No. 891,383. PATENTED JUNE 23, 1908.

C. P. STEINMETZ.

ELASTIC FLUID TURBINE.

APPLICATION FILED DEC. 9, 1907.

Fig. 1.

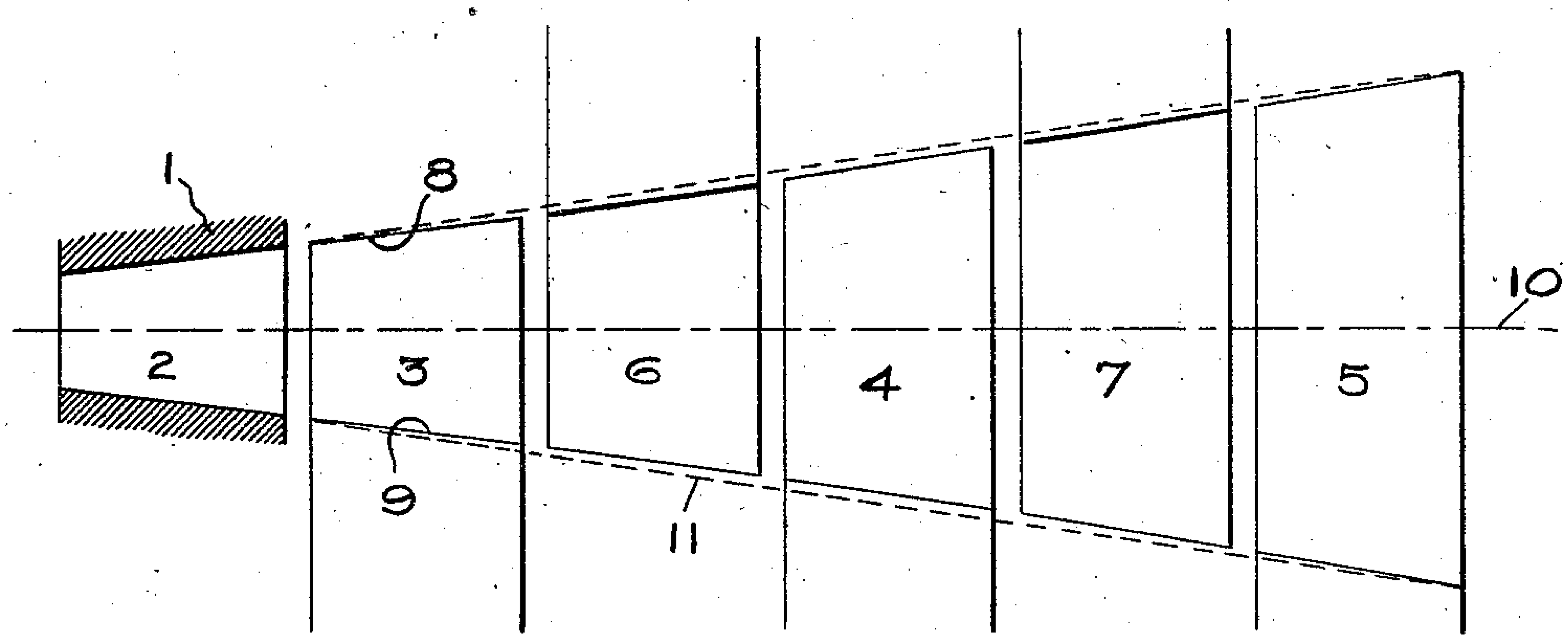
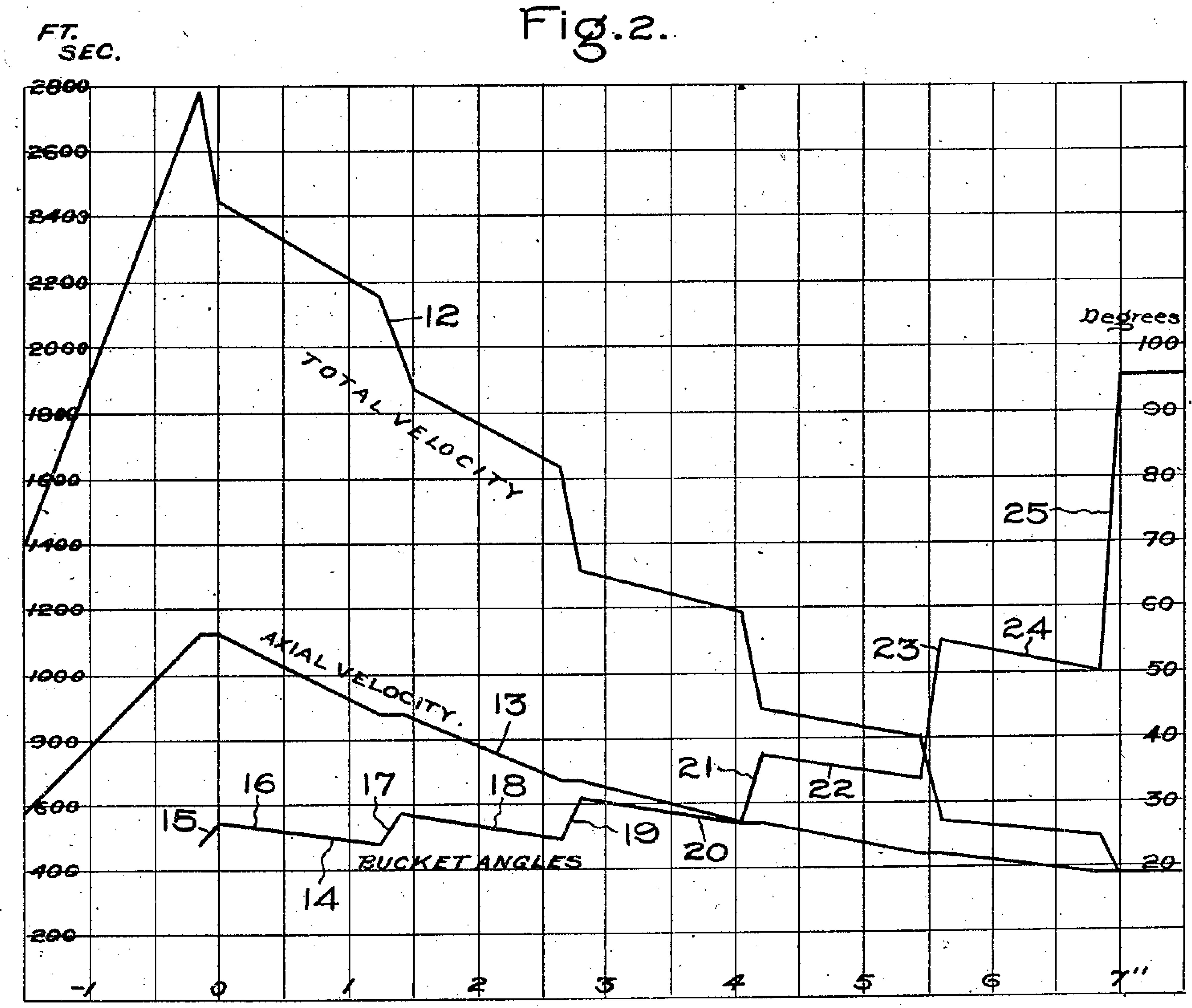


