value to generate an error signal;
filtering the error signal to generate a compensated total flow area control signal in a logarithm domain with a controller;
exponentiating the compensated total flow area control signal in the logarithm domain to provide a compensated total flow area control signal in the physical domain; and
moving at least one valve in communication with the combustion chamber in response to the compensated total flow area control signal in a physical domain.

REJECTIONS

Claims 1, 2, 5, 7–10, and 12–14 are rejected under 35 U.S.C. § 103(a) as unpatentable over Beardsley (US 3,948,042, iss. Apr. 6, 1976) and Hill (Hill and Peterson, *Mechanics and Thermodynamics of Propulsion,* Addison-Wesley, Reading 1965, pp. 19, 323–324, 330–337 (1965)).

Claim 3 is rejected under 35 U.S.C. § 103(a) as unpatentable over Beardsley, Hill, and Eicher (US 4,071,886, iss. Jan. 31, 1978).

Claim 4 is rejected under 35 U.S.C. § 103(a) as unpatentable over Beardsley, Hill, Eicher, and Ulyanov (US 6,609,060 B2, iss. Aug. 19, 2003).

Claim 6 is rejected under 35 U.S.C. § 103(a) as unpatentable over Beardsley, Hill, Eicher, and Morris (US 5,456,425, iss. Oct. 10, 1995).

Claim 15 is rejected under 35 U.S.C. § 103(a) as unpatentable over MacCallum (US 7,441,473 B2, iss. Oct. 28, 2008), and Hill.

Claims 16 and 19 are rejected under 35 U.S.C. § 103(a) as unpatentable over MacCallum, Hill, and Beardsley.

Claim 17 is rejected under 35 U.S.C. § 103(a) as unpatentable over MacCallum, Hill, Beardsley, and Eicher.

Claim 18 is rejected under 35 U.S.C. § 103(a) as unpatentable over MacCallum, Hill, Beardsley, Eicher, and Ulyanov.

ANALYSIS

Claims 1, 2, 5, 7–10, and 12–14 as unpatentable over Beardsley and Hill

Appellants argue claims 1, 2, 5, and 7–10 and claims 12–14 as groups. Appeal Br. 17–45. We select claims 1 and 12 as the representative claims of each group. 37 C.F.R. § 41.37(c)(1)(iv).

Claims 1, 2, 5, and 7–10

The Examiner found that Beardsley teaches the method of claim 1 by measuring combustion chamber pressure with transducer 28, calculating a difference between the measured pressure and a reference pressure to generate an error signal that is filtered to generate a total area flow control signal used to move servo valve 20. Final Act. 3. The Examiner found that Beardsley does not perform these calculations in a logarithmic domain. *Id.*

The Examiner found that Hill teaches that logarithmic calculations as conventional in the art for gas-dynamic and for rocket trajectory and motion calculations. *Id.* at 3, 5. The Examiner determined that it would have been obvious to perform Beardsley's operations in a logarithmic domain as a way to simplify those calculations by mapping them onto the logarithmic domain and reducing the rank of the calculations. *Id.* at 3–4.

Appellants argue that the Examiner concedes that Beardsley does not teach calculating a logarithm of a measured combustion chamber pressure, calculating a difference between the logarithm of the measured combustion chamber pressure and a reference combustion chamber pressure value, filtering the error signal to generate a compensated total flow area control signal, and exponentiating the compensated total flow area control signal, and that Hill does not teach or suggest these acts either. Appeal Br. 18.

This argument is not persuasive because the Examiner relied on the combined teachings of Beardsley and Hill to render there limitations obvious where Beardsley teaches these steps in a non-logarithmic domain and Hill teaches the use of logarithmic calculations for such and similar calculations.

Appellants also argue that the Examiner has not explained how or why a skilled artisan would have combined the mass flow ratio equations of Hill with Beardsley to obtain the claimed acts. *Id.* at 19. Appellants further argue that over 30 years have passed since Beardsley was patented, and the Examiner has not found any prior art teaching the claimed acts. *Id.* at 20.

