C. G. CURTIS.

ELASTIC FLUID COMPRESSOR.

APPLICATION FILED AUG. 4, 1896.

**1,086,755.**

Patented Feb. 10, 1914.

3 SHEETS—SHEET 1.

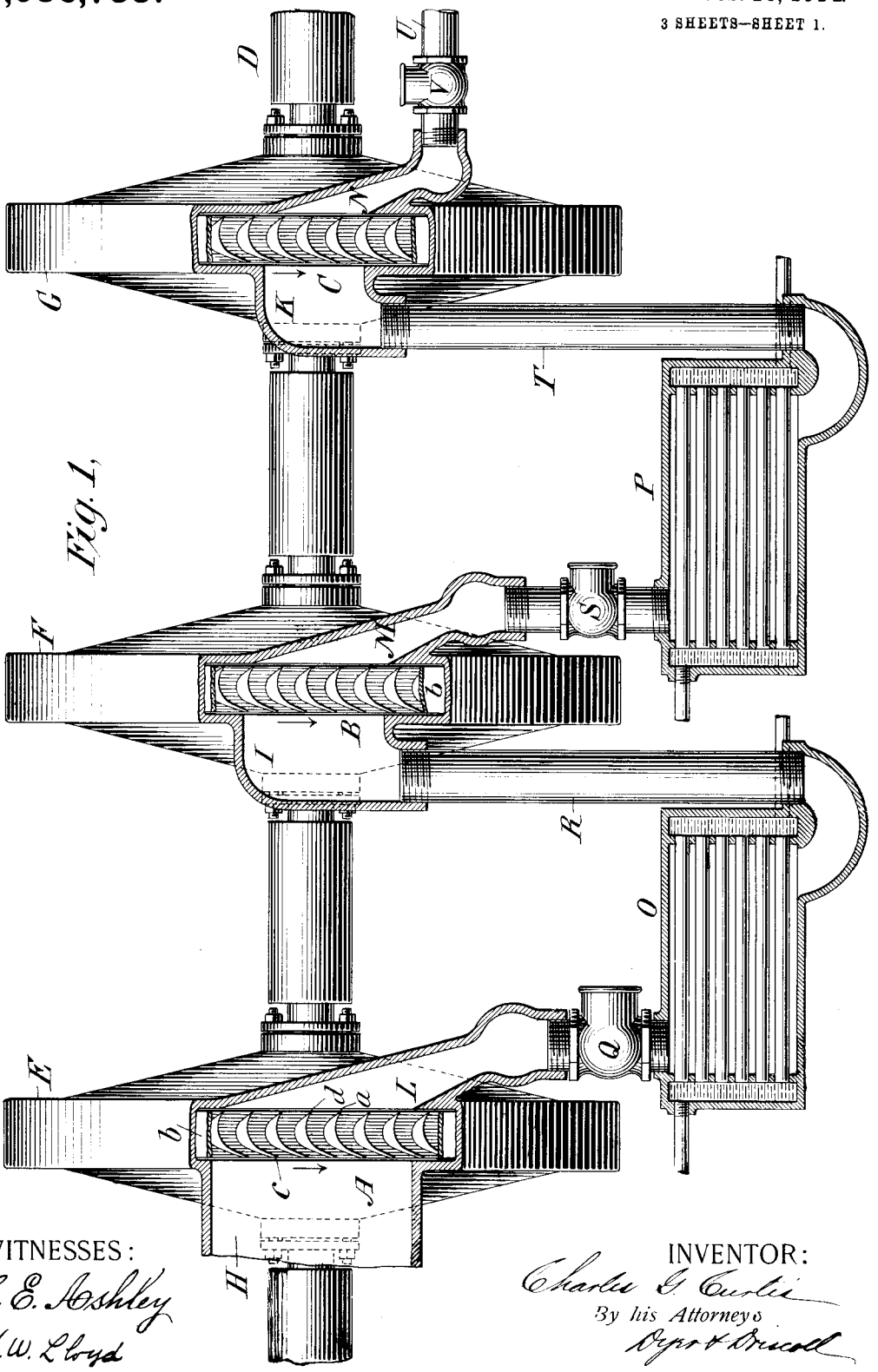



Fig. 1.

