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McDow et al.

[11] **3,807,891**

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[54] **THERMAL RESPONSE TURBINE SHROUD**

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[52] **U.S. Cl.** **415/116**, 415/134, 415/138, 415/178

[51] **Int. Cl.** **F10l 5/00**, F10l 5/08, F10l 25/28

[58] **Field of Search** ..... 415/115, 116, 117, 170 R, 415/217, 216, 134, 136, 178

[56] **References Cited**

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3,391,904	7/1968	Albert et al.	415/170 R
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[57] **ABSTRACT**

In a turbine engine the vanes and shrouds around the turbine blade tips are constructed to provide for radial positioning and axial movement. The shroud for the first turbine stage includes a growth control ring having a low expansion material while a high expansion material is used for the shroud. In order to maintain the desired temperature of the control ring, a heat shield is provided. All of the cooling air for the first and second vane is routed through the control ring. The second vane has a floating seal which can grow outwardly against the inner platforms of the vane.

The invention described herein was made in the course of or under a contract with the Department of the Army.

13 Claims, 5 Drawing Figures

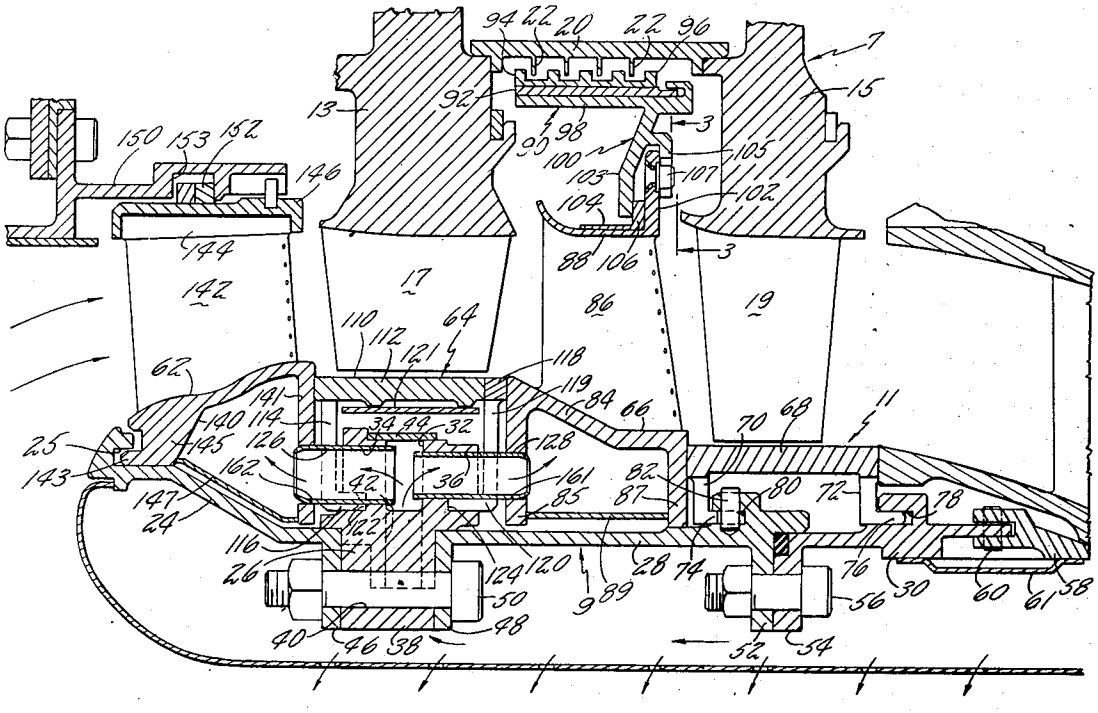


FIG. 1

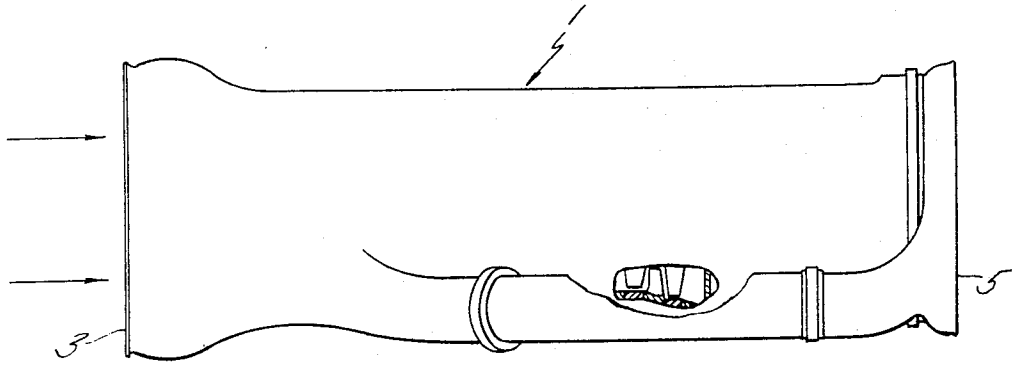


FIG. 4

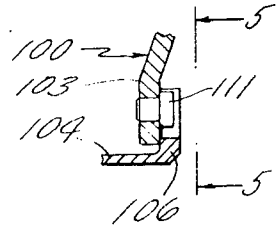


FIG. 5

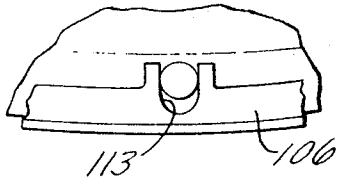
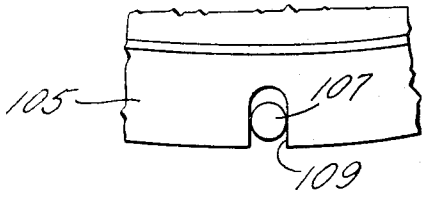


