Patents Act 1977 **Opinion Number** **02/19**

OPINION UNDER SECTION 74A

Patent	EP 2809922
Proprietor(s)	United Technologies Corporation
Exclusive Licensee	
Requester	Rolls-Royce plc
Observer(s)	
Date Opinion issued	10 May 2019

The request

1. The comptroller has been requested to issue an opinion as to whether the invention claimed in EP 2809922 ("the patent") is novel and inventive in light of certain prior art documents. The request also alleges that several of the figures in the patent do not embody the invention claimed.

2. Observations have been received from Dehns on behalf of the proprietor and observations in reply have been received from the requester.

Preliminary matters

3. The question of whether certain figures embody the invention claimed is not in itself a question according to rule 93(6) on which an opinion can be given. It may however be relevant to how a claim is to be construed, although the request does not explain if that is the case here. I shall not consider the issue further.

4. In the observations in reply the requester introduces an additional prior art document which is referred to in the context of inventive step. It seems to me that this document cannot properly form part of observations strictly in reply to the observations of the proprietor. The nature of the opinions process also means that the proprietor has had no opportunity to make any observations on the new document. For these reasons it would be unreasonable of me to consider this document in coming to my opinion.

The patent

5. Deriving from a Patent Cooperation Treaty application, the patent was granted with

effect from 20 June 2018, having been filed on 30 January 2013, claiming priority of 31 January 2012. It remains in force and I note that two notices of opposition have recently been filed at the European Patent Office.

6. The title of the patent is Geared Turbofan Gas Turbine Engine Architecture and the invention seeks to provide such engines having "*very high efficient operation, and increased fuel efficiency and lightweight* (sic) *relative to their thrust capability*" (see paragraph 0069).

