Jan. 9, 1968 L. F. RICHARDSON 3,362,470

BOUNDARY WALL STRUCTURES FOR HOT FLUID STREAMS

Filed Oct. 18, 1965 2 Sheets-Sheet 1

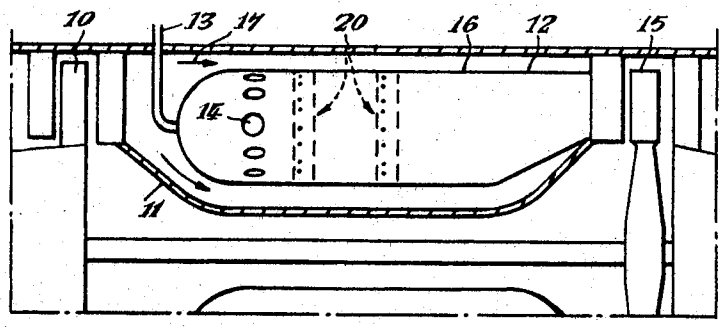


Fig. 1.

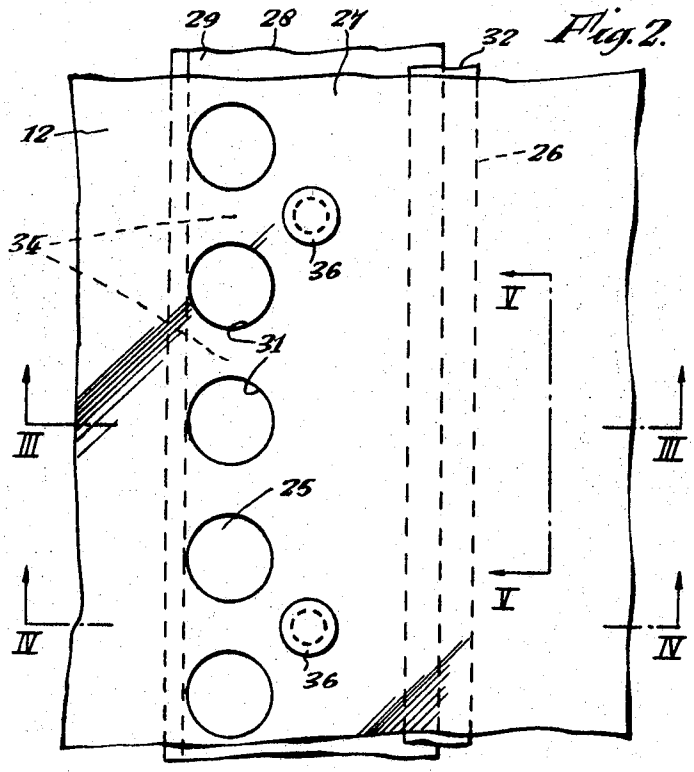


Fig. 2.

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BOUNDARY WALL STRUCTURES FOR HOT FLUID STREAMS

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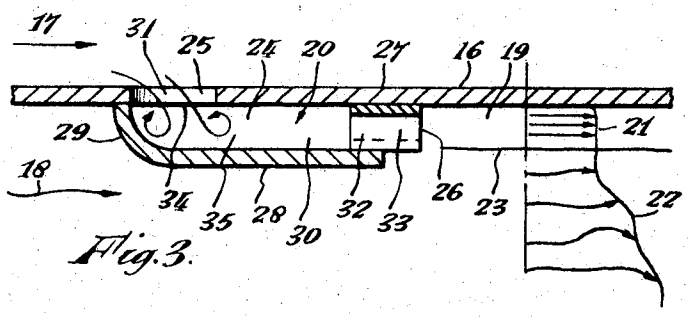


Fig. 3.

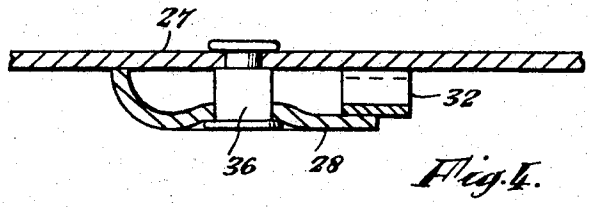


Fig. 4.

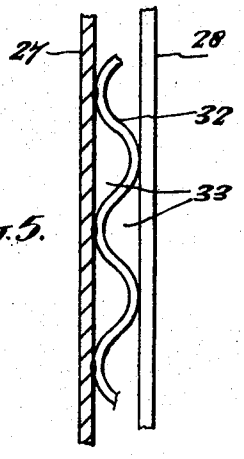


Fig. 5.

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BOUNDARY WALL STRUCTURES FOR HOT FLUID STREAMS

Leslie Frederick Richardson, Bristol, England, assignor to Bristol Siddeley Engines Limited, a British company

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ABSTRACT OF THE DISCLOSURE

The disclosure of this invention pertains to cooling a wall by forming a film separating a wall to which a cold fluid passes from a wall through which a hot fluid passes in a gas turbine jet engine.

