June 13, 1967 S. J. KEATING, JR., ET AL 3,325,658

MAGNETOHYDRODYNAMIC GENERATOR DIFFUSER-SPLITTER VANE CONSTRUCTION

Filed Nov. 17, 1964 2 Sheets-Sheet 1

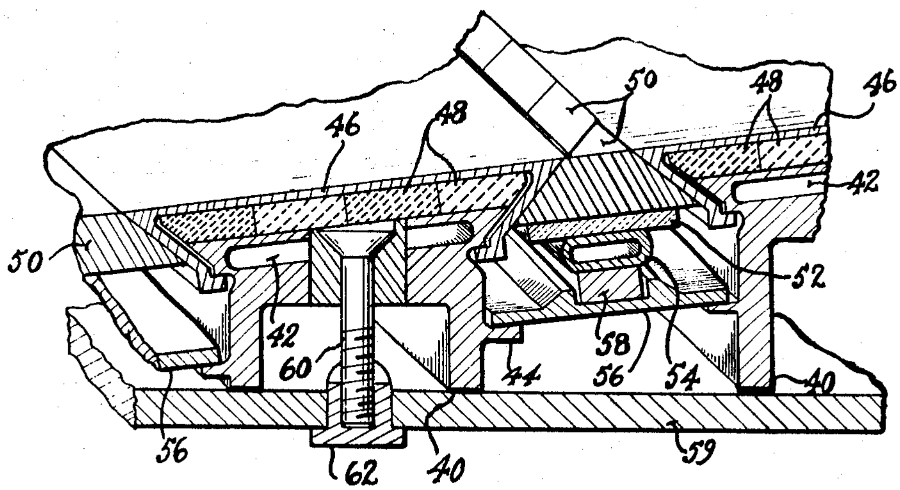

FIG. 3

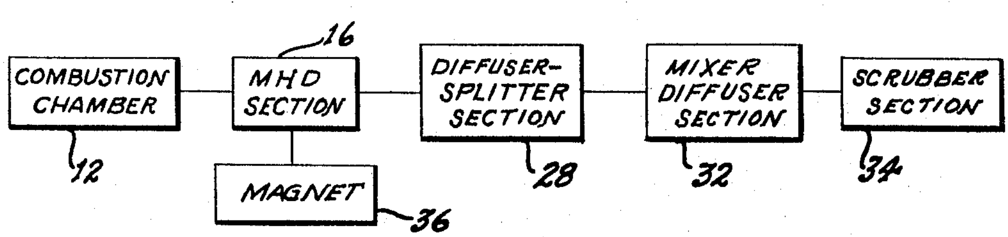

FIG. 1

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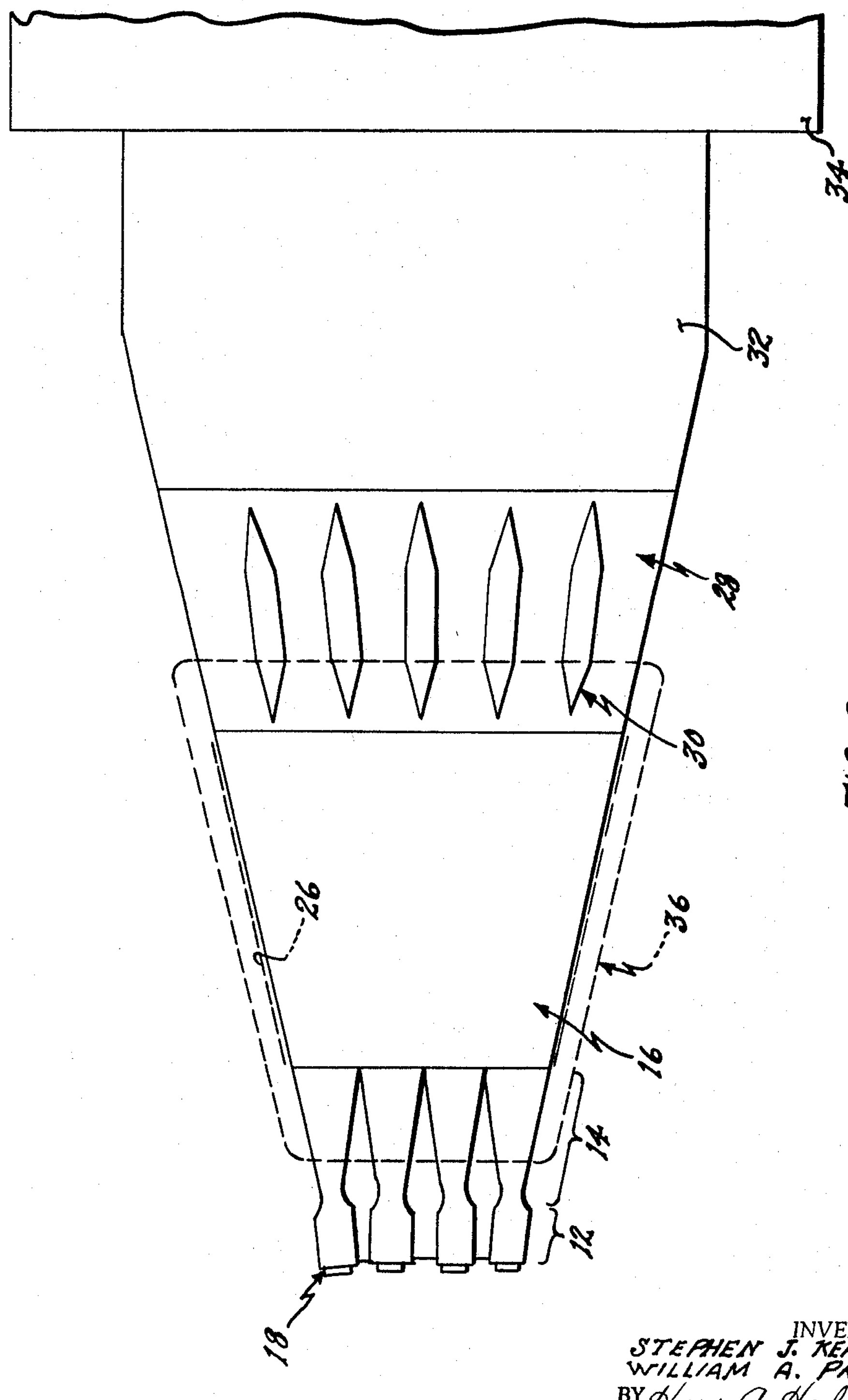

FIG. 2

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MAGNETOHYDRODYNAMIC GENERATOR DIFFUSER-SPLITTER VANE CONSTRUCTION

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2 Claims. (Cl. 310—11)

This invention relates generally to the diffuser-splitter section of a magnetohydrodynamic generator, and more particularly, to the diffuser-splitter vanes and the construction thereof for high temperature and electrical isolation.

The diffuser-splitter section of an MHD generator is provided to eliminate losses caused by the end effect from the generator channel due to current induced by the combined effect of an abrupt change in magnetic field strength with axial distance and changes due to termination of active electrodes, blooming, etc. Splitter-diffuser vanes in this section provide physical barriers to the flow of the unwanted eddy currents while simultaneously acting as supersonic diffusers in order to decelerate the high-velocity exhaust flow from the MHD generator channel and cause recovery of pressure in the process. Thus, the generator section itself is permitted operation at lower, more desirable static pressures.

By using the splitter vanes as diffusers also, they may be made thicker and stronger, the need for a separate diffuser is eliminated, and by splitting the flow into several sections in the diffuser-section, the length of the section may be greatly reduced.

By mounting the splitter-diffuser vanes parallel to the applied magnetic field, they should have no appreciable electric field parallel to their length across the channel. Thus they need be made resistive to the electrical fields in only two directions; along the length flow-wise and through the thickness from one side to another. Flow-wise insulation is provided by strips of non-conductor blocks separating and retained by conducting cover plates on load carrying members. Transverse isolation is provided by a center, non-conducting slab.

Since the splitter-diffuser vanes may be subject to appreciable side loadings, due to unbalance pressure forces, they must have structural strength which is not compromised by the high temperature environment.

