April 13, 1954 A. T. BOWDEN 2,674,849

PLURAL COMBUSTORS WITH COOLING MEANS

Filed Dec. 3, 1949

2 Sheets-Sheet 1

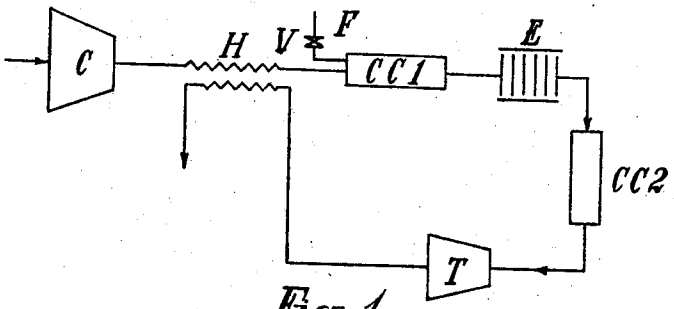


Fig 1.

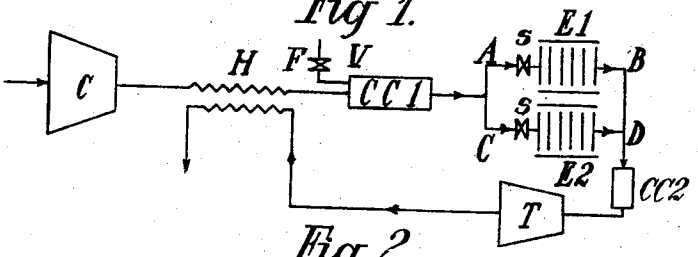


Fig 2.

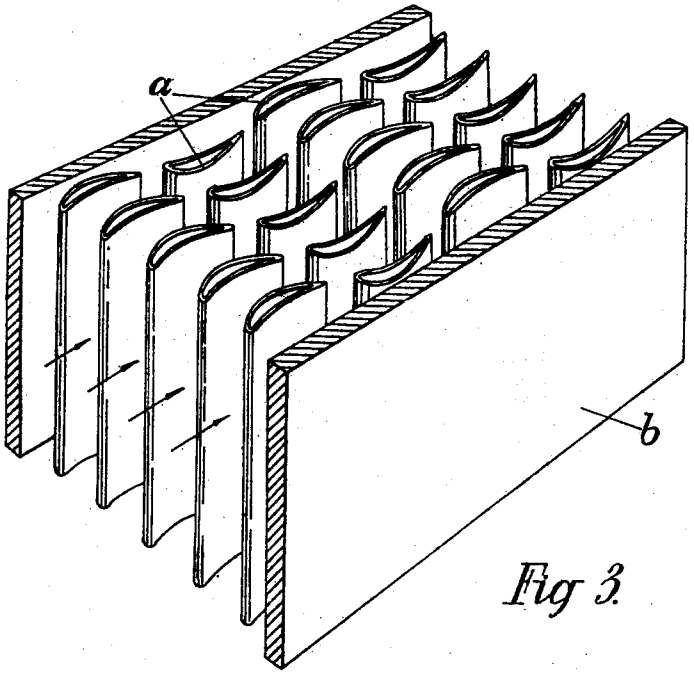


Fig 3.

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2 Sheets-Sheet 2

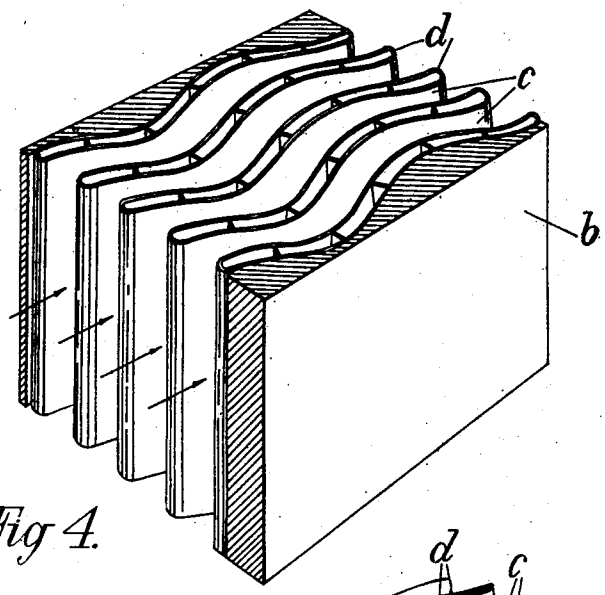


Fig 4.

