Feb. 18, 1958 M. S. BAKER ET AL 2,823,891

STEAM TURBINE

Filed May 20, 1953 2 Sheets-Sheet 1

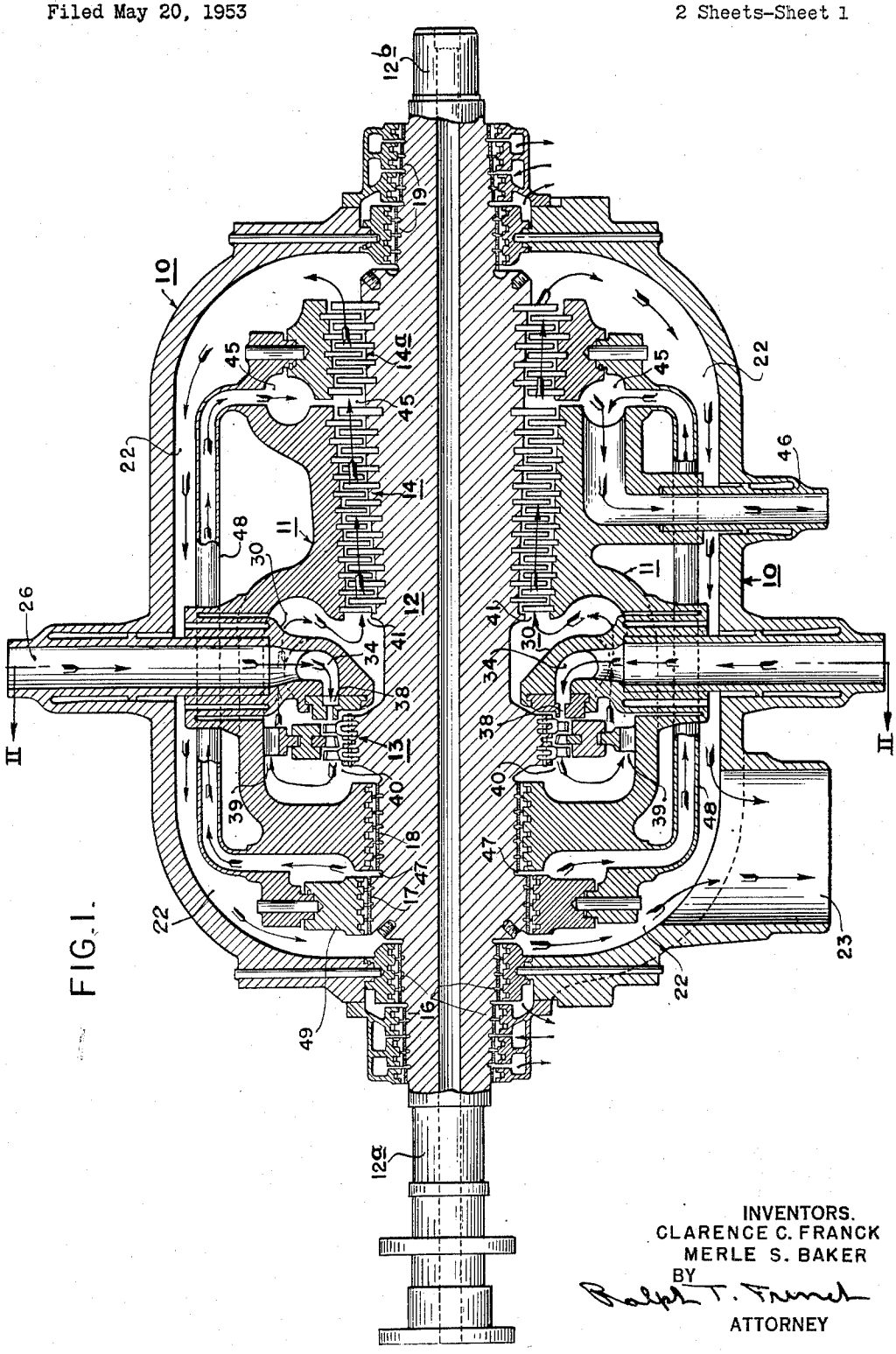


FIG. 1.