FIG. 3



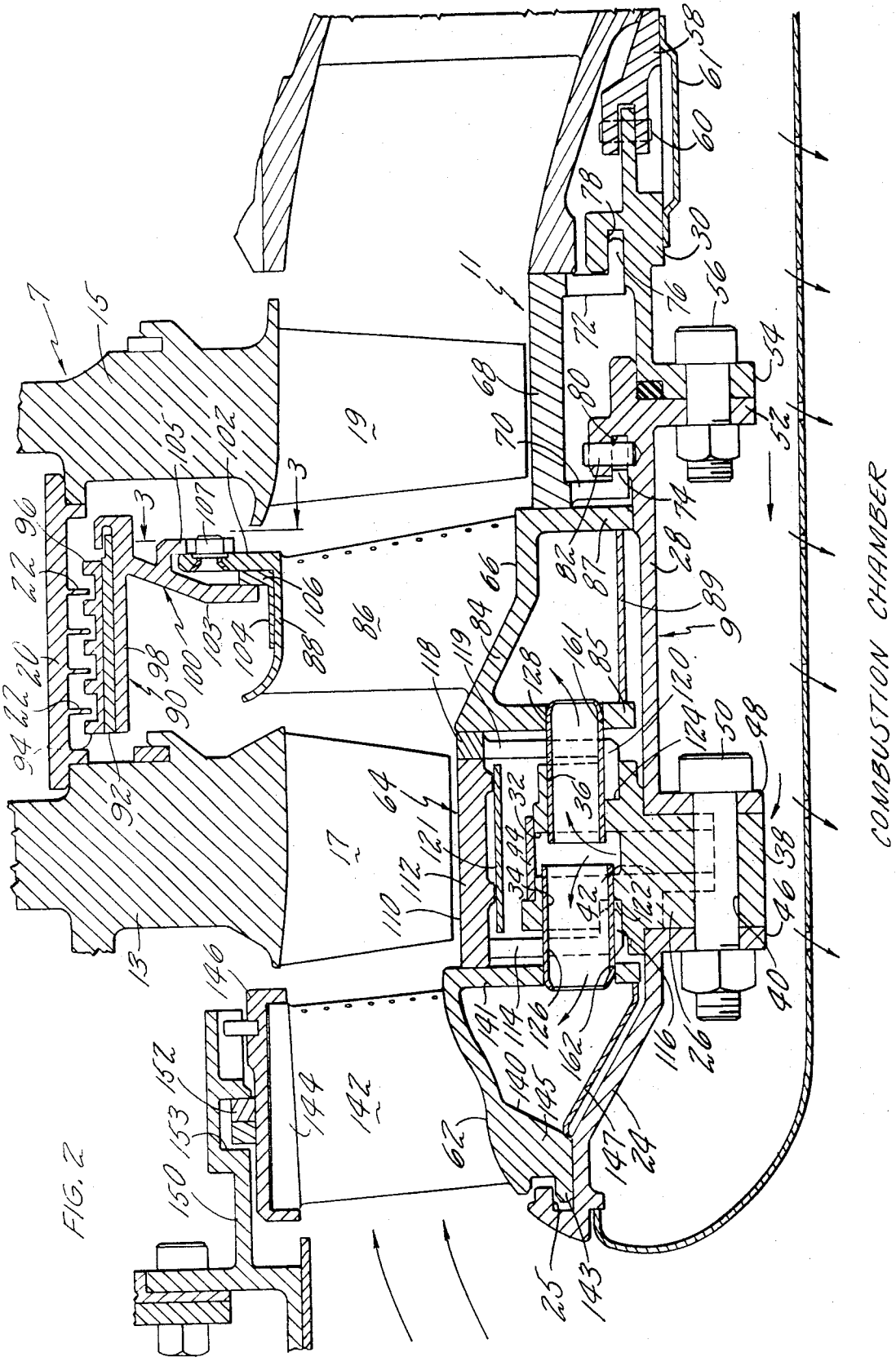


FIG. 2

THERMAL RESPONSE TURBINE SHROUD

BACKGROUND OF THE INVENTION

This invention relates to turbine shrouds and more particularly to those which are arranged to move in response to thermal changes to maintain best turbine performance, this is a close tip clearance during operation and a large tip clearance during shutdown and operating transients. A sample of these are shown by U.S. Pat. Nos. 3,391,904; 2,859,934; and 3,443,791. A thermal response shroud is also shown in U.S. Application Ser. No. 101,481 to Perry P. Sifford filed Dec. 8, 1970 now U.S. Pat. 3,742,705.

SUMMARY OF THE INVENTION

A primary object of the present invention is to provide a thermal response turbine shroud that will maintain the required radial clearance for a turbine blade tip throughout the operating regime of the engine with a minimum of variation.

In accordance with the present invention, this construction provides close tip clearance when operating for best turbine performance, a large tip clearance to prevent rotor seizure or rub during shutdown and operating transients, a large build clearance for ease of assembly, and good durability and life.

In accordance with a further aspect of the present invention a growth control ring is provided of low expansion material while the shroud is constructed of a high expansion material. The low expansion control ring keeps the shrouds from growing outwardly and the high expansion shroud fingers connected to the control ring push back inwardly towards the blade tips to close the clearance.

In accordance with another aspect of the present invention all of the cooling air for the first and second vane is passed through the blade control ring. This arrangement helps to maintain the desired temperature at the control ring.

In this construction the vanes and shrouds are axially floating and aerodynamically loaded against each other during engine operation and transients to eliminate axial gap and control leakage between vanes and shrouds.

The inner stage seal is mounted to permit radial movement with respect to the second stage vanes.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevation of a power plant showing the location of the invention.

FIG. 2 is an enlarged view showing the turbine construction in accordance with the present invention.

FIG. 3 is a view taken along the line 3—3 of FIG. 2.