7. Various embodiments are disclosed including figure 2 showing an example gas turbine engine:

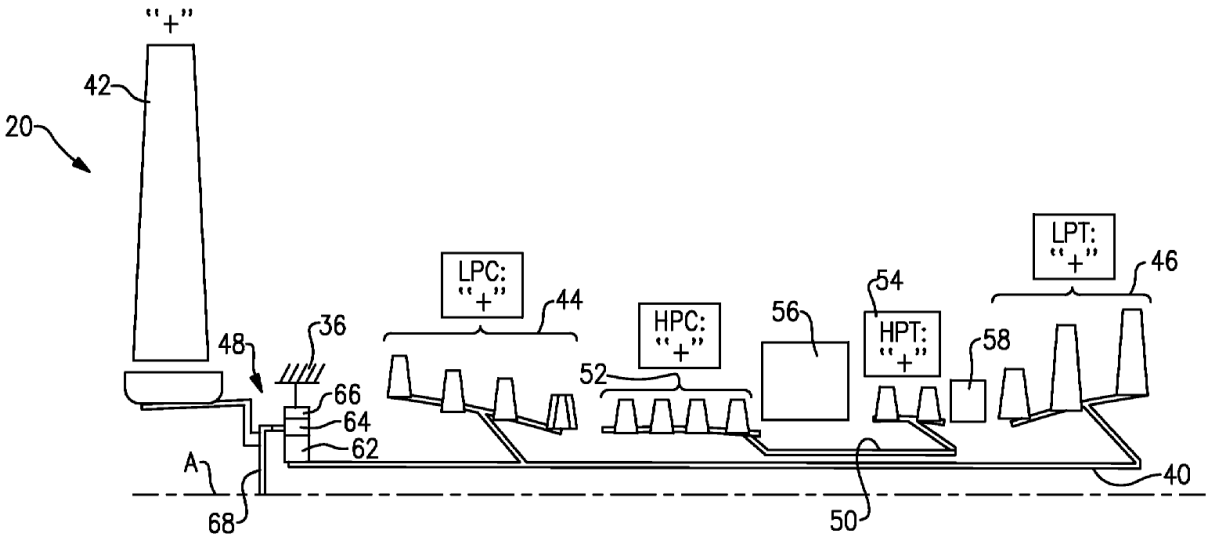

FIG.2

8. As paragraph 0042 explains:

> *[0042] The example gas turbine engine includes the fan 42 that comprises in one non-limiting embodiment less than about 26 fan blades. In another non-limiting embodiment, the fan section 22 includes less than about 18 fan blades. Moreover, in one disclosed embodiment the low pressure turbine 46 includes no more than about 6 turbine stages schematically indicated at 34. In another non-limiting example embodiment the low pressure turbine 46 includes about 3 or more turbine stages. A ratio between the number of fan blades 42 and the number of low pressure turbine stages is between 2.5 and 8.5. The example low pressure turbine 46 provides the driving power to rotate the fan section 22 and therefore the relationship between the number of turbine stages 34 in the low pressure turbine 46 and the number of blades 42 in the fan section 22 disclose an example gas turbine engine 20 with increased power transfer efficiency.*

9. Figure 7 is a schematic view of a bearing configuration supporting rotation of example high and low spools of the example gas turbine engine:

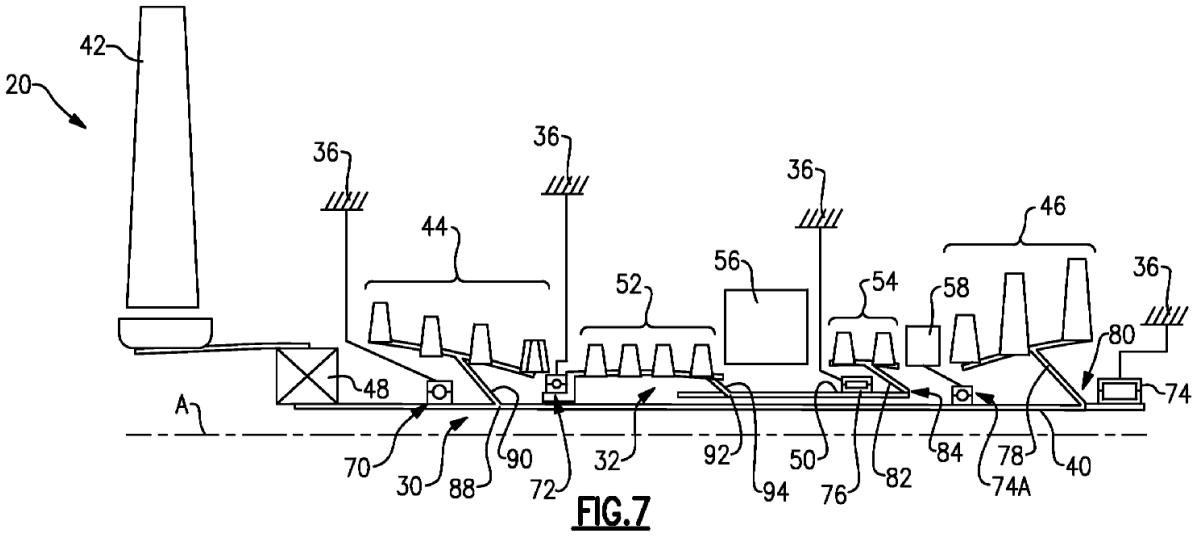

FIG.7

10. Paragraph 0055 explains the figure as follows:

> *[0055] Referring to Figure 7, an example shaft support configuration includes the first and second forward bearing assemblies 70, 72 disposed to support the forward portion of the corresponding inner shaft 40 and outer shaft 50. The first aft bearing 74 is disposed aft of the connection 80 between the rotor 78 and the inner shaft 40. The first aft bearing 74 is a roller bearing and supports the inner shaft 40 in a straddle configuration. The straddle configuration can require additional length of the inner shaft 40 and therefore an alternate configuration referred to as an overhung configuration can be utilized. In this example the outer shaft 50 is supported by the second aft bearing assembly 76 that is disposed forward of the connection 84 between the high pressure turbine rotor 82 and the outer shaft 50. Accordingly, the connection hub 84 of the high pressure turbine rotor 82 to the outer shaft 50 is overhung aft of the bearing assembly 76.This positioning of the second aft bearing 76 in an overhung orientation potentially provides for a reduced length of the outer shaft 50.*

Claim construction

11. Firstly I need to construe the claims of the Patent. That is to say I must interpret them in the light of the description and drawings as instructed by Section 125(1). In doing so I must interpret the claims in context through the eyes of the person skilled in the art. Ultimately the question is what the person skilled in the art would have understood the patentee to be using the language of the claims to mean.

