J. F. M. PATITZ.

STEAM TURBINE.

APPLICATION FILED JAN. 11, 1904.

971,555. Patented Oct. 4, 19

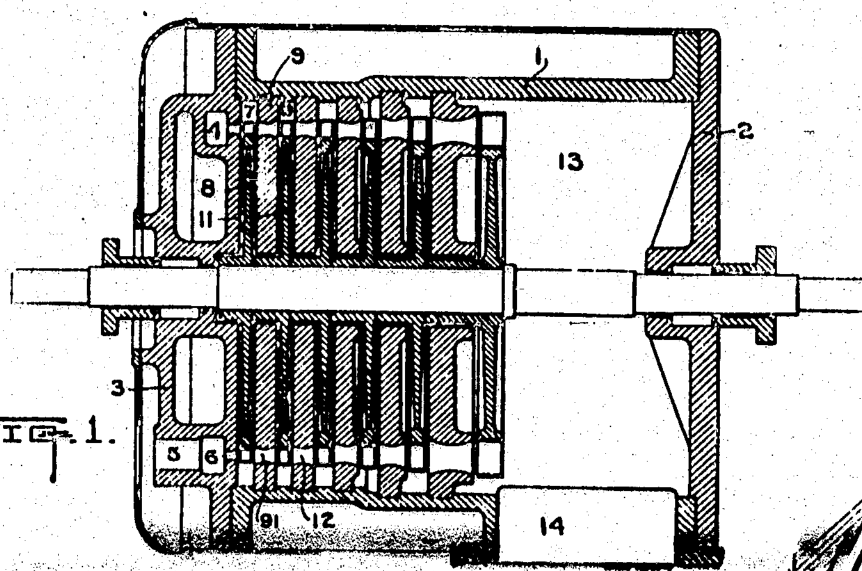
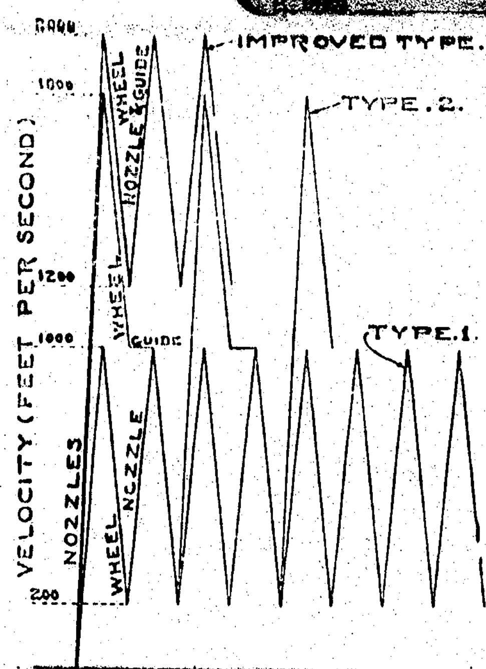


FIG. 1.



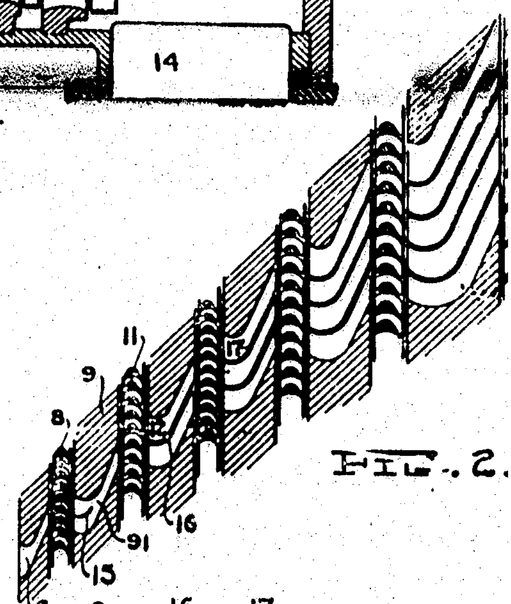


FIG. 2.

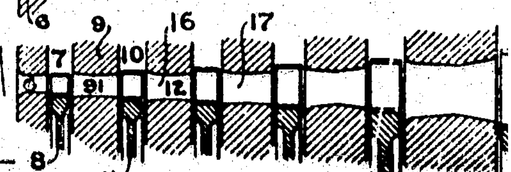


FIG. 4.

