March 5, 1946. R. W. YOUNGASH 2,396,068

TURBINE

Filed Feb. 17, 1942 4 Sheets-Sheet 1

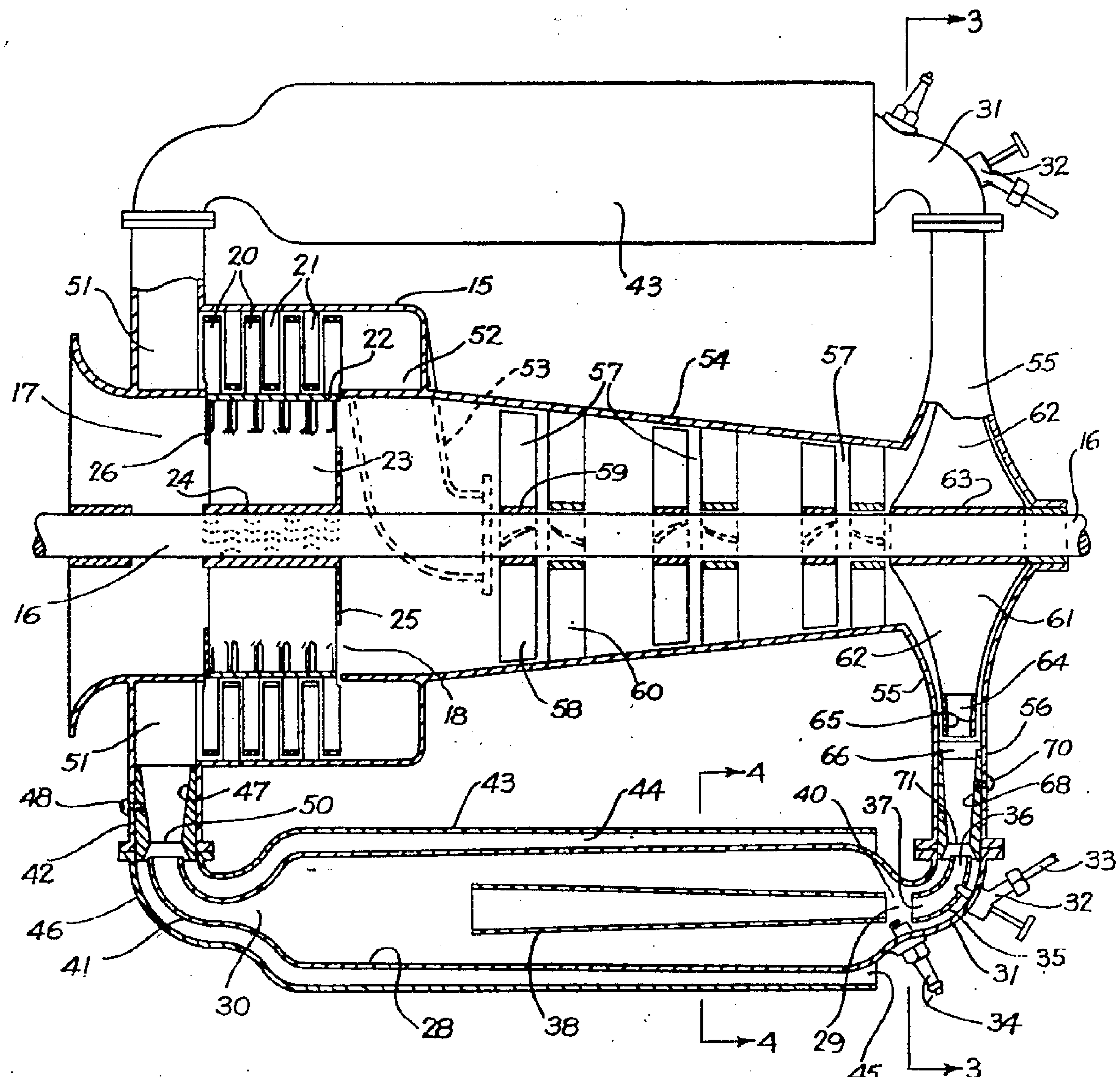
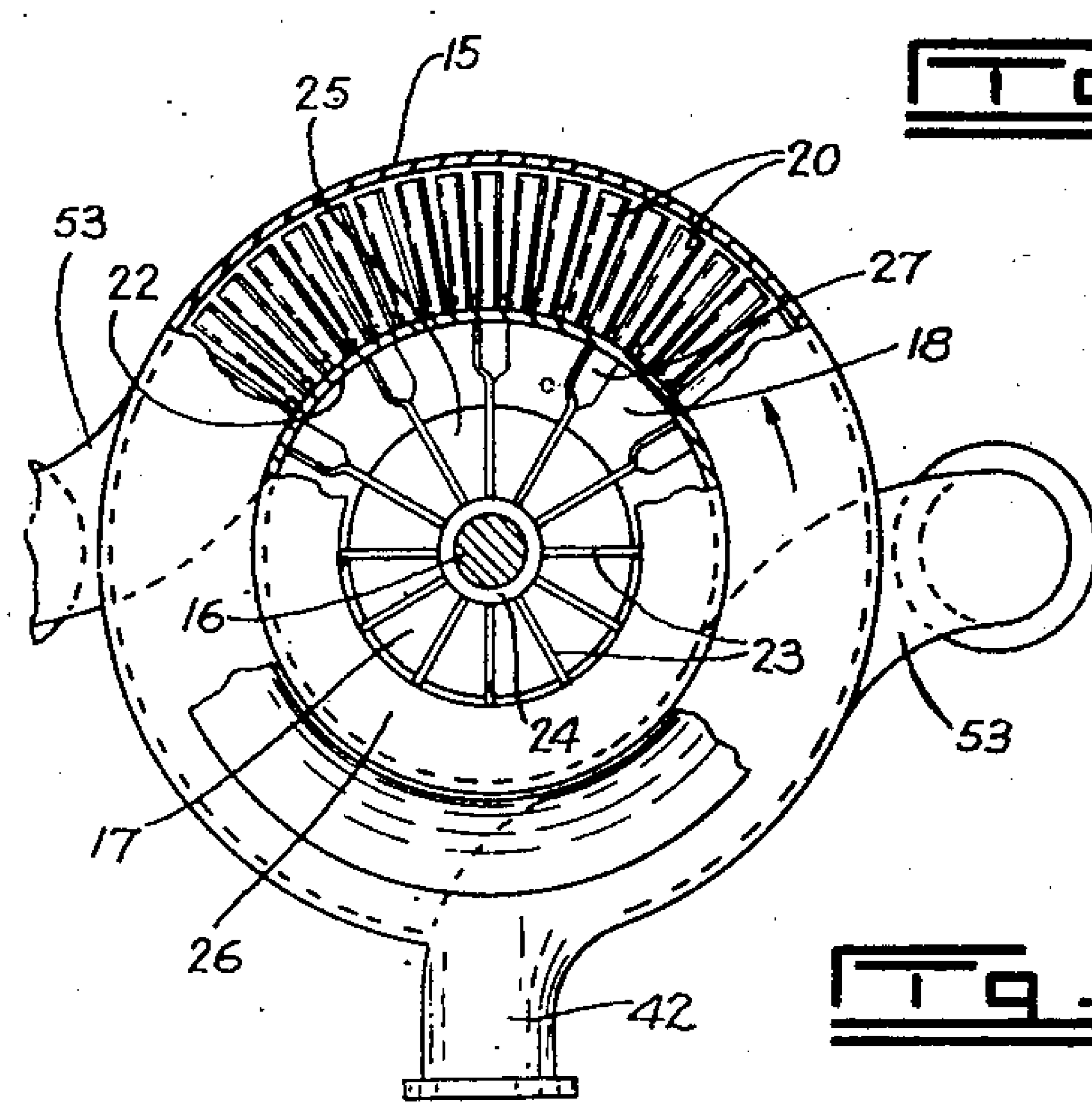


Fig.1.



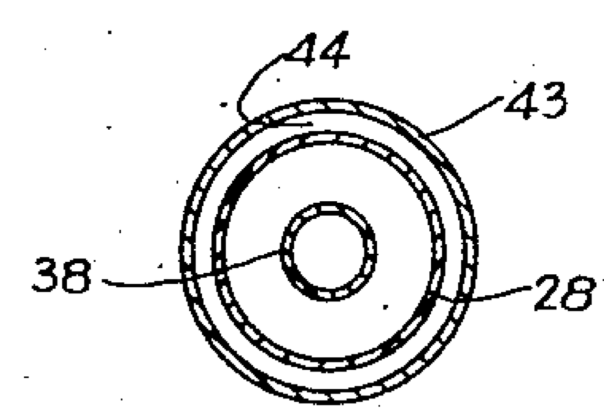


Fig.4.

Fig.2.