WITNESSES:

C. E. Ashley

H. W. Lloyd

INVENTOR:

Charles G. Curtis

By his Attorneys

Dyer & Driscoll

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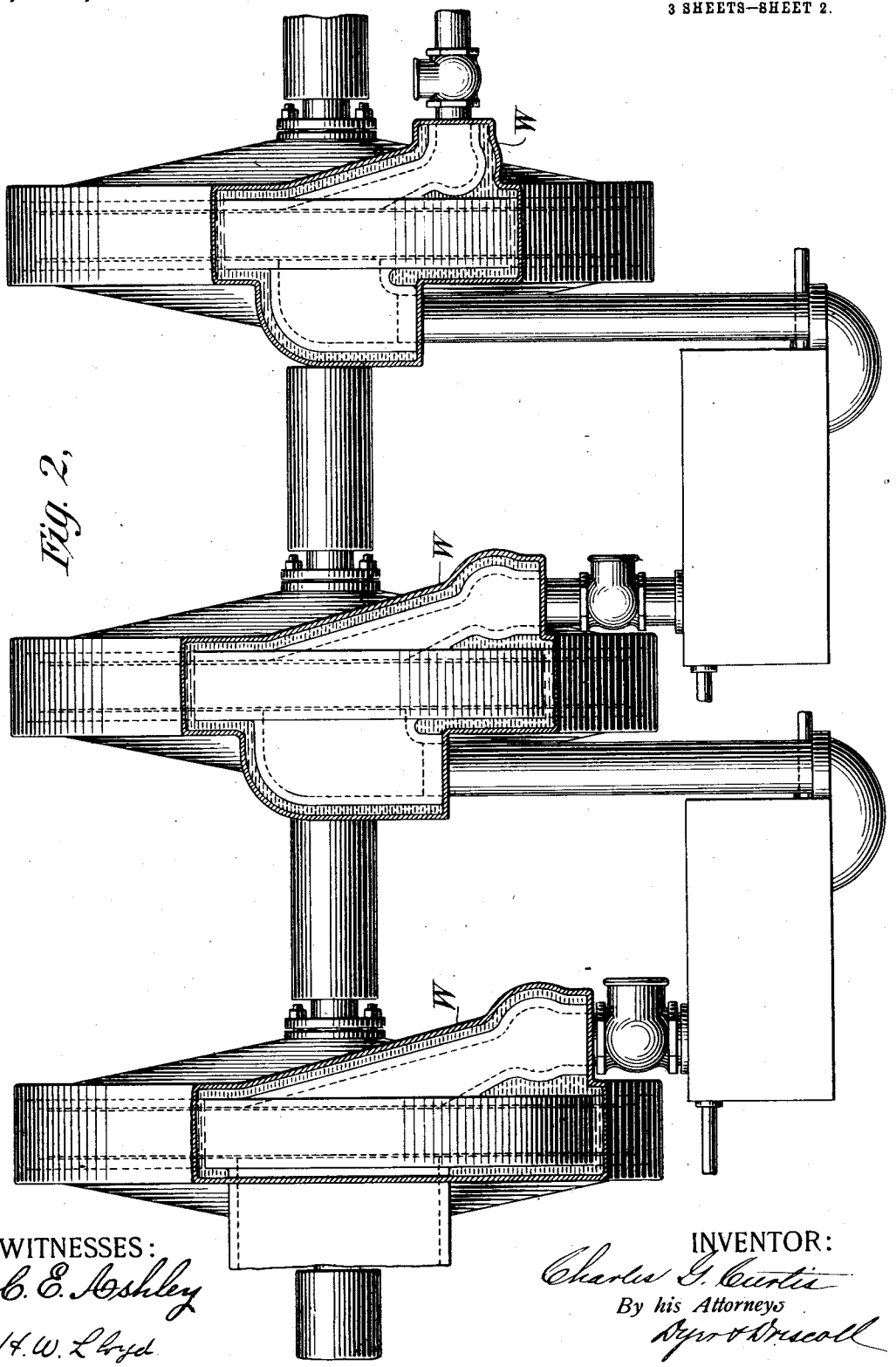



Fig. 2.

WITNESSES:

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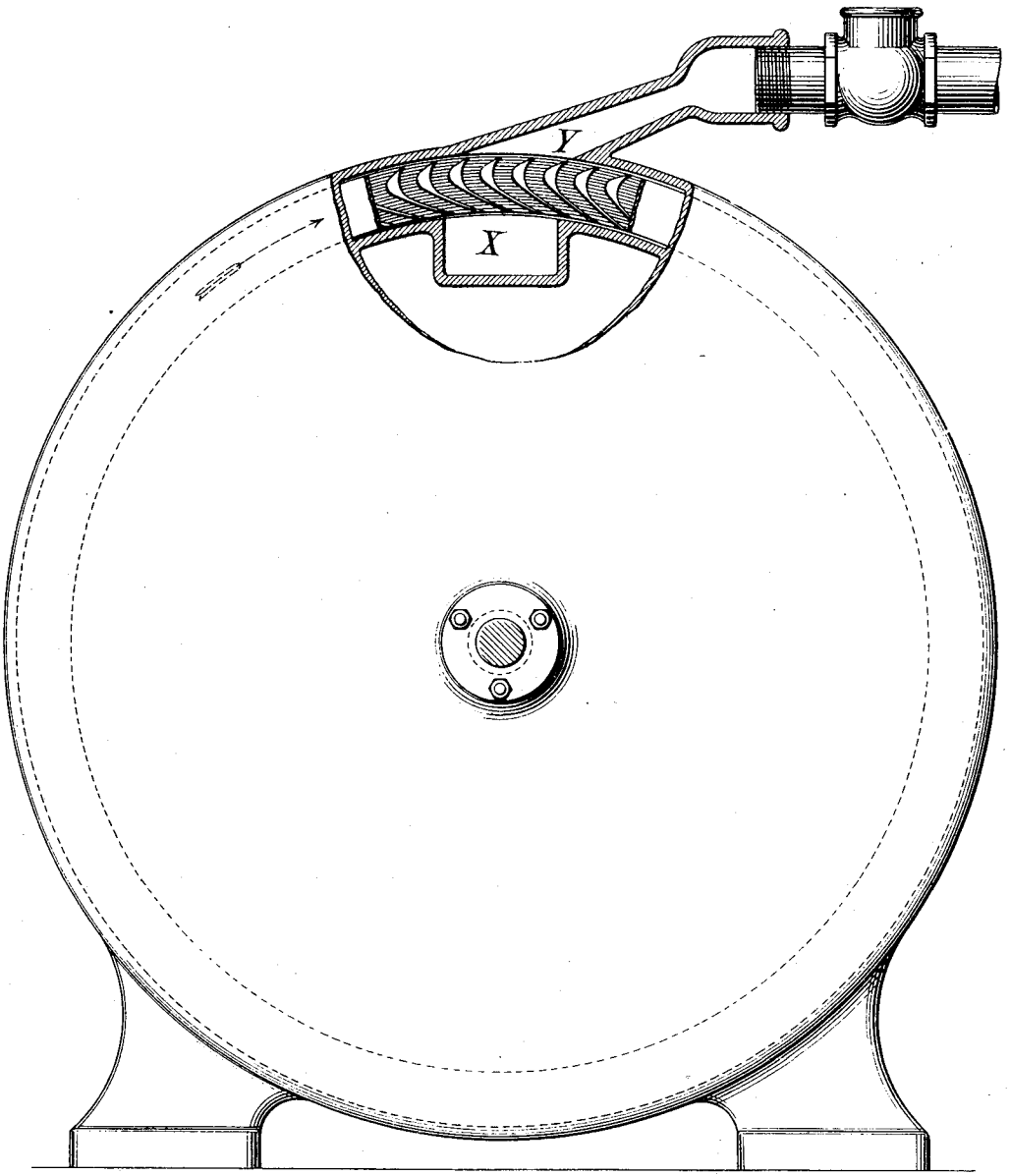
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3 SHEETS—SHEET 3.

*Fig. 3,*




WITNESSES:

C. E. Ashley

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# UNITED STATES PATENT OFFICE.

CHARLES G. CURTIS, OF NEW YORK, N. Y., ASSIGNOR, BY MESNE ASSIGNMENTS, TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

## ELASTIC-FLUID COMPRESSOR.

1,086,755. Specification of Letters Patent. Patented Feb. 10, 1914.

Application filed August 4, 1896. Serial No. 601,606.

*To all whom it may concern:*

Be it known that I, CHARLES G. CURTIS, a citizen of the United States, residing at New York city, in the county and State of New York, have invented a certain new and useful Improvement in Elastic-Fluid Compressors, of which the following is a specification.

The object I have in view is to produce a method and apparatus for compressing air or other elastic fluid with a less expenditure of power and with a very much simpler and less costly form of apparatus than have heretofore been required. I have found that, when velocity is imparted to air or other elastic fluid, the velocity may be converted into pressure by passing the fluid through a passage with gradually converging or tapering walls; and that when such passage is properly proportioned, it will convert the velocity wholly or largely into pressure without impeding the flow of the fluid beyond that resulting from friction on the walls of the passage. I have also found that a rotating wheel having a series of unsymmetrically curved buckets or vanes similar to those of some forms of turbine, is a highly efficient means for imparting velocity to an elastic fluid, the fluid being drawn in on one side of the wheel and discharged on the other side at a speed greater than that of the buckets.

