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Datasheet for the decision of 13 December 2024

Case Number: T 1539/21 - 3.4.01

Application Number: 15793081.9

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Title of invention:
ENERGY EFFICIENT HIGH POWER PLASMA TORCH

Applicant:
Pyrogenesis Canada Inc.

Headword:
Plasma torch / Pyrogenesis

Relevant legal provisions:
EPC 1973 Art. 52(1), 56

Keyword:
Main request and auxiliary request - inventive step (no)

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Case Number: T 1539/21 - 3.4.01

D E C I S I O N
of Technical Board of Appeal 3.4.01
of 13 December 2024

Appellant: Pyrogenesis Canada Inc.
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Decision under appeal: **Decision of the Examining Division of the European Patent Office posted on 4 March 2021 refusing European patent application No. 15793081.9 pursuant to Article 97(2) EPC.**

Composition of the Board:

Chair P. Scriven
Members: T. Petelski
R. Romandini

Summary of Facts and Submissions

I. The Examining Division refused the application, because the subject-matter of claim 1 of the only claim request lacked an inventive step.

II. The decision is based on the following documents:

D1: WO 2006/058258 A1
D2: GB 1 268 843 A
D3: US 2005/0284374 A1
D9: WO 90/03095 A1
D10: WO 2013/134619 A1

III. The decision was appealed, and the appellant requested that it be set aside and that a patent be granted on the basis of the claims underlying the decision (main request), or, alternatively, on the basis of an auxiliary request, filed for the first time on appeal. The appellant unconditionally requested the scheduling of oral proceedings.

IV. During the appeal proceedings, which included oral proceedings, the appellant maintained their requests unchanged.

V. Claim 1 of the main requests reads as follows (reference signs omitted):

A gas heater plasma torch, comprising:

- a torch body,

- a tubular rear electrode mounted within the torch body,

- a pilot tubular electrode, mounted in front of the rear electrode,

- a tubular insert, mounted in front of the pilot electrode,

- a front electrode, mounted in front of the tubular insert,

- a housing mounted between both the electrodes and the tubular insert and the torch body to provide passages for a fluid coolant circulated through said passages,

- a first feeding system for providing the gas in a chamber between the rear electrode and the pilot electrode,

- a second feeding system for providing the gas in the tubular insert,

- a third feeding system for providing the gas in the front electrode,

- a power supply for sustaining an arc through the flow of gas provided by the feeding systems,

- an ignition system to ignite an arc discharge between the rear electrode and the pilot electrode, said arc being elongated in the tubular insert so as to reach the front electrode,

- a coordination system for coordinating the arc parameters of electrical current and voltage with the gas flows provided by the feeding systems, the first, second and third feeding systems include respectively first, second and third vortex generators,

wherein the coordination system is adapted to coordinate the arc parameters of electrical current and voltage with the gas flows provided by the feeding systems or vortex generators in such way that the arc attachment point on the surface of the pilot electrode and on the front electrode move rapidly on the said electrode surfaces in a circular motion as to distribute evenly the erosion of metal from the electrode, thereby extending the torch life.

VI. Claim 1 of the auxiliary request differs from claim 1 of the main request in the last part (amendment marked, reference signs omitted):

... as to distribute evenly the erosion of metal from the electrode, <u>and orifices are provided in a tubular insert at various locations, to inject a gas tangentially in a vortex flow around the arc column,</u> thereby extending the torch life.

Reasons for the Decision

The invention

1. The invention aims at providing a high-power plasma torch operating under high voltage and low current conditions, resulting in low electrode erosion and low maintenance costs, without suffering from the low energy efficiency typically associated with these conditions ([0046], [0047], considering also [0005] - [0011] of the published application).

2. This is achieved by equipping the torch with a pilot insert at a short distance from the cathode. The pilot insert acts as a temporary anode during the start phase of torch operation. After a plasma arc has been established between the cathode and the pilot insert, the voltage is switched from the pilot insert to a more distant anode, which is separated from the pilot insert by a thermally and electrically insulating tubular insert. Due to this measure, a long arc (and high voltage) can be established despite using a short anode, the short anode allowing a reduction of the energy transfer losses caused by the contact of the plasma gas with the cooled anode ([0048] - [0053], considering [0003] and [0004]).

3. Furthermore, plasma gas is injected at three locations along the plasma channel, in order to generate vortices that force the arc attachment point at the pilot insert or the anode to move along the tubular inner surface of the electrodes in a circular motion. Due to this additional measure, erosion is distributed evenly across the electrode surfaces ([0058], [0059]).