FIG. 3.

WITNESSES –

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STEAM-TURBINE.

971,555. Specification of Letters Patent. Patented Oct. 4, 1910.

Application filed January 11, 1904. Serial No. 188,562.

To all whom it may concern:

Be it known that I, JOHANN FRIEDRICH MAX PATITZ, a citizen of the United States, residing at Milwaukee, in the county of Milwaukee and State of Wisconsin, have invented certain new and useful Improvements in Steam-Turbines, of which the following is a specification.

This invention relates to an apparatus for converting potential energy of a fluent medium into work, and more specifically may be substantiated in a turbine in which a fluid is the fluent medium.

The object of the invention is to provide an apparatus which is designed to be operated with the fluent medium at high velocities whereby the size of the apparatus will be reduced to a minimum considering the amount of energy converted into work.

In its specific application to turbines the object is to reduce the number of working wheels.

In order to lead up to the disclosure of this invention, it will be well to consider the existing apparatuses designed to convert energy into work, and more specifically, existing types of steam turbine. In modern turbines the conversion of the energy of the steam into work takes place in several wheels instead of in a single wheel, in order to avoid the enormous resulting turbine velocity should the entire conversion of energy take place in a single wheel. In other words, the energy of the steam is by various methods fractionally converted for abstraction as work by a plurality of wheels.

In the first type of steam turbine, which will be designated Type 1, the wheels revolve in a series of closed chambers and the steam is passed to them through stationary expanding nozzles located in the walls of the chambers. In the first set of nozzles a part of the potential energy of the steam appearing as pressure is converted into kinetic energy appearing as velocity of the steam. Practically all this converted kinetic energy is abstracted in the first wheel as work in turning the wheel, that remaining being merely sufficient to overcome the friction of the passages during its flow to the next chamber. In the nozzles located in the partition between the first and second wheel chambers the steam, having lost a part of its pressure by conversion into work in the first wheel as stated, is again expanded to the same initial velocity by partially transforming its remaining potential energy into kinetic energy appearing as velocity of the steam. Practically all this converted kinetic energy is abstracted in the second wheel as work in turning the wheel. Such fractional conversion of energy and abstraction as work continues until all the potential energy of the steam has been converted into work.

In the second type of steam turbines, which will be designated Type 2, the expansion of the steam takes place in stages. In the first set of nozzles a part of the potential energy of the steam appearing as pressure is converted into kinetic energy appearing as velocity of the steam. Practically all this converted kinetic energy is fractionally abstracted as work in a series of wheels having stationary guiding vanes between them. These guiding vanes have no effect on the expansion or reduction of pressure of the steam, except inasmuch as the friction might influence these conditions. This is the action taking place in the first stage. In the nozzles located between the first and second stages the steam, having lost a part of its pressure by conversion into kinetic energy abstracted as work in the wheels of the first stage as stated, is again expanded to the same initial velocity by converting a part of its remaining potential energy into kinetic energy appearing as velocity of the steam. Practically all this converted kinetic energy is fractionally abstracted as work in a series of wheels having stationary guiding vanes between them. This is the action taking place in the second stage. Such fractional abstraction of energy as work continues in the successive stages until all the potential energy of the steam has been converted into kinetic energy and abstracted as work. The number of stages and the number of wheels in each stage may, of course, be varied.

The difference between these two types is that in Type 1 the velocity is developed for each stage only to the point where one wheel abstracts as work practically all of the kinetic energy the velocity represents, whereas in Type 2 the velocity is developed for each stage to a much higher point and several wheels are necessary in that stage to fractionally abstract as work practically all of the kinetic energy the higher velocity represents.