To prevent the condensation from the plasma stream (see patent application Ser. No. 406,952, filed Oct. 27, 1964, by Stephen J. Keating, Jr., and Donald H. Wood for further description of an MHD generator) of electrically conductive materials on the non-conductor section of the diffuser-splitters which would destroy their effectiveness, these insulators must be operated at very high temperatures. Only refractory ceramics have been found suitable for this purpose. As noted in the referenced patent application, these ceramics are not suitable structural materials unless subjected to compressive forces only when at high temperatures. They must, thus be supported to provide only compressive forces within them.

Because of well-known boundary layer phenomenon, the cover plate beneath which the temperature control and thermal isolation ceramic pieces are retained must be operated such that their outer surface temperature is very near that desired for the outer non-conducting ceramic pieces. This temperature is, however, so high that these sections cannot be used for primary structural supports but must, in fact, be thermally isolated from them as provided in this invention.

Accordingly, it is an object of this invention to provide a method of construction for an MHD generator diffuser-splitter vane which has the ability to function in a very high temperature environment and to control electrical current flow along the surface from member to member with variation in the heat flow while maintaining surface temperature within allowable limits.

It is another object of this invention to provide a non-conductor insulating separator for use in the outer surface construction of an MHD generator diffuser-splitter vane which is arranged to be loaded only to carry compression stress.

It is a further object of this invention to provide an outer surface construction of an MHD generator diffuser-splitter vane wherein expansion produces a wedging of an insulator in a direction normal to the surface against resistance stress inducting only compressive stresses in it.

It is a still further object of this invention to provide separators for an MHD generator diffuser-splitter vane outer surface construction wherein the separators are allowed to conform to an elastic curve developed by the conductor members.

Another object of this invention involves an electrical and/or pressure isolation of the conductive portion to the non-conductive portion with variance in chord shape of a diffuser-splitter vane.

These and other advantages, features and objectives of the invention will become more apparent from the following description taken in connection with the illustrative embodiments in the accompanying drawings, wherein:

FIGURE 1 is a block diagram of an MHD generator system;

FIGURE 2 is a schematic representation of the MHD generator of FIGURE 1; and

FIGURE 3 is an isometric cut-away drawing of one-half of the diffuser-splitter vane of this invention.

Referring to FIGURE 1, there is shown schematically in diagram form, basic components of a magnetohydrodynamic generating system which is more fully described in U.S. patent application Ser. No. 406,952 filed on Oct. 27, 1964 by Stephen J. Keating, Jr. and Donald H. Wood. Basically, the system (see also FIG. 2) comprises a combustion chamber section **12**, which in one particular embodiment comprises multiple chambers which lead to converging-diverging nozzles **14** which merge into the MHD section **16** having electrodes **26** on the top and bottom walls thereof. The combustion chamber is utilized to con- chemical energy of the reactants to thermal energy and also has injectors **18** to add an easily ionizable substance along with propellant to assure ionization of the combustion components. The nozzle section converts the thermal energy to kinetic energy by accelerating the high temperature plasma. The MHD section forms a channel wherein the kinetic energy of the plasma is converted to electrical energy. Connected with and surrounding the MHD section is a magnet **36** for providing a magnetic field with which the plasma interacts to produce power. A diffuser-splitter section **28** is provided to eliminate losses due to current induced by the combined effect of an abrupt change in magnetic field strength with axial distance and changes due to termination of active electrodes, blooming, etc. Splitter-diffuser vanes **30** in this section **28** provide physical barriers to the flow of eddy currents and also act as diffusers providing pressure recovery.

A mixer diffuser section **32** follows the diffuser-splitter section and provides a means of destroying the conductivity of the plasma before it reaches the scrubber section which follows. Cooling is achieved in the mixer section as well as in the scrubber section which also removes seed compound and particles eroded from the liner, which must be eliminated from the exhaust.

The scrubbed exhaust products are then passed into the exhaust section **34** and out of the system.

A control system, not shown, which is capable of operating all the components of the system, would also be provided in order to complete the device. By utilizing the aforementioned components, a magnetohydrodynamic generator may be provided which is capable of production of 1000 megawatts of D.C. electric power for utilization in continuous wave radio frequency energy conversion systems with a high power range.

