

July 26, 1960

J. D. ANNEAR ET AL
STATOR BLADE MOUNTING OF CONDITION SENSING
ELEMENTS IN FLUID FLOW MACHINES

2,946,221

Filed July 9, 1954

2 Sheets-Sheet 1

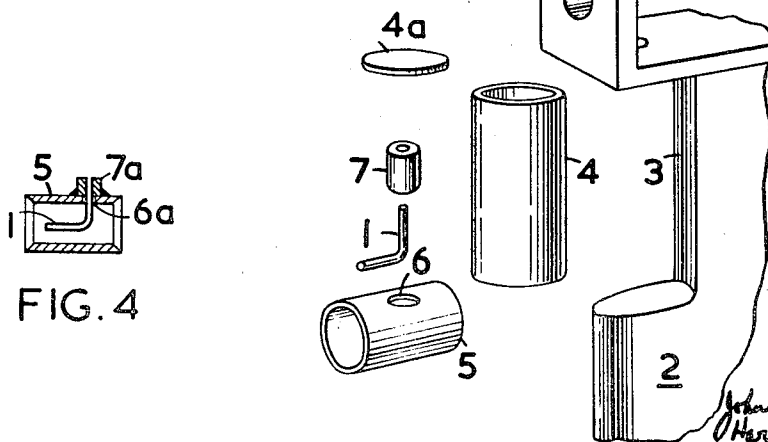
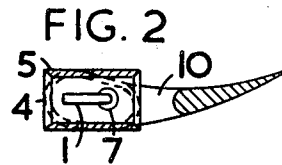
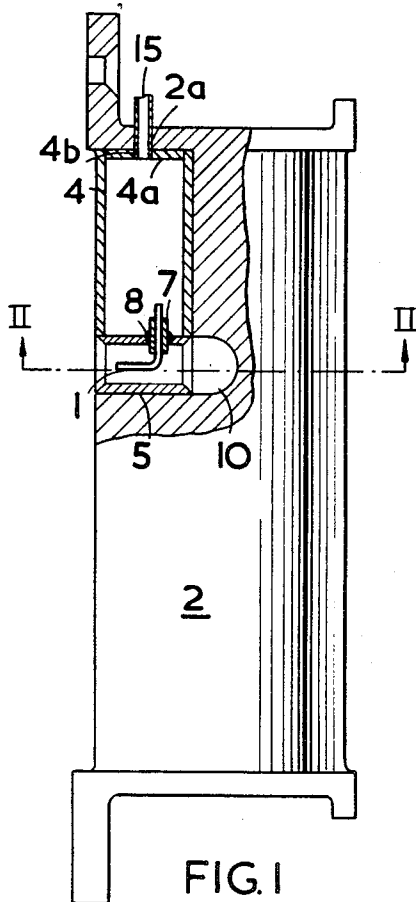


FIG. 4

FIG. 3

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FIG. 6

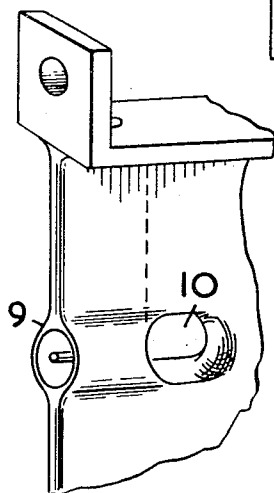
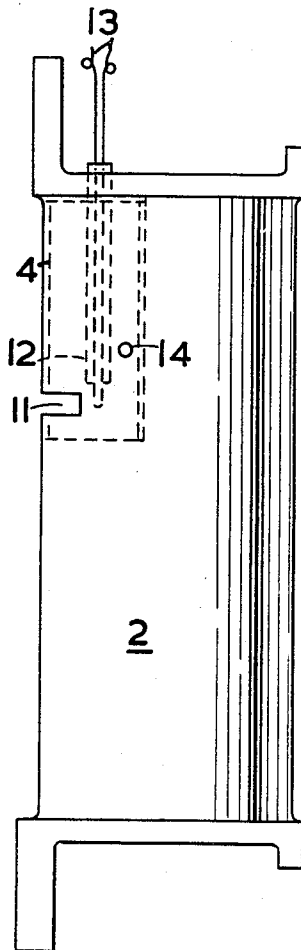


FIG. 5

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STATOR BLADE MOUNTING OF CONDITION SENSING ELEMENTS IN FLUID FLOW MACHINES

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Filed July 9, 1954, Ser. No. 442,246

Claims priority, application Great Britain July 14, 1953

4 Claims. (Cl. 73—212)

To determine the performance of a steam or gas turbine, such quantities as the working fluid pressure, rate of flow, and temperature must be measured in the turbine itself and, in the case of a gas turbine plant, in the compressor. A very convenient location for thermocouples, and for Pitot tubes and like gauges is in the leading edge of a stator guide vane but the drilling of a hole therefor partly along the length of the vane and a communicating hole through the edge of the vane is a difficult operation which may not lead to satisfactory results.

