K. BAUMANN.

STEAM TURBINE.

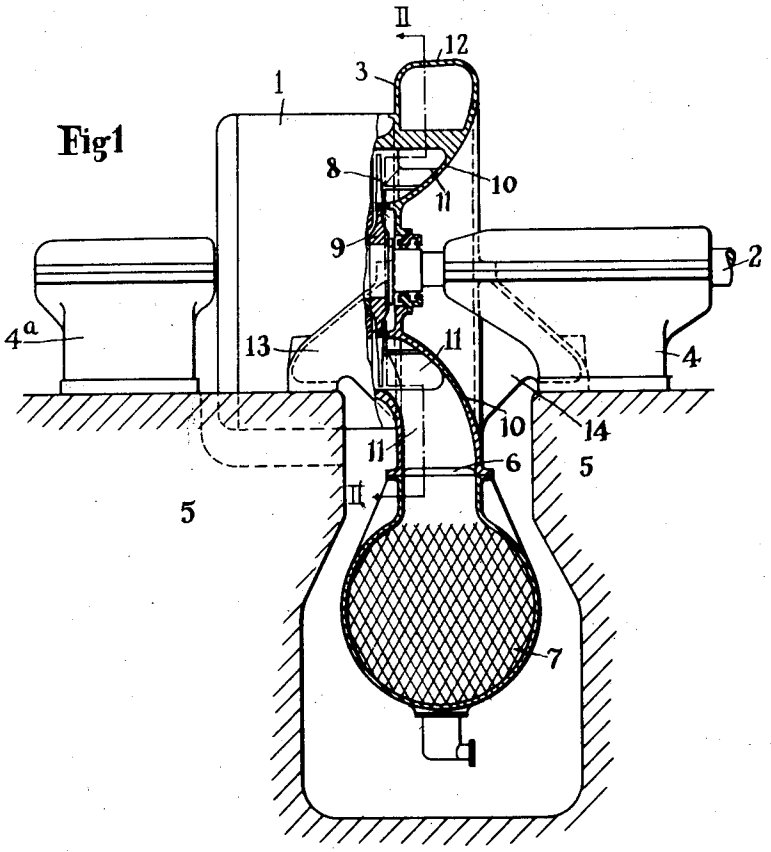
APPLICATION FILED OCT. 4, 1916. RENEWED JAN. 20, 1921.

1,405,565.

Patented Feb. 7, 1922.

11 SHEETS—SHEET 1.

Fig1



INVENTOR:

Karl Baumann

Green & McCallister

ATTORNEYS

K. BAUMANN.

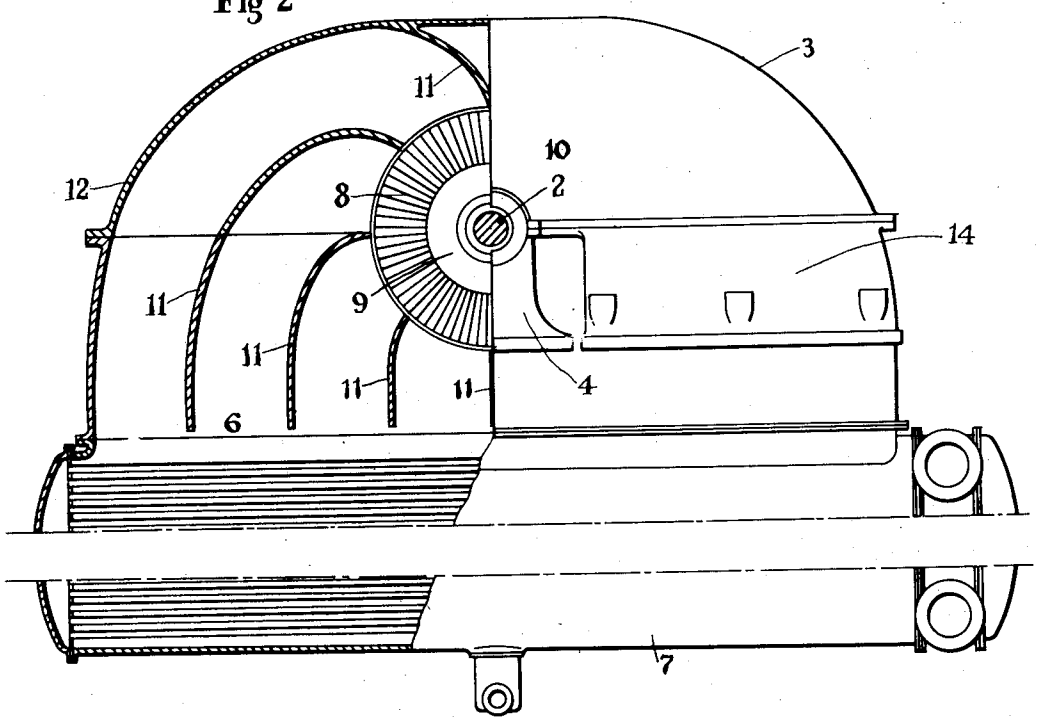
STEAM TURBINE.

APPLICATION FILED OCT. 4, 1916. RENEWED JAN. 20, 1921.

1,405,565. Patented Feb. 7, 1922.

11 SHEETS—SHEET 2.

Fig 2



INVENTOR:

Karl Baumann

Green & McCallister

ATTORNEYS.

K. BAUMANN.

STEAM TURBINE.

APPLICATION FILED OCT. 4, 1916. RENEWED JAN. 20, 1921.

1,405,565.

Patented Feb. 7, 1922.