12. Section 125(1) of the Act states that:

> *For the purposes of this Act an invention for a patent for which an application has been made or for which a patent has been granted shall, unless the context otherwise requires, be taken to be that specified in a claim of the specification of the application or patent, as the case may be, as interpreted by the description and any drawings contained in that specification, and the extent of the protection conferred by a patent or application for a patent shall*

be determined accordingly.

13. The claims are as follows:

1. A gas turbine engine (20) comprising:

a compressor section (24);

a combustor (26) in fluid communication with the compressor section (24);

a turbine section (28) in fluid communication with the combustor (26), the turbine section (28) including a fan drive turbine (46) and a second turbine (54), the fan drive turbine (46) including a plurality of turbine stages (34);

a fan (42) including a plurality of blades rotatable about an axis (A); and

a speed change system (48) driven by the fan drive turbine (46) for rotating the fan (42) about the axis (A), wherein the fan drive turbine (46) includes a first aft rotor (78) attached to a first shaft (40) and the second turbine (54) includes a second aft rotor (82) attached to a second shaft (50), and a first aft bearing assembly (74) is disposed axially aft of a first connection (80) between the first aft rotor (78) and the first shaft (40), and a second aft bearing assembly (76) is disposed axially forward of a second connection (84) between the second aft rotor (82) and the second shaft (50);

characterised in that :

a ratio between the number of fan blades and the number of fan drive turbine stages (34) is between 2.5 and 8.5; and

the second turbine (54) includes at least two stages and performs at a first pressure and the fan drive turbine (46) includes more than two stages and performs at a second pressure less than the first pressure.

2. The engine (20) as recited in claim 1, wherein the first aft bearing assembly (74) and the second aft bearing assembly (76) comprise roller bearings.

3. The engine (20) as recited in claim 1 or 2, wherein the compressor section (24) comprises a first compressor (44) driven by the fan drive turbine (46) through the first shaft (40) and a second compressor (52) driven by the second turbine (54) through the second shaft (50), wherein the first aft bearing (74) supports an aft portion of the first shaft (40) and the second aft bearing (76) supports an aft portion of the second shaft (50).

4. The engine (20) as recited in claim 3, wherein a forward portion of each of the first and second shafts (40, 50) are supported by a thrust bearing assembly (70, 72).

5. The engine (20) as recited in any preceding claim, wherein the fan drive turbine (46) has a first exit area (110) at a first exit point (106) and rotates at a first speed, the second turbine (54) has a second exit area (112) at a second exit point and rotates at a second speed, which is faster than the first speed, a

first performance quantity is defined as the product of the first speed squared and the first area (110), a second performance quantity is defined as the product of the second speed squared and the second area (112), and a performance ratio of the first performance quantity to the second performance quantity is between 0.5 and 1.5.

6. The engine (20) as recited in claim 5, wherein the performance ratio is above or equal to about 0.8.

7. The engine (20) as recited in claim 5 or 6, wherein the first performance quantity is above or equal to about 4.

8. The engine (20) as recited in any preceding claim, wherein the speed change system (48) comprises a gearbox, and wherein:

the fan (42) and the fan drive turbine (46) both rotate in a first direction about the axis (A) and the second turbine section (54) rotates in a second direction opposite the first direction;

the fan (42), the fan drive turbine (46), and the second turbine (54) all rotate in a first direction about the axis (A);

the fan (42) and the second turbine (54) both rotate in a first direction about the axis (A) and the fan drive turbine (46) rotates in a second direction opposite the first direction; or

the fan (42) is rotatable in a first direction and the fan drive turbine (46) and the second turbine (54) rotate in a second direction opposite the first direction about the axis (A).

9. The engine (20) as recited in any preceding claim, wherein the speed change system (48) comprises a gear reduction having a gear ratio greater than 2.3.

10. The engine (20) as recited in any preceding claim, wherein the fan (42) delivers a portion of air into a bypass duct, and a bypass ratio, being defined as the portion of air delivered into the bypass duct divided by the amount of air delivered into the compressor section (24), is greater than 6.0, or greater than 10.0.

11. The engine (20) as recited in any preceding claim, wherein a fan pressure ratio across the fan (42) is less than 1.5.