Fig. 2.



Witnesses:

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UNITED STATES PATENT OFFICE.

CHARLES P. STEINMETZ, OF SCHENECTADY, NEW YORK, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

ELASTIC-FLUID TURBINE.

No. 891,383. Specification of Letters Patent. Patented June 23, 1908.

Application filed December 9, 1907. Serial No. 405,705.

To all whom it may concern:

Be it known that I, Charles P. Steinmetz, a citizen of the United States, residing at Schenectady, county of Schenectady, State of New York, have invented certain new and useful Improvements in Elastic-Fluid Turbines, of which the following is a specification.

The present invention relates to elastic-fluid turbines and has for its object to improve their efficiency.

In carrying out my invention, expanding nozzles are employed to give velocity to the steam or other elastic motive fluid and to direct it against the wheel buckets, which abstract the velocity by successive operations. These nozzles comprise a plurality of closely associated passages, so arranged that they have no circumferential enlargement or expansion between the throat and the discharge end. Whatever enlargement or expansion is necessary to provide a passage of suitable area to obtain the desired velocity of the fluid, takes place wholly in a radial direction. By reason of this arrangement the losses incident to the interference of the fluid streams issuing from the several passages and caused by tangential expansion of the jets are avoided as are those arising from variations in the angle of impact of the fluid on the buckets and accompanied by the production of standing waves of velocity and direction of stream flow. Radial expansion of the nozzle walls results in a spreading of the fluid jet after it leaves the nozzle, and this spreading can only be interfered with at the sacrifice of economy.

The steam jet has a tangential velocity due to the nozzle and the pressure behind it, an axial velocity due to the axial movement of the steam particles, and a radial velocity due to the spreading of the jet.

With a nozzle inclined 20° to the plane of the wheel (a usual arrangement), the axial velocity amounts to 34.2 per cent. of the total and this must be utilized to a large degree if the highest economy is to be attained. This I accomplish by reducing its speed by properly increasing the heights of the buckets as will appear hereinafter.

During the passage of steam through the buckets, an interchange takes place between tangential and axial velocities. The radial velocity of the steam, or the radial spread due to the radial expansion of the nozzle is not affected however, providing sufficient space is allowed for the broadening of the jet by increasing the radial height of the buckets.

The axial velocity decreases toward the exhaust while the radial velocity remains constant, hence the increase in radial height should be proportional to the time the steam requires to pass in the axial direction through the wheels. From this, it follows that the buckets' heights should increase from the nozzle toward the exhaust, not uniformly, but first slowly and then more rapidly.