11 SHEETS—SHEET 3.

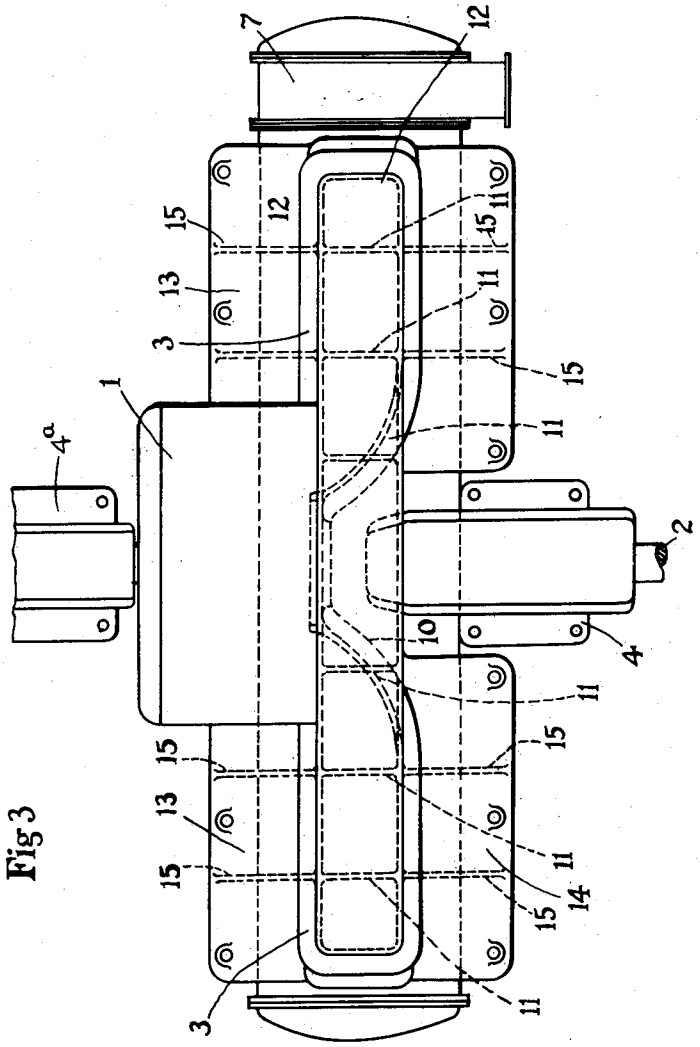


Fig 3

INVENTOR.

Karl Baumann

BY Green & McCallister

HIS ATTORNEY IN FACT

K. BAUMANN.

STEAM TURBINE.

APPLICATION FILED OCT. 4, 1916. RENEWED JAN. 20, 1921.

1,405,565. Patented Feb. 7, 1922.

11 SHEETS—SHEET 4.

Fig4

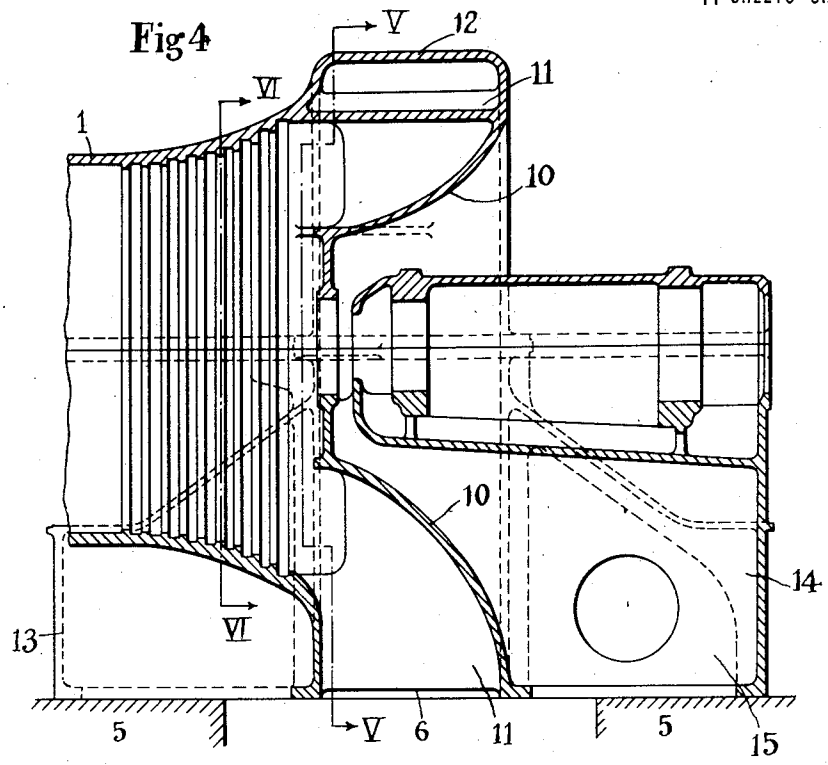
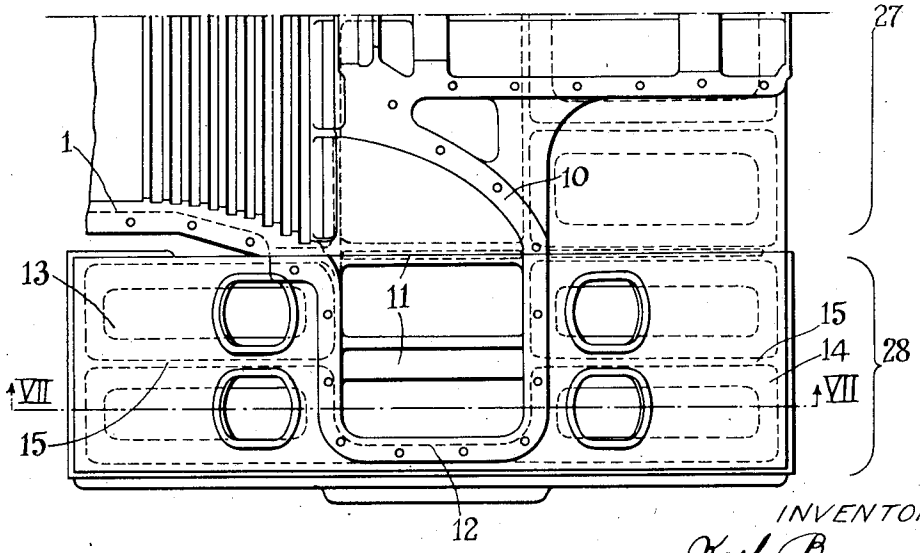


Fig6.



INVENTOR:

Karl Baumann

Green & McCathran

ATTORNEYS.

K. BAUMANN.

STEAM TURBINE.

APPLICATION FILED OCT. 4, 1916. RENEWED JAN. 20, 1921.

1,405,565. Patented Feb. 7, 1922.

11 SHEETS—SHEET 5.

Fig 5.