12. The engine (20) as recited in any preceding claim, wherein the fan (42) has 26 or fewer blades.

13. The engine (20) as recited in any preceding claim, wherein said fan drive turbine (46) has between 3 and 6 stages.

14. The engine (20) as recited in any preceding claim, wherein a pressure ratio across the fan drive turbine (46) is greater than 5:1.

15. The engine (20) as recited in any preceding claim, including a power density

greater than 1.5 lbf/in³ (407 kN/m³) and less than or equal to about 5.5 lbf/in³ (1493 kN/m³).

14. In fact the claims seem to me to be clear and neither the request, the observations nor the observations in reply see any need to construe the claims in the sense of section 125(1), although at paragraph 40 the observations do state that "*the inventive concept of claims 1 and 3 can be construed as the provision of a more efficient geared turbofan engine*".

Novelty

15. The request argues that claims 1, 2, 8 and 10 to 13 lack novelty in light of a prior art document that the request refers to as D101. This is a lengthy technical report entitled *TF-34 turbofan quiet engine study*. It was prepared for NASA and published in 1972 with reference CR-120914. The request provides an annotated copy of figure 2 from the report as reference D101a, shown below:

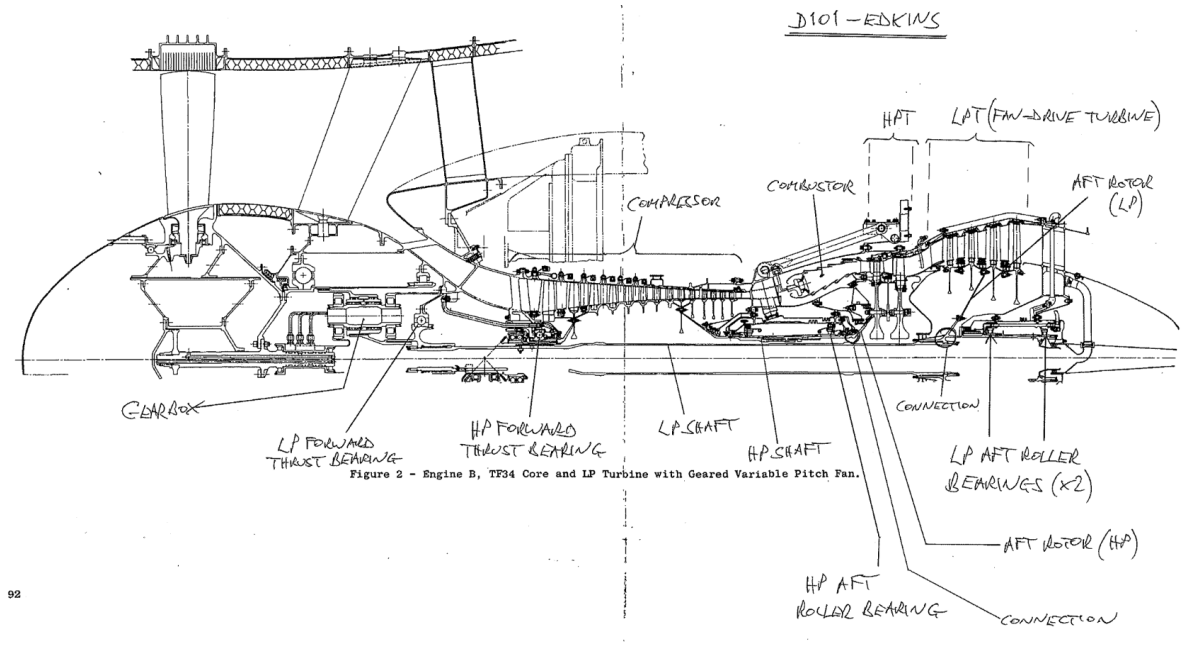

Figure 2 - Engine B, TF34 Core and LP Turbine with Geared Variable Pitch Fan.

16. The request breaks the claims down into parts and uses a table to demonstrate where in D101 and D101a those parts can be found. The observations do not dispute the detail of this breakdown and indeed make no direct reference to the novelty of the claims save to say that the observations are offered "*without prejudice to the novelty and inventiveness of independent claim 1*". The observations then move on to the patentability of claims 1 and 3 combined.