FIG. 4 is another sectional view of the seal support in FIG. 3 showing a pin mounting.

FIG. 5 is a view taken along the line 5—5 of FIG. 4.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In FIG. 1, a gas turbine power plant 1 is shown having an inlet 3 and exhaust section 5. The details of a similar power plant are shown in U.S. Pat. No. 3,152,443. While the power plant as shown in the patent is adapted to deliver power to a power shaft, and the power plant herein provides thrust by a jet, this has no bearing on the invention disclosed herein.

As shown in FIG. 2 the turbine section comprises three main parts: (1) the turbine rotor means 7, (2) the composite outer turbine housing 9, and (3) a thermal response turbine shroud 11. The turbine rotor means 7 comprises two rotor discs 13 and 15, supported for rotation within said power plant by bearing means not shown. Turbine disc 13 has blades 17 mounted thereon and turbine disc 15 has blades 19 mounted thereon. These blades can be connected to the discs by any means desired. The turbine discs 13 and 15 are fixedly connected by a cylindrical member 20. Member 20 can be bolted to the discs or fixed by any other means desired. Knife edges extend outwardly from the member 20 to provide a sealing action to be later herein described.

The outer turbine housing 9 consists of four members which are bolted together to form a rigid structure. These parts comprise the forward nose section 24, a shroud support ring section 26, an intermediate section 28, and a rear support section 30.

The shroud support ring section 26 is of annular construction having an annular groove 32 around the inner circumference thereof, said groove extends into said ring section for approximately one half of its radial thickness, a plurality of openings 34 extend through the forward part of the ring section between the groove 32 and the forward wall and a plurality of holes 36 extend through the rearward part of the ring section between the groove 32 and the rearward wall. The outer circumference of the ring section is formed having projections 38 through which a plurality of longitudinal openings 40 extend. Radial passages 42 connect the bottom of the groove 32 to the outer circumference of the ring section between the projections 38. A cylindrical member 44 is fixed to the inner circumference of the ring section 26 closing the inner opening of the groove 32.