The apparatus employed by me for carrying out my invention is in fact, a reversed elastic fluid turbine, having an expansion nozzle and provided with unsymmetrically curved buckets or vanes such as is described in applications for patent already filed by me (Serial No. 574,031, filed January 2, 1896 Patent No. 566,967, granted September 1, 1896 and Serial No. 575,679, filed January 16, 1896 Patent No. 566,969, granted September 1, 1896.)

The turbine is revolved by a suitable power connection in the opposite direction to that in which it rotates as a means for developing mechanical power, the air or other elastic fluid being drawn into the exhaust opening of the turbine and being expelled through the expansion nozzle which now becomes a device for converting velocity into pressure, instead of one for converting pressure into velocity. I prefer to employ two or more such fluid compressors connected in series or succession, and having progressively smaller fluid passages, to accommodate the reduced volume of the fluid as its pressure is increased, and between the different compressors I prefer to locate coolers for reducing the temperature of the fluid and lessening the power required to produce further compression. In this way the compression is produced by stages in two or more compressors, each comprising a wheel with unsymmetrically curved buckets for imparting velocity to the fluid, and discharging converging passages for converting that velocity into pressure. Each of these fluid compressors is contained in a separate fluid-tight shell so as to diminish the leakage at the clearances. The wheels of the several compressors are preferably located upon the same shaft, although they may be located upon different shafts. To further reduce the power required to effect the compression, the shells and passages may be water-jacketed. The rotating wheels may have their curved buckets arranged so as to carry the fluid from one side to the other of the wheel at its periphery, or these buckets may be arranged so as to discharge outwardly or inwardly with reference to the periphery of the wheel. Check valves may be located between the different elements of the compressor to prevent any backward flow of the fluid should the rotation of the compressor cease.

In the accompanying drawings, forming a part hereof, Figure 1 is a view partly in elevation and partly in section, of my elastic fluid compressor, composed of three elements. Fig. 2 is a view of the same apparatus illustrating the water-jacket upon the shells and passages: and Fig. 3 is an end elevation and partial section showing a single compressor having its buckets arranged to proluce an outward flow of the fluid.

Referring particularly to Figs. 1 and 2; A, B and C are rotating wheels mounted upon a shaft D, having a suitable power connection. These wheels are provided on their periphery with complete circular ranges of curved vanes *a*, which are held between the periphery of the wheel and a ring or band *b*, which surrounds them. These buckets or vanes I make unsymmetri

cal in form, that is to say, their receiving ends *c*, are placed at a lesser or sharper angle than their discharging ends, *d*. The wheels, A, B and C are located in separate shells or casings, E, F and G, which are packed about the shaft so as to be fluid-tight. Entering these shells are inlet passages, H, I, K, and opposite these inlet passages, are converging discharging passages, L, M, N, set at the proper positions, the vanes of the wheels occupying the space between these passages. The contracting passage and the shape and speed of the buckets and the angles of entrance and leaving must, of course, be adapted in each case to the work to be done: In other words, they must be such as would, if the machine were a turbine developing power, convert the given pressure into velocity and then extract practically all the velocity and deliver the fluid practically in a state of rest at the discharge side of the buckets. If the conditions are properly fulfilled in this way, the operation of the buckets in compressing, will be precisely the reverse of what takes place in expanding—that is, the buckets will take the air at the initial pressure in a state of rest and impart to it a high velocity, delivering it to the contracting or compressing passage—the column of air on the receiving side being drawn in by the slight vacuum created there by the unsymmetrical shape of the buckets. In this way, the column of air is drawn into the buckets at a very low velocity, and in traversing the curved passages, its velocity is continually augmented until finally it is delivered from the other side of the buckets at a velocity which may be actually greater than that of the buckets themselves.

It is to be observed, that the column or jet of air enters the buckets only at a segmental portion where there is a free opening or passage, the walls of the case or shell in which the wheel revolves being set as closely as practicable to the edges of the buckets in order to prevent the drawing in of air at the other points of the circumference, and the loss by circulation from one side of the wheel to the other that would result therefrom.