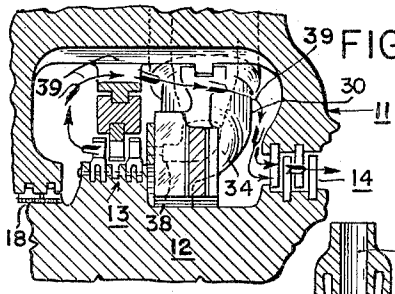
INVENTORS.
CLARENCE C. FRANCK
MERLE S. BAKER
BY
Ralph T. Franck
ATTORNEY

Feb. 18, 1958 M. S. BAKER ET AL 2,823,891

STEAM TURBINE

Filed May 20, 1953 2 Sheets-Sheet 2

FIG. 3.



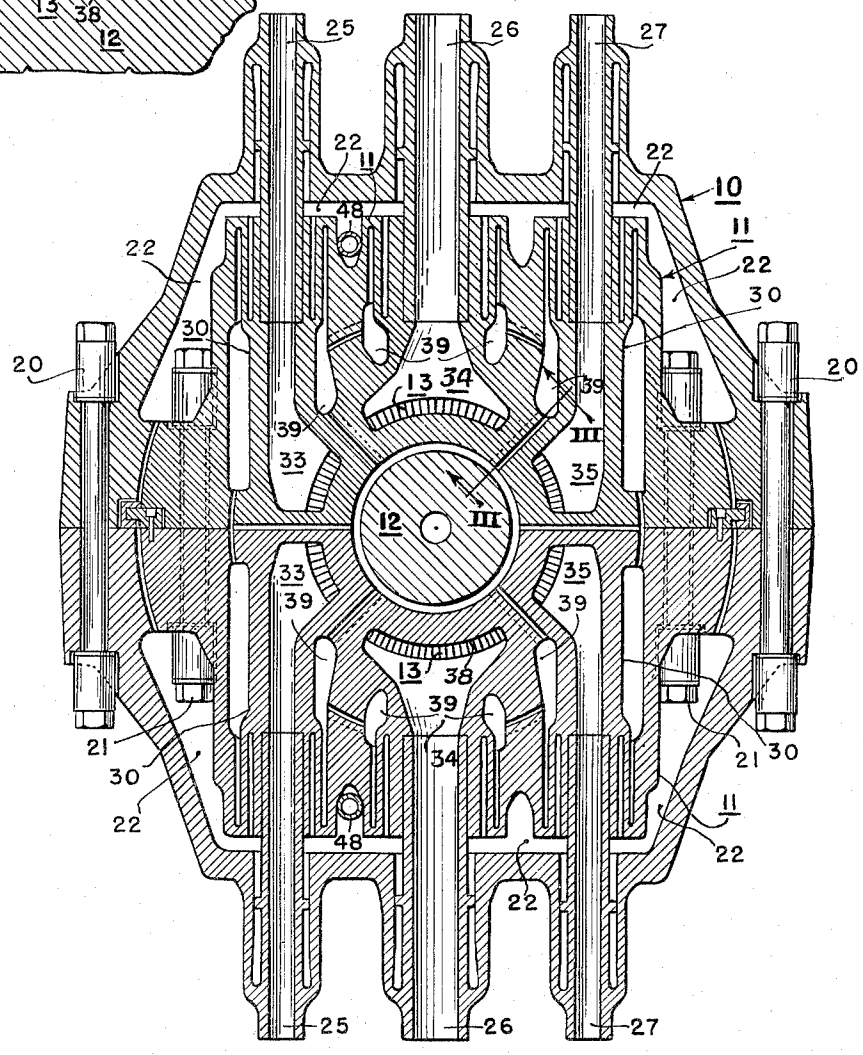


FIG. 2.

INVENTORS.
CLARENCE C. FRANCK
MERLE S. BAKER
BY
ATTORNEY

United States Patent Office 2,823,891 Patented Feb. 18, 1958

2,823,891

STEAM TURBINE

Merle S. Baker, Prospect Park, and Clarence C. Franck, Swarthmore, Pa., assignors to Westinghouse Electric Corporation, East Pittsburgh, Pa., a corporation of Pennsylvania

Application May 20, 1953, Serial No. 356,268

7 Claims. (Cl. 253—39.1)

This invention relates to elastic fluid turbines, and more particularly to a turbine adapted for high temperature service and equipped with double casing structure having outer and inner cylinders.