The forward nose section 24 has an outwardly extending annular flange 46 which is placed against an outer forward face of the support ring section 26 and the intermediate section 28 has an outwardly extending flange 48 at the forward end thereof which abuts an outer rearward face of the support ring section 26. Openings in these flanges 46 and 48 align with the openings 40 in the outer circumference of the ring section and bolts 50 rigidly hold these three sections together. The intermediate section 28 has an outwardly extending flange 52 at its rear end and the rear support section 30 has an outwardly extending flange 54 at its forward end. These flanges are arranged to engage each other and are bolted together by a plurality of bolts 56. An O-ring seal can be provided between the flanges if necessary. The rear end of the rear support section 30 is attached to fixed engine structure 58 by a sheet metal strip 61 which axially positions the outer turbine housing and a pin 60 prevents rotation. The forward part of the forward nose section 24 has a rearwardly facing annular groove 25 for a purpose to be hereinafter described.

The thermal response turbine shroud 11 consists of four members which are mounted within said outer turbine housing 9 for axial movement therein. These parts comprise a forward first vane supporting means 62, a shroud means 64 for the first stage blades 17, a second vane supporting means 66, and a shroud means 68 for

the second stage turbine blades 19. The shroud means 68 is formed of eight segments and surrounds the tips of the blades 19. Each segment has outwardly projecting radial fingers 70 and 72. Finger 70 has a rearwardly extending flange 74 and finger 72 has a rearwardly extending annular flange 76. The rear flange 76 is slidably located in a groove 78 which is formed in the rear support section 30 and the forward flange 70 is slidably located in a groove 80 which is formed in the intermediate section 28. A pin 82 is located in aligned openings in each side of the groove 80, a notch in each flange 74 is axially aligned with its pin 82 permitting axial movement and restraining rotation between the shroud means 68 and the intermediate section 28 and rear support section 30.

The second vane supporting means 66 is comprised of a plurality of segments. Each segment comprises an outer channel member 84, vane 86, and inner shroud member 88. The outer channel member 84 includes a forward side 85 which faces the shroud means 64 and a rearward side 87 which faces the shroud means 68. A cover plate 89 connects the ends of sides 85 and 87. The inner shroud member 88 is connected to a sealing means 90 located between the rotor discs 13 and 15. Sealing means 90 includes an annular member 92 with another annular member 94 fixed thereto. Member 94 comprises a plurality of outwardly extending projections 96 which are spaced so as to enclose each of the knife edges 22 extending outwardly from the member 20.

The sealing means 90 also includes an annular ring 98 having an outwardly extending flange means 100. Flange means 100 consists of an outwardly extending flange 103 and an outwardly extending flange 105 spaced therefrom. A flange 102 extends inwardly from each inner shroud member 88. An annular member 104 is positioned around the inner face of the inner shroud members 88 and has a flange 106 which extends outwardly along the flange 102. Flanges 103 and 105 are spaced to encompass flanges 106 and 102.

A pin member 107 extends from each flange 102 and is positioned in a slot 109 located around the outer edge of flange 105. The slots 109 are equally spaced about the flange 105 and there is one for each vane 86. The pin 107 can be fixed to its flange 102 by any means desired. It is shown riveted in this construction. These pins 107 and grooves 109 permit for radial growth between the sealing means 90 and the vanes 86. The annular member 104 is positioned by pin member 111 which projects from the flange 103 and is guided in a groove 113 formed in flange 106.

The shroud means 64 surrounds the tips of the blades 17 and comprises a shroud face 110 facing the tips of the blade 17. This face is formed on a plurality of arcuate segments 112 which are fitted together around the blade tips. At the forward end of the segments radial members or fingers 114 project outwardly therefrom, each with a rearwardly projecting flange 116. A rear face extension means 118 abuts the rearward end of the segments 112 and has radial members or fingers 119 projecting radially outwardly having flange means 120 at the outward end thereof which extend forwardly. The flanges 116 and 120 extend into grooves 122 and 124 respectively to position the shroud means 64. The rear face extension means 118 can be fixed to the segments 112 by any means desired. A heat shield means 121 is positioned against projections on the outer side of the segments 112.

The forward first vane supporting means 62 is formed of a plurality of segments. Each segment comprises an outer channel member 140, vane 142, and an inner shroud member 144. Each inner shroud member is mounted in an annular member 146 having an outwardly positioned groove. The member 146 is pinned to inner fixed structure 150 to permit axial movement and prevent rotation thereof and sealing rings 152 are positioned in a groove 153 in the fixed structure and engage the inner surface of the annular member 146. The outer channel member 140 includes a rearward side 141 which faces the shroud means 64 and a forward side 145 which has a projection 143 which is located in the groove 25. A cover plate 147 connects the ends of sides 145 and 141.