17. As detailed in the request it seems to me that the majority of features from claim 1, 2, 8 and 10 to 13 can be found in figure 2 of D101 as annotated by the requester, concerned with what the report refers to as Engine B, one of three study engines investigated for the report. The request explains that figure 2 does not show the requirement of claim 1 that "*a ratio between the number of fan blades and the number of fan drive turbine stages (34) is between 2.5 and 8.5*". However, Table V - A on page 11 of the report states that Engine B had 20 fan blades and on page 42

the report explains that the fan turbine had four stages, as also shown in figure 2, giving a ratio of 5. Although the directions of rotation of the components of the engine are not discussed in D101, logically one of the options in claim 8 must be implicitly disclosed. The bypass ratio of 13 for Engine B is stated on page 1 of the report, satisfying the requirement of claim 10. Table IV on page 9 of the report states fan pressure ratios of 1.25 and 1.14 at the tip and hub respectively in Engine B, both of which are less than the value of 1.5 required by claim 11. As noted above the fan in Engine B had 20 blades, meeting the requirement of 26 or fewer in claim 12.

18. It is my opinion that claims 1, 2, 8 and 10 to 13 of the patent lack novelty in light of NASA Technical Report CR-120914 *TF-34 turbofan quiet engine study*, D101 in the request.

Inventive step starting from D101

19. The request seeks an opinion as to whether dependent claims 3 to 7, 9, 14 and 15 involve an inventive step. The request identifies two starting points for consideration of inventive step, document D101 as discussed above in the context of novelty and document D102 which I will consider later. D101 is used in an effort to show that claims 3, 4 and 9 lack an inventive step.

20. To determine whether or not an invention defined in a particular claim is inventive over the prior art, I will rely on the principles established in *Pozzoli SPA v BDMO SA [2007] EWCA Civ 588*, in which the well-known Windsurfing steps were reformulated:

> *(1)(a) Identify the notional "person skilled in the art";*
> *(1)(b) Identify the relevant common general knowledge of that person;*
> *(2) Identify the inventive concept of the claim in question or if that cannot readily be done, construe it;*
> *(3) Identify what, if any, differences exist between the matter cited as forming part of the "state of the art" and the inventive concept of the claim or the claim as construed;*
> *(4) Viewed without any knowledge of the alleged invention as claimed, determine whether those differences constitute steps which would have been obvious to the person skilled in the art.*

21. The request itself does not follow this structured approach. Without saying so explicitly, the requestor effectively confines themselves to the last two steps of identifying the difference or differences and determining whether they constitute steps which would have been obvious.

22. According to the observations from the proprietor the person skilled in the art would be "*a gas turbine engineer familiar with the operation and design of such engines generally, in 2012*". This seems entirely reasonable to me and the observations in reply from the requester say nothing on the point.

23. As for his or her common general knowledge, the request is silent, a point noted by the proprietor. According to the observations in reply "*It is not necessary for D101-*

D104 to be common general knowledge in order for the arguments in the Request to succeed; neither is such a position asserted". Consequently I have no evidence on the question of the common general knowledge of the skilled person beyond an agreement that it does not include documents d101 to D104.

24. I noted earlier that I see no need to construe the claims, the inventive concept is clear.

25. According to the request the only difference between D101 and claim 3 is the requirement in claim 3 for "*a first compressor (44) driven by the fan drive turbine (46) through the first shaft (40)*". Engine B in D101 had only a single compressor that was driven by a high pressure turbine separate from a second, low pressure turbine driving only the fan.

26. Whilst acknowledging that Engine B "*does not embody a low pressure compressor*", the observations state that D101 differs from the inventive concept in that "*the geared architecture does not improve engine efficiency though decoupling of a fan and a low-pressure compressor separate from the high-pressure compressor*".

27. The request goes on to argue that two modifications would have been obvious to the person skilled in the art, firstly to increase the gear ratio of the reduction gear to increase the speed of the low pressure spool to improve the efficiency of the low pressure turbine and then to add a compressor to the low pressure spool to increase the pressure ratio of the compressor section. This seems to be much the same as the difference in the observations that I noted above. The requester shifts ground in their observations in reply, stating that "*The difference is the presence of a low pressure compressor (LPC) on the low pressure spool. There is no other difference.*".