The improved type of turbine, exemplifying the present invention, differs from both Type 1 and Type 2 just discussed. Instead of converting a part of the potential energy of the steam appearing as pressure into kinetic energy appearing as velocity of the steam to a point where one wheel abstracts as work practically all of the energy the velocity represents, it is proposed to effect such a conversion to a point where the velocity representing the converted energy is about the same as in the case of the turbine of Type 2, but of lower amount than complete conversion would afford. After such conversion, instead of fractionally abstracting as work in a stage including a series of wheels practically all of the energy this velocity represents as in Type 2, only a portion of the energy the velocity represents is abstracted as work in a single wheel, leaving a remanent kinetic energy represented by a velocity greater than the reduction of velocity taking place by reason of the abstraction of the energy as work in the wheel. This remanent kinetic energy appearing as velocity is augmented in expansion nozzles located between the first wheel and a second wheel by a further conversion of a part of the potential energy of the steam appearing as pressure into kinetic energy until the velocity representing the augmented energy is as high as the initial velocity. A partial abstraction of energy as work then takes place in the second wheel to the same extent as occurred in the first wheel. Further conversion and abstraction then take place as before until all of the potential energy of the steam has been converted into work.

The advantage of the improved type of turbine over Types 1 and 2 is that the number of wheels necessary for the conversion of a given amount of energy into work is greatly reduced. For the purposes of demonstration a numerical example of the conditions obtaining during the conversion of a given amount of energy will be stated for each of the three types of turbine. The statement of amounts is approximate and in round numbers only. At an initial pressure of approximately 150 pounds, the velocity attained by steam on free expansion is 4,000 feet per second. The kinetic energy of a mass, m, moving with a velocity, v, is proportional to half the product of the mass by the square of the velocity. The total kinetic energy, K. E., of a given mass of steam at the assumed pressure would therefore be, by the formula

$$\text{K. E.} = k\,v^2, \text{ where } k \text{ is a constant,}$$
$$= k\,4{,}000^2$$
$$= k\,16{,}000{,}000.$$

Assuming that the change of velocity of the steam in passing through a single wheel to be 800 feet in each type of turbine, the velocity and energy changes appear as follows,

Type 1.

Velocity of steam after conversion in each nozzle	1,000 feet.
Velocity change in passing through each wheel	800 "
Velocity remaining to compensate for friction and other losses	200 "
Kinetic energy of steam entering each wheel	$= k\,v^2$ $= k\,1{,}000^2$ $= k\,1{,}000{,}000$
Kinetic energy of steam leaving each wheel	$= k\,v^2$ $= k\,200^2$ $= k\,40{,}000$
Kinetic energy abstracted as work by each wheel	$= k\,1{,}000{,}000 - k\,40{,}000$ $= k\,960{,}000$
Number of wheels in Type 1	$= k\,16{,}000{,}000 / k\,960{,}000$ = 16, approximately.

Type 2.

Assume two wheels to each stage.

Velocity of steam after conversion in each nozzle	1,800 feet.
Velocity change in passing through first wheel of each stage	800 "
Velocity remaining for second wheel of each stage and to compensate for friction and other losses	1,000 "
Velocity change in passing through second wheel of each stage	800 "
Velocity remaining to compensate friction and other losses	200 "
Kinetic energy of steam entering first wheel of each stage	$= k\,v^2$ $= k\,1{,}800^2$ $= k\,3{,}240{,}000$
Kinetic energy of steam leaving first wheel of each stage	$= k\,v^2$ $= k\,1{,}000^2$ $= k\,1{,}000{,}000$
Kinetic energy abstracted as work by first wheel of each stage	$= k\,3{,}240{,}000 - k\,1{,}000{,}000$ $= k\,2{,}240{,}000$
Kinetic energy of steam entering second wheel of each stage	$= k\,v^2$ $= k\,1{,}000^2$ $= k\,1{,}000{,}000$
Kinetic energy of steam leaving second wheel of each stage	$= k\,v^2$ $= k\,200^2$ $= k\,40{,}000$
Kinetic energy abstracted as work by second wheel of each stage	$= k\,1{,}000{,}000 - k\,40{,}000$ $= k\,960{,}000$
Total kinetic energy abstracted as work by each stage	$= k\,2{,}240{,}000 + k\,960{,}000$ $= k\,3{,}200{,}000$
Number of stages in Type 2	$= k\,16{,}000{,}000 / k\,3{,}200{,}000$ = 5, of two wheels each.
Number of wheels in Type 2	= 5 times 2 = 10.

Improved Type.