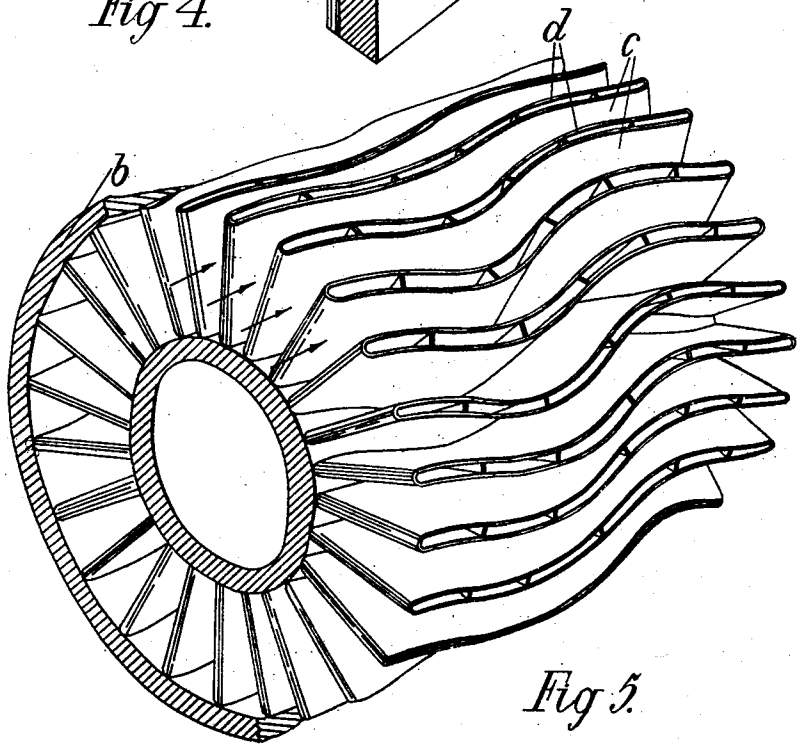


Fig 5.

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PLURAL COMBUSTORS WITH COOLING MEANS

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5 Claims. (Cl. 60—39.66)

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This invention relates to gas turbines.

In gas turbine plant working according to an "open" or "mixed" cycle the fuel used is burned directly in air compressed to a suitable pressure above atmospheric and the resultant products of combustion together with additional diluent air form the working medium which is expanded in one or more turbines thus producing useful power. In such cycles, as distinct from the "closed" cycle wherein air or other suitable gas only is circulated and expanded in the turbine or turbines, the products of combustion must be acceptable to the turbine and other components associated therewith, that is to say, they should not for example contain constituents which if deposited on the turbine blades or other channels would partially or completely block same, nor preferably should they chemically attack the materials of which the turbine and other components are made and through which they are being carried in the working medium.

Such deposition of or attack by the constituents of the products of combustion results in the first place from the complete or partial combustion of certain constituents contained in the fuel or in the air used for its combustion. Such constituents are unfortunately often associated with the cheaper fuels which from the point of view of economy it is desirable to use. Their harmful effects may, however, depend in whole or in part upon their temperature. For example, in the process of burning the fuel certain products of complete or partial combustion may occur in the form of a gas or liquid and may remain in this state in the working medium at the outlet of the combustion chamber or the inlet to the turbine and with the fall in temperature of the working medium due to loss of heat or the conversion of heat into work may change their state from the gaseous to the liquid or from liquid to viscous or solid state. While therefore in the gaseous or even the liquid state such constituents may pass freely through the channels of the turbine and its associated equipments such as the heat exchanger, they may in the viscous or solid state become deposited on the surfaces forming such channels and cause complete or partial blocking of same with resultant loss in power and/or efficiency.

The object of the present invention is to prevent or inhibit the harmful effects of the constituents in the working medium arising from the combustion of the fuel or brought in with the combustion and/or diluent air.

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According to the invention suitable surfaces are interposed, hereinafter referred to as extractors, or extractor elements, in a stream of working medium after combustion and prior to its entry into a gas turbine.

The invention consists in a method of inhibiting the harmful effects of the constituents in the working medium of a gas turbine wherein an extractor element is interposed in a stream of working medium after combustion and prior to its entry into the turbine, said element forming the boundaries of suitable channels through which the working medium is led and being of such form and of such material as will ensure that the constituents in the working medium which would deposit upon or attack the turbine and/or its associated components, e. g. a heat exchanger, are deposited in whole or in part, and/or their power of chemical attack expended in whole or in part upon such surfaces and wherein the combustion products subsequently pass through a secondary combustion chamber where they are raised to a higher temperature by the combustion of further fuel.

The invention also consists in a method as set forth in the preceding paragraph, wherein the relation of the fuel to air is so adjusted that the combustion products enter the extractor within a prescribed temperature range.

The invention also consists in apparatus for carrying into effect the method set forth in either of the two preceding paragraphs.

The invention also consists in apparatus as set forth in the preceding paragraph embodying a bifurcated combustion chamber outlet having an extractor element in each leg and a valve or valves for switching the flow through either leg.

The invention also consists in apparatus as set forth in either of the two preceding paragraphs wherein the extractor elements take the form of hollow blades or tubes.

Referring to the accompanying diagrammatic drawings—

Figure 1 illustrates the simplest application of the present invention.

Figure 2 illustrates a modified arrangement.

Figures 3, 4 and 5 illustrate three alternative forms of extractor elements that may be employed in connection with the present invention.