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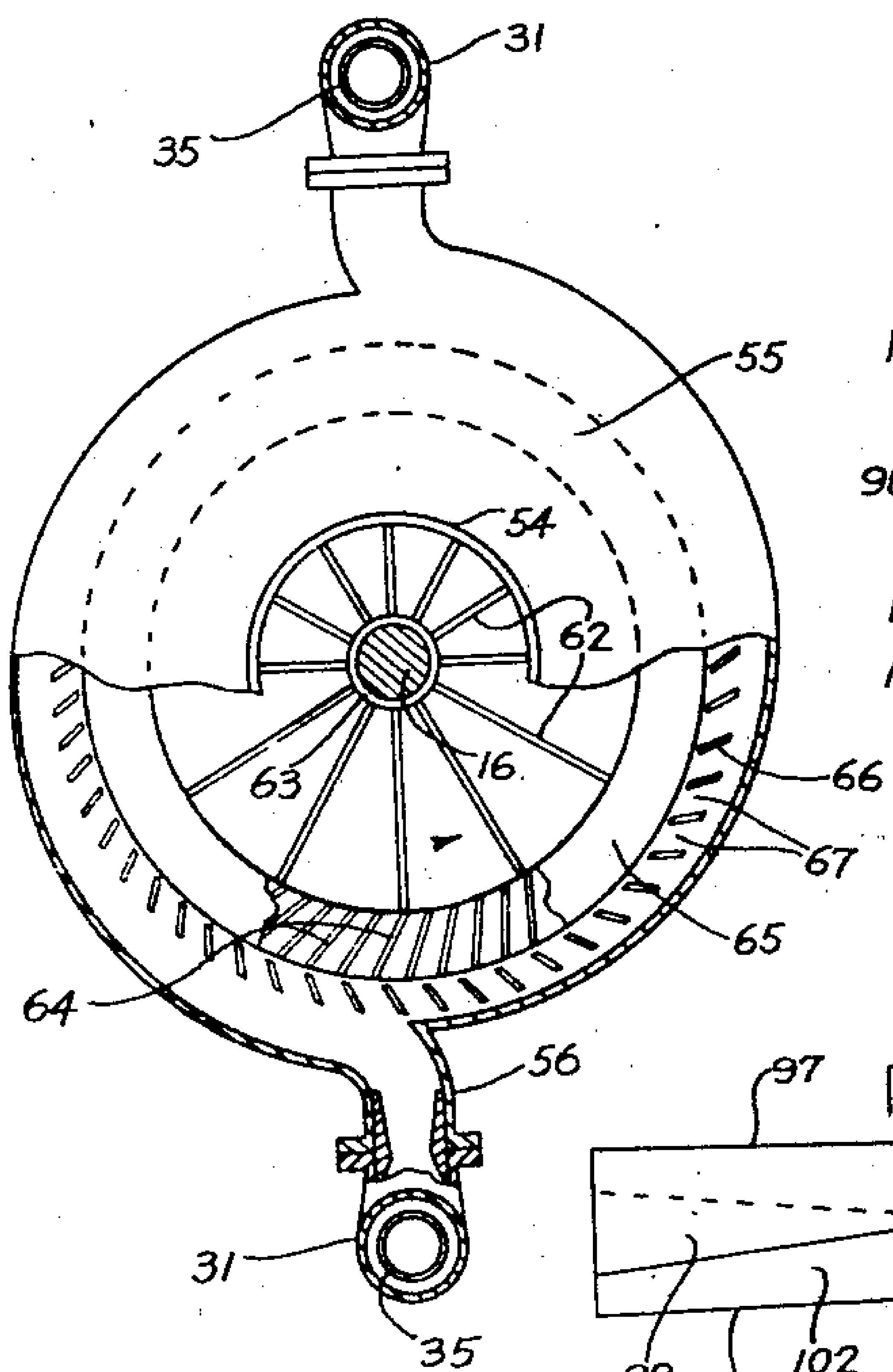

Fig. 3.

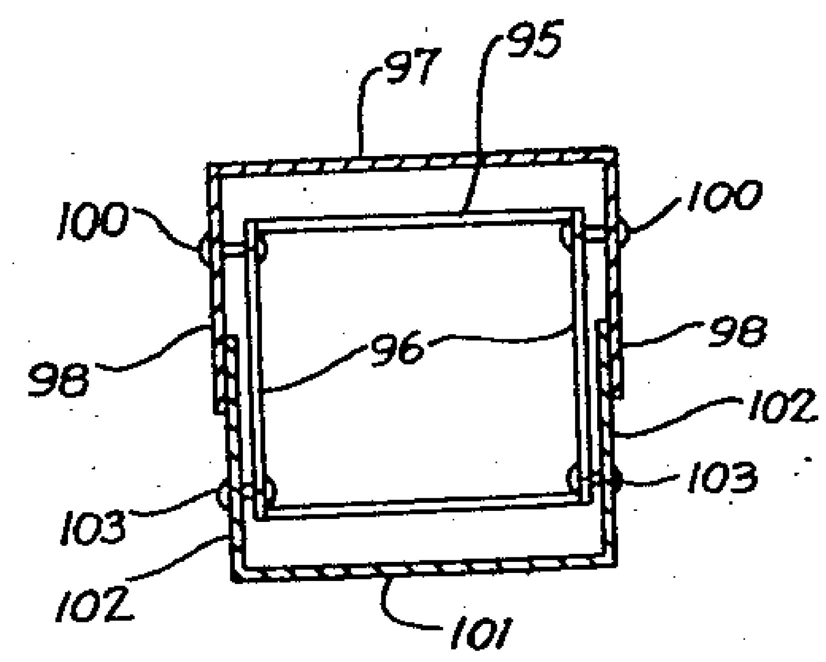

Fig. 8.

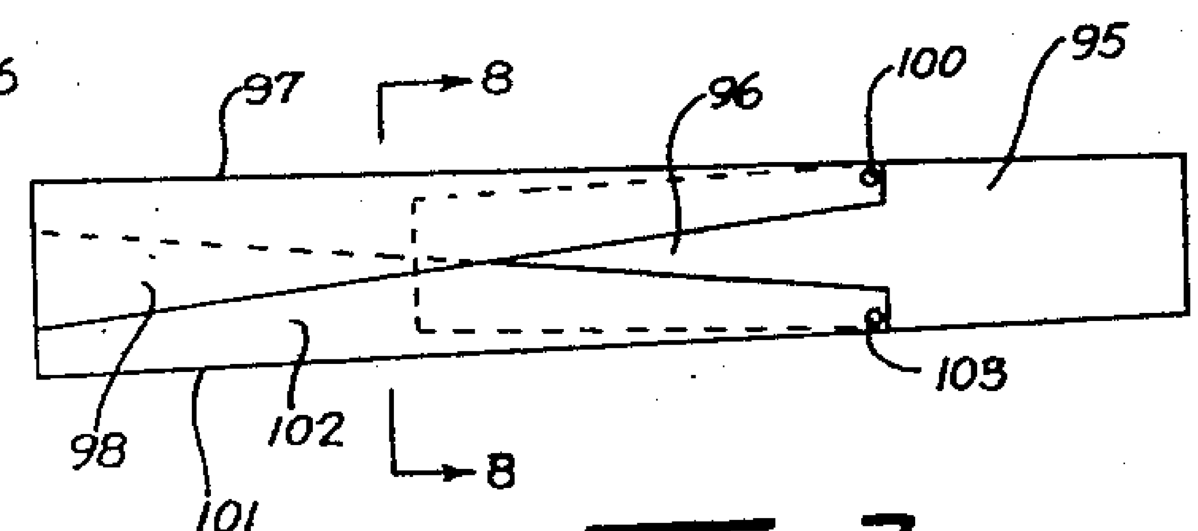

Fig. 7.