Owing to development of a rising demand for power, the rate of installation of central station turbine power apparatus must be increased. The natural course followed to meet this demand has been to increase the sizes of the power plants. In the design of a large power plant comprising, for example, a 185 megawatt three cylinder triple exhaust 3600 R. P. M. reheat turbine adapted for steam conditions of 2350 p. s. i. g. and 1100°/1050° F. total temperature, the high temperature unit necessarily involves a considerable cooling problem. It is an object of this invention to provide an improved high temperature turbine unit particularly adapted for such service, having a double wall construction and means for effecting mass flow cooling of the aparatus by the motivating steam.

Another object of the invention is the provision of an improved turbine unit adapted for mass flow cooling to render feasible the use of less costly materials and lighter walls and bolting than would otherwise be practicable.

A further object of the invention is the provision of an improved turbine adapted to utilize substantially all of the motivating fluid for cooling.

It is another object of the invention to provide an improved turbine adapted to receive motive fluid, such as steam, at about 1100° F. T. T., and provided with a double casing forming passages through which steam that has done work in one or more turbine stages is conducted at reduced temperature over the hotter parts to limit the temperature of such parts of the turbine.

Another object of the invention is to provide an improved turbine apparatus with a plurality of stages comprising a first stage or Curtis element of the impulse type through which steam at maximum temperature is directed from a set of nozzle chambers in one direction into a communication which then reverses the direction of the steam for flow over the Curtis element and between the nozzle chambers to the inlet of a second stage of blading constituting the reaction element of the turbine, so that the total flow of steam over the hot parts will minimize transfer of radiant heat that might otherwise result in development of temperatures higher than the impulse chamber temperature.

A further object is the provision of turbine apparatus of the foregoing construction which includes reaction blading supported by the inner cylinder in which the steam at higher temperature is confined, and means for reversing exhaust steam from the last row of blading for flow between the inner and outer cylinders to an exhaust opening in the base of the inlet end of the machine, flow areas of the steam passages involved being made ample to minimize steam velocities and pressure drop.

Still another object is the provision of an improved double cylinder turbine having high temperature steam inlet connections intermediate impulse and reaction

stages contained in the inner cylinder, passages for reversing steam exhausted from the impulse stages for flow around the inlet connections to the inlet nozzle of the reaction stages, and passage means encompassing the inner cylinder through which the mass flow of steam exhausted from the low pressure end of the reaction stages is conducted over the extent of all stages to an exhaust outlet in the opposite end of the machine, the resultant mass flow cooling effect of the steam rendering feasible the use of casing and bolting components having favorable weight and strength characteristics.

An important mass flow cooling principle of the invention is exhibited in the provision of a turbine comprising outer cylinder structure having a plurality of steam inlet sleeves adapted to be connected to suitable steam chests and arranged in a common plane normal to the turbine axis, inner cylinder structure mounted in spaced relation therein and housing axially spaced impulse and reaction turbine elements on a common shaft, an annular nozzle chamber formed in the inner cylinder structure for supplying steam in one direction to the reaction element, a plurality of circumferentially spaced nozzle chambers having walls integral with the inner casing structure and interposed between the annular nozzle chamber and the impulse turbine element for supplying steam to the latter directly from the inlet sleeves and in a direction opposite that of flow to the reaction element, and a plurality of passages formed in the inner cylinder between the walls of the separate nozzle chambers through which steam exhausted from the impulse element is reversed and conducted to the annular nozzle chamber of the reaction element. The outer cylinder structure is further provided with an exhaust opening adjacent the high pressure end thereof opposite the exhaust portion of the reaction turbine element, to which exhaust opening the steam exhausted from the reaction element is conducted by way of the spacing between the inner and outer cylinders.

These and other objects are effected by our invention as will be apparent from the following description taken in connection with the accompanying drawings, forming a part of this application, in which:

Fig. 1 is an axial sectional view of a turbine constructed in accordance with the invention;

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

Fig. 3 is a fragmentary sectional view along line III—III of Fig. 2.