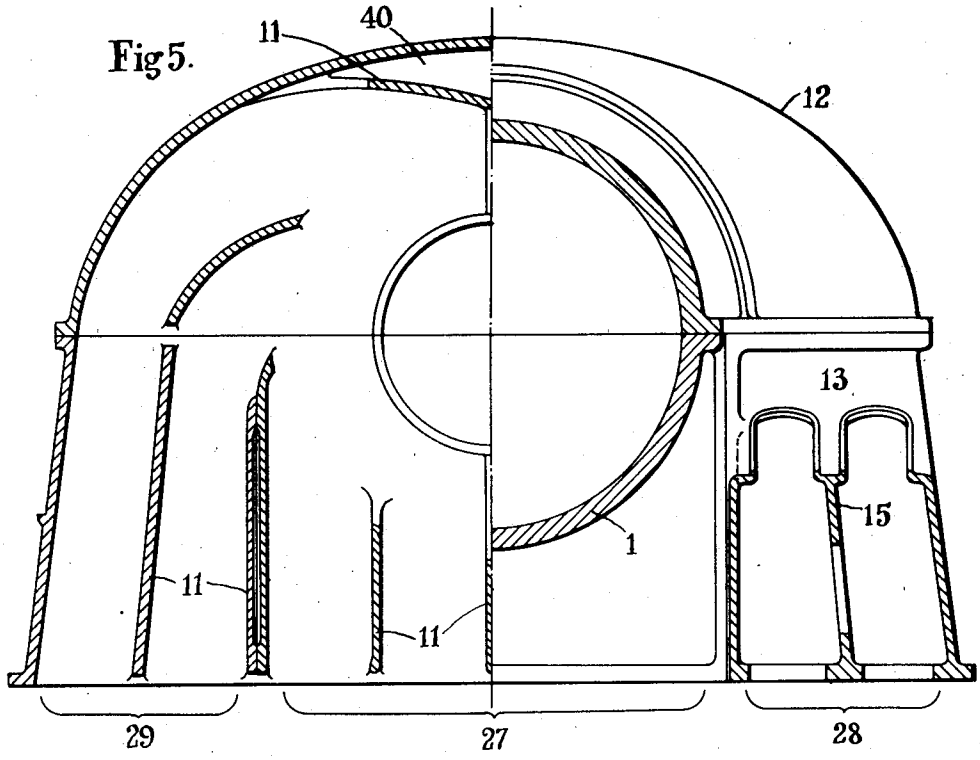
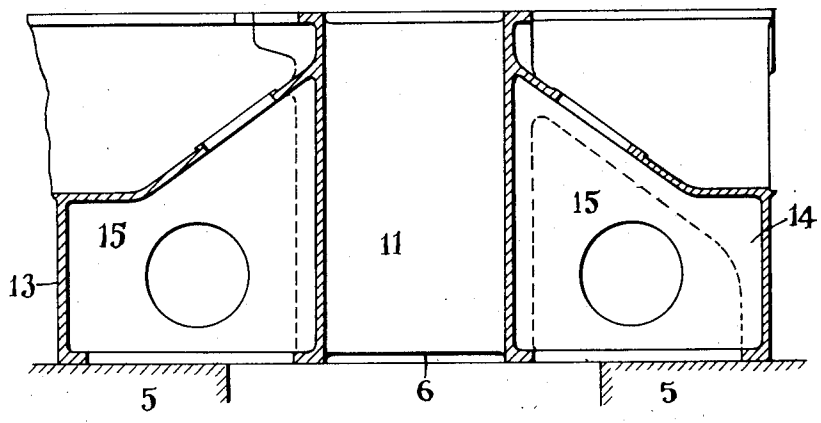


Fig 7



INVENTOR:

Karl Baumann

Green & McCallister

ATTORNEYS.

K. BAUMANN.

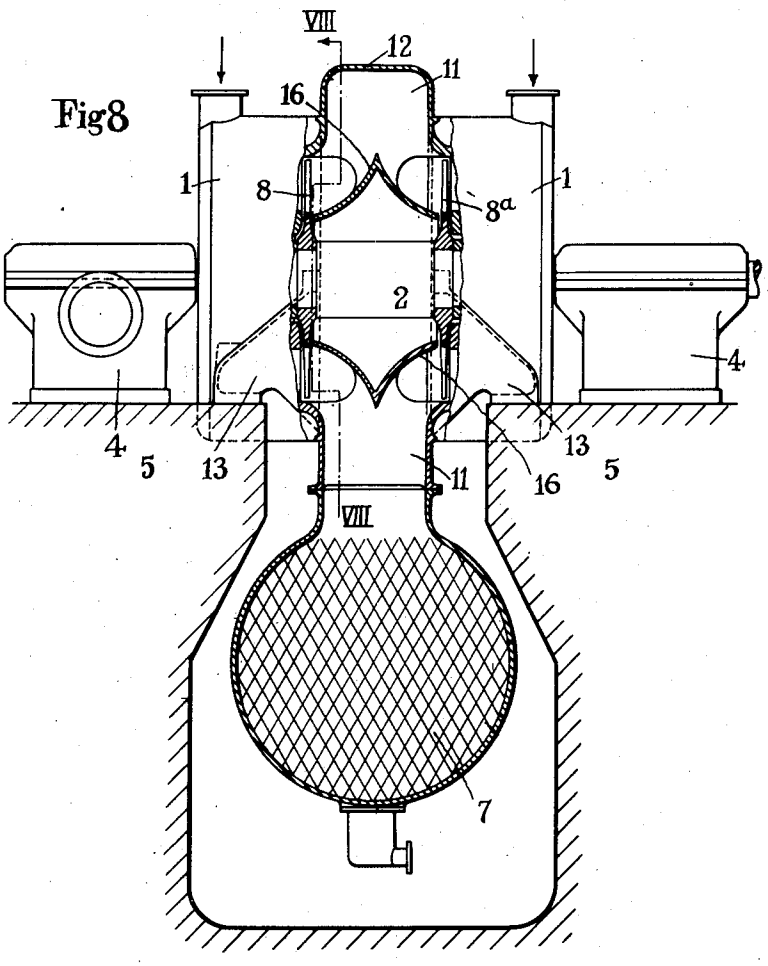
STEAM TURBINE.

APPLICATION FILED OCT. 4, 1916. RENEWED JAN. 20, 1921.