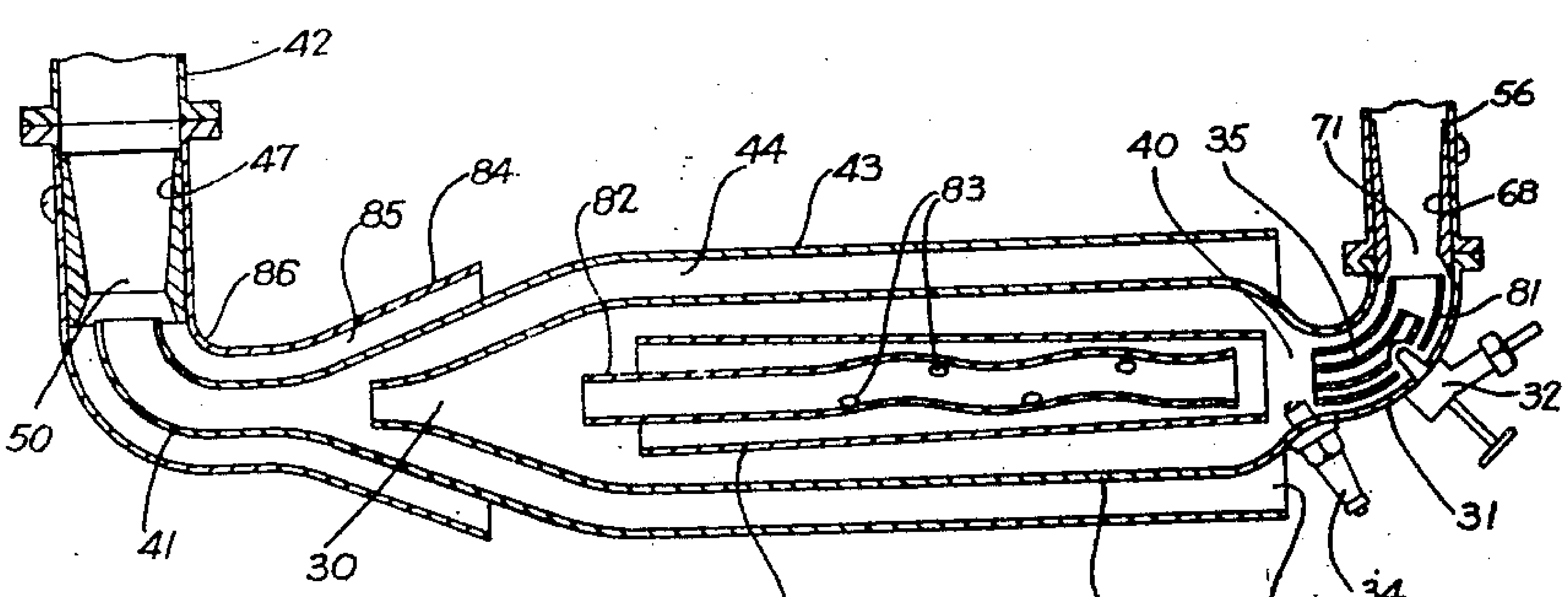

Fig. 5.

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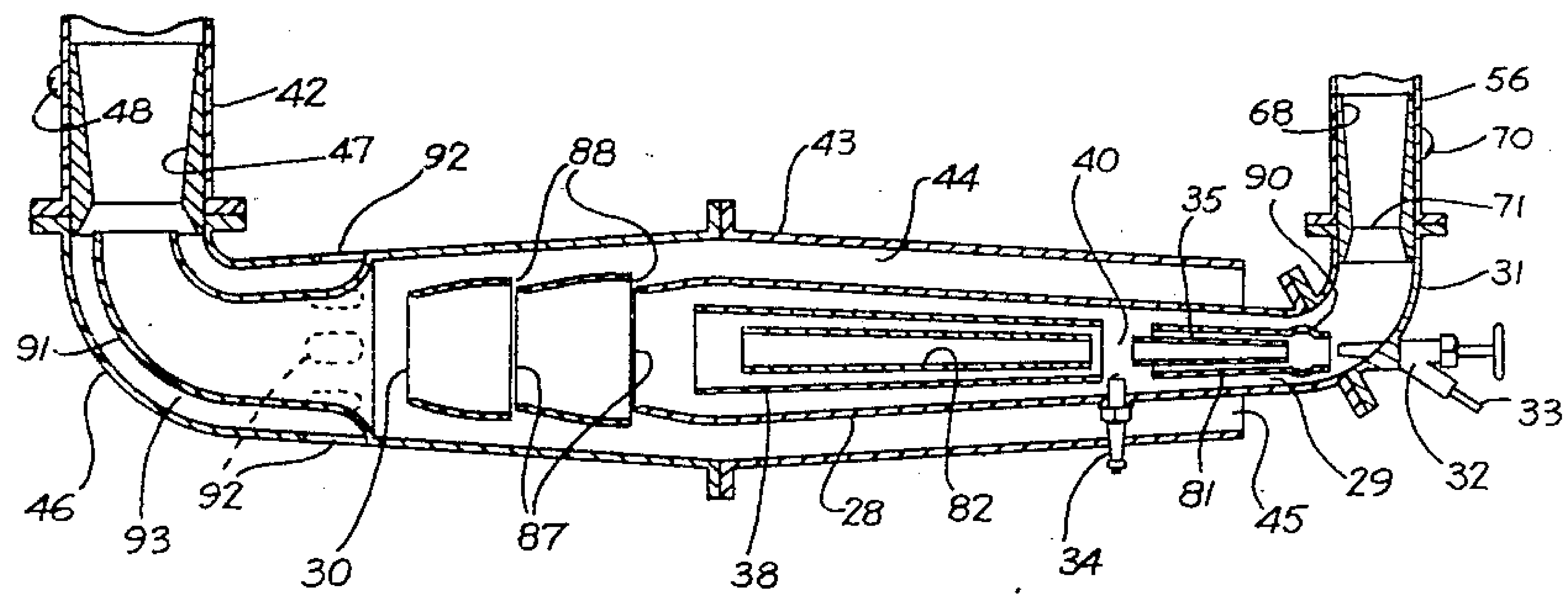

Fig. 6.

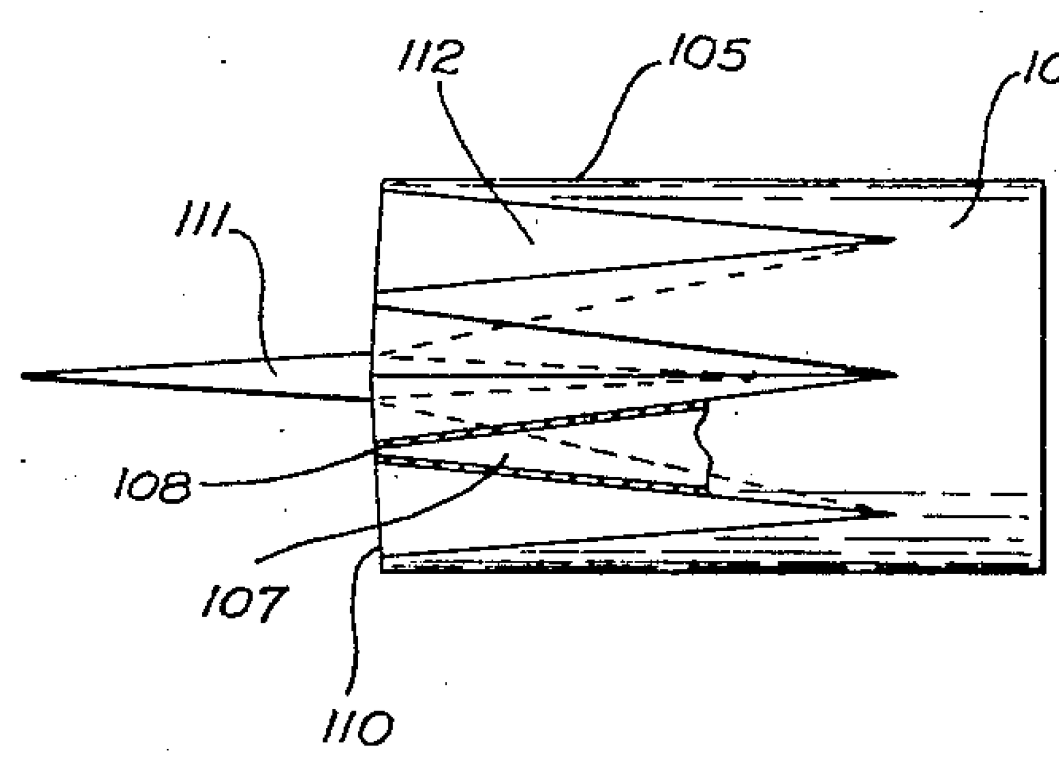

Fig. 9.

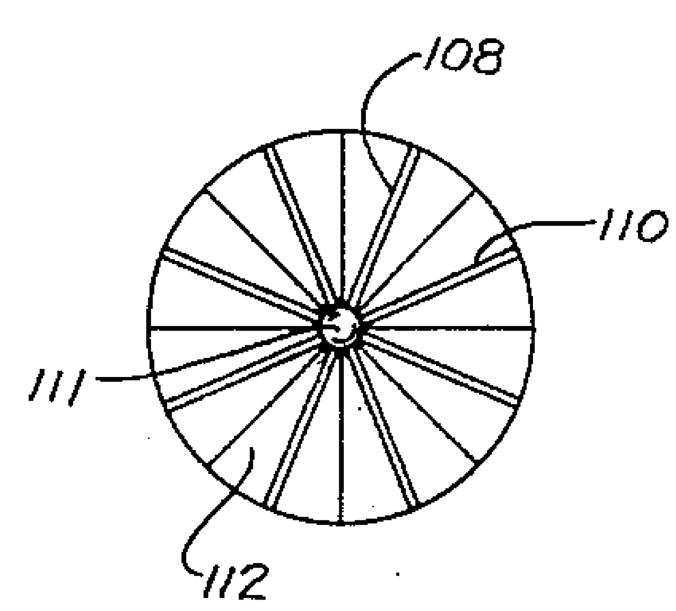

Fig. 10.