In the accompanying drawing, which illustrates one of the embodiments of my invention, Figure 1 is a view showing a nozzle with the coöperating buckets; and Fig. 2 is a diagram showing the total and axial velocities and also the entrance and exit angles for the buckets.

1 indicates a sectionalized nozzle, each passage 2 of which expands in a radial but not in a circumferential direction.

3, 4 and 5 indicate rows of buckets mounted on a suitable wheel or rotating member, and 6 and 7 indicate partial rows of stationary buckets carried by the turbine casing.

The top and bottom walls 8 and 9 of the buckets and therefore of the working passage or bucket spaces diverge from the nozzle to the exhaust, both above and below the center line 10. These walls, instead of being straight from end to end, follow a curve composed of a series of short straight lines or a continuous curve, as will be readily seen by comparing them with the straight dotted lines 11.

The entrance to each row of buckets should have a cross-sectional area sufficient to receive the motive fluid at the given temperature and pressure. The intermediate and exit areas should be such that the bucket spaces are filled and steam is conveyed through them without choking, the upper and lower walls of the buckets diverging by an amount proportional to the time required for the steam at predetermined axial velocity to pass through the rows of wheel buckets. By following this arrangement the bucket spaces will be completely filled, the axial velocity of the fluid decreased and more effectively utilized, and the increased height of the buckets will permit the radial spread to take place without restriction and at constant radial velocity.

Fig. 2 is a curve wherein the abscissæ represent steam velocity in feet per second and the ordinates distance. 12 indicates the total velocity curve of the steam, which velocity rises from 1400 feet per second at the bowl to 2780 feet per second at the discharge end of the nozzle. From this point the velocity is decreased by successive operations of the buckets to the point of exhaust where the velocity is 380 feet. The curve is arranged directly below Fig. 1 so that by comparison the velocities at intermediate points can be ascertained.

The axial velocity of the steam is represented by the curve 13. In this case the velocity rises in the nozzle from 580 feet per second to 1130 feet per second and thereafter falls as indicated to 380 feet per second at the exhaust from the last wheel.

The curve 14 indicates the proper entrance and exit angles for the buckets. For this purpose the abscissæ on the right-hand side represent degrees. The curve being directly below the buckets, the relation of the various angles can readily be seen. The position of the lower end of line 15 and the points of intersection of the various short lines 15 to 25 of which the curve is composed indicate the nozzle and bucket angles. The angles are determined in the following manner: As the numbers on the right-hand side of the curve indicate degrees, horizontally project the various points to the right. Projecting the end of the line 15, it will be found to pass through 24° which is the nozzle angle. In a similar manner the following will be found:

Entrance angle first row of buckets	27½°
Exit angle first row of buckets	24°
Entrance angle second row of buckets	28½°
Exit angle second row of buckets	24½°
Entrance angle third row of buckets	31°
Exit angle third row of buckets	27°
Entrance angle fourth row of buckets	37½°
Exit angle fourth row of buckets	33½°
Entrance angle fifth row of buckets	55°
Exit angle fifth row of buckets	50°

I have shown my invention in connection with a turbine of the axial-flow impact type, but it is evident that it may be employed in radial-flow turbines as well.

In accordance with the provisions of the patent statutes, I have described the principle of operation of my invention, together with the apparatus which I now consider to represent the best embodiment thereof; but I desire to have it understood that the apparatus shown is only illustrative and that the invention can be carried out by other means.

What I claim as new and desire to secure by Letters Patent of the United States, is,—

1. In an elastic-fluid turbine, the combination of a nozzle with rows of buckets and their spaces which receive and convey the fluid from the nozzle without choking, the height of said buckets and spaces increasing in proportion to the length of time required for the fluid to pass through the buckets.

2. In an elastic-fluid turbine, the combination of a nozzle with rows of buckets and their spaces coöperating with the nozzle, the height of the buckets and spaces increasing from the nozzle to the exhaust, first slowly and then more rapidly, the said increase in height being proportional to the length of time required for the fluid to pass through the buckets.

3. In an elastic-fluid turbine, the combination of a nozzle having radial expansion with buckets coöperating therewith also having radial expansion, the amount of said expansion being proportional to the time required for the motive fluid to pass between the buckets in the direction of flow.

4. In an elastic-fluid turbine, the combination of a nozzle which expands in a radial direction only with rows of wheel and stationary buckets whose spaces form an expanding working passage for the motive fluid issuing from the nozzle, the expansion of said passage taking place in a radial direction and at a rate proportional to the length of time required for the fluid to pass through the buckets.

In witness whereof, I have hereunto set my hand this 7th day of December, 1907.

CHARLES P. STEINMETZ.

Witnesses:

BENJAMIN B. HULL,
HELEN ORFORD.