This invention relates to boundary wall structures for hot fluid streams.

It is known to cool a wall dividing a hot fluid flow from a cold fluid flow of higher pressure by providing at the wall a passage admitting some of the cold fluid for the latter to form a film separating the wall from the hot fluid.

It has been found that for good cooling efficiency the velocity of the film must be related to the nature of the hot flow. Also the film should be free from undue turbulence. It can be the case that the pressure difference between the hot and the cold flow is too high for the establishment of a satisfactory film. The main object of this invention is to overcome or reduce this difficulty.

According to this invention a passage system for cooling a wall dividing a hot fluid flow from a cooler fluid flow of higher pressure comprises:

(a) A chamber formed at said wall;

(b) An inlet opening connecting the cold flow side of the wall to the chamber;

(c) An outlet opening connecting the chamber to the hot flow side of the wall;

(d) The interior of the chamber defining a flow passage extending between said openings and shaped to direct flow from the high pressure side of the wall through the outlet opening so as to form a film between the wall and the hot flow adjacent thereto;

(e) The flow passage including a substantially sudden enlargement of the flow area to create turbulence in the flow and thereby to reduce the mean velocity of the flow without a significant rise in static pressure;

(f) The flow passage including, downstream of said sudden enlargement, a portion of substantially uniform flow area to assist in settling said turbulence and in forming a uniform flow; and

(g) the outlet opening being dimensioned for the effective flow area thereof to be not less than the effective flow area of the inlet opening.

A constructional example of this invention will now be described with reference to the accompanying drawings wherein:

FIG. 1 relates to the first example and is an elevation of a gas turbine jet engine shown partly in section and including a combustion chamber.

FIG. 2 is an enlarged detail of the said combustion chamber.

FIG. 3 is a section on the line III—III in FIG. 2.

FIG. 4 is a section on the line IV—IV in FIG. 2.

FIG. 5 is a section on the line V—V in FIG. 2.

Referring to the drawings, the engine (FIG. 1) comprises a compressor **10** supplying air under pressure to the interior of an air casing **11** which surrounds a series of can-type combustion chambers **12** of which only one is shown. Fuel supplied to the chamber **12** through a supply

pipe **13** reacts with air entering the chamber **12** through holes **14** to produce a flow of burning gases which is exhausted through a turbine **15** which drives the compressor **10**. The temperature and pressure conditions at the wall, denoted **16**, of the combustion chamber **12** are such that at the outside of the wall **16** there exists a flow **17** of air which is substantially cooler and has a substantially higher static pressure than the flow **18** (FIG. 3) of the burning gases at the inside of the wall **16**. Some of the air at the outside of the wall **16** is allowed to enter the chamber **12** through a passage system **20** in such a way that a layer or film **19** of this relatively cool air is formed at the inside of the wall **16** to protect it from the heat of combustion. The film is only effective for a limited distance downstream of the passage system **20** because it tends to dissipate. Therefore it is usually necessary to provide two or more passage systems **20** so that the film **19** is renewed at intervals along the length of the chamber **12**. The efficiency of the cooling can be measured in terms of the distance, downstream of any one passage system **20**, over which the film is effective in preventing a rise of the wall temperature above a predetermined value.

It has been found that for good cooling efficiency the film **19** should have a uniform flow, i.e., it should be free from undue turbulence and there should be no undue velocity gradients in the cross section of the flow. Further, it has been found that cooling efficiency can be improved by adjusting the velocity of the film in relation to the velocity of the combustion gases, and as a general rule the velocity of the film should be approximately the same as that of the mean velocity of the directly adjacent part of the flow of the combustion gases so that mixing between the two flows **18**, **19** is minimized. The term "means velocity" is applied to the combustion gases because of the turbulence of these gases. FIG. 2 shows purely diagrammatically a desired velocity profile **21** for the film **19**, an indication at **22** of the velocity profile of the hot flow **18**, and at **23** the junction of the flows **18**, **19** across which mixing should be minimized. It is one of the objects of this invention to provide means for bringing about these desirable conditions. In this connection one must have regard to the pressure drop across the wall **16**, i.e., the pressure difference between the flows **17**, **18**. This pressure drop has to be high enough to force combustion air through the holes **14** in such a way that the air penetrates deeply into the chamber **12**. It has been found that such a drop is usually too high for establishing a cooling film of good uniformity of flow and of a velocity sufficiently low to match the velocity of the adjacent hot flow. The difficulty is overcome or reduced by the construction described next below.