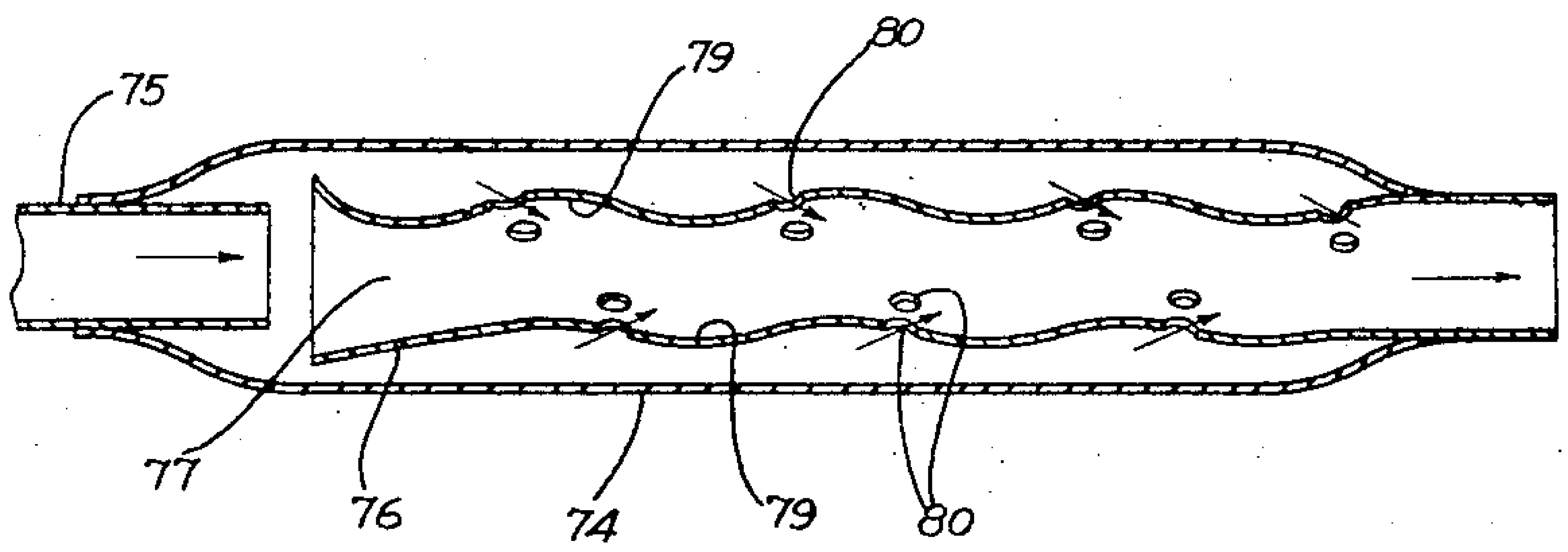

Fig. 11.

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TURBINE

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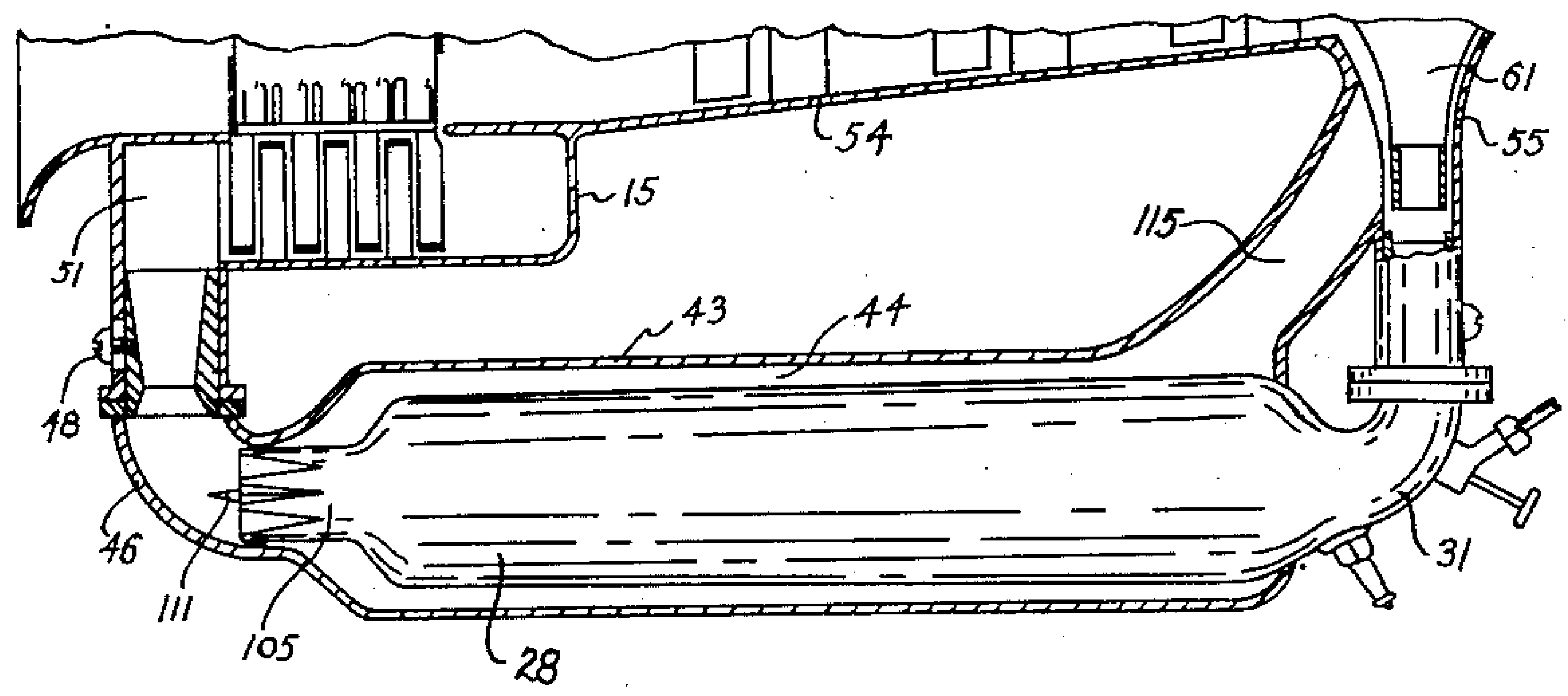

Fig. 12.

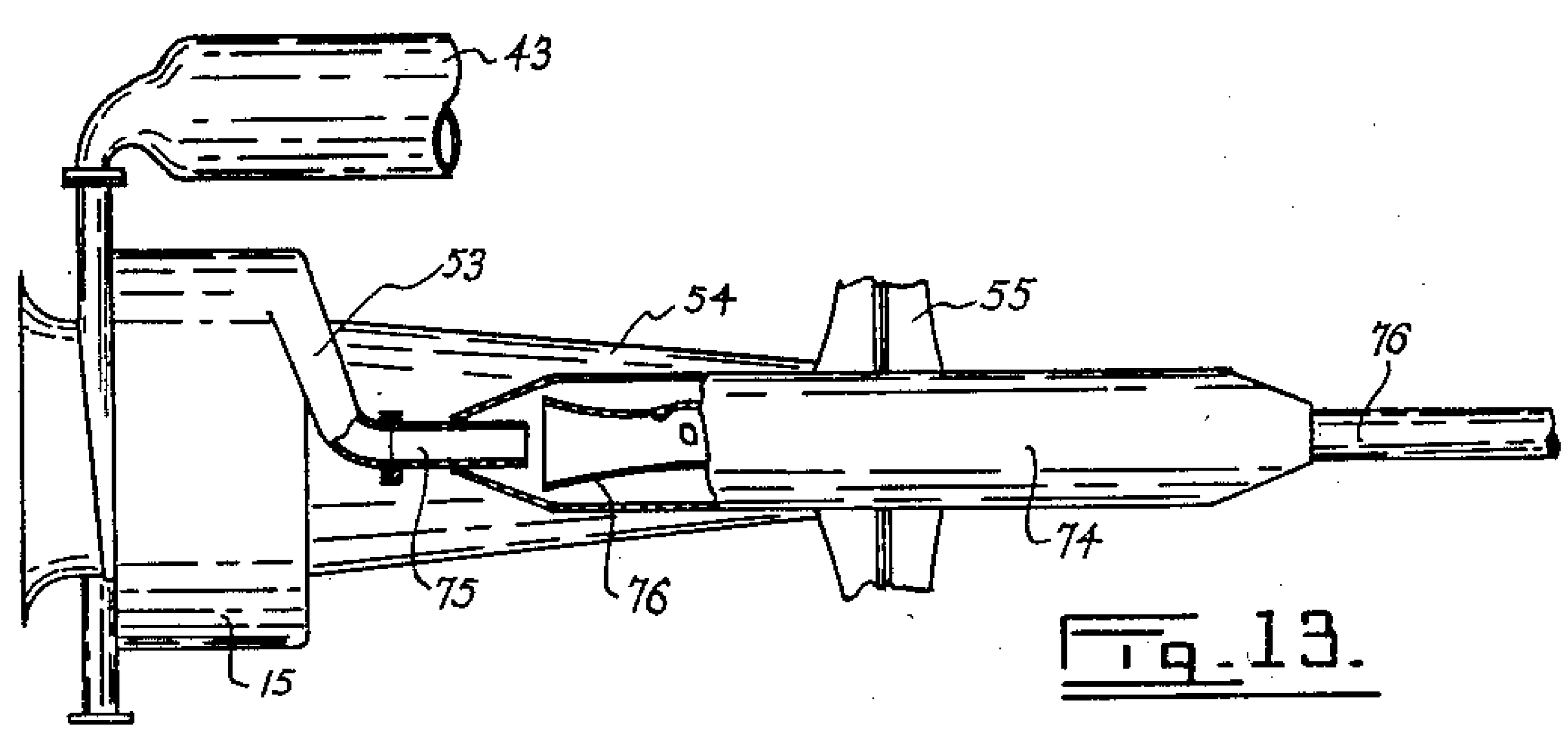

Fig. 13.