1,405,565. Patented Feb. 7, 1922.

11 SHEETS—SHEET 6.

Fig8



INVENTOR:

Karl Baumann

Green & McCallister

ATTORNEYS.

K. BAUMANN.

STEAM TURBINE.

APPLICATION FILED OCT. 4, 1916. RENEWED JAN. 20, 1921.

1,405,565.

Patented Feb. 7, 1922.

11 SHEETS—SHEET 7.

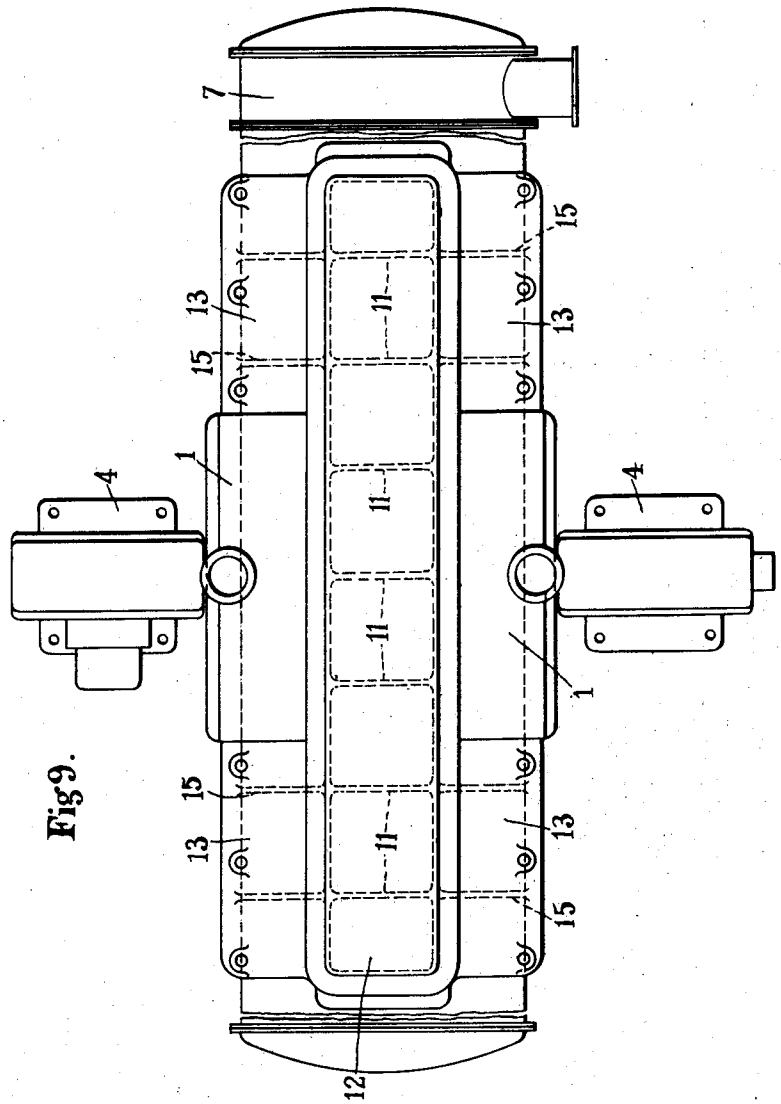


Fig 9.

INVENTOR:

Karl Baumann

Green & McCallister

ATTORNEYS.

K. BAUMANN.

STEAM TURBINE.

APPLICATION FILED OCT. 4, 1916. RENEWED JAN. 20, 1921.

1,405,565. Patented Feb. 7, 1922.

11 SHEETS—SHEET 8.

Fig. 10.

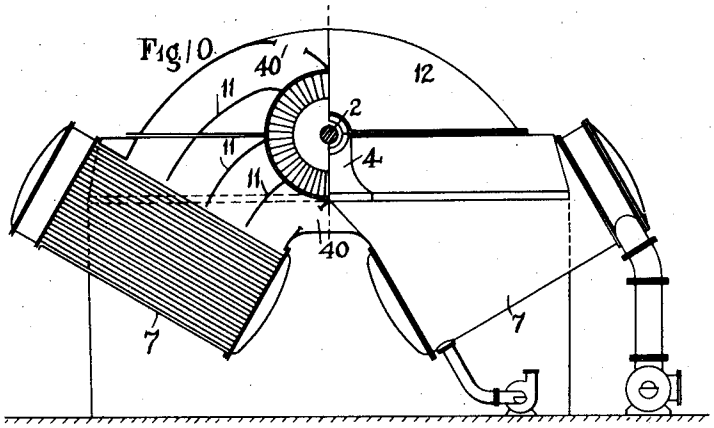
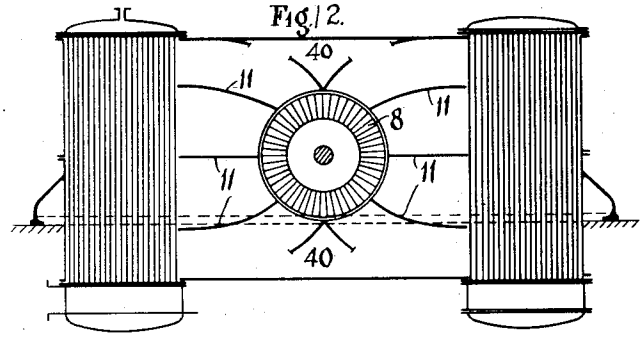


Fig. 12.



INVENTOR:

Karl Baumann

Green & McCallister.

ATTORNEYS.

K. BAUMANN.

STEAM TURBINE.

APPLICATION FILED OCT. 4, 1916. RENEWED JAN. 20, 1921.

1,405,565.

Patented Feb. 7, 1922.

11 SHEETS—SHEET 9.

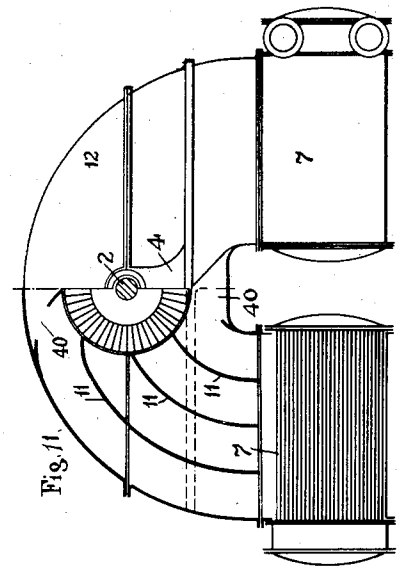


Fig. 11.