The passage system **20** comprises a chamber **24** (FIGS. 2, 3) situated at the wall **16** and having an inlet opening **25** from the cold flow **17** and an outlet opening **26** to the interior of the wall **16**. The chamber **24** is constituted by an outer wall **27** which is a portion of the wall **12**, and by an inner wall **28** which has a curved portion **29** closing the upstream end of the chamber **24**. Between its inlet and outlet openings **25**, **26** the interior of the chamber **24** defines a passage **30** and air flow is established through the passage **30** on account of the pressure drop across the wall **16**.

The inlet opening **25** comprises holes **31** in the wall **16**. At the outlet opening **26** a corrugated strip **32** is secured to the wall **27** in position between the walls **27**, **28** partly in order to ensure that the walls **27**, **28** remain at their correct spacing, and the outlet opening **26** is defined by spaces **33** between the corrugations of the strip **32** and the walls **27**, **28**. The holes **31** and spaces **33** are so dimensioned that the effective flow area of the spaces **33** is not

less than the effective flow area of the holes **31**. As a result it is the holes **31** which meter the flow through the passage **30** and the static pressure drop across the passage **30** occurs substantially at the holes **31**. Immediately downstream of the holes **31** the passage has a sudden enlargement **34** of the flow area which has the effect of creating turbulence and thereby reducing the mean velocity of the flow without a rise in static pressure. Downstream of the enlargement **34** the passage **30** has a portion **35** of substantially uniform flow area whereby the turbulence created at the enlargement **34** has the opportunity to settle and the flow approaches the outlet opening **26** in substantially uniform manner. The corrugations of the strip **32** assist in making the flow uniform for two reasons. Firstly, since the flow area of the spaces **33** is necessarily less than the flow area in the portion **35** there is created in the portion **35** slightly higher pressure than would otherwise be the case, and this helps in the settling of said turbulence. Secondly, the sides of the corrugations help to straighten the flow because they lie parallel to the intended direction of flow.

In many cases, because of the random nature of the hot flow, it is difficult to determine the mean velocity of that part of the hot flow which influences the cooling film and the optimum film velocity is obtained experimentally by adjusting the outlet opening **26**. If the distance between the walls **27, 28** is reduced at the position of the strip **32** then the velocity of the film increases and vice versa. However, the flow area of the outlet opening must not be so reduced that it becomes less than the flow area of the inlet opening because then the film velocity would rise to a value exceeding that of the inlet velocity.

The wall **28** is secured to the wall **27** by rivets **36** situated downstream of the inlet opening **25** so as to be cooled by the air flow. The flow through the passage **30** is also important for the cooling of the wall **28**, and the curved end **29** of the wall **28** is situated close to the holes **31** as otherwise it would not be able to benefit from the cooling effect of the incoming air.

What I claim is:

1. A passage system for cooling a wall dividing a hot fluid flow from a cooler fluid flow of higher pressure comprising:

(a) a chamber formed at said wall;

(b) an inlet opening connecting the cold flow side of the wall to the chamber;

(c) an outlet opening connecting the chamber to the hot flow side of the wall;

(d) the interior of the chamber defining a flow passage extending between said openings and shaped to direct flow from the high pressure side of the wall through the outlet opening so as to form a film between the wall and the hot flow adjacent thereto;

(e) the flow passage including a substantially sudden enlargement of the flow area to create turbulence in the flow and thereby to reduce the mean velocity of the flow without a significant rise in static pressure;

(f) the flow passage including, downstream of said sudden enlargement, a portion of substantially uniform flow area to assist in settling said turbulence and in forming a uniform flow; and

(g) the outlet opening being dimensioned to be not less than the effective flow area of the inlet opening.

2. A passage system according to claim **1**, including members situated in said passage downstream of said sudden enlargement and having surfaces lying parallel to the intended direction of flow to assist in straightening the flow and settling said turbulence.

3. A passage system for cooling a wall dividing a hot fluid flow from a cooler fluid flow of higher pressure comprising:

(a) a chamber formed at said wall;

(b) an inlet opening connecting the cold flow side of the wall of the chamber;

(c) an outlet opening connecting the chamber to the hot flow side of the wall;

(d) the interior of the chamber defining a flow passage extending between said openings and shaped to direct flow from the high pressure side of the wall through the outlet opening so as to form a film between the wall and the hot flow adjacent thereto;

(e) the flow passage being dimensioned to include a substantially sudden change from the flow area determined by the inlet opening to a larger flow area downstream thereof to create turbulence in the flow and thereby reduce the mean velocity of the flow without a significant rise in static pressure;

(f) the flow passage including, downstream of said sudden enlargement, a portion of substantially uniform flow area to assist in settling said turbulence and in forming a uniform flow; and

(g) the outlet opening being dimensioned to be not less than the effective flow area of the inlet opening.

4. A passage system according to claim **3**, said wall lying substantially parallel to the general direction of the hot and cold flows, the inlet opening being constituted by holes in the wall, and said chamber projecting from the wall into the hot stream.

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ROBERT A. O'LEARY, *Primary Examiner.*

M. A. ANTONAKAS, *Assistant Examiner.*