Main request - inventive step

4. D1 discloses a high-voltage, low current plasma arc torch (Figures 1 and 8; page 5, line 23) with a similar arrangement to the torch of claim 1, comprising a pilot insert (PI/126) acting as a temporary anode during the start phase, a more distant anode (A/130), and an inter-electrode (tubular) insert (IEI/128). Gas can be inserted at three distinct positions (136, 170, 172; Figure 8), in some embodiments with a swirl (page 11, lines 10 - 12 and page 12, lines 3 - 8). During operation, the torch is controlled by a coordination system ("control module" CT in Figure 1), which "may control the plasma electrical parameters, plasma gas flow rates; sequence of events", etc. (page 3, lines 19 - 21).

5. The Examining Division rightly found that D1 differed from the subject-matter of claim 1 in that the implicitly disclosed housing did not have passages for a fluid coolant.

6. According to the appellant, D1 additionally differed from the subject-matter of claim 1 in that the coordination system was not adapted to coordinate current and voltage with the gas flow in such a way that the arc attachment points on the pilot and front electrodes moved rapidly in a circular motion so as to distribute, evenly, the erosion of metal from the electrode.

7. The appellant pointed out that the tangential insertion of the plasma gas, in D1, was used to stabilize the anode root position, as disclosed on page 3, lines 28 to 30; and page 10, lines 19 to 23, and not to enable its rapid movement. Further, D1 taught that the plasma

gases were inserted in such a way as to control parameters of the plasma, like its temperature and velocity distribution, and not in order to generate a rotation of the arc root attachment. Disclosure for that was found on page 12, lines 9 to 15. The swirl of the plasma gas, in D1, did not necessarily cause a rotation of the root position and did not have the purpose of reducing erosion. In the appellant's view, none of D2, D9, and D10 contained sufficient evidence to prove that a swirl necessarily caused a rotation of the arc attachment point, and even less that the rotation was rapid, in the sense that it evenly distributed erosion.

8. The appellant added that the swirl disclosed in the embodiment according to Figure 9b was not compatible with the different embodiment of a plasma torch according to Figure 8.

9. The appellant's arguments are not compelling. First of all, because it is clear from the disclosure on page 11, lines 4 to 8, from the use of common reference signs, and from the technical content, that the cited passages on pages 11 and 12 are in conformity with the general setup of the plasma torch illustrated in Figures 1 and 8. The different "embodiments" are merely configurations of this common setup that employ certain flow rates, certain types of plasma gas, or, when referring to Figure 9b, a certain way of inserting the plasma gases.

10. Furthermore, the swirl of the plasma gas will inevitably have an effect on the plasma arc by causing the gas molecules to collide with the plasma arc ions, exerting a force on them in the circumferential direction. For the low-current torch in D1, this force

will easily be sufficient to overcome the tendency of the ions to follow the beaten path of the established arc, forcing the arc attachment to rotate about the rotationally symmetric anode surface.

11. Evidence for this physical phenomenon is found in D2, D9, and D10.

12. D2 discloses a plasma arc torch similar to that in D1. One of the goals of D2 is to reduce electrode erosion (page 1, lines 81 - 86), which is achieved by tangentially injecting the plasma gas, which causes the anode arc root to rotate round the anode throat, thereby distributing heat more evenly (page 1, lines 56 - 69).

13. D9 discloses a plasma arc torch, in which the position of the anode arc root is repeatedly changed between several electrodes during operation (page 4, lines 2 - 13; see also Figure 2). It further discloses a tangential injection of the plasma gas at various locations between the electrodes in order to introduce swirl in the gas stream (page 7, lines 16 - 21; Figure 1; page 8, lines 6 - 11). According to page 8, lines 11 - 15:

> *That swirl characteristic tends to cause the point of attachment between the arc and each electrode to rotate about the relevant surface of the electrode, thereby reducing localised heating and erosion of the electrode.*

14. D10 shares the fundamental setup of the plasma arc torch with D1 (compare Figure 1 of D1 and Figure 3 of D10). It discloses that the high efficiency gas swirl

of G2 (page 14, lines 5 - page 15, line 6) causes a rotation of the anode arc root, as long as the current stays at or below 500 A (page 12, lines 20 - 23). The swirl conditions at the pilot insert are comparable to those at the anode module, due to the vortex caused by the gas G1, and hence, an anode arc root rotation will also occur at the pilot insert. The arc rotation is necessary in order to "control the heat flux" to the anode (page 12, lines 20 - 23), thereby minimizing erosion, which is one of the purposes of the gas insertion (page 9, lines 17 - 20).