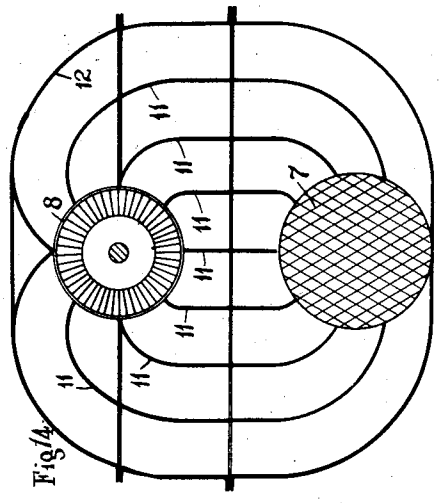


Fig. 14.

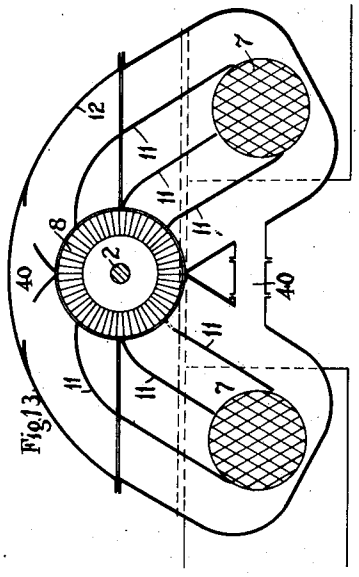


Fig. 13.

INVENTOR:

Karl Baumann

Green & McCallister.

ATTORNEYS.

K. BAUMANN.

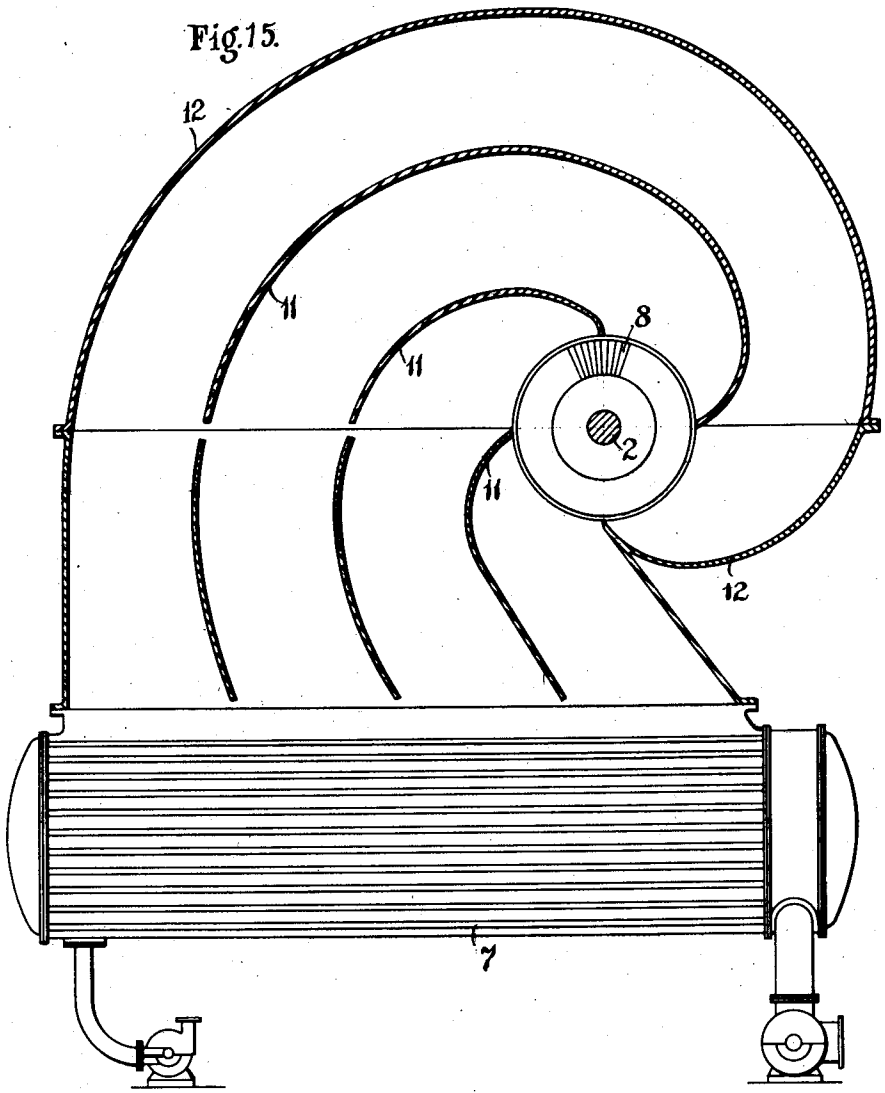
STEAM TURBINE.

APPLICATION FILED OCT. 4, 1916. RENEWED JAN. 20, 1921.

1,405,565. Patented Feb. 7, 1922.

11 SHEETS—SHEET 10.

Fig. 15.



INVENTOR:
Karl Baumann

Green & McCallister

ATTORNEYS:

K. BAUMANN.

STEAM TURBINE.

APPLICATION FILED OCT. 4, 1916. RENEWED JAN. 20, 1921.

1,405,565. Patented Feb. 7, 1922.

11 SHEETS—SHEET 11.

Fig. 17.