It is particularly difficult to mount in the edge of a vane a so-called Kiel type Pitot probe. This useful device is a Pitot tube within an open-ended circular section tubular shroud of which the purpose is to straighten out the air flow in the immediate vicinity of the Pitot tube. The device gives a measure of total head which is independent of the angle of incidence of the fluid stream, over the range of angles experienced in practice, and up to about 40°, and so can be fixed and need not be mounted for angular movement to suit variations in flow conditions.

The present invention provides a stator guide vane having as part of its leading edge a separately formed hollow member extending from one end to a position intermediate its ends, a substantially major portion of the exterior surface of the hollow member forming a working surface portion of the leading edge, a shroud tube secured to the vane with its axis lying along the fluid path to define a passage for fluid, a pressure condition sensing Pitot tube element, said element having an inlet head portion and an outlet portion, means mounting said element in said hollow member with the head portion extending into said shroud tube and the vane having an aperture through the thickness of the vane downstream of said head portion of the element constituting an outlet for the said passage for fluid.

In particular a Kiel type probe or shrouded Pitot tube is mounted by securing the shroud tube thereof to the deformed tube with its axis transverse to that of the deformed tube and with the outlet of the Pitot tube within the deformed tube and securing the tube assembly to the vane to fill the recess whilst maintaining a fluid outlet at the downstream end of the shroud tube permitting the free flow of fluid through the shroud tube.

According to another particular form of the invention the instrument is a thermocouple and one or more apertures are provided in the deformed tube remote from the leading edge to create a fluid passage within which the thermocouple lies.

The present invention also includes a stator guide vane within which an instrument is supported by the above-mentioned method.

In the accompanying drawings:

Fig. 1 is a part-sectioned side elevation of a stator guide vane containing an instrument.

Fig. 2 is a sectional view along the line II—II of Fig. 1.

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Fig. 3 is an exploded view of part of the device of Fig. 1.

Fig. 4 is a sectional view of a slightly modified part of the stator guide vane assembly of Fig. 1.

Fig. 5 is a perspective view of part of the device of Fig. 1.

Fig. 6 is a side elevation of another form of stator guide vane assembly.

In one particular construction according to the invention, for mounting the Pitot tube 1 of a Kiel type probe approximately in the middle of the leading edge of a stator guide vane 2, an appropriate length of the leading edge and the adjacent part of the blade is cut away to a sufficient distance back by a milling cutter leaving a recess having an arcuate seating 3, in Fig. 3, for the tube which is to replace the edge. A tube 4 of radius larger than the radius of the leading edge and shorter than the length cut away is deformed to the contour of the cut-away portion so that it will fit into the seating and line up with the remaining part of the edge, to serve as a connecting tube. A short tube 5 of larger diameter forming the shroud is drilled through its cylindrical wall with a hole 6. The Pitot tube 1 is a right angled bend of fine bore tube. It is inserted through the hole in the wall of the shroud and temporarily held accurately centrally in the shroud tube, with its inlet pointing along the axis of the shroud tube, for example by a forked tubular locating tool. A third tube or sleeve 7 which fits closely around the Pitot tube is then put in place to complete the Pitot head unit. In Figs. 1 and 3, the sleeve 7 surrounding the Pitot tube 1 fits in the countersunk hole 6 in the shroud tube 5; these three pieces are united by heating them in a flame and running weld metal into the countersink at 8 to weld the sleeve 7 to the shroud tube 5, the heat simultaneously causing the sleeve to weld to the Pitot tube, thus securing it to the shroud tube without risk of blocking the bore with weld metal. In the alternative assembly shown in Fig. 4, the tube fitting around the Pitot tube is a collar 7a welded to the Pitot tube 1 and shroud tube 5, the hole 6a in the latter fitting the Pitot tube.