15. D1 operates under the same high-voltage, low-current conditions as D10 (D1: page 5, line 23; D10: page 7, lines 27 - 29) and uses currents between 300 and 500 Amperes (D1: page 10, lines 12 - 15), thereby fulfilling the condition for rotation of the arc attachment, similarly to D10 (page 5, line 16; page 7, lines 27 - 29; page 12, lines 8 - 24).

16. Hence, considering the low currents used in D1, the technical information in D2, D9, and D10 supports the conclusion that the swirl of the gas at the location of the pilot insert and at the location of the anode module in D1 will inevitably cause a rotation of the respective anode arc root. This rotation will distribute the erosion over the movement path and, thereby, increase the lifetime of the anodes, regardless of whether this was intended by the designer of D1 or not. The same physical effect is stated in [0059] the (published) application:

> *The gas 19 is injected tangentially with respect to the anode surface, primarily, in order to force the arc attachment point to move rapidly on the anode surface in a*

> *circular motion as to distribute evenly the erosion of metal from the electrode ....*

17. Similarly to D2, D9, and D10, the arc attachment points in D1 will move "rapidly" enough (i.e. at least one full revolution) to cause an even distribution of erosion over the duration of the torch's use in at least some of its possible applications.

18. The opponent rightly noted that D1 was concerned with the stabilization of the arc root position. A stabilization can be achieved, for example, by using an anode with a rounded edge (page 7, lines 22 - 25; Figure 4c), or by providing the anode with a rotationally symmetric step, to which the arc may attach (step 162 in Figure 7; page 10, lines 19 to 23). According to the paragraph spanning pages 3 and 4 of D1, such a step "may stabilize the arc root position", which results in "stability of the arc length and related voltage".

19. From this, the skilled person understands that the stabilization in D1 only refers to a stabilization of the arc length, and, hence, of the axial position. Not only does the rotational symmetry of the step and the edge impede a stabilization of the arc attachment point in the circumferential direction, but it is also implausible from a physical point of view that the swirl of the plasma gas could stabilize the arc attachment point in the circumferential direction. It would also counteract the purpose of reducing erosion and prolonging electrode life, to force the arc to impinge on the same point on the anode for a prolonged period of time.

20. In fact, it is generally known, in the field of plasma arc torches, that it is the axial fluctuation of the arc attachment point ("arc shunting") that causes undesired voltage pulsation (see D10: page 5, lines 5 - 8; and page 11, line 26, to page 12, line 6). Introducing the plasma close to the anodes and in a swirl improves "anode arc root attachment rotation and stabilization" and reduces "excessive axial fluctuation of arc root position" (D10: page 14, lines 12 - 18).

21. Hence, the coordination system defined in claim 1 is disclosed by D1. Accordingly, the Examining Division correctly found that the subject-matter of claim 1 differed from D1 only in that the housing had passages for a fluid coolant.

22. Starting from D1, the objective technical problem is to cool the electrodes. The skilled person would have been aware that excessive heating of the electrodes was a common problem with all high-power plasma arc torches, caused by the plasma transferring large amounts of heat to its attachment points on the electrodes, thereby causing erosion and reducing lifetime. D1 proposes to enhance the cooling conditions at the cathode through a flush configuration of the cathode with regard to the cathode holder, which "may result in a longer life of the cathode" (page 9, line 28, to page 10, line 5; Figure 6b). The flush cathode configuration, however, comes at the cost of higher voltage requirements (page 9, lines 26 - 31), and it does not mitigate the problem of erosion at the anodes.

23. In its decision, the Examining Division found that the skilled person, faced with that problem, would have adopted the idea, from D2, of using water cooling (see page 1, lines 28 - 29 and 64 - 69; page 2, lines 4 - 9,

12 - 13, and 37 - 39) in D1, thus arriving at the subject-matter of claim 1.

24. The appellant's argumentation on inventive step was based exclusively on the alleged distinguishing feature of the coordination system, which, however, is not recognized by the Board. Hence, the appellant's arguments in this respect are moot, and need not be discussed. The Examining Division's reasoning, based on the coolant passages as the only distinguishing feature, on the other hand, was not addressed by the appellant. As the Examining Division's argumentation appears persuasive, and as the appellant did not say why it was wrong, the Board endorses the Examining Division's conclusion.