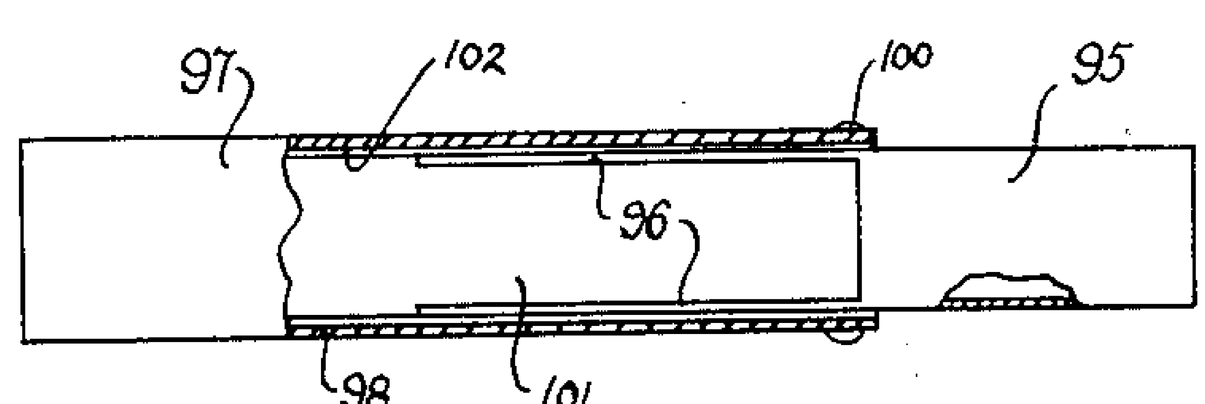

Fig. 14.

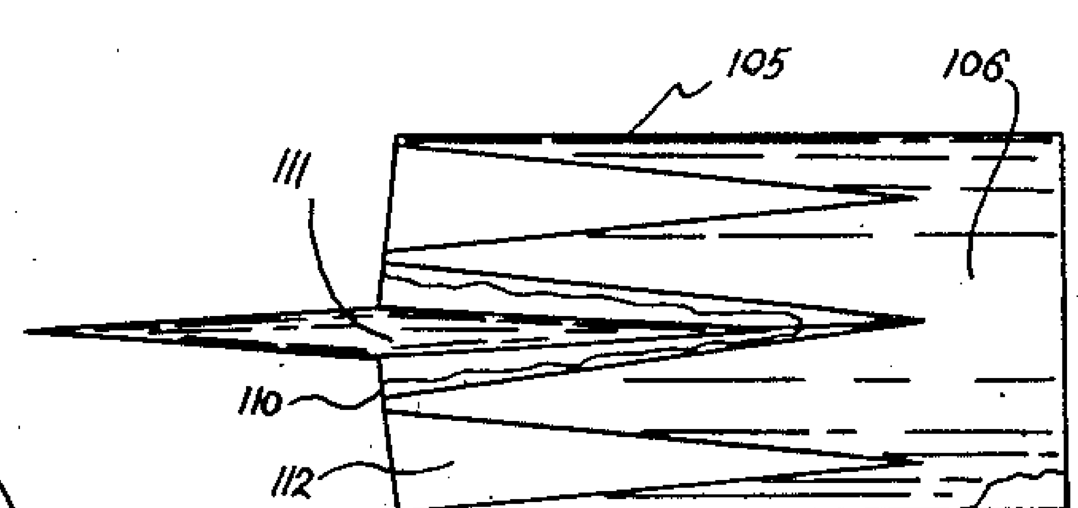

Fig. 15.

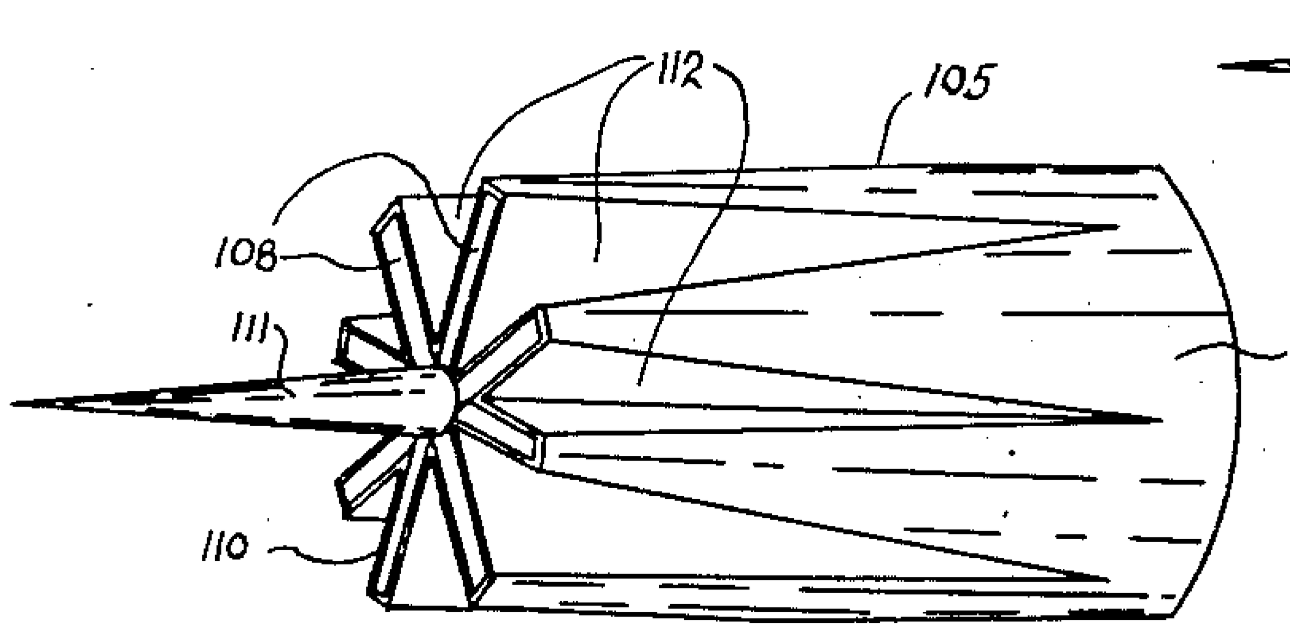

Fig. 16.

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UNITED STATES PATENT OFFICE

2,396,068

TURBINE

Reginald William Youngash, Vancouver, British Columbia, Canada

Application February 17, 1942, Serial No. 431,286
In Canada June 10, 1941

11 Claims. (Cl. 60—44)

This invention relates to turbines and particularly to air or combustion turbines.

An object of the present invention is the provision of a turbine which utilizes or converts into power a greater portion of the heat developed than has heretofore been achieved.

Another object is the provision of a turbine in which the blades are not subjected to damaging temperatures.

Another object is the provision of a turbine in which high temperatures are created and yet the structure of the turbine is protected against the extreme heat without diverting any or losing a great deal of the latter.

A further object is the provision of a turbine in which the bearings operate in comparatively cool air.

A still further object is the provision of a turbine including means for directing air under pressure thereto which will function efficiently despite changes in barometric pressure.

A further object is the provision of a turbine including efficient means for directing air under pressure thereto which provides for multiple compression stages without the necessity of airtight bearings between the stages for the prevention of pressure leakage.

Yet another object is the provision of a compact turbine unit of extremely simple construction and which is very small in comparison to its power output.

Many attempts have been made to produce hot air or combustion turbines but these have not been very successful for two principal reasons: (1) thermal inefficiency, and (2) the damage or destruction of the turbine blades, the combustion chamber, and other parts thereof by the extremely high temperatures involved.

In all internal combustion engines, such high temperatures are created that it is necessary to provide means for removing a substantial portion of the heat in order to protect the various parts of the engine, while a considerable amount of the heat passes through the engine as a surplus. In both cases, a large percentage of the heat is lost or wasted.