These arguments are not persuasive of error in the Examiner's reasons for modifying the calculations of Beardsley to be in the logarithmic domain, as taught by Hill, to simplify the high order calculations by mapping them onto the logarithmic domain. Final Act. 3–4, 5–6. The Examiner's reasons are supported by rational underpinning and Appellants have not persuaded us of error in the Examiner's determination of obviousness. Nor is the Examiner combining mass flow ratio equations of Hill with the system of Beardsley. Instead, the Examiner is performing Beardsley's calculations in the logarithmic domain, for simplification, in view of Hill's teachings.

Appellants further argue that, in the Advisory Action, the Examiner's proposed transformation of Beardsley's inputs into the LaPlace domain to read on the claimed logarithmic calculations relies on an unreasonably broad interpretation of the claims. Appeal Br. 20–22. Appellants argue that their Specification does not state or imply that logarithmic calculations involve a LaPlace transform, and a skilled artisan would not equate these calculations understand a Laplace domain to teach a logarithm domain. *Id.* at 21–22.

Appellants' arguments are not persuasive because the Examiner did not rely on Laplace transforms to teach or suggest the claimed logarithmic calculations or to provide a basis for modifying Beardsley's calculations. *See* Ans. 3. The Examiner discussed the Laplace domain as an example of a common mathematical transformation used to simplify calculations as the Examiner proposes to do with Beardsley in view of Hill. *Id.* The Examiner also cited the slide rule as another example of a mathematical transformation into the logarithmic domain for ease of calculation. *Id.*

Appellants also argue that the Examiner failed to explain how Hill's disclosure of logarithmic relationships for changes in pressure, velocity and mass ratios, and distances and atmospheric densities would have motivated a skilled artisan to modify Beardsley to obtain the acts in question. Appeal Br. 23–24. Appellants argue that the mere existence of logarithmic relationships in Hill that do not apply to the specific process of Beardsley does not render obvious modifying teachings of Beardsley to obtain the acts in question. *Id.*

Appellants' arguments are not persuasive of error in the Examiner's determination that a skilled artisan would have been led by Hill's teachings to modify Beardsley's processes into the logarithm domain to *simplify* the calculations, and Hill teaches logarithmic calculations for similar processes.

Appellants further argue that reducing the order or rank of Beardsley's multiplication operations by placing them in a logarithmic domain would not have motivated a skilled artisan to modify Beardsley's operations to obtain the acts in question. Appeal Br. 25–27. Appellants also argue that not all logarithmic calculations are less memory-intensive and not all calculations of Beardsley are amenable to such simplification. *Id.* at 26–28.

These arguments are not persuasive of error in the Examiner's finding that logarithms are used for gas dynamics and rocket trajectory calculations or determination that it would have been obvious to perform Beardsley's calculations in a logarithmic domain to simplify those calculations. Nor do Appellants' arguments persuade us of error in the Examiner's findings that Beardsley discloses the steps of claim 1 by measuring the chamber pressure, calculating a difference between the measured pressure and a reference pressure value to generate an error signal, filtering the error signal with a proportional-Integrator (PI) filter to generate a total flow area control signal, and moving servo valve 20 in response thereto. Final Act. 3–4; Ans. 10. The Examiner relied on Hill to teach the use of logarithmic calculations in the same or similar environment, and to provide a motivation to modify Beardsley's processes to that domain with subsequent exponentiation. Final Act. 3–4. Even if logarithmic calculations do not simplify *all* calculations, as Appellants allege, a skilled artisan still would have been motivated to modify Beardsley when the advantages outweigh any alleged disadvantages. Ans. 7; Appeal Br. 29–30. Appellants' arguments that the range of values reduced by the modification of Beardsley (Appeal Br. 30–36) does not teach all of the limitations of claim 1 are not persuasive in view of the foregoing combined teachings of Beardsley and Hill relied upon by the Examiner.

The remainder of Appellants' arguments regarding the Examiner's remarks in the April 23, 2014, Advisory Action and an interview summary are not persuasive of error in the findings and determination of obviousness set forth by the Examiner in the Final Action and Answer.