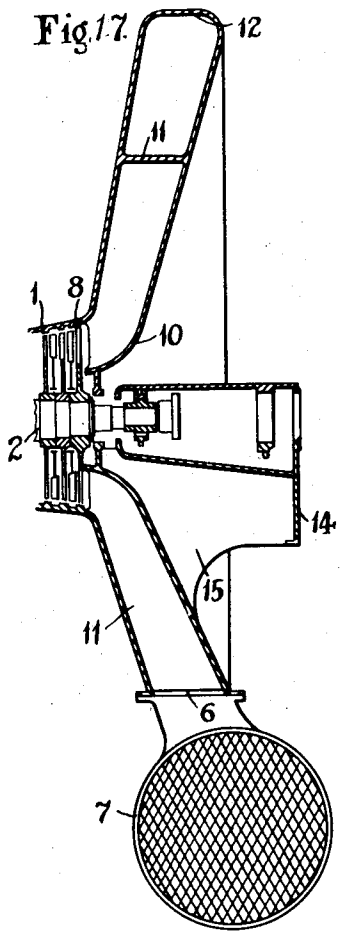
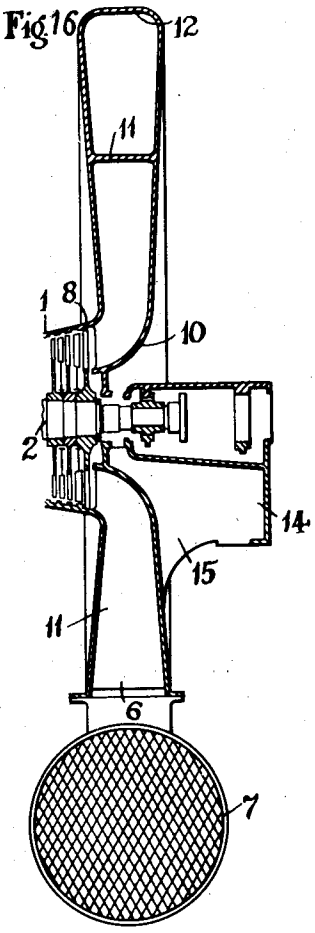


Fig. 16.



INVENTOR:

Karl Baumann

Green & McCallister

ATTORNEYS.

UNITED STATES PATENT OFFICE.

KARL BAUMANN, OF URMSTON, ENGLAND, ASSIGNOR TO THE BRITISH WESTINGHOUSE ELECTRIC AND MANUFACTURING COMPANY LIMITED.

STEAM TURBINE.

1,405,565. Specification of Letters Patent. Patented Feb. 7, 1922.

Application filed October 4, 1916, Serial No. 123,697. Renewed January 20, 1921. Serial No. 438,760.

To all whom it may concern:

Be it known that I, KARL BAUMANN, a citizen of the Confederation of Switzerland, and a resident of Urmston, in the county of Lancaster, England, have invented a new and useful Improvement in or Relating to Steam Turbines, of which the following is a specification.

This invention relates to steam turbines of the axial flow type, and, although not limited in this respect, is especially applicable to turbines of this type in which the steam is led away to the exhaust outlet of the turbine from a plurality of rows of moving blades.

It is one of the objects of this invention to provide an improved construction of turbine exhaust casing by means of which the exhaust steam is conducted from the last row of moving or exhaust blades, or where there is more than one row, from some or all the rows of exhaust blades, to the exhaust outlet or outlets or the condenser or condensers.

Another object of the invention is so to improve the construction of the exhaust casing of a turbine that the steam leaving the turbine is uniformly distributed over a large area of the condensing surface of the condenser. In the case of a surface condenser for example, the steam may be distributed over the greater part, in some cases substantially the whole of the perimeter of the tube nest, while in the case of a jet condenser the steam may be distributed equally over the whole number of jets employed. In this way the utilization of the condensing surface of the conderser to the greatest possible advantage is ensured.

A further object of the invention is to increase the strength and rigidity of the exhause casing so that the turbine may be supported on its foundations from the two ends only of the exhaust casing. With turbines having large exhaust outlets, as at present constructed, it is generally found necessary to support the turbine not only from the ends but also partly from both sides, necessitating the employment of a bed-plate supported on girders between the two main foundation blocks. With a turbine having its exhaust casing constructed in accordance with the present invention a complete bedplate is unnecessary as the turbine may be supported on sole plates on foundations provided for the ends only of the exhaust casing. With the improved rigid construction of turbine exhaust of this invention the condenser may in many cases advantageously be suspended direct from the turbine exhaust, no other support therefor being provided, and in this way the use of expansion pieces between the turbine and the condenser is obviated. In some cases, however, the condenser may in addition be provided with a resilient support.

Still another object of the invention is to reduce the cost of the construction of the exhaust casing of turbines in which the steam is led away to the exhaust from a plurality of rows of moving blades.

In a turbine exhaust casing constructed in accordance with this invention a suitably curved guide or guides are provided which deflect the whole of the steam leaving the exhaust blades outwardly into an approximately radial direction of flow. The enclosing walls of the exhaust casing are so formed as to conduct the steam, which has been deflected by the guide or guides aforementioned into an approximately radial direction of flow, to the exhaust outlet or outlets of the turbine or to the condenser or condensers outwardly in a direction substantially transverse to and away from the turbine axis. Guide walls are preferably also provided which divide the steam leaving one or more rows of moving exhaust blades into separate segmental portions. Said guide walls in conjunction with the enclosing walls of the exhaust casing of the turbine form passages which conduct the several segmental portions of steam to the exhaust outlet or outlets of the turbine or to the condenser or condensers where more than one is used.

Several forms of turbine exhaust constructed in accordance with the present invention are shown by way of example in the accompanying drawings in which Figure 1 is a front elevation partly in section, Figure 2 an end elevation half being in section on the line II—II of Figure 1, viewed from the right and Figure 3 a plan of a turbine and its condenser the turbine having an exhaust casing constructed in accordance with this invention.

Figure 4 is a central longitudinal section of a turbine cylinder. Figure 5 a cross section taken as regards its left-hand portion on the live V—V of Figure 4 and as regards

its right-hand portion on the line VI—VI of Figure 4 viewed from left to right, Figure 6 a half plan of the lower half of the turbine cylinder, and Figure 7 a cross section taken on the line VII—VII of Figure 6 showing another constructional form of an exhaust casing in accordance with this invention.

Figure 8 is a view similar to Figure 1 and Figure 9 a plan view showing the invention applied to a double flow turbine. The cross sectional view taken on the line VIII—VIII of Figure 8 is similar to the left-hand portion of Figure 2 and is therefore not repeated.

Figures 10 to 17 inclusive show diagrammatically various other constructional forms which the invention may take.

The same reference numerals are used to indicate like parts in the various figures of the drawings and the arrow heads on the section indicating lines indicate the direction in which the corresponding sectional views are taken.