This invention overcomes these problems by introducing cool air into the hot air or gases being directed to the turbine blades in sufficient quantity to absorb and use the available heat. Suitable means is provided for rapidly and intimately mixing the hot and cool air and the expansion of the increased volume of air is converted into a forward movement. At the same time, at least some of the cool air is utilized to form a sheath of air around the combustion or heating area of the device. This sheath protects the equipment against the high temperatures by absorbing some of the heat and this heated air is used to augment the volume of the air directed to the turbine blades. Cooler air may be introduced into the hot air in one or more stages and all or only some of the cooler air may be utilized as a sheath for the combustion or heating area. Thus, the additional air protects the combustion or heating area, assists in utilizing all the heat generated, increases the volume and decreases the temperature of the air being directed to the turbine blades, and it reduces the velocity of said air to a desired point.

Another advantage of this invention is that some or all the air to be directed to the turbine blades may, before being heated, be directed through and/or around the housing of the turbine to absorb any excess heat which may exist there. Furthermore, suitable means is provided for directing air to the unit which operates at maximum efficiency regardless of the barometric pressure of said air.

With the above and other objects in view, the present invention consists essentially of a turbine comprising a casing, a rotatable shaft extending through the casing, a plurality of turbine blades mounted on the shaft within the casing, a chamber, means for directing a stream of hot air under pressure through the chamber, means for introducing cool air into the hot stream, means for rapidly and intimately mixing the hot and cooler air, and means for directing the mixture to the turbine blades, as more fully described in the following specification and illustrated in the accompanying drawings, in which

Figure 1 is a longitudinal section through a turbine illustrating one form of combustion chamber,

Figure 2 is an elevation of the forward end of the turbine, partly in section,

Figure 3 is a section taken substantially on the line 3—3 of Figure 1,

Figure 4 is a section taken on the line 4—4 of Figure 1,

Figure 5 is a longitudinal section through an alternative form of the combustion chamber,

Figure 6 is a longitudinal section of another alternative combustion chamber,

Figure 7 is a side elevation of an adjustable nozzle tube,

Figure 8 is a section taken on the line 8—8 of Figure 7,

Figure 9 is an enlarged side elevation of a mixing nozzle,

Figure 10 is an end elevation of the mixing nozzle,

Figure 11 is a longitudinal section through an exhaust evacuator,

Figure 12 is a fragmentary sectional view of an alternative form of the invention,

Figure 13 is a reduced elevation of the turbine, with some parts omitted, showing an exhaust evacuator in position,

Figure 14 is a plan view, partly in section, of the nozzle tube shown in Figures 7 and 8,

Figure 15 is a view similar to Figure 9 with parts of the nozzle broken away, and

Figure 16 is an enlarged perspective view of the discharge end of the latter nozzle.

Referring more particularly to Figures 1 to 4 of the drawings, **15** is a casing having a rotatable shaft **16** extending therethrough, said casing having relatively large openings **17** and **18** in its opposite ends. A plurality of turbine blades **20** having stators **21** therebetween, are mounted on the shaft **16** in any suitable manner. While the blades **20** have been shown in multiple rows, it will be understood that a single row thereof may be employed. These blades are preferably mounted on a drum **22** which, in turn, is carried by a plurality of supporting blades **23** attached at their inner ends of a hub **24** fixedly mounted on the shaft **16**. The blades **23** may be twisted in the form of fan blades to direct air through the drum **22** or they may be flat, as shown. If desired, in the latter case, an inner deflector **25** may be mounted on the inner end of the hub **24** with its periphery spaced from the drum **22**, and an outer deflector **26** may be mounted on the outer end of the drum, the free edge of said outer deflector being substantially in line with the periphery of the outer deflector. The outer ends of the blades **23** may be formed with a plurality of small fan blades **27**, so that the blades **23** and **27** form a centrifugal fan within the drum, the purpose of which will hereinafter appear.

One or more elongated chambers **28** are provided through which hot air is directed towards the turbine blades **20** and for convenience only one of these chambers will now be described in detail.

A stream of hot air is directed under pressure through the chamber **28** and this stream may be generated outside or inside the chamber, preferably the latter, in any suitable manner.

The chamber tapers down at opposite ends to an inlet **29** and an outlet **30**, and at the inlet end, said chamber is formed with a cylindrical extension **31** which is preferably curved, as shown.

Atomized or vaporized fuel alone or fuel and air are supplied to the extension **31** of the chamber by a fuel nozzle **32** connected by a pipe **33** to a suitable source of supply (not shown). Suitable means is provided for igniting the atomized or vaporized fuel in the chamber **28**, a spark plug **34** being shown for this purpose in the drawings. In this way, a stream of hot air (the products of combustion) is directed through the chamber **28** centrally thereof.

If fuel alone is injected into the chamber through the nozzle **32**, it is necessary to mix air therewith before it reaches the spark plug **34**. Air may be supplied to the outer end of the extension **31** in any suitable manner and a rapid mixture of the fuel and air is obtained by curving said extension, as shown.

It is preferable to form one or more sheaths of cool air around the stream of hot air in the chamber **28** to absorb heat therefrom to be utilized later and to protect the chamber and its associated elements from the extremely high temperatures generated.

One way of accomplishing this is to supply cool air under pressure through the extension **31** to the chamber. One or more concentric "Venturi" tubes **35** which diverge from their inlet ends **36** towards their outlet ends **37**, are mounted in the extension **31** and/or one or more similar and relatively long "Venturi" tubes **38** are mounted in the chamber **28** at its inlet end and extend longitudinally thereof. If the extension **31** is curved, the tube or tubes **35** is or are similarly curved. Actually, the tube **38** may be a continuation of the tube **35** but it is preferable to have an opening **40** therebetween at the inlet of the chamber. The nozzle **32** injects the fuel into the tube **35** and the spark plug **34** may project into the opening **40**.

With this arrangement, the air passing through the tube **35** mixes with the fuel and the mixture is ignited by the spark plug, the curve of the tube assisting in the mixture of the fuel and air. If the tube **38** is provided, the flame and the stream of hot air are directed down this tube. The cool air around the outside of the tubes **35** and **38**, or the combustion area, forms a protective sheath which absorbs heat from said area and protects these tubes and the chamber, while some of the cool air is drawn in through the opening **40** and passes through the tube **38** along its inner surface.

In its passage through the tube **38**, the hot stream expands with the consequent increase in velocity and drop in temperature. Beyond the end of the tube, the hot stream mixes with the air of the sheath and the mixture is conducted by the tapering of the outlet end of the chamber into the constricted outlet **30** where the intimate contact transfers some of the velocity and a proportionate part of the heat to the sheath air.

Suitable means is provided for converting the volume of air in the chamber **28** under pressure to velocity or forward movement at a lower pressure. In Figure 1, a constricted nozzle **41** is provided for this purpose. The nozzle extends outwardly from the constricted outlet **30** of the chamber and it is preferably curved, as shown. This nozzle expands the mixture after its passage through the constricted outlet forming said mixture into a high velocity jet. The constricted area and the curve of this nozzle assists in completely mixing the hot and cooler air from the chamber, and the curve reduces the possibility of any liquid fuel proceeding further in that state. This result is due to the fact that any liquid fuel, which would be very much heavier than the surrounding air, is smashed against the curved wall of the nozzle, thus being broken into minute particles. The expansion of the air at this point creates a further drop in temperature. The nozzle discharges into a pipe **42**.

At this point, it is preferable to entrain more cool air with the stream of air from the chamber and this may be done in any suitable manner. In Figure 1, a shell **43** is concentric with and spaced from the chamber **28** to form a passage **44** therebetween. This shell, which preferably covers most of the chamber, opens out to the atmosphere outside the device at its entrance **45**, or it may be connected to any suitable source of compressed air, and at its opposite end it tapers to a curved extension 46 surrounding the nozzle 41, said extension being connected to the pipe 42. If compressed air is used, it may be supplied in any desired manner, such as, by means of a pipe 115 extending from the fan casing 55 to the end of the shell 43, which is closed in this case, see Figure 12.

Another constricted nozzle 47 is movably mounted in the pipe 42 and it may be retained in any adjusted position in said tube in any suitable manner, such as by a set screw 48. The constriction 50 of this tube is spaced a little from its entrance and the tube diverges from the constriction to the opposite end thereof.

The constriction 50 is spaced from the end of the nozzle 41. The jet from the nozzle entrains cooler air from the passage 44 in the shell 43. This air, entering the shell through the entrance 45, forms a protective sheath of cool air around the chamber 28 to absorb heat therefrom and protect it from the excessive heat generated therein. This causes the air in the passage to expand, acquiring some velocity, and this expanded air is mixed with the hot air of the jet. The constriction 50 causes a rapid and intimate mixture of the hot air from the jet and the cooler air from the passage 44. This air further mixes beyond the constriction in the tube 47 and it expands therein with a further drop in temperature. The tube 47 confines this greatly increased volume of air so that the expansion is converted into velocity or forward movement.