28. According to the original request the two modifications would have been obvious to a skilled person since documents D102, D103 and D104 show engines that "*have such an architecture*" i.e. a low pressure spool having a low pressure compressor in addition to a low pressure turbine (fan drive turbine) and a reduction gear having a gear ratio greater than 2.3. There seems to be no dispute that these documents show this architecture and I do not propose to describe them in further detail, except to say that each document predates the priority date of the patent.

29. By acknowledging that changes to the reduction gear ratio and to the speed of the low pressure spool would be required it seems to me that the request is also acknowledging that the difference between D101 claim 3 is more complex than simply adding an additional component to the low pressure spool in the form of a compressor. One might argue therefore than more than one step is involved in the sense of the last of the reformulated *Windsurfing* steps. Alternatively one might view these changes as relevant to the fourth *Windsurfing/Pozzoli* step of whether the differences would have been obvious to the skilled person. By this I mean that the changes reflect the complexity inherent in adding an additional compressor stage.

30. I think that the difference for the purpose of *Windsurfing/Pozzoli* step (3) is the presence in claim 3 of "*a first compressor (44) driven by the fan drive turbine (46) through the first shaft (40)*". It is worth acknowledging that providing this additional compressor would not be a trivial task practically or conceptually, as recognised by

the modifications to the reduction gear ratio and pressure ratio that the request identifies.

31. It seems to me that the argument relies on a simple mosaic of two documents, or rather any of a series of mosaics. The requester seeks to combine D101 with any of D102, D103 or D104. The request offers no motivation for the skilled person to combine these documents and none of them are shown to be commonly known, a point made by the proprietor in the observations. As noted earlier, the observations in reply respond that "*It is not necessary for D101-D104 to be common general knowledge in order for the arguments in the Request to succeed*". Whilst using such mosaics to demonstrate a lack of inventive step is not expressly forbidden, the Manual of Patent Practice makes it clear that there are a number of considerations around combining the disclosures of patent documents in the context of obviousness (see paragraph 3.40 onwards). The request makes no mention of such considerations.

32. Would the steps required have been obvious to the person skilled in the art? According to its abstract D101 reports a study evaluating sound-suppressed engine nacelles based on an existing engine. The three study engines do not seem to involve modifications to the core of the engine, although the fan in Engine C is "*directly driven by a new, larger four stage turbine*". So it seems to me that in itself D101 would not invite the skilled person, or unimaginative addressee as he was described in *Windsurfing*, to make modifications to the core of the Engine B such as an additional compressor stage. The document is not concerned with the efficiency improvements to which the patent and observations refer.

33. It seems to be common ground that documents D102 to D104 show arrangements including a second compressor. However, as noted above I have no evidence to suggest that the documents themselves were commonly known or even that the second compressor they disclose is commonly known. Even if such an arrangement had been shown to be commonly known, it remains the case that there is no reason for the skilled person to contemplate adding a second compressor when presented with document D101. Consequently I believe that the invention of claim 3 involves an inventive step.

34. Since claim 4 depends upon claim 3 it follows that it must be the case that claim 4 is also not obvious.

35. Claim 9 to which the request also refers depends upon "*any preceding claim*" and requires "*a gear reduction having a gear ratio greater than 2.3*". I find the request a little unclear concerning claim 9. I referred earlier to a table in the request demonstrating where in D101 the various parts of the claims can be found. The table is silent regarding claim 9 although the request refers several times to claim 9 lacking an inventive step. According to the summary on page 1 of D101 Engine B described in D101 has a 1.9:1 reduction gear which is clearly not "*a gear ratio greater than 2.3*" and this variation in ratio is therefore the difference between the inventive concept of claim 9 and Engine B in D101.

36. The proprietor argues that "*there is no teaching in D101 regarding changing the gear reduction ratio*". This seems to be true and D101 does not explain how the particular ratio came about, beyond stating in the summary on page 1 that this "*permits direct*

use of the TF34 four stage low-pressure turbine". It seems that the particular ratio disclosed in D101 results from characteristics of the existing TF34 low pressure turbine and the design of the new, larger fan of Engine B.