The length of the connecting tube 4 and the diameter of the shroud tube 5 are together equal to the length of the cut-away portion of the edge of the vane. Accordingly they are put together at right angles, with the sleeve 7 or collar 7a of the head projecting into the connecting tube, and welded together. Preferably an end-plate 4a is welded to the connecting tube 4 to prevent leakage of fluid between the communicating tube and the end of the vane. Then the assembly is fitted in the gap in the vane, bearing against the arcuate seating, and flame welded to the vane, at least along the connecting tube; weld metal is added at 9 in Fig. 5 as necessary to make up the exterior of the connecting tube to the correct vane profile and possibly afterwards machined or filed to correct size. If the vane is of the type having a massive platform at each end for fixing and forming shrouds at the end, the Pitot shroud tube itself is preferably not directly welded to the rest of the vane; this leaves freedom to avoid undue stresses due to unequal thermal expansion and contraction on sudden and large temperature fluctuations.

A large aperture 10 is drilled in the vane just behind the shroud tube and cut back to provide a free outlet for fluid at the downstream end of the shroud-tube, and finally a hole 4b is drilled and tapped in the end-plate 4a through an aperture 2a simultaneously or previously drilled in the end of the guide vane to permit a pressure connection 15 to be inserted to communicate with the interior of the tube 4.

There thus results a stator guide vane having a Pitot

probe pointing upstream from its leading edge, the profile of the leading part of the vane being normal, except where, in the centre, it bulges out slightly and smoothly into the shroud for the Pitot tube with an aperture at the rear of the shroud.

A similar technique can be used for housing a thermocouple in the leading edge of a stator guide vane as shown in Fig. 6, for measuring gas temperature which may differ substantially from the stator guide vane temperature. If the thermocouple were completely enclosed in the leading edge, the walls would act as a radiation shield and prevent the couple from picking up heat radiated from the surfaces in contact with the gas stream. Accordingly, the thermocouple junction is exposed to the gas stream; the gas is brought substantially to rest but is not allowed to stagnate in the vicinity of the couple. Hence, as with the Pitot tube, the thermocouple is mounted in a connecting tube, but again there is an open "window" 11 exposing the instrument to the gas. Preferably the length of the connecting tube is now such as to fill the space left by the cutting away, and the tube wall is notched to form the desired gap or window. A refractory insulating tube 12 is inserted in the metal tube either before or after the latter has been welded in place in the guide vane. The connecting wires 13—insulated from each other—for the thermocouple extend through this tube with the couple itself projecting beyond the insulating tube into the gap to expose the junction to the hot gas. As the gas stream passes through the window and impinges on the rear wall of the connecting tube, its velocity energy is destroyed and the resulting rise in temperature is picked up by the thermocouple junction. In order to prevent the formation of a stagnant pocket, provision is made for flow of the gas over the thermocouple and at least partly along the metal connecting tube, whence it leaks away. This provision may conveniently be made by drilling a hole 14 through the wall at some intermediate position along the length of the metal connecting tube not far from the window.

If the vane has a massive platform at each end, the end of the connecting tube may be closed up but not welded to the rest of the vane, so as to leave freedom for unequal thermal expansion and contraction.

For use in a turbine and particularly in a gas turbine the metal tubes must withstand the high temperature of the working fluid and they should therefore be of the same metal as the vanes and blades, which will usually be an alloy of the kind known under the trade name of "Nimonic."

We claim:

1. A stator guide vane for a fluid flow machine having as part of its leading edge a separately formed hollow member constituting a mounting for a Pitot tube and extending from one end of the vane to a point intermediate its ends, a shroud tube secured to the vane with its axis lying along the fluid path through the machine defining a passage in the leading edge, a Pitot tube mounted on said hollow member with the head of said Pitot tube in said shroud tube and the outlet of said Pitot tube in said hollow member so that said shroud tube affords fluid access to the head of said Pitot tube, and means defining an aperture through the thickness of the vane constituting a fluid outlet of said shroud tube downstream of the head of said Pitot tube.
2. A stator guide vane as recited in claim 1 having a sleeve fitting closely and secured to the outlet end of the Pitot tube and to the shroud tube to unite said tubes.
3. A stator guide vane for a fluid flow machine having as part of its leading edge a separately formed hollow member extending from one end to a position intermediate its ends, a substantially major portion of the exterior surface of the hollow member forming a working surface portion of the leading edge, a shroud tube secured to the vane with its axis lying along the fluid path through the machine to define a passage for fluid, a pressure condition sensing Pitot tube element, said element having an inlet head portion and an outlet portion, means mounting said element in said hollow member with the head portion extending into said shroud tube and the vane having an aperture through the thickness of the vane downstream of said head portion of the element constituting an outlet for the said passage for fluid.
4. A stator guide vane as claimed in claim 3 having a sleeve fitting closely to the outlet portion of the pressure condition sensing Pitot tube element and secured to the shroud tube.

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