Thus, we sustain the rejection of claims 1, 2, 5, and 7–10.

Claims 12–14

Independent claim 12 recites a rocket with a combustion chamber, a pressure sensor, at least one valve for regulating gas flow from the chamber, and a controller programmed to calculate a logarithm of a signal from the pressure sensor, determine and filter an error signal, and exponentiate the compensated control signal in the physical domain to cause the at least one valve to be positioned in response thereto. Appeal Br. 63.

The Examiner found that Beardsley teaches a rocket with combustion chamber 26, pressure sensor 28, valve 20, and controller 22 that performs the claimed control calculations but not in a logarithmic domain. Final Act. 5. The Examiner relied on Hill to teach logarithmic calculations for gas dynamics and rocket trajectory calculations. *Id.* The Examiner determined that it would have been obvious to perform Beardsley's calculations in the logarithmic domain to simplify high order calculations. *Id.* at 5–6.

Appellants argue that the Examiner has not provided any reasons to modify Beardsley's teachings with those of Hill and has not explained how a skilled artisan would have modified the teachings of Beardsley with those of Hill to obtain the controller of claim 12. Appeal Br. 45. Appellants also argue that there does not appear to be any reason for the combination. *Id.*

These arguments are not persuasive for the reasons discussed above for claim 1. Thus, we sustain the rejection of claims 12–14.

Claim 3 as unpatentable over Beardsley, Hill, and Eicher

Claim 3 depends from claim 2 and recites the step of changing a gain of an integrating filter of the proportional-plus-integral filter of claim 2 as a free volume of the combustion chamber increases. The Examiner found that Beardsley teaches filtering of the error signal with proportional amplifier 54 and integrated amplifier 64 as recited in claim 2, but does not teach changing the gain of the integrator. Final Act. 4, 6. The Examiner found that Eicher teaches changing the gain of the integrator for a rocket controller. *Id.* at 6 (citing Eicher, 3:27–62). The Examiner determined that it would have been obvious to combine Beardsley in view of Hill with Eicher's gain change in order to control for the non-linearity of rocket motors as taught by Eicher. *Id.* (citing Eicher, 4:63–5:23).

Appellants argue that the background section of Eicher relied upon by the Examiner teaches increasing the gain of a *feedback loop* in response to a component saturating, but does not teach or suggest that the feedback loop is an integrating filter of a proportional-plus-integral filter, as claimed. Appeal Br. 47. Appellants also argue that Eicher teaches a separate system having a supplementary device composed of integrators, but Eicher does not teach or suggest that a gain of any integrators in any integration stages changes. *Id.* Appellants further argue that a skilled artisan would not have combined the teachings of Beardsley and Eicher because Eicher teaches increasing gain in a feedback loop to stabilize a regulation system that tends toward instability due to a non-linearity of a saturatable component, whereas Beardsley teaches a control system that is not prone to excessive oscillation even under severe operating conditions. Reply Br. 33–34. We agree.

The Examiner's reason for combining teachings of Beardsley and Eicher "to control for the non-linearity of rocket motors as taught by Eicher in col. 4, l. 63 – col. 5, l. 23" is not supported by a rational underpinning. Final Act. 6; *see also* Ans. 11. The cited portion of Eicher describes the differences in processing feedback for a regulation circuit that operates in linear and non-linear modes of behavior, rather than the operation of rocket motors. Eicher, 4:63–67. When the regulation circuit exhibits *linear* behavior or operation, differences in feedback magnitude are processed in a supplementary device that includes integration states and integrators, but Eicher does not teach any gain of any of these integrators. Eicher, 4:26–38; *see also* Appeal Br. 47. When the regulation circuit exhibits *non-linear* operation, the action of the supplementary device is eliminated and the regulation circuit experiences the necessary accommodation to avoid instability while all of the integrators maintain the last output values that prevailed prior to the occurrence of the non-linear behavior. Eicher, 5:2–13. Thus, Eicher does not teach changing a gain of an integrator or integration stage when the supplementary device is used for linear operation, and Eicher teaches to retain the values of integrators unchanged during non-linear operation. Even if Eicher teaches to change a gain of some component of the regulation circuit during the non-linear operation to restore stability to the system, Beardsley teaches a control system that is not prone to excessive oscillation even under severe operating conditions. Beardsley, 3:38–40. Beardsley teaches the use of integrator-amplifier 64 as desirable in some cases to decrease chamber pressure steady-state error substantially to zero, but does not teach a change in gain in integrator-amplifier 64. *Id.* at 3:38–47. Thus, we do not sustain the rejection of claim 3.