25. Therefore, the subject-matter of claim 1 does not involve an inventive step, in view of a combination of D1 with the cooling system of D2 (Articles 52(1) and 56 EPC).

26. It is noted that, even under the assumption that the tangential insertion of the plasma gases in D1 did not cause a rotation of the arc attachment points, the subject-matter of claim 1 would still not have involved an inventive step. Under that assumption, the rapid circular movement of the arc attachment point would have been a second difference from the subject-matter of claim 1, which is unrelated to the first difference of the cooling passages. The objective technical problem related to the second difference would have been to increase the lifetime of the anodes. The skilled person, looking for a solution, would have found one in D10. As the geometry of the plasma torch and the current of the plasma arc in D10 are similar to those in D1, the only parameter that would have had to

be changed would have been the flow rate of the plasma gas. Considering D10, the skilled person would have increased the flow rate of the plasma gas in D1 to a level that was sufficient to force a movement of the arc attachment point, which would have brought the significant advantage of a prolonged lifetime of the anodes, without any apparent disadvantage.

27. Hence, the main request is not allowable.

Auxiliary request - inventive step

28. Irrespective of the question of admission of the auxiliary request into the proceedings, the answer to which is left open, the auxiliary request is not allowable, as will be shown in the following.

29. Claim 1 differs from that of the main request in the further definition that "orifices are provided in a tubular insert at various locations, to inject a gas tangentially in a vortex flow around the arc column".

30. The indefinite article, "a", in front of "tubular insert" signifies that the tubular insert with the orifices is not necessarily the one that is previously defined in the claim.

31. Figure 8 of D1 shows a plasma arc torch, in which the plasma gas is inserted through passages 136, 170, and 172 (page 11, lines 7 - 23). In some embodiments (page 11, line 27 to page 12, line 16; Figures 9a and 9b), the insertion is realized by "distribution elements", like the ring 216 shown in Figure 9b. This ring has orifices ("passages 196") at four locations to inject gas "at an angle to the radius" in order to create a

vortex flow ("swirl") in the gas (page 12, lines 3 - 8). In this embodiment in D1, the gas is injected "tangentially" in the sense of claim 1, because, in view of the constructional constraints of a plasma torch, the skilled person would understand "tangentially" to mean that the injection direction has a predominantly tangential component.

32. According to page 12, lines 7 to 8 of D1, the ring 216 can be used to feed the secondary gas to the passage 170 shown in Figure 8. The ring 216 itself, or the combined structure of the ring and the "inter-electrode inserts" 128, is a "tubular insert" in the sense of claim 1.

33. According to the appellant, however, the embodiment with tangential insertion of the plasma gas according to Figure 9b of D1 could not be combined with the embodiment of Figure 8, and the latter did not disclose a tangential insertion. Features could not be randomly combined from different embodiments. Such a combination would also not have been obvious, and amounted to a further step the skilled person would have had to take in addition to the employment of the cooling system of D2. There would have been no motivation to take these steps, because D1 did not address the problem, tackled by the invention, of providing sufficient cooling for a high-power system.

34. Contrary to the appellant's argument, the above-cited embodiments in D1 are not mutually exclusive. Rather, they propose options for different aspects of the same general plasma arc torch shown in Figure 1 (page 3, lines 15 - 17). Figure 8 shows a plasma arc torch according to the general setup of Figure 1, which, in contrast to having the single plasma gas insertion

passage 136 shown in Figure 2, has two additional plasma gas passages, 170 and 172 (page 11, lines 4 - 26). Figures 9a and 9b show "a specific profile of upstream portion of the anode 130" (page 11, lines 27 - 29), where Figure 9a shows a magnified, and more detailed, section including anode 130 of Figure 8 (in a mirrored view), and Figure 9b shows a cross-sectional view of this section. According to page 12, lines 7 to 8, distribution ring 126 "may be used to feed secondary gas 170", the gas feeding passage 170 being the one shown in Figure 8.

35. Accordingly, the "embodiment" in which the plasma gas is inserted tangentially through the orifices 196 into passage 170 merely simply represents one particular way of inserting the plasma in the torch shown in Figure 8, which, in turn, shows one particular arrangement of the torch shown in Figure 1.

36. Therefore, D1 discloses the feature that was added to claim 1 of the main request, and the reasoning regarding the lack of inventive step of claim 1 of the main request applies equally to the auxiliary request (Articles 52(1) and 56 EPC).

37. Hence, the auxiliary request is not allowable, either.

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar: The Chair:

C. Moser P. Scriven

Decision electronically authenticated