Velocity of steam after conversion in each nozzle	2,000 feet
Velocity change in passing through each wheel	800 "
Velocity remaining after passing through each wheel	1,200 "
Kinetic energy of steam entering each wheel	$= k\,v^2$ $= k\,2{,}000^2$ $= k\,4{,}000{,}000$
Kinetic energy of steam leaving each wheel	$= k\,v^2$ $= k\,1{,}200^2$ $= k\,1{,}440{,}000$
Kinetic energy abstracted as work by each wheel	$= k\,4{,}000{,}000 - k\,1{,}440{,}000$ $= k\,2{,}560{,}000$
Number of wheels in improved type	$= k\,16{,}000{,}000 / k\,2{,}560{,}000$ = 6, approximately.

From these numerical examples it will be seen that in the turbine exemplifying this invention, the number of wheels is reduced two-thirds and one half of those in the existing types of turbine hereinabove compared.

A direct comparison cannot be made with another existing type of turbine wherein the reaction of steam enters as an element of the process practiced by such turbine. In that type of machine the steam must be admitted throughout the entire circumference and this causes the first wheels to be smaller, necessitating higher velocity of turbine. The larger last wheels in turn limit the safe velocity of the turbine and the velocity representing the energy abstracted as work in the first wheels will therefore be less, and the number of wheels must be increased. In practice, 42 to 80 wheels are necessary in that type of machine.

In the turbine exemplifying this invention, the kinetic energy abstracted as work by each wheel is greater than in existing turbines, for the reason that this kinetic energy is not proportional to the difference between the velocities of the fluid entering and leaving the wheel, but is proportional to the difference of the squares of these velocities. The higher the entering and leaving velocities are, with a constant difference between them determined by the allowable speed of wheel, the greater becomes the kinetic energy abstracted as work by each wheel.

Referring to the numerical examples, the turbine of Type 2 has fewer wheels than the turbine of Type 1 because in the former the first wheels of each stage abstract energy at high entering and leaving velocities; but as practically all the kinetic energy appearing as velocity is abstracted as work in each stage, the last wheels of each stage abstract energy at low entering and leaving velocities. The turbine of Type 2 has more wheels than the turbine exemplifying this invention because in the latter practically all the wheels abstract kinetic energy as work at high entering and leaving velocities. The turbine of Type 2 also has structural disadvantages inasmuch as it is difficult to prevent leakage in the clearance spaces between the wheel buckets and the stationary vanes at the large wheel circumference. In the turbine of Type 1, and in the improved type of turbine, the leakage is much reduced as it can only take place at the small shaft circumferences and can be reduced to a minimum for this reason. The turbine exemplifying this invention thus possesses the structural advantage of the turbine of Type 1 in reducing leakage, and it improves the turbine of Type 2 by a further reduction in the number of wheels necessary for the same amount of energy converted.

The disclosure herein is substantiated on a steam turbine of the impulse type.

In the drawings,—Figure 1 is a central vertical section of the turbine. Fig. 2 is an enlarged sectional development through the vanes of the wheels and stationary passages of the casing. Fig. 3 is an enlarged central vertical section of the vanes and passages. Fig. 4 is a diagrammatic view illustrating the velocity changes occurring in Ty and 2 and in the improved type, all h after described.

Referring to the drawing, the cas is made in two parts to facilitate assen and dismantling. It is closed at the e the inlet 3 and the exhaust head 2. Tl bine shaft is supported in bearings passes through stuffing boxes in the In the inlet head 3 is formed an a steam chamber 4 provided with inlet sages 5. Nozzle passages 6 are form the inlet head 3 and connect the a steam chamber 4 with the first wheel ber 7 of a series of such chambers form the casing 1. The first wheel 8 of a of wheels mounted on the turbine sh located in the first chamber 7, and A partition 9 separates the first chan from the second chamber 10 in which cated the second wheel 11, and in th tition 9 are formed guide nozzles 91. next partition are formed guide nozz and so on throughout the turbine. last wheel of the series is located in t haust chamber 13 connecting with th denser, not shown, through the exhaus sage 14. The circumferential extent passages through the partition walls guide nozzles increases from inlet to ex of the turbine and as steam at high ve has to be reversed in direction and exp to higher velocity, guide vanes 15, t are placed in the guide nozzles to c reverse and direct all parts of the stre steam passing through the guide nozzl