Coolers O and P are located at the intermediate points between the elements of the compressor, being connected by check valves Q, S and pipes R, T respectively, between the converging discharging passage L and inlet I and between the converging discharging passage M and inlet K. The converging discharging passages L, M, N, discharge as shown into conduits of materially larger cross-section than the smaller ends or throats of such passages. These conduits which extend through the coolers O, P, and pipes R, T, to the inlets B, C, and through the pipe U, to the final receiving chamber, act as reservoirs, and the rate of flow of the compressed air in them is little or nothing compared with the velocity of flow through the converging discharging passages. As the column of air approaches the throats of the converging discharging passages its pressure continually increases and its velocity diminishes; but at these points it still has a very considerable velocity which is converted into pressure in entering the larger conduits in which the pressure is higher than in the throats of the discharging passages. The pressure in each case at the throat of the converging discharging passage will be approximately fifty-three per cent. of the total rise in pressure in this stage of the operation, and the cross-section of the throat must be of the proper area to convey the given quantity of air at the pressure and velocity existing at this point. The pressure existing at any point of the passage-way will be the equivalent in energy of the *vis viva* that has been consumed in developing such pressure less incidental losses by friction, etc. The elastic fluid under compression is finally discharged from the pipe U provided with check valve V.

The shaft D being rotated by power in the direction shown by the arrows, air or other elastic fluid is drawn in at the inlet H by reason of the fact that the unsymmetrical form of the curved buckets of the wheel A causes those buckets to draw the air inwardly at their ends *c*, which have a sharp angle, with a greater effect than at their ends *d*, which have a flat angle. The fluid is discharged from the ends *d* of the buckets of the wheel A, with a velocity greater than that of the wheel, and enters the gradually tapering or converging passage L, which converts the velocity into pressure.

The amount of convergence or ratio of contraction that takes place in the discharging passage will depend upon the velocity with which the fluid is delivered to that passage by the wheel, or in other words the amount of velocity which it is desired to convert into pressure—the conditions here being exactly the reverse of those of an expansion apparatus or turbine as explained in the applications filed by me hereinbefore referred to. In other words, this ratio of contraction, or the ratio between the larger and smaller ends of the converging discharging passage will depend upon the respective pressures before and after compression at each stage of the operation. In any case, the convergence of the discharging passage will be such that its successive cross-sections will be diminished in area in the direction of the flow of the fluid to such a degree that the *vis viva* or energy contained in the fluid in the form of velocity will be con-

verted into a substantial equivalent in the form of pressure by compression of the fluid in the converging passage.

The apparatus operates against the back pressure contained in the receiving chamber into which it discharges, and the pressure in that chamber is greater than that which exists in the fluid at the vanes of any one of the velocity-producing wheels.

From the passage L the fluid passes through the check valve Q, the cooler O, and pipe R, into the inlet I of the second wheel B, where the operation is repeated, the discharging passage being made as much smaller than the similar part of the preceding wheel as the volume of the fluid jet is smaller by reason of its greater pressure. The converging or gradually tapering discharging passage M converts the velocity produced by the wheel B into pressure, and thence the fluid passes through the check valve S, cooler P and pipe T into the inlet opening K of the third wheel C, from whence it is drawn through the buckets of the third wheel, being given an additional velocity which is converted into pressure by the gradually converging discharging passage N.

To further reduce the power required to compress the elastic fluid, a water-jacket W (Fig. 2) may be employed, through which water-jacket a circulation of water may be maintained.

In Fig. 3 a single compressor element is shown, having its rotating buckets arranged to produce an outward flow of the fluid, X being the inlet opening, and Y the converging discharging passage. In this construction the centrifugal force imparted to the fluid by the rotation of the wheel is also employed in producing the discharge of the fluid from the buckets and in increasing its velocity.

What I claim is:—

1. In an elastic fluid compressor, the combination of a velocity producing wheel, and means for converting the velocity into pressure, such means comprising a passage which receives the fluid from the wheel, and having tapered walls so as to produce a gradually diminishing cross sectional area, the amount of taper being such that the *vis viva* of the fluid will be converted into a substantially equivalent pressure, and an enlarged passage connected with the posterior portion of the contracted passage, such enlarged passage being enlarged into a pressure chamber, in which the remaining velocity will be substantially converted into pressure.

2. In an elastic fluid compressor, the combination of a velocity producing wheel and means for converting the velocity into pressure, such means comprising a passage which receives the fluid from the wheel and having tapered walls so as to produce a gradually diminishing cross-sectional area, the amount of taper being such that the *vis viva* of the fluid will be converted into a substantially equivalent pressure.

3. In an elastic fluid compressor, the combination of a velocity producing wheel having unsymmetrical buckets, and means for converting the velocity into pressure, such means comprising a passage which receives the fluid from the wheel, and having tapered walls so as to produce a gradually diminishing cross sectional area, the amount of taper being such that the *vis viva* of the fluid will be converted into a substantially equivalent pressure, and an enlarged passage connected with the posterior portion of the contracted passage, such enlarged passage being enlarged into a pressure chamber, in which the remaining velocity will be substantially converted into pressure.