This air is now directed by the tube 47 and the pipe 42 into an annular intake passage 51 at the forward end of the casing 15, and this passage directs the air to the turbine blades 20. An annular exhaust passage 52 formed at the rearward end of the casing 15, receives the exhaust air from the turbine blades, and this air is removed from this chamber through one or more exhaust pipes 53, see Figure 2.

The pressure of the cool air supplied to the chamber 28 may be created in any desired manner. This is preferably done in the following manner:

A housing 54 extends from a point adjacent the rearward end of the drum 22 through and beyond the inner opening 18 of the casing 15. This housing converges from the casing 15 towards its outer end and it may be connected directly to the extension 31 of the chamber 28, or it may be connected to a fan casing 55 which, in turn, is connected by a pipe 56 to said extension. The shaft 16 extends through the housing 54 and the casing 55.

One or more compression units 57 are mounted in said housing. Each unit consists of blades 58 projecting outwardly from a hub 59 mounted on the shaft 16, and stator blades 60 carried by the housing, mounted behind the blades 58.

If the fan casing 55 is provided, a centrifugal fan 61 is mounted therein upon the shaft 16. This fan consists of flat blades 62, see Figures 1 and 3, projecting outwardly from a hub 63 and having a plurality of tangential blades 64 mounted on their outer ends in suitable manner, such as by means of spaced annular plates 65 located on each side of the blades, said plates being mounted on the outer ends of the blades 62.

A collector ring 66 is removably mounted in the casing 55 around the centrifugal fan 61. This ring has a plurality of tangential tapered passages 67 formed therein which lie on the opposite tangent to that of the blades 64 of the fan 61.

A constricted tube 68 is movably mounted in the pipe 56 and it may be retained in any desired position by a set screw 70. This tube has a constriction 71 adjacent its outlet end.

While one or more compression units 57, a centrifugal fan 61, and a centrifugal or ordinary fan arrangement in the drum 22, have been described, any one or any combination of these may be employed. With this compression arrangement, the air is compressed in multiple stages and by screw and centrifugal fans. The combination of these two types of fan has the effect of securing a more constant output of air at varying barometric pressures. The efficiency of the screw type fan depends chiefly on the velocity of the air through the blades, while the centrifugal type depends largely on the weight of the air. At sea level, the centrifugal fans will have their maximum efficiency while the screw blades are operating on a smaller volume of air than they are capable of moving, the loaded centrifugal fans forming a back pressure, but with a reduction of the barometric pressure, the load of the centrifugal fans is reduced, thus allowing the screw blades to increase their volumetric efficiency to compensate for the loss in the centrifugal fans.

A preferred form of exhaust evacuator is illustrated in Figure 11. This evacuator consists of an elongated cylinder 74 and a pipe 75 extending from one of the exhaust pipes 53, see Figure 13, projects a short distance into said cylinder. A curvilinear tube 76 with a constriction 77 at its forward end, extends longitudinally of the cylinder from a point adjacent the end of the pipe 75 through the opposite end of the cylinder. The curves of the tube 76 create a plurality of concave pockets 79 therein, and one or more orifices 80 are formed in said tube at the bottom of each pocket.

The movement of the exhaust air through the tube 76 tends to form vacuums in the pockets 79 by drawing air therefrom so that air rushes into said pockets through the orifices from the space surrounding the tube. At the same time, the increase in the velocity of the air through the constriction 77 sucks air into the tube from the surrounding area. Thus, by removing air from the cylinder 74, the movement of the exhaust air through the tube 76 lowers the pressure in said cylinder to a point below atmospheric pressure. The pipe 75 projects into the cylinder 74 and, consequently, the difference between the pressure of the air entering the chamber 28 and the pressure of the air into which the exhaust is discharged, is greater than if it were discharged directly into the atmosphere.

The general operation of the turbine is as follows:

Air entering the system through the hub of the turbine blades 20, assists in keeping the temperature of these blades down, it conserves the mechanical strength of the hub and said blades, and it protects the shaft 16 and its bearings from the heat. At the same time, the heat absorbed by this air is utilized later. The pressure of this air is increased by the centrifugal and ordinary fans described above and it is directed under pressure to the chamber 28. Some of this air is mixed with the fuel and burned in the tubes 35 and 38 while the remainder of the air forms a protective sheath around said tubes. The proportioning of the air through and around the tubes is regulated by moving the tube 68 along the pipe 56. As the constriction 71 is moved closer to the entrance of the tube 35, the more air is directed through said tube, and as the constriction is moved away therefrom, the more is directed around the tube. The adjustment and size of the tubes 68 and 47 regulates the pressure in the chamber 28.

The hot stream of air expands in the tube 35 and in the chamber 28 and it is mixed with the cooler air of the sheath therein. The expansion of this mixture is converted into velocity in the nozzle 41 wherein further mixing and limited expansion takes place. The sheath of air around the outside of the chamber 28 is entrained with the air from the nozzle and the two are mixed and expanded in the Venturi tube 47 further to cool the hot stream and to increase the volume of air which is constrained so that the velocity thereof is increased. This air is directed to the turbine blades 22 which rotate the shaft 16. The exhaust air from the turbine blades passes through the exhaust evacuator 74 which functions as described.

Air is used to cool the various parts of the turbine and yet the heat absorbed by this air is returned to and utilized in the turbine. Cooler air is added to the hot stream both inside the chamber 28 and beyond said chamber but it is to be understood that this may be done in either place or together, as shown.

An alternative form of chamber 28 is illustrated in Figure 5. In this case, another tube 81 surrounds the tube 35 to divide the sheath of air around the latter tube into two layers. The tube may or may not be used in this alternative but, in any event, a curvilinear tube 82 is provided centrally of the chamber 28, within the tube 38, if the latter is used. The tube 82 has a plurality of orifices 83 found in the bottoms of the pockets created by the curves of the tube. The stream of hot air from the tube 35 is directed through the tube 82 and as it must follow a tortuous passage therein, it is intimately mixed with the cooler air which has been drawn in through the opening 40 and through the orifices 83. The tube 38 divides the surrounding sheath of cool air into layers.

The chamber 28 converges to the constricted outlet 30, but in this example the nozzle 41 is formed on the forward end of the shell 43. The stream of hot air from the tube 82 is rapidly and intimately mixed with the air of the surrounding sheath in the chamber 28 and the jet of air therefrom entrains cooler air from the passage 44 and these are mixed and expanded in the nozzle 41 to convert the expansion into velocity. Another shell 84 surrounds at least a portion of the shell 43 forming a passage 85 therebetween. The shell 84 converges to a curved extension 86 which is connected to the pipe 42. The tube 47 is shown as being mounted in the extension 86 instead of in the pipe 42, but it may be mounted in the latter, if desired.

The jet of air from the nozzle 41 entrains cooler air from the passage 85 and these are intimately mixed and expanded in the tube 47. Here again, the air is cooled, and the velocity thereof increased. This air is directed to the turbine blades.

Figure 6 shows another alternative chamber 28. This chamber diverges slightly from its inlet 29 and it has one or more constrictions 87 formed therein with an opening 88 at each restricted point. The outlet 30 is larger in relation to the chamber than in the above alternatives but still constricted.

This form of the invention may have only the tube 35 or it may also have the tube 81 and these tubes may be curved or they may be straight, as shown. The tube 81 may have an enlargement 90 adjacent its entrance, in which fuel from the nozzle 32 is mixed with the compressed air entering the tubes 35 and 82. Either or both the tubes 38 and 82 may be located in the chamber and the latter tube may be straight, as shown, or it may be curvilinear as in Figure 5.

The shell 43 surrounds the chamber 28 and gradually converges to the extension 46 which is connected to the pipe 42. A curved nozzle 91 is mounted in the shell 43 adjacent the outlet end of the chamber 28. The inlet end of this nozzle extends to the walls of the shell so that all of the hot air from the chamber and the cooler air from the passage 44 enters said nozzle. A plurality of orifices 92 may be formed in the extension 46 adjacent the point where the nozzle 91 joins the shell 43. These orifices communicate with a passage 93 surrounding the nozzle 91 and supply cool air for mixing at the outlet of the nozzle 91.

The stream of hot air from the nozzle 82 is expanded and mixed in the chamber 28 with the cooler air of the surrounding sheaths. Some of the air from the passage 44 is drawn into the chamber through the openings 88 while the remainder of the air from said passage is mixed with the air from the chamber in the nozzle 91. The air is mixed and expanded in this nozzle and the jet therefrom draws in cooler air through the orifices 92 and the passage 93. These streams of air are mixed and expanded in the tube 42 and then directed to the turbine blades.

Figures 7, 8 and 14 illustrate an adjustable nozzle tube of rectangular cross section which may be used in place of any of the Venturi tubes above described. This consists of a tube 95 having opposed sides 96 projecting forwardly therefrom, the other two opposed sides being omitted at this point. A section 97 having sides 98 is pivotally mounted by means of pivots 100 on the end of the tube 95 at one side thereof, while another section 101 having sides 102 is pivotally mounted by means of pivots 103 on the end of said tube at the opposite side thereof. The side of the sections 97 and 101 overlap the sides 96 of the tube and the sides of one section overlap the sides of the other.