The turbine unit illustrated in the drawings may constitute the high pressure element of a multiple unit power plant, the other elements (not shown) being aligned along the common axis. The turbine unit comprises an outer cylinder or casing structure **10**, an inner cylinder or casing structure **11** contained therein, and a rotor **12** which carries axially spaced groups of blades, including impulse or Curtis blading cooperative with stator blading to constitute an impulse element generally indicated at **13**, and reaction blading which together with the usual reaction stator vanes constitute a reaction element, generally indicated at **14**. The rotor **12** includes outwardly projecting bearing portions **12***a* and **12***b* which are adapted to be journaled in suitable bearing pedestals (not shown). Labyrinth packings are associated with the rotor at points indicated generally by reference characters **16**, **17**, **18** and **19**. In each of the elements **13** and **14**, the stator vanes are, of course, supported from the inner cylinder **11**. The outer cylinder **10** consists of lower and upper halves secured together by bolts **20**, as shown in Fig. 2. The inner cylinder **11** likewise includes lower and upper halves secured by bolts **21**, and is suitably keyed to the outer cylinder to provide longitudinally extending spaces **22** substantially encompassing the inner cylinder. Formed in the lower half of the outer cylinder **10**, at the inlet end

nearest to the impulse element **13**, is an exhaust connection **23**, which communicates with the spaces **22**.

According to the invention, the impulse element **13** is constructed and arranged for initial flow therethrough of steam at maximum inlet temperature in a direction opposite that of the steam as it subsequently flows through the reaction element **14**. Two groups of parallel upper and lower steam inlet sleeve structures, forming inlet passages indicated respectively at **25**, **26** and **27** in Fig. 2, are carried on the outer cylinder **10** along a common center plane normal to the turbine axis. In the illustrated machine, the three inner ends of the inlet sleeve structures of each group extend through the spaces **22** and are suitably mounted in bores formed in juxtaposed nozzle chamber sections **30** carried by the inner cylinder **11**, in which are formed nozzle chambers **33**, **34** and **35** that communicate with the inlet passages **25**, **26** and **27**, respectively. As shown in Fig. 1, the nozzle chamber sections **30** extend into the inner cylinder **11** between the inlet ends of the respective impulse and reaction elements **13** and **14**, and terminate in nozzles **38** directed toward the impulse element **13**. The nozzle chamber sections **30**, which are arranged in substantially encompassing relation with respect to the turbine axis, are intersticed with a plurality of longitudinal flow passages **39** (see Fig. 2), providing reversed steam flow communication between an annular outlet **40** of the impulse element **13** and an annular nozzle chamber **41** of the reaction element **14**. The passages **39** have a total flow area which is ample to ensure sufficiently low steam velocities to minimize pressure drop, and are thus adapted to conduct the total flow of steam outwardly of the impulse element and between the nozzle chambers **33**, **34** and **35** to minimize transfer of radiant heat to adjacent members.

In the form of turbine apparatus illustrated, the reaction element is associated with an annular extraction passage **45**, through which extracted steam flows to a slip joint connection **46** carried in the outer cylinder. Part of the high pressure packing leakage, which is collected at the point **47** between packings **18** and **17**, may be conducted through leak-off piping **48** to the extraction passage **45** for removal with extracted steam. For turbine installations wherein extracted steam is not needed, or is not extracted from this zone, the packing leakage may readily be returned to the blade path, in any well known manner.

A second group or stage of reaction blading **14***a* may be provided downstream of the extraction point. This blading is supported by the inner cylinder **11** at the end opposite that from which the usual low pressure balance piston ring **49** is supported. Substantially the total exhaust steam flow from the reaction element **14**—**14***a* is conducted over the inner cylinder **11** by way of the passages **22**, and is discharged through the exhaust connection **23**, which may communicate with a reheater (not shown), or the like.