In carrying the invention into effect according to one convenient form illustrated by way of example in Figure 1, air from a compressor C passes through a heat exchanger H where it picks up heat from the exhaust gases discharged by a turbine T. After combustion in a combustion chamber CC1, supplied with fuel through fuel line F at a rate regulated by valve V, the products of combustion pass through an extractor E and the constituents which would adhere to the turbine blading or auxiliary equipment such as, for example, the heat exchanger, are deposited on the surfaces of the said extractor. A further combustion chamber or chambers is introduced, in which the extractor element is interposed between two stages of the combustion process. In the first stage there takes places the combustion of the fuel which gives rise to the constituents which would but for the intervention of the extractor become deposited upon or chemically attack the turbine and/or its associated components. But since the temperature of the products of combustion together with such diluent as may have been used may, after passing the extractor either because of the amount of fuel burned or because of being cooled while passing through the special element as already described, is insufficient to provide the required efficiency of the plant, provision is made for a further stage or stages of combustion preferably using a fuel free from the constituents which give rise to deposits or chemical attack when passing through the turbine and/or its associated components. In this manner the temperature may be raised to the required degree and without materially adding to the working medium undesirable constitutents in the products of combustion. As will be seen from Figure 1 the combustion takes place in two stages, one before the extractor in the combustion chamber CC1 and the other in a combustion chamber CC2 following the extractor. Thereafter the products of combustion are expanded in the turbine T and are then led through the heat exchanger H to atmosphere.

The process permits of using in the first combustion stage or stages grades of fuel that are in general cheaper than those which do not give rise on combustion to products harmful to the output and/or efficiency of the turbine and its associated components.

In the particular applications or combination of applications outlined in Figure 1, the extractor E may be contained in a bifurcated outlet from the first combustion chamber CC1, and by means of suitable valves S and ducting the flow from the combustion chamber may be diverted through one leg or the other of the bifurcated outlet, thus allowing of the one extractor element being cleaned or repaired while the other is functioning.

As shown in Figure 2 the working medium at outlet from the combustion chamber CC1 may flow alternatively along the path AB through the extractor E1 or along the path CD through the extractor E2 and so in either case to the turbine T by way of the second combustion chamber CC2. The extractors may, if necessary, be of such form as, for example, hollow blades or tubes as allows of their being cooled by air or other suitable medium.

It is desirable to ensure that the combustion products shall pass through the extractor within a prescribed temperature range and this may be achieved by suitable selection of air/fuel ratio or by cooling the extractor.

Figures 3, 4 and 5 show by way of example three constructions of extractor elements which may be used.

In the extractor of Figure 3, the products of combustion pass between the blades of a series of blades *a* in a casing *b*, the said blades being cooled if necessary as described above, by air tapped from the compressor or by air or other coolant derived from a separate source and passed through the hollow blades. The extractor has the structure of a tubular surface condenser, the coolant being circulated through the hollows within the blades *a* and the blades *a* defining passages between them for flow of the gas and combustion products from the primary combustion chamber CC1 to the secondary combustion chamber CC2.

In Figure 4 the extractor element consists of tortuous passages *c* contained between hollow sections *d* which change the direction of the products of combustion continuously and not in a series of steps as in Figure 3. The said sections allow if necessary, of cooling by air or other coolant being passed through them.

In Figure 5 is shown an extractor somewhat similar to that of Figure 4, but in this instance it is in the form of an annulus through passages *c* in which the combustion gases pass as indicated by the arrows. As in Figures 3 and 4, the coolant may pass through the hollow boundaries which form the channels through which the combustion gases pass in which case suitable means are provided for bringing the coolant to and taking the coolant away from the blades or tubular passages through which it passes. Interrupted passages such as those shown in Figure 3 may be used in annular forms of extractor such as shown in Figure 5.

By the provision of suitable form and material for the extractors and by providing that they are more easily and speedily removable or renewable than the turbine and/or its associated components, e. g., a heat exchanger, the useful running life of the plant is increased and repair or renewal shut down time reduced.

The effectiveness of the extractor element depends upon the products of combustion when passing through it being at a temperature or within a temperature range such that objectionable constituents will adhere to the extractor surfaces, and this is achieved by so adjusting the relation of fuel to air that the combustion products enter the extractor at the prescribed temperature and subsequently pass through a secondary combustion chamber where they are raised to the full temperature by the combustion of further fuel.

I claim:

1. In a gas turbine installation, a primary combustion chamber, a secondary combustion chamber, an extractor between the two combustion chambers, each having its own fuel supply, and means connecting the primary combustion chamber directly to the extractor and the extractor directly to the secondary combustion chamber, the extractor having surfaces for depositing harmful constituents of the combustion products, and means for cooling the said surfaces to cause deposition thereon of such constituents.

2. An installation according to claim 1, comprising means for regulating supply of fuel to the primary combustion chamber to regulate the

temperature of the combustion products passing through the extractor.

3. An installation according to claim 1, having a second such extractor and valve and conduit means for directing the flow from the primary combustion chamber to the secondary combustion chamber selectively through either of the two extractors.

4. An installation according to claim 1, in which the extractor comprises a tubular surface condenser.

5. An installation according to claim 4, in which the tubular elements are formed as blades, defining flow channels for the passage of gas and combustion products through the extractor.

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