The diffuser-splitter vane 30 of FIGURE 2 is shown in FIGURE 3 and provides a structure which meets the aforementioned requirements. Conductor and non-conductor portions of the outer wall construction of the MHD channel must provide for variations in heat rate such as through a changing boundary layer thickness on a vane which is impinged by a flowing gas.

FIGURE 3 also shows the arrangement for the high temperature and electrical isolation of the outer surface construction where there are variations in heat flow along the surface.

Basically, the device comprises a main load carrying member 40 which has therethrough a cooling passage 42 extending along the length thereof. The upper portion of each main load carrying member will conform to the surface inclination relative to vane center line and the lower portion of the member will establish the chord thickness.

The load-carrying members 40 are electrically isolated from each other by use of a vane center member 59 made of non-conducting material which is shielded from the higher temperatures by water-cooling of the elements in contact with it. The structural members 40 are bolted to this slab in a fashion which does not connect them electrically from one side of the slab to the other. Bolt 60 is provided for this purpose and is arranged to threadably engage an insert 62 through slab 59. Coolant in tube 42 prevents the transfer of high temperatures to slab 59 by the bolt 60. The connections are also made to transmit shear forces such that combined beam strength of the load-carrying members on either side of the slab are fully developed.

The side portions of the general channel shaped main load members 40 have anchor pads 44 which are integral with the load carrying member. The load carrying member lies beneath the conducting portion 46 which comprises a conducting cover plate. Interposed between the cover plate 46 and the main load carrying member 40 are heat-rate control materials 48 which allows for variance in heat flow from the conductor portion through to the coolant. The long blocks of heat control material 48 may be of aluminum oxide, titanium dioxide, or zirconium dioxide with various porosity. The members 48, even though they accommodate various heat rates, may be of constant thickness.

Disposed between conducting portions are non-electrically conducting portions designated generally as 50. The non-conductor portion 50 overlies a heat rate control material 52 which is also of constant thickness and utilizes at least one of the aforementioned materials for heat rate control blocks 48 in order to provide for the proper heat transfer to a tube 54 through which coolant is made to flow. This arrangement is mounted to the anchor pad 44 by means of a flexible beam 56 which has a low elastic modulus and is made of non-conducting material. The flexible beam 56 has a channelled portion therein which is arranged to support an elastic pad 58 which in turn supports the coolant tube 54. This arrangement provides a spring rate in the vertical plane which resists thermal expansion of the cover plate 46, because it extends along the surface of insulator 50, wedges the insulator 50 in a direction normal to the surface against resistance thereby providing only compression strain on the insulator. To allow complete conformance of the separators to the elastic curve developed by the conductor member, the inner attachment of the members is to a common end support which comprises the main load carrying members. The same support provides, through the elastic type coupling, the support for the coolant conveyance member of the non-conductor portion. Surfaces between adjacent non-conductors 50 are formed such that the resulting joints are not parallel to the flow of plasma.

Thus, there has been described an outer surface construction for a magnetohydrodynamic generator splitter-diffuser vane which allows for attachment of portions of surface construction onto both sides of a non-conducting member situated at the mid-point.

Although the invention has been described with reference to a particular embodiment, it will be understood to those skilled in the art that the invention is capable of a variety of alternative embodiments within the spirit and scope of the appended claims.

We claim:

1. An outer surface construction for high temperature and electrical isolation for a magnetohydrodynamic generator diffuser-splitter vane wherein a non-conductor member is situated between a pair of conducting members comprising main load carrying members each having a coolant passageway therethrough, heat rate control material overlying each of said members, and a conducting cover plate overlying said heat rate control material and engaging its main load carrying member, anchor pads extending laterally from each of said members, a flexible beam supported on the anchor pads of adjacent load carrying members, an elastic pad supported on said flexible beam, a coolant tube superposed on said elastic pad, an insulator wedged between adjacent cover plates and heat rate control material between said insulator and said coolant tube.

2. An outer surface construction as defined in claim 1 wherein said heat rate control materials beneath said cover plates are of constant thickness and the heat rate control material beneath said insulator is of constant thickness.

No references cited.

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