Referring to Figures 1, 2 and 3, which illustrate an axial flow turbine of the usual construction wherein the steam is led away to the condenser from a single row of moving exhaust blades, the turbine cylinder is indicated at 1, the shaft at 2 and the exhaust casing at 3. The shaft is supported in bearings in pedestals 4, 4ª secured to the foundations 5 as usual. The exhaust outlet from the exhaust casing is shown at 6 and directly attached thereto is the condenser 7 here indicated as being of the surface type. The single row of low pressure exhaust blades 8 from which the steam leaves the turbine, is mounted on a wheel 9 on the shaft 2, and in this form of the invention the guide which changes the direction of the flow of steam leaving the exhaust blades from an axial direction into a substantially radial direction, is constituted by a portion 10 of the rear enclosing wall of the exhaust casing which, as will be seen from Figures 1 and 3, is curved and flaring and resembles somewhat in shape the bell of a trumpet. The exhaust casing 3 is also provided with guide walls 11 which divide the steam leaving the row of exhaust blades 8 into a plurality of segmental portions. Said guide walls extend across the exhaust casing substantially parallel to the turbine axis and may be cast integral with the enclosing walls of the exhaust casing or formed separately and secured thereto by flanges and bolts or otherwise as may be found most convenient, and are here shown as being continued along the exhaust casing until they reach the exhaust connection or outlet 6 of the turbine. These guide walls and also the outer side or boundary wall 12 of the exhaust casing, are shaped for the greater part of their length to evolute curves. The guide walls 11 in conjunction with the enclosing walls of the exhaust casing of the turbine form a number of separate passages, each of which conducts a segmental portion of the steam leaving the moving blades 8 to the exhaust outlet 6 of the turbine. The guide walls 11, or some of them, need not necessarily be continued, as shown, till they reach the exhaust outlet as in some cases they may be discontinued after the point is reached at which portions of steam in adjacent passages are flowing in substantially the same direction. Preferably, however for a purpose hereinafter explained, they are continued, as shown down to the exhaust outlet 6.

As will be seen, the exhaust outlet has the form of a wide and short opening located transversely to the shaft of the turbine and may conveniently be of approximately the same length as the tube nest of the condenser. With this construction the steam leaving the moving blades and flowing through the passages formed by the guide walls and the exhaust casing 3 of the turbine, is distributed over approximately the whole length of the condenser and the condensing surface is thus utilized to the greatest possible advantage.

An exhaust casing constructed as above described and shown in Figures 1, 2 and 3, and especially in those cases in which the guide walls 11 are carried down to the exhaust outlet 6, may, by making the walls 11 of sufficient thickness, be made so strong and rigid as to enable the turbine to be supported from feet located at the two ends only of the exhaust casing, namely transversely of the turbine axis. The supporting feet are indicated at 13, 14 and are preferably cast integral with the lower half of the exhaust casing in the usual way, and rest either directly or on sole plates on the foundations 5. The supporting feet 13 and 14 may advantageously be strengthened by transverse stiffening webs 15 indicated in dotted lines in Figure 3, preferably formed, as shown, as continuations of the guide walls 11.

The exhaust casing constructed as above described will in many cases be sufficiently rigid to enable the condenser 7 to be suspended direct from the turbine exhaust outlet 6 as shown in Figures 1 and 2, no other support therefor being necessary, thus obviating the use of expansion pieces between the turbine and the condenser. In some cases, however, it may be found desirable to provide in addition a resilient support for the condenser.

Figures 4 to 7 inclusive show a modified construction in which the axial length of the exhaust casing parallel with the turbine axis is increased and its width reduced. The form of the exhaust casing of the turbine and of the supporting feet therefor is also varied somewhat from that shown in Figures 1 to 3. As will be seen from an inspection of the left hand portion of Figure

5, the width of the exhaust casing increases towards the exhaust outlet, enabling the paths for the steam flowing through the outer passages formed by the guide walls 11 to be made easier and the area of said passages to be increased in the direction of the flow of steam, with beneficial results.

The shape of the supporting feet 13, 14 is somewhat different from that shown in Figures 1 to 3 and their size is also increased. In this construction the supporting feet 14 serve to support the bearing at the exhaust end of the rotor of the turbine thus obviating the use of a separate bearing pedestal.

As will be seen from Figure 7 the shape of the lower half of the exhaust casing and the supporting feet is that of a girder the greatest strength of which is found in the centre where the bending moment is a maximum. As shown in Figure 5 the outer portions of the lower half of the exhaust casing are made separately. This will be found advantageous as it enables the size of the castings to be kept within reasonable limits and also enables metal of suitable quality to be used for these portions and otherwise to be constructed of sufficient strength to carry the centre portion of the turbine casing as well as the condenser if desired, the supporting feet in this construction not being extended beneath the high pressure end of the turbine cylinder.

Figures 8 and 9 show the invention applied to a double flow turbine, in which the steam leaving the two final rows of exhaust blades at the middle of the turbine flows in opposite directions. In this case a guide 16 is provided for changing the direction of flow of the steam leaving the final rows of moving blades 8, 8^a from an axial into a substantially radial direction. Otherwise the construction is substantially the same as that described with respect to Figures 1 to 3 and will be understood without further description. The cross section taken on the line VIII—VIII of Figure 8 will be similar to the left-hand portion of Figure 2.

The invention is especially useful when applied to multiple exhaust turbines, that is axial flow turbines in which the steam flows in substantially the same direction from a plurality of rows of exhaust blades, a turbine of this kind being described for example in the specification of Patent No. 1,302,282, dated April 29, 1919, and reissued as No. 15,092, dated April 26, 1921, and the application of the invention to a turbine of this type constitutes the subject-matter of my application Serial No. 404,147, filed August 17, 1920, which is a division of this application.

Figures 10 to 14 inclusive show diagrammatically several other constructional forms of the present invention which may be adopted.

In Figure 10 the steam from the moving exhaust blades of the turbine is delivered to two condensers the axes of which are located perpendicular to that of the turbine axis and inclined to the horizontal as shown. This provides a very convenient and suitable arrangement for turbines designed to have a large output the condensers being particularly well located to enable cleaning, inspection or repairs to be carried out with facility.

Figure 11 shows a very similar arrangement to that illustrated in Figure 10 in which, however, the two condensers are placed horizontally.