The openings 34 and 36 have short pipe sections 126 and 128 mounted therein, respectively. These pipe sections 126 and 128 pass between the fingers 114 and 119, respectively and are slidably mounted in openings 162 and 161, respectively, in the sides 141 and 85. The pipe sections locate the vanes 142 and 86 and prevent relative rotation therebetween and also prevent shroud 112 from rotating.

In a construction built, the high expansion material was Haynes 188 and the low expansion material was NX 188.

We claim:

1. A turbine construction including a rotor having blades, a thermal response shroud surrounding said blades, a ring means surrounding said shroud, said shroud having arm means connecting said shroud to said ring means, said ring means being made of a material having a low coefficient of expansion, said shroud and connecting means being formed of a material having a high coefficient of expansion.

2. A turbine construction as set forth in claim 1 wherein said connecting arm means comprises fingers extending outwardly from the front and rear edges of the circumference of the shroud.

3. A turbine construction as set forth in claim 1 wherein said ring means has an annular passageway therein, radial passage means in said ring means connecting said annular passageway to the exterior of said ring means, means for directing air to said radial passage means, vane means located forwardly of said blades, conduit means extending forwardly of said ring means through said arm means, said conduit means being connected at one end to said annular passageway, air from said conduit means being directed to said vane means for cooling.

4. A turbine construction as set forth in claim 3 wherein said connecting arm means comprises fingers extending outwardly from the front and rear edges of the circumference of the shroud, and the conduit means extends between the fingers.

5. A turbine construction as set forth in claim 2 wherein said arm means has means connecting said shroud to said ring means for limited axial movement of said shroud on said ring means, vane means located forwardly of said blades, said vane means being mounted for a limited axial movement with respect to said ring means.

6. A turbine construction as set forth in claim 5 wherein said arm means has axial extending flanges for radially spacing said shroud and ring means, said

flanges engaging grooves in said ring means, said flanges of said arm means and the bottom of said ring means being spaced so that a limited axial movement is provided therbetween.

7. A turbine construction including a rotor having blades, a thermal response shroud surrounding said blades, a ring means surrounding and supporting said shroud, said ring means having an annular passageway therein, radial passage means in said ring means connecting said annular passageway to the exterior of said ring means, means for directing air to said radial passage means, said ring means having conduit means extending forwardly of said ring means, said conduit means being connected at one end to said annular passageway, vane means located forwardly of said blades, air from said conduit means being directed to said vane means for cooling.

8. A turbine construction as set forth in claim 7 wherein said vane means and said thermal response shroud are mounted for limited axial movement with respect to said ring means, said vane means being axially guided on said conduit means.

9. A turbine construction as set forth in claim 8 wherein said vane means has a wall means facing said ring means, said conduit means being slidable in opening means in said wall means.

10. A turbine construction as set forth in claim 7 wherein second vane means are located rearwardly of said blades, said ring means having second conduit means extending rearwardly out of said ring means, said second conduit means being connected at one end to said annular passageway, air from said second conduit means being directed to said second vane means for cooling.

11. A turbine construction as set forth in claim 10 wherein said vane means located forwardly of said blades, said thermal response shroud, and said second vane means located rearwardly of said blades are permitted limited axial movement therebetween, said vane means located forwardly of said blades being axially guided on said conduit means extending forwardly of said ring means and said second vane means located rearwardly of said blades being axially guided on said second conduit means.

12. A turbine construction as set forth in claim 10 whereby said conduit means extending forwardly out of said ring means has a larger cross-sectional area than the second conduit means extending rearwardly out of said ring means for permitting more air to flow to said vane means located forwardly of said blades.

13. A turbine construction including an outer housing, said outer housing having a ring means forming a part thereof and extending inwardly from said housing, a thermal response shroud mounted on said ring means, said thermal response shroud being permitted a limited axial movement on said ring means, a rotor having blades being mounted for rotation within said thermal response shroud, a first vane means located forwardly of said blades being slidably mounted in an axial direction within said turbine housing, a second vane means located rearwardly of said blades being slidably mounted in an axial direction within said turbine housing, said ring means having a coolant passageway, therein, first conduit means extending forwardly of said ring means with one end being connected to said coolant passageway, a second conduit means extending rearwardly of said ring means with one end being connected to said coolant passageway, said first vane means being circumferentially positioned by said first conduit means, second vane means being circumferentially positioned by said second conduit means, each conduit means directing coolant to its respective vane means.

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