As the sides of the lower section 101 are positioned inside the sides of the upper section 97, the nozzle tube is adjusted to its smallest size when the sides 102 contact the top of the section 97. To increase the size of the venturi, the sections may be spread apart as long as the sides thereof overlap the sides 96. The degree of expansion which may take place in the Venturi tube is regulated, within certain limits, by regulating the sections 97 and 101.

An enlarged view of a mixing nozzle which may be used in any of the alternatives of the invention is illustrated in Figures 9, 10, 15 and 16. This nozzle 105 consists of a cylindrical section 106 from which a plurality of internal radiating passages 107 extend forwardly, each of said passages converging to a relatively thin outlet 108 at the outlet end 110 of the nozzle. A double ended cone 111 is located in the outlet end 110 centrally thereof and projects outwardly therefrom, as shown in Figures 9, 15 and 16. The spaces between the radial passages 107 form external V-shaped passages 112 in the outside of the nozzle. These passages are the same depth as the radial passage at the discharge end 110 but they become shallower and narrow towards the opposite end thereof.

This nozzle is always situated where the hot stream of air passes through it and cooler air passes around it. In Figure 12, the nozzle 105 has been substituted for the nozzle 41 at the discharge end of the chamber 28 of the alternative of Figure 1. The hot air from said chamber passes through the radial passages 107 and is divided into a plurality of thin radial streams passing out through the outlets 108. In this way, a very large surface of hot air comes into direct contact with the cooler air which is drawn or propelled through the passages 112 from the passage 44. The cooler air flows from the passages 112 between the thin radial streams of hot air. Thus, a larger percentage of the cooler air comes into direct contact with the hot air than is the case with ordinary nozzles, such as the nozzle 41. This ensures an extremely rapid and intimate mixing of the air and it also permits a larger quantity of cooler air to be mixed with the hot air with increased efficiency than otherwise possible.

Various modifications may be made in this invention without departing from the spirit thereof or the scope of the claims, and therefore, the exact forms shown are to be taken as illustrative only and not in a limiting sense, and it is desired that only such limitations shall be placed thereon as are set forth in the accompanying claims.

What I claim as my invention is:

1. In a turbine of the type described, having cooperating turbine and stator blades, means for supplying hot gases to the blades comprising, a chamber having an inlet and an outlet at opposite ends thereof, an inner tube in the inlet of the chamber, a constricted tube connected to the inlet of the chamber beyond the tube therein and having an outwardly flaring portion adjacent the end of said inner tube, means for supplying air to the chamber through the constricted tube, said constricted tube directing the air through and around the inner tube, means for igniting the fuel of the inner tube to form a stream of hot air flowing through the chamber centrally thereof, the cooler air in the chamber forming a sheath around the hot stream, means for intimately mixing the hot and cooler air in the chamber adjacent its outlet end, a nozzle extending outwardly from the outlet of the chamber forming a jet of the mixed air, means forming a sheath of cool air around the chamber, a second constricted tube with reversed tapered portions therein adapted to receive the jet from the nozzle, means for directing cooler air from the sheath to the jet at the entrance of the last mentioned tube, the mixture of hot and cooler air being expanded and the expansion converted to velocity in said tube, and means for directing the mixture to the turbine blades.

2. A device according to claim 1, in which both constricted tubes are adjustable in relation to the chamber to regulate the pressure therein.

3. In a turbine of the character described, fluid supply means comprising an internally constricted nozzle adapted to effect an increase in the velocity of the supply fluid, a fuel supply chamber having inlet and outlet tubes, the inlet tube being connected to the nozzle, a fuel supply tube of less diameter than the inlet tube and mounted within the same whereby the air supply will be divided into two concentric layers, means for supplying fuel to the inlet tube, means within the fuel supply chamber for dividing fuel flowing through the same into a plurality of concentric layers, an air supply tube surrounding the fuel chamber having a restricted outlet adjacent to the outlet of the fluid supply chamber and adapted to supply a layer of air around the fluid passing from the outlet, a constricted nozzle adjacent to the outlet of the fuel supply chamber.

4. In a turbine of the type described having cooperating turbine and stator blades, means for supplying hot gases to the blades, comprising an elongated chamber restricted at each end to form an inlet at one end and an outlet at the other, an inlet tube extending outwardly from said inlet and an outlet tube extending outwardly from said outlet, means for supplying air under pressure to the inlet tube, supply nozzle means mounted in said inlet tube and adapted to divide the incoming air into at least two concentric layers, a constricted nozzle mounted adjacent to the supply end of said supply nozzle means and adapted to receive said air under pressure and pass it to said inlet tube and said supply nozzle means, means for supplying such supply nozzle means with fuel to form with the innermost layer of air a combustible mixture, means for igniting such mixture to form a stream of hot gases flowing through said chamber centrally thereof, an open-ended tube mounted within said elongated chamber and adapted to receive such hot gases while the greater part of the remaining air passes around the exterior of said open-ended tube to form a cooling sheath, a nozzle formed with an internal constriction adjacent to the end of said outlet tube, and means for conducting the gases from the last mentioned nozzle to said blades.

5. In a turbine of the type described having cooperating turbine and stator blades, means for supplying hot gases to the blades comprising an elongated chamber restricted at each end to form an inlet at one end and an outlet at the other, a curved inlet tube extending outwardly from said inlet and a curved outlet tube extending outwardly from said outlet, means for supplying air under pressure to the inlet tube, supply nozzle means monted in said inlet tube and adapted to divide the incoming air into at least two concentric layers, a constricted nozzle adapted to receive said air under pressure and pass it to said inlet tube and supply nozzle means, said nozzle being mounted adjacent to the supply end of said supply nozzle means and being movable towards and away therefrom to vary the amount of air in respective concentric layers, means for supplying such supply nozzle means with fuel to form with the innermost layer of air a combustible mixture, means for igniting such mixture to form a stream of hot gases flowing through said chamber centrally thereof, an open-ended tube mounted within said elongated chamber and adapted to receive such hot gases while the greater part of the remaining air passes around the exterior of said open-ended tube to form a cooling sheath, a nozzle formed with an internal constriction adjacent to the end of said curved outlet tube, and means for conducting the gases from the last mentioned nozzle to said blades.

6. In a turbine of the type described having cooperating turbine and stator blades, means for supplying hot gases to the blades comprising an elongated chamber restricted at each end to form an inlet at one end and an outlet at the other, a curved inlet tube extending outwardly from said inlet and a curved outlet tube extending outwardly from said outlet, means for supplying air under pressure to the inlet tube, supply nozzle means mounted in said inlet tube and adapted to divide

the incoming air into at least two concentric layers, a constricted nozzle adapted to receive said air under pressure and pass it to said inlet tube and supply nozzle means, said nozzle being mounted adjacent to the supply end of said supply nozzle means and being movable towards and away therefrom to vary the amount of air in respective concentric layers, means for supplying such supply nozzle means with fuel to form with the innermost layer of air a combustible mixture, means for igniting such mixture to form a stream of hot gases flowing through said chamber centrally thereof, an open-ended tube mounted within said elongated chamber and adapted to receive such hot gases while the greater part of the remaining air passes around the exterior of said open-ended tube to form a cooling sheath, said open-ended tube increasing in diameter towards the outlet of said elongated chamber, a nozzle formed with an internal constriction adjacent to the end of said curved outlet tube, an air supply tube surrounding said elongated chamber and having one end open to atmosphere and the other end constricted adjacent to the end of said outlet tube, the air space defined by the constricted end of said air supply tube surrounding the outlet tube of said elongated chamber and communicating with the bore of the constricted nozzle adjacent to said outlet tube whereby gases from said outlet tube are mixed in said constricted nozzle with cooling air from said air supply tube, and means for conducting the mixture from said constricted nozzle tube to said blades.

7. The turbine as claimed in claim 6 in which the open-ended tube mounted within the elongated chamber is formed with adjustable sections by means of which the rate of increase in its diameter may be regulated.

8. The turbine as claimed in claim 5 in which said outlet tube is formed with a cylindrical portion having a plurality of internal radiating passages, each of said passages converging to a relatively thin slot-like outlet.

9. The turbine as claimed in claim 5 in which said outlet tube is formed with a cylindrical portion having a plurality of internal radiating passages, each of said passages converging to a relatively thin slot-like outlet and a centrally located conical member extending outwardly in the direction of flow of the gases.

10. The turbine as claimed in claim 5 in which means are provided for adjusting the taper of the open-ended tube mounted within the elongated chamber.

11. The turbine as claimed in claim 5 in which the open-ended tube is curvilinear, the curved sections forming pockets at points at which the tube is provided with openings through which air is drawn from the outside to the inside of the tube.

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