Figure 12 illustrates another somewhat similar arrangement in which, however, the condensers are installed in a perpendicular position.

Figure 13 indicates still another arrangement in which two separate condensers are employed but with their axes parallel with that of the turbine axis, and Figure 14 a similar arrangement in which however, only a single condenser is used. Both of these latter arrangements are such as to enable the steam leaving the turbine to be admitted over substantially the whole perimeter of the nest of tubes of the condenser.

Where the steam is delivered to two condensers as shown for example in Figures 11 to 13, passages 40 are provided to allow the exhaust steam from the turbine to flow to either one or other of the condensers to ensure equality of vacuum or to allow one of the condensers to be shut down for cleaning or repairs without shutting down the whole plant. Passages are preferably also provided where only one condenser is employed to allow the several segmental portions of exhaust steam to escape through the atmospheric relief valve in case the turbine has, for any reason, to be run non-condensing. Usually the free space between the exhaust outlet and the condenser tubes is sufficient for this purpose.

Another form which the exhaust casing may take is shown diagrammatically in Figure 15, Figure 16 being a central vertical section of the exhaust shown in Figure 15, and Figure 17 a similar view illustrating a modification.

It will be seen that in this arrangement the passages for the exhaust steam formed by the guide and enclosing walls of the exhaust casing are of substantially evolute shape along the greater part of their length. The end walls of the exhaust casing diverge from the centre outwards thus increasing the area of the passages for the segmental portions of steam towards the exhaust outlet in a very simple manner.

Figure 17 shows an exhaust casing of conical shape which may sometimes be found desirable.

While the several constructions of exhaust

casing herein described and illustrated are all of them shown as being provided with internal guide walls for dividing the steam into segmental portions and forming in conjunction with the exhaust casing separate passages for conducting said portions of steam to the exhaust outlet or outlets, it is to be understood that in many cases some or all of said guide walls may be omitted if desired. In those cases in which all of the guide walls are omitted the exhaust steam leaving the moving blades will be deflected into an approximately radial direction of flow by the guide or guides provided for that purpose and conducted to the exhaust outlet or outlets or to the condenser or condensers solely by the enclosing walls of the exhaust casing. The preferred construction is, however, that in which guide walls are provided.

I claim as my invention—

1. In an axial flow steam turbine, an exhaust casing arranged so as to deflect the entire steam leaving the low pressure section of the turbine outwardly from an axial into an approximately radial direction, the enclosing walls of said exhaust casing being so formed as to conduct the radially flowing stream outwardly in substantially the same transverse plane, and guide walls located within said casing for dividing the exhaust steam into separate streams.

2. A structure such as set forth in claim 1 in which the guide walls for dividing the exhaust into separate streams are shaped to substantially involute curves along a portion at least of their length.

3. In combination with an axial flow turbine, an exhaust casing so formed as to direct all of the fluid exhausted from the low pressure stage outwardly in substantially radial directions and in substantially the same transverse plane, and partitions within said casing for dividing the fluid passing therethrough to the turbine exhaust into segmental portions.

4. In combination with an axial flow turbine, an exhaust casing so formed as to direct the entire fluid received from the low pressure stage outwardly in substantially radial directions and in substantially the same transverse plane, a dividing wall located within said casing for dividing the steam passing therethrough into segmental portions, said wall and said casing being so constructed as to form steam passages of gradually increasing area in the direction of fluid flow.

5. In combination with an axial flow turbine, an exhaust casing having a plurality of circumferentially extending guiding surfaces arranged in substantially the same transverse plane for directing the fluid issuing from the low pressure stage away from the axis of the turbine and from an axial to a substantially radial direction of flow, and a plurality of partitions located within said casing for dividing the fluid passing therethrough into segmental portions.

6. In combination with an axial flow turbine, an exhaust casing for receiving the fluid discharged from the low pressure stage of the turbine, partitions formed within said casing for dividing the interior of the casing into segmental passages disposed substantially in the same transverse plane each of which at any given instant serves a segmental section only of the last blades of the low pressure stage, characterized by that said casing and said partitions are so formed that fluid entering the casing is deflected outwardly away from the turbine axis and from an axial direction to a substantially radial direction of flow.

7. In combination with an axial flow turbine, an exhaust casing receiving the fluid discharged from the low pressure stage and extending substantially radially away from the turbine axis, and partitions formed within said casing and dividing the interior thereof into substantially radially extending passages disposed substantially in the same transverse plane.

8. In combination with an axial flow turbine, an exhaust casing receiving the fluid discharged from the low pressure stage and extending substantially radially away from the turbine axis and partitions formed within the said casing and dividing the interior thereof into substantially radially extending passages having their discharge openings disposed in substantially the same transverse plane.

9. In combination with an axial flow turbine, an exhaust casing receiving the fluid discharged from the low pressure stage and extending substantially radially away from the turbine axis, and partitions formed within the said casing and dividing the interior thereof into substantially radially extending passages having their discharge openings disposed in substantially the same transverse plane and terminating on a substantially longitudinal plane.

10. The combination with a condenser and a turbine having an exhaust casing surrounding a final stage of a turbine provided with a transverse exhaust connection of greater length than the width of the exhaust casing, of a series of vanes in the casing dividing it into separate passages adapted to receive fluid from different sections of the said stage, and discharge the fluid into the condenser at different points of the exhaust connection.

11. The combination with a condenser and a turbine having an exhaust casing surrounding a final stage of a turbine provided with a transverse exhaust connection of greater length than the width of the exhaust casing, of a series of vanes in the casing dividing it into separate passages adapted to

receive fluid from different sections of the said stage, and discharge the fluid into the condenser at different points along the exhaust connection.

12. The combination with a surface condenser and a turbine having an exhaust casing surrounding a final stage of the turbine and provided with an exhaust connection adapted to discharge fluid exhausted from the said stage into the condenser along substantially the entire length of the condensing elements, of a series of vanes in the casing dividing it into separate passages adapted to receive fluid from different sections of the said stage and discharge the fluid into the condenser at different points along the exhaust connection.

In testimony whereof, I have hereunto subscribed my name this eighth day of August, 1916.

KARL BAUMANN.

Witnesses:
C. G. LLOYD,
J. D. WALKER.