It will now be seen that the improved turbine apparatus constructed in accordance with the invention is particularly well adapted for high capacity service in which inlet temperatures of 1100° F. T. T. are desirable. Features of the improved construction include the use of a double wall cylinder structure, separate nozzle chambers and separate steam chests to accommodate the high initial temperatures, and reversal of the Curtis or impulse element to facilitate efficient operation on the mass flow cooling principle. In operation, steam from separate steam chests flows through the inlet sleeves to the first nozzle chambers at 1100° F. T. T., as shown by the arrows in Fig. 1. From these nozzle chambers, the steam expands through the nozzles and exhausts from the impulse element at a temperature approximately 100° lower than the initial temperature. This cooler steam reverses and flows over the impulse element and between the nozzle chambers to the inlet of the reaction blading, the total flow of steam over the hot parts minimizing radiant heat that might otherwise be transfered to the adjacent members and possibly result in temperatures undesirably higher than the impulse chamber temperature. The steam then expands through the first reaction blading group to the extraction point, where the temperature is approximately 800° F. T. T. Steam expanding through second reaction blading group is exhausted at about 700° F. T. T., and in traveling back between the inner and outer cylinders to the exhaust connection **23**, serves to cool the inner cylinder exterior surface and bolting, as well as the entire outer cylinder and its bolting. Owing to the availability of this mass flow cooling effect, the wall thickness of the inner and outer cylinders, and the bolting, may safely be reduced to save material and weight, and to minimize the time required for assembly and dismantling of the turbine unit.

While the invention has been shown in but one form, it will be obvious to those skilled in the art that it is not so limited, but is susceptible of various changes and modifications without departing from the spirit thereof.

What is claimed is:

1. In a turbine, an outer cylinder structure having elastic motive fluid inlet sleeves intermediate its ends and an exhaust outlet adjacent one end thereof, an inner cylinder structure mounted in said outer cylinder structure and receiving said inlet sleeves, said cylinder structures forming longitudinal passages therebetween, axially spaced impulse and reaction stator blade groups mounted in said inner cylinder structure, a turbine rotor mounted in said inner cylinder structure and carrying axially spaced impulse and reaction blading groups cooperating with the respective stator blade groups to constitute impulse and reaction elements of the turbine, a circumferential array of motive fluid nozzles communicating with said inlet sleeves and said impulse element and interposed between said impulse and reaction elements for initially supplying motive fluid in one direction to said impulse element, an annular nozzle chamber formed in said inner cylinder structure and in communication with said reaction element, and passages formed in said inner cylinder and disposed between the first-mentioned nozzles, said passages extending from the exhaust side of said impulse element to said annular nozzle chamber and serving to conduct motive fluid in the opposite direction from the exhaust side of said impulse element to said annular nozzle chamber, said reaction element being adapted to exhaust motive fluid at the end of said outer cylinder structure remote from said exhaust outlet for flow thereto over the axial extent of both turbine elements by way of said longitudinal passages.

2. In a turbine, double-wall cylinder structure having laterally aligned steam inlets intermediate the ends thereof, an axial flow bladed impulse element adapted to receive high temperature steam flowing in one direction, an axial flow bladed reaction element adapted to receive steam flowing in the opposite direction, said elements being arranged in tandem with their inlet ends disposed on opposite sides of a central plane through said inlets, a plurality of circumferentially spaced nozzle chambers adapted to supply steam at initial inlet temperature to said impulse element, said nozzle chambers communicating with said inlets and being interposed between said impulse and reaction elements, and passages extending through the spaces between said nozzle chambers for receiving steam exhausted from said impulse element and adapted to conduct such steam in the opposite direction to the inlet of said reaction element, whereby steam that has done work in said impulse element is utilized for cooling said inlet nozzle chambers prior to introduction into said reaction element, so that the total flow of steam over hot surfaces between the impulse element and the reaction element will minimize undesired transfer of radiant heat.

3. Apparatus as set forth in claim 2, in which the reaction element has a steam outlet adjacent one end of the cylinder structure, the cylinder structure has an exhaust

outlet formed therein adjacent the end remote from said steam outlet of the reaction element, and longitudinal spaces extending through the double-wall cylinder structure for conducting substantially the total flow of exhaust steam from said steam outlet of the reaction element past said reaction element and said impulse element to said exhaust outlet, for limiting temperatures of the cylinder structure surfaces.