The process practiced by the turbin closed, is to convert in the nozzle 6 t tential energy of the steam coming the boiler and appearing as pressure kinetic energy appearing as high vel Kinetic energy is then partially abstr as work by the first wheel 8 and the anent kinetic energy of the steam leavin wheel appearing as comparatively hig locity is augmented by a further conve of part of the potential energy in the in the guide nozzles 91, the direction o being reversed at the same time. K energy is then further partially abstr as work by the second wheel 11 and, fore, the remanent kinetic energy o steam leaving the wheel 11 appearin comparatively high velocity is augm by a still further conversion of part o potential energy in the steam in the nozzles 12. Similar abstraction and version take place until the steam is fi exhausted of all its potential energy passes to the condenser.

In Fig. 4 is shown a comparison of grams of the three types of turbine he fore discussed. The changes in veloci steam are represented as ordinates and tion along the length of the turbine abscissæ. The comparison shows the relative number of wheels used in each type for the same amount of energy converted. The diagrams illustrate the numerical examples presented hereinabove except that they are shown for only half the amount of energy in the entering steam thus showing only half the number of wheels necessary for each type.

In all three types nozzles are used to convert potential energy to kinetic energy from any velocity of steam below 200 feet to a higher velocity. When the direction of the steam at high velocity is to be changed, a guide will be used, as indicated in the diagram for Type 2. When the direction of the flow of steam at a high velocity is to be changed, and at the same time potential energy of the steam is to be converted into kinetic energy to augment that represented by the high velocity, a combined guide and nozzle is used, as indicated in the improved type. When the direction of the flow of steam at any velocity below 200 feet is to be changed, no guide is necessary, as the friction of the steam in the passages is low. Any form of communication from the wheel discharge at low steam velocity to the next nozzles is sufficient.

In the diagram of Fig. 4, it will be seen that in Type 1 the energy of the steam undergoes a conversion in a nozzle from potential to kinetic and appears with a velocity of 1000. It then passes through the first wheel losing velocity by abstraction of kinetic energy as work by the wheel until it leaves at about 200. This velocity is so low as to require no special guide in reversing the direction of flow and any form of communication between the wheel discharge and the next nozzle will be sufficient. The energy of the steam undergoes a second conversion in this next nozzle from potential to kinetic and appears with a velocity of 1000 when it is passed to the second wheel. This series of changes is repeated until the energy of the steam is exhausted, its pressure becoming so low as to preclude its being further used.

In Type 2 the energy of the steam undergoes a conversion in a nozzle from potential to kinetic and appears with a velocity of 1800. It then passes through the first wheel losing velocity by abstraction of kinetic energy as work by the wheel until it leaves at about 1000. The direction of flow of steam at this velocity is then reversed through a guide but no conversion of energy takes place therein. It is then passed through the second wheel losing velocity by further abstraction of kinetic energy as work by the wheel until it leaves at about 200. The steam is then passed through any form of communication to a second nozzle wherein it undergoes a similar change in the first nozzle, appearing with a veloci of 1800. It is then passed through t third wheel. This series of changes is r peated until the energy of the steam is e hausted, as before.

In the improved type the energy of t steam undergoes a conversion in a nozz from potential to kinetic and appears wi a velocity of 2000. It then passes throug the first wheel losing velocity by abstractic of kinetic energy as work by the wheel unt it leaves at about 1200. It then passes at th high velocity to a combined nozzle and guic where its direction of flow is reversed an at the same time further conversion of p tential into kinetic energy takes place ther in and it again appears with a velocity c 2000. It then passes to a second whee This series of changes is repeated until th energy of the steam is exhausted, as befor

It should be noted that the successive con versions in the turbine exemplified are n the small quantities of energy heretofor converted to compensate and restore fri tion losses, but are so substantial as to b abstracted as work, and such abstractio actually takes place when the fluid move the wheels. But the abstraction is not com plete and at points just before the fluid en ters a nozzle between wheels, there still re mains in the fluid kinetic energy sufficien to be abstracted as work, but such kineti energy is not actually abstracted as wor until later. In this manner work is ab stracted by the wheels and the velocity o the fluid directed to a wheel is higher tha its velocity as it passes from the precedin wheel which latter velocity represents ki netic energy so substantial as to be converti ble into work later.