37. I can find nothing in the patent to explain the significance of the gear ratio being greater than 2.3. The background section of the patent and in particular paragraph 0003 explains that a reduction gear might be useful generally in a gas turbine engine "*such that both the turbine section and the fan section can rotate at closer to optimal speeds*".

38. It seems to me that the skilled person presented with D101 would understand that the choice of reduction gear for Engine B was imposed by other design choices for the engine and might vary depending upon different design choices, especially for the fan and fan drive turbine. In other words I do not feel that the skilled person would see the difference between a ratio of 1.9:1 and a gear ratio of greater than 2.3 as a step that would have been inventive.

39. In light of document D101 it is my opinion that claim 3 involves an inventive step and claim 9 does not involve an inventive step.

Inventive step starting from D102

40. D102 is another technical report prepared for NASA. Entitled *Energy efficient engine preliminary design and integration studies*, it was published in 1978 with reference CR-135396. According to the request all of the claims are obvious in light of D102.

41. Figure 29 from D102 has been annotated as D102a by the requester thus:

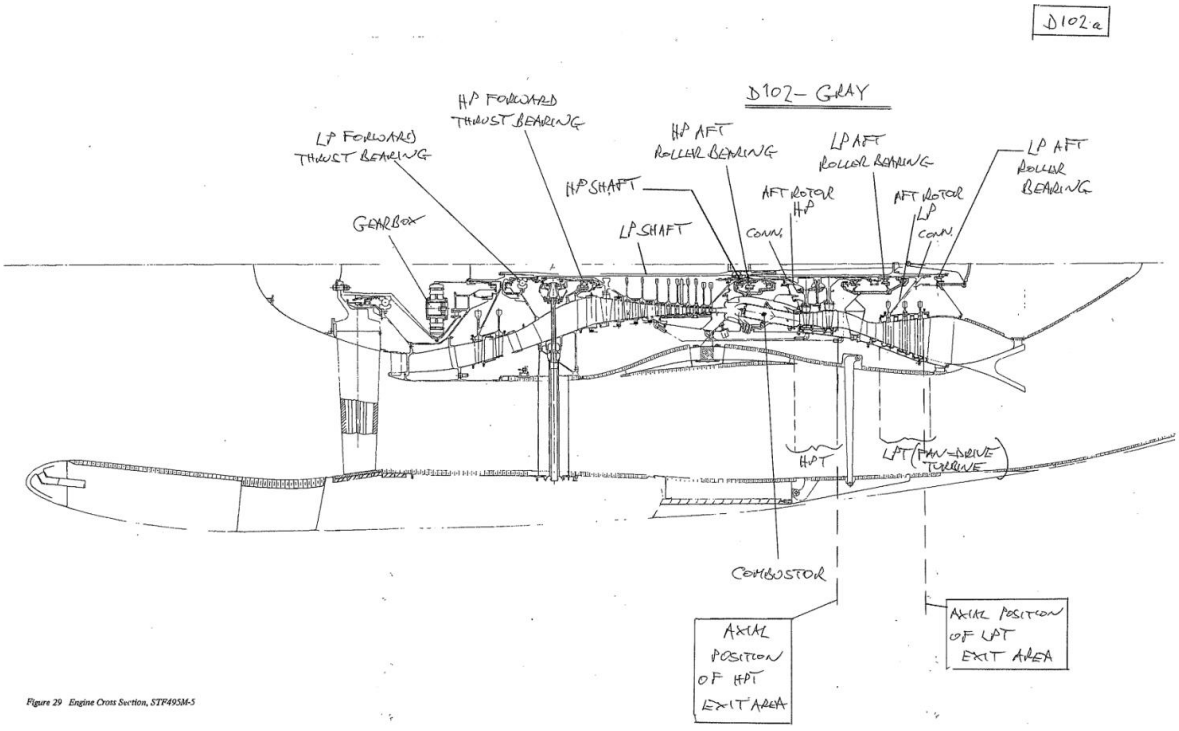

Figure 29 Engine Cross Section, STF495M-5

42. Once again the request breaks the claims down into parts and uses a table to

demonstrate where in D102 and D102a those parts can be found. This suggests that all of the features of claim 1 can be found in D102 apart from "*a ratio between the number of fan blades and the number of fan drive turbine stages (34) is between 2.5 and 8.5*". In the engine shown in figure 29 of D102 there are 28 fan blades (Table C-LVI on page 225) and the fan drive turbine has 3 stages, giving a ratio of 9.33. The observations from the proprietor do not dispute this analysis.