4. In a turbine, an outer cylinder having an exhaust outlet adjacent one end, an inner cylinder mounted therein, opposed axial flow bladed impulse and reaction elements mounted coaxially within said inner cylinder, said reaction element having its exhaust end remote from the end of said outer cylinder having said exhaust outlet, means forming a plurality of spaced steam inlet nozzle chambers extending laterally through said cylinders intermediate said impulse and reaction elements of the turbine for directing steam to said impulse element, passages formed in said inner cylinder and extending through the spaces between said nozzle chambers for reversing the flow of steam exhausted from said impulse element and for conducting such steam between said nozzle chambers to said reaction element, and exhaust flow guiding means encompassing the inner cylinder through which the mass flow of steam exhausted from said reaction element is conducted over the portion of the inner cylinder structure containing both said impulse and reaction elements to said exhaust outlet.

5. In a turbine, outer cylinder structure having an exhaust outlet adjacent one end and a plurality of steam inlet sleeves intermediate its ends and arranged about the turbine axis in a common plane normal thereto, inner cylinder structure receiving said inlet sleeves and mounted in spaced relation within said outer cylinder structure, said outer and inner cylinder structures forming longitudinally extending passages disposed between said inlet sleeves and communicating with said exhaust opening, axially spaced opposed-flow bladed impulse and reaction turbine elements mounted in tandem within said inner cylinder with their inlet ends adjacent and on opposite sides of the plane of said inlet sleeves, an annular nozzle chamber formed in said inner cylinder for directing steam in one direction into said reaction element, a plurality of circumferentially spaced nozzle chambers having walls integral with the inner casing structure and interposed between said annular nozzle chamber and said impulse turbine element for supplying steam to the latter directly from said inlet sleeves and in a direction opposite that of flow through said reaction element, a plurality of passages formed in said inner cylinder between the walls of said pulrality of nozzle chambers and extending from the outlet end of said impulse elements to said annular nozzle chamber through which steam exhausted from said impulse element is reversed and conducted to said annular nozzle chamber of the reaction element, and a reaction element exhaust passage communicating with said longitudinally extending passages adjacent the end of said outer cylinder remote from said exhaust outlet.

6. In a turbine, a cylinder having a steam inlet sleeve intermediate its ends and disposed in a plane normal to the turbine axis, first and second bladed turbine element groups axially spaced within said cylinder and disposed in opposed-flow tandem relation to each other, said turbine element groups having inlet ends disposed adjacent and on opposite sides of said plane, a first nozzle chamber member communicating with said inlet sleeve for supplying incoming stream in one direction to said first turbine element group, a second nozzle chamber member formed in said cylinder for directing steam to said second turbine element group in a direction opposite to said one direction, and a plurality of passages formed in said cylinder and extending through said first nozzle chamber member for supplying steam exhausted by said first turbine element group to said second nozzle chamber member, said passages being disposed in good heat exchange relation to said first nozzle chamber member and said cylinder.

7. In a turbine, a cylinder having a steam inlet sleeve intermediate its ends and disposed in a plane normal to the turbine axis, first and second bladed turbine element groups axially spaced within said cylinder and disposed in opposed-flow tandem relation to each other, said turbine element groups having inlet ends disposed adjacent and on opposite sides of said plane, a first nozzle chamber member communicating with said inlet sleeve for supplying incoming steam in one direction to said first turbine element group, a second nozzle chamber member of annular shape formed in said cylinder for directing steam to said second turbine element group in a direction opposite to said one direction, and a plurality of passages formed in said cylinder and extending past said first nozzle chamber member for supplying steam exhausted by said first turbine element group to said second nozzle chamber member, said passages being disposed in good heat exchange relation to said first nozzle chamber member and said cylinder, said first nozzle chamber member comprising a plurality of circumferentially spaced nozzle chambers and said passages extend through the spaces between the latter and communicate with said second nozzle chamber.

References Cited in the file of this patent

UNITED STATES PATENTS

641,074	Burgum	Jan. 9, 1900
670,303	Ashton	Mar. 19, 1901
702,826	Schulz	June 17, 1902

FOREIGN PATENTS

208,622	Switzerland	May 1, 1940