It should be noted that the abstraction o energy as work by the wheels except pos sibly the last, takes place preferably at th same high ranges of velocities. In the dia gram Fig. 4, these ranges are between 120 and 2000 feet and all the wheels are ther represented as working at these ranges.

It should be understood that it is no desired to be limited to the exact detail of construction shown and described, fo obvious modifications will occur to a perso skilled in the art.

It is claimed and desired to secure by Let ters Patent,—

1. In a fluid turbine, means providing path for the flow of a fluid through the tur bine including in combination, means fo establishing in the fluid a high initial veloc ity, a series of sets of movable vanes, an means located between sets of vanes for in creasing the velocity of the fluid issuin from the preceding set of vanes, the las three means coacting to leave a substantially

high velocity in the fluid as it passes from each set of vanes delivering to the velocity increasing means.

2. In an elastic fluid turbine, means for establishing a flow of fluid therethrough including in combination, means for expanding the fluid to a high initial velocity, a series of sets of movable vanes, and means located between sets of vanes for reversing and increasing the velocity of the flow of the fluid issuing from the preceding set of vanes, the last three means coacting to leave a substantially high velocity in the fluid as it passes from a set of vanes delivering to the reversing and velocity increasing means.

3. In an elastic fluid turbine, means for establishing a flow of fluid therethrough including in combination, a nozzle for expanding the fluid to a high initial velocity, a series of sets of movable vanes, and a nozzle located between adjacent sets of vanes for expanding the fluid issuing from the preceding set of vanes to approximately initial velocity, the last three means coacting to leave a substantially high velocity in the fluid as it passes from a set of vanes delivering to one of the nozzles.

4. In an elastic fluid turbine, means for establishing a flow of fluid therethrough including in combination, a nozzle for expanding the fluid to a high initial velocity, a series of sets of movable vanes, and a nozzle located between adjacent sets of vanes for reversing and increasing the velocity of the flow of the fluid issuing from the preceding set of vanes to approximately initial velocity, the last three means coacting to leave a substantially high velocity in the fluid as it passes from a set of vanes delivering to one of the nozzles.

5. In an elastic fluid turbine, the combination of a casing, walls dividing the casing into a plurality of chambers, an inlet and an outlet for the casing, a shaft, a series of wheels on the shaft one located in each of the chambers, vanes on the wheels, and nozzles in the walls of the chambers for directing fluid to the vanes, each nozzle expanding the fluid to a high velocity and coacting with the passages between the vanes to leave a substantially high velocity in the fluid as it passes from a set of vanes delivering to one of the nozzles.

6. In an elastic fluid turbine, the combination of a casing, walls dividing the casing into a plurality of chambers, an inlet and an outlet for the casing, a shaft, a series of wheels on the shaft one located in each of the chambers, vanes on the wheels, and nozzles in the walls of the chambers for directing fluid to the vanes, the intermediate nozzles also reversing the flow of the fluid, each nozzle expanding the fluid to a high velocity and coacting with the passages between the vanes to leave a substantially high velocity in the fluid as it passes from a set of vanes delivering to one of the nozzles.

7. In combination with an elastic fluid turbine, means providing a path for the flow of a fluid through the turbine including a stationary nozzle receiving the fluid at a high velocity reversing its flow and expanding it to a substantially higher velocity.

8. In combination with a fluid turbine, means providing a path for the flow of a fluid through the turbine including stationary means receiving the fluid at a high velocity and delivering it at a substantially higher velocity.

9. In a device for converting energy into work, the combination of means for establishing in a fluent medium a portion of the energy in the kinetic form at a high velocity, impulse receivable means to which said fluent medium is directed for abstraction of a portion only of said kinetic energy at high velocities in the form of work of moving said impulse receivable means leaving in said medium kinetic energy at substantially high velocity, and means for augmenting the remanent kinetic energy of said fluent medium by conversion of a further portion of energy to the kinetic form at a high velocity, said fluent medium being again directed to said impulse receivable means for further abstraction of kinetic energy in the form of work.

In testimony whereof I affix my signature in presence of two witnesses.

JOHANN FRIEDRICH MAX PATITZ

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