Claim 4 as unpatentable over Beardsley, Hill, Eicher, and Ulyanov

The Examiner's reliance on Ulyanov to teach features of claim 4 does not overcome deficiencies of Beardsley, Hill, and Eicher as to claim 3 from which claim 4 depends. *See* Final Act. 7; *see also* Appeal Br. 49–50. Thus, we do not sustain the rejection of claim 4.

Claim 6 as unpatentable over Beardsley, Hill, Eicher, and Morris

The Examiner's reliance on Morris to teach features of claim 6 does not overcome deficiencies of Beardsley, Hill, and Eicher as to claim 3 from which claim 6 depends. *See* Final Act. 7–8; *see also* Appeal Br. 50–51. Thus, we do not sustain the rejection of claim 6.

Claim 15 as unpatentable over MacCallum and Hill

Claim 15 recites a method of evaluating a rocket design using a computer simulation system by calculating a combustion chamber pressure value for the rocket design, calculating a logarithm of that value and an error value based on the difference between that value and the predetermined pressure, filtering the error value to determine a compensated control signal, and exponentiating the compensated control signal in the physical domain.

The Examiner found that MacCallum teaches inputting parameters of rocket design into a memory of a simulation system (control computer 506), calculating combustion chamber pressure with controller 509, and correcting for errors. Final Act. 8. The Examiner also found that MacCallum does not teach doing calculations in the logarithmic domain and exponentiating the values to transform from that domain. *Id.* The Examiner relied on Hill for teaching the use of logarithms similar to claim 1. *Id.* at 8–9.

Appellants argue that MacCallum measures antechamber pressure rather than calculating combustion chamber pressure. Appeal Br. 52.

The Examiner has not established by a preponderance of evidence that MacCallum teaches the step of "calculating a combustion chamber pressure value for the rocket design" as recited in claim 15. MacCallum teaches a system for simulating dynamic flight environments during suborbital flight and its on-board flight-vehicle systems. MacCallum, 1:16–19. MacCallum also teaches that pressure is measured and controlled in main pressure vessel 124 to simulate onboard and extra-vehicular fast-changing environments that may occur during a complete suborbital flight by flight vehicle 103 and test various flight-vehicle systems. *Id.* at 5:63–6:11. Main pressure vessel 124 should match the size and volume of a suborbital vehicle's pressurized cabin and be of sufficient size to accommodate subsystems testing or crewmember training for a range of suborbital vehicle platforms. *Id.* at 9:3–18, Fig. 3. Control computer 506 communicates with hardware controller 509 to enable operation of antechamber pressure modulating computer program 505 that controls antechamber pressures in antechambers 126 of main pressure vessel 124. *Id.* at 8:47–60, Figs. 3, 4.

Thus, we do not sustain the rejection of claim15.

Claims 16–19 as unpatentable over MacCallum, Hill, and Beardsley, Eicher, or Ulyanov

The Examiner relied on Beardsley, Eicher, and Ulyanov to disclose features of dependent claims 16–19 and not to overcome any deficiencies of MacCallum or Hill as to claim 15, from which claims 16–19 depend directly or indirectly. Final Act. 9–11; *see also* Appeal Br. 55–57. Thus, we do not sustain the rejection of claims 16–19.

DECISION

We affirm the rejection of claims 1, 2, 5, 7–10, and 12–14, and reverse the rejections of claims 3, 4, 6, and 15–19.

No time period for taking any subsequent action in connection with this appeal may be extended under 37 C.F.R. § 1.136(a)(1)(iv).

AFFIRMED-IN-PART