4. In an elastic fluid compressor, the combination of a velocity producing wheel having unsymmetrical buckets and means for converting the velocity into pressure, such means comprising a passage which receives the fluid from the wheel, and having tapered walls so as to produce a gradually diminishing cross-sectional area, the amount of taper being such that the *vis viva* of the fluid will be converted into substantially equivalent pressure.

5. The combination with a velocity-producing wheel, discharging fluid at a forward angle, of a pressure producing passage having contracting walls receiving the fluid from the wheel and set at a forward angle corresponding with the angle of discharge of the fluid from the wheel, substantially as set forth.

6. In an elastic fluid compressor, the combination of a velocity producing wheel, the wheel discharging at a forward angle, and means for converting the velocity into pressure, such means comprising a passage which receives the fluid from the wheel, the passage being set at a forward angle corresponding with the angle of discharge of the fluid from the wheel, and having tapered walls so as to produce a gradually diminishing cross sectional area, the amount of taper being such that the *vis viva* of the fluid will be converted into a substantially equivalent pressure, and an enlarged passage connected with the posterior portion of the contracted passage, such enlarged passage being enlarged into a pressure chamber, in which the remaining velocity will be substantially converted into pressure.

7. In an elastic fluid compressor, the combination of a velocity producing wheel, the wheel discharging at a forward angle, and means for converting the velocity into pressure, such means comprising a passage which receives the fluid from the wheel, the

passage being set at a forward angle corresponding with the angle of discharge of the fluid from the wheel, such passage being enlarged into a pressure chamber, in which the velocity will be substantially converted into pressure.

8. In an elastic fluid compressor, the combination of a velocity producing wheel having unsymmetrical buckets, the wheel discharging at a forward angle, and means for converting the velocity into pressure, such means comprising a passage which receives the fluid from the wheel, the passage being set at a forward angle corresponding with the angle of discharge of the fluid from the wheel, and having tapered walls so as to produce a gradually diminishing cross sectional area, the amount of taper being such that the *vis viva* of the fluid will be converted into a substantially equivalent pressure, and an enlarged passage connected with the posterior portion of the contracted passage, such enlarged passage being enlarged into a pressure chamber, in which the remaining velocity will be substantially converted into pressure.

9. In an elastic fluid compressor, the combination of a velocity producing wheel, having unsymmetrical buckets, the wheel discharging at a forward angle, and means for converting the velocity into pressure, such means comprising a passage which receives the fluid from the wheel, the passage being set at a forward angle corresponding with the angle of discharge of the fluid from the wheel, such passage being enlarged into a pressure chamber, in which the velocity will be substantially converted into pressure.

10. In an elastic fluid compressor, the combination of two or more velocity producing wheels and converging pressure producing passages located in series or succession, the said passages being of successively diminished cross-section to carry the fluid at decreased volume and increased densities.

11. In an elastic fluid compressor, the combination of two or more velocity producing wheels, such wheels being connected together in series or succession, and means between the wheels for converting the velocity into pressure, such means comprising passages which receive the fluid from the wheels, the passages being of successively diminished cross section to carry the fluid at decreased volume and increased densities each of such passages having tapered walls so as to produce a gradually diminishing cross sectional area, the amount of taper being such that the *vis viva* of the fluid will be converted into a substantially equivalent pressure, and an enlarged passage connected with the posterior portion of the contracted passage, such enlarged passage being enlarged into a pressure chamber, in which the remaining velocity will be substantially converted into pressure.

12. In an elastic fluid compressor, the combination of two or more velocity producing wheels, such wheels being connected together in series or succession, and means between the wheels for converting the velocity into pressure such means comprising passages which receive the fluid from the wheels, the passages being of successively diminished cross section to carry the fluid at decreased volume and increased densities, each of such passages being enlarged into a pressure chamber in which the velocity will be substantially converted into pressure.

13. In an elastic fluid compressor, the combination of two or more velocity producing wheels and converging pressure producing passages located in series or succession the said passages being of successively diminished cross-section to carry the fluid at decreased volume and increased densities, with one or more coolers connected between the two or more elements of the compressor.