43. The request argues that it would have been obvious to the skilled person to reduce the number of fan blades shown in D102 from 28 to 24 for a number or desirable reasons and thus arrive at an engine meeting all the requirements of claim 1. I think that in fact the difference between claim 1 and D102 is slightly less specific than this. To meet the requirement of claim 1 it would be necessary to reduce the number of fan blade to less than 26, but more than 7.

44. The request goes on to point out that that document D104, an extract from Jane's Aero Engines, shows that the number of fan blades used in the Pratt & Whitney PW8000 geared engine was reduced from 26 to 22 to 18 and that the engine had 3 fan drive turbine stages, giving a ratio of fan blades to fan drive turbine stages of 6:1. The request points out the documents D101 and D103 also disclose engines with ratios meeting the requirement of claim 1.

45. It remains the case that these documents have not been shown to be commonly known and I have no basis on which to believe that a mosaic of D102 with any of the other documents would have been obvious to the skilled person.

46. The observations from the proprietor argue that the skilled person would not consider it obvious to start redesigning the engine shown in figure 29 of D102 since the report did not choose that engine as the basis for further development (see pages 63 and 64). In my view this slightly changes the last *Windsurfing/Pozzoli* step. I believe that the question is not whether the skilled person would consider redesigning an engine that the study has rejected, but rather whether the skilled person would consider the difference identified, i.e. reducing the number of fan blades from 28, would involve an inventive step.

47. I am reluctant to mosaic the disclosure of D102 with that of the other documents to come to a view that less than 26 blades would have been obvious. Nevertheless I feel that the skilled person would not see that a number of fan blades less than 26 represents an inventive step over 28 blades. Whilst I am not suggesting that the number of fan blades is an arbitrary choice for the skilled person or team, I do not feel that there is any special significance in 28 blades and there would be no invention in slightly reducing that number. Consequently in my view the difference between D102 and claim 1 would have been obvious to the person skilled in the art.

48. Dependent claim 12 specifies 26 or fewer blades and it follows that I also do not believe that this number of blades would require an inventive step.

49. Dependent claim 11 specifies a fan pressure ratio of less than 1.5, whereas D102 discloses a ratio of 1.52. In itself this small variation does not strike me as involving an inventive step. I am alive to the fact that to arrive at the invention of claim 11 the skilled person would have to consider that both reducing the number of fan blades and reducing the fan pressure ratio would be obvious, but nevertheless I do not feel

that the additional step required by claim 11 would be inventive.

50. The request goes on to identify a basis in D102 for the additional features required by dependent claims 2 to 10 and 13 to 15. The observations do not accept that the requirements of claims 5, 6 and 15 are disclosed in D102 since the calculations involved rely on measurements taken from figure 29 rather than on values given in the document. On this point I agree with the proprietor, there is nothing to suggest that figure 29 should be treated as anything other than a schematic drawing or that dimensions should be derived from it.

51. Otherwise the observations from the proprietor are silent on whether the requirements of the dependent claims are disclosed in D102.

52. In my view the invention of claims 1 to 4 and 7 to 14 do not involve an inventive step in light of document D102.

Conclusion

53. It is my opinion that claims 1, 2, 8 and 10 to 13 of the patent lack novelty in light of NASA Technical Report CR-120914 *TF-34 turbofan quiet engine study*, D101 in the request. In light of document D101 it is my opinion that claim 3 involves an inventive step and claim 9 does not involve an inventive step.

54. Further, it is my opinion that claims 1 to 4 and 7 to 14 do not involve an inventive step in light of NASA Technical Report CR-135396 *Energy efficient engine preliminary design and integration studies*, document D102 in the request.

Application for review

55. Under section 74B and rule 98, the proprietor may, within three months of the date of issue of this opinion, apply to the comptroller for a review of the opinion.

Karl Whitfield
Examiner

NOTE

This opinion is not based on the outcome of fully litigated proceedings. Rather, it is based on whatever material the persons requesting the opinion and filing observations have chosen to put before the Office.