14. In an elastic fluid compressor, the combination of two or more velocity producing wheels, such wheels being connected together in series or succession, and means between the wheels for converting the velocity into pressure, such means comprising passages which receive the fluid from the wheels, the passages being of successively diminished cross section to carry the fluid at decreased volume and increased densities, each of such passages having tapered walls so as to produce a gradually diminishing cross sectional area the amount of taper being such that the *vis viva* of the fluid will be converted into a substantially equivalent pressure, and an enlarged passage connected with the posterior portion of the contracted passage, such enlarged passage being enlarged into a pressure chamber, in which the remaining velocity will be substantially converted into pressure, and with coolers between the two or more elements of the compressor.

15. In an elastic fluid compressor, the combination of two or more velocity producing wheels, such wheels being connected together in series or succession, and means between the wheels for converting the velocity into pressure, such means comprising passages which receive the fluid from the wheels, the passages being of successively diminished cross section to carry the fluid at decreased volume and increased densities, each of such passages being enlarged into a pressure chamber in which the velocity will be substantially converted into pressure, and with coolers between the two or more elements of the compressor.

16. In an elastic fluid compressor, the combination of two or more velocity produc-

ing wheels, such wheels being connected together in series or succession, and means between the wheels for converting the velocity into pressure, such means comprising passages which receive the fluid from the wheels, the passages being of successively diminished cross section to carry the fluid at decreased volume and increased densities, each of such passages having tapered walls so as to produce a gradually diminishing cross sectional area, the amount of taper being such that the *vis viva* of the fluid will be converted into a substantially equivalent pressure, and an enlarged passage connected with the posterior portion of the contracted passage, such enlarged passage being enlarged into a pressure chamber, in which the remaining velocity will be substantially converted into pressure, and check valves for preventing backward flow of the fluid.

17. In an elastic fluid compressor, the combination of two or more velocity producing wheels, such wheels being connected together in series or succession, and means between the wheels for converting the velocity into pressure, such means comprising passages which receive the fluid from the wheels, the passages being of successively diminished cross section to carry the fluid at decreased volume and increased densities, each of such passages being enlarged into a pressure chamber, in which the velocity will be substantially converted into pressure, and check valves for preventing backward flow of the fluid.

18. The combination with two or more velocity producing wheels and converging pressure-producing passages, located in series or succession, with one or more coolers connected between the two or more elements of the compressor, and check valves for preventing the backward flow of the fluid.

19. In an elastic fluid compressor, the combination of two or more velocity producing wheels, such wheels being connected together in series or succession, and means between the wheels for converting the velocity into pressure, such means comprising passages which receive the fluid from the wheels, the passages being of successively diminished cross section to carry the fluid at decreased volume and increased densities, each of such passages having tapered walls so as to produce a gradually diminishing cross sectional area the amount of taper being such that the *vis viva* of the fluid will be converted into a substantially equivalent pressure, and an enlarged passage connected with the posterior portion of the contracted passage, such enlarged passage being enlarged into a pressure chamber, in which the remaining velocity will be substantially converted into pressure, and with coolers between the two or more elements of the compressor, and check valves for preventing backward flow of the fluid.

20. In an elastic fluid compressor, the combination of two or more velocity producing wheels, such wheels being connected together in series or succession, and means between the wheels for converting the velocity into pressure, such means comprising passages which receive the fluid from the wheels, the passages being of successively diminished cross section to carry the fluid at decreased volume and increased densities, each of such passages being enlarged into a pressure chamber in which the velocity will be substantially converted into pressure, and with coolers between the two or more elements of the compressor, and check valves for preventing backward flow of the fluid.

21. In an elastic fluid compressor, the combination of two or more velocity producing wheels and two or more separate fluid-tight shells, in which such wheels are located, such wheels and shells being connected together in series or succession, with converging passages receiving the discharge from such wheels and converting velocity into pressure, each said passage enlarging upon a curved line, the enlargement being such that the velocity will be substantially converted into pressure, substantially as set forth.

22. In an elastic fluid compressor, the combination of two or more velocity producing wheels, such wheels being connected together in series or succession, two or more separate fluid tight shells in which said wheels are located, and means between the wheels for converting the velocity into pressure, such means comprising passages which receive the fluid from the wheels, the passages being of successively diminished cross section to carry the fluid at decreased volume and increased densities, each of such passages having tapered walls so as to produce a gradually diminishing cross sectional area, the amount of taper being such that the *vis viva* of the fluid will be converted into a substantially equivalent pressure, and an enlarged passage connected with the posterior portion of the contracted passage, such enlarged passage being enlarged into a pressure chamber, in which the remaining velocity will be substantially converted into pressure.

23. In an elastic fluid compressor, the combination of two or more velocity producing wheels, such wheels being connected together in series or succession, two or more separate fluid tight shells in which said wheels are located, and means between the wheels for converting the velocity into pressure, such means comprising passages which receive the fluid from the wheels, the passages being of successively diminished cross

section to carry the fluid at decreased volume and increased densities, each of such passages being enlarged into a pressure chamber, in which the velocity will be substantially converted into pressure.

24. In an elastic fluid compressor, the combination with two or more velocity producing wheels located in separate fluid-tight shells, and two or more converging discharging passages converting velocity into pressure, each said passage enlarging upon a curved line, the enlargement being such that the velocity will be substantially converted into pressure, of a water-jacket surrounding the shells and passages, substantially as set forth.

25. In an elastic fluid compressor, the combination of two or more velocity producing wheels, such wheels being connected together in series or succession, two or more separate fluid tight shells in which said wheels are located, and means between the wheels for converting the velocity into pressure, such means comprising passages which receive the fluid from the wheels, the passages being of successively diminished cross section to carry the fluid at decreased volume and increased densities, each of such passages having tapered walls so as to produce a gradually diminishing cross sectional area, the amount of taper being such that the *vis viva* of the fluid will be converted into a substantially equivalent pressure, and an enlarged passage connected with the posterior portion of the contracted passage, such enlarged passage being enlarged into a pressure chamber, in which the remaining velocity will be substantially converted into pressure, and a water jacket surrounding the shells and passages.

26. In an elastic fluid compressor, the combination of two or more velocity producing wheels, such wheels being connected together in series or succession, two or more separate fluid tight shells in which said wheels are located, and means between the wheels for converting the velocity into pressure, such means comprising passages which receive the fluid from the wheels, the passages being of successively diminished cross section to carry the fluid at decreased volume and increased densities, each of such passages being enlarged into a pressure chamber, in which the velocity will be substantially converted into pressure, and a water jacket surrounding the shells and passages.

27. The combination with two or more velocity producing wheels connected in succession, of means for converting velocity into pressure following each wheel consisting of a passage which receives the fluid from the wheel, such passage being gradually enlarged into a pressure chamber in which the pressure produced is maintained, and a passage connecting each pressure producing means except after the last wheel with the inlet of the next succeeding velocity producing wheel which conveys the fluid without material reduction in its pressure, substantially as set forth.

28. An elastic fluid compressor, having a velocity producing wheel which discharges into a means for converting velocity into pressure, the said means consisting of a reversed expansion nozzle.

29. An elastic fluid compressor having a velocity producing wheel which discharges into a means for converting velocity into pressure, the said means consisting of a passage with converging and diverging walls, the amount of convergence being such that the pressure at the throat of the passage is approximately 53 per cent (for air) of the total rise in pressure by the traverse of the fluid through the passage, the cross-section of the throat being of the proper area to convey a given quantity of fluid at the pressure and velocity existing at this point.

30. In an elastic fluid compressor, the combination with a rotary impeller with outward flow, having curved radiating buckets which produce velocity by centrifugal action as well as by the configuration of the buckets, of a means for converting velocity into pressure into which said impeller discharges, the said means consisting of a reversed expansion nozzle.

31. In an elastic fluid compressor, the combination with a rotary impeller with outward flow, having unsymmetrical curved buckets, the receiving ends of which are placed at a sharper angle than their discharge ends, which produce velocity by centrifugal action as well as by the configuration of the buckets, of a means for converting velocity into pressure, into which said impeller discharges, the said means consisting of a reversed expansion nozzle.

32. In an elastic fluid compressor, the combination with a rotary impeller with outward flow, having curved buckets which discharge at a forward angle, thereby producing velocity by centrifugal action, of a means for converting velocity into pressure, into which said impeller discharges, the said means consisting of a reversed expansion nozzle.

33. In an elastic fluid compressor, the combination with a rotary impeller with outward flow, having curved radiating buckets which produce velocity by centrifugal action as well as by the configuration of the buckets, of a nozzle adapted to receive fluid from the impeller which has inclined walls, producing a change of area in the direction of flow and has such position and dimensions that it will guide the fluid in its passage from the impeller in substantially the direction of the movement imparted to

it by the impeller, the rate of change of area being so proportioned to the movement and elasticity of the fluid that a considerable portion or all of the velocity of the fluid will be converted into pressure during its passage through the nozzle.

34. In an elastic fluid compressor, the combination with a rotary impeller with outward flow, and having unsymmetrical curved buckets, the receiving ends of which are placed at a sharper angle than their discharge ends, which produce velocity by centrifugal action as well as by the configuration of the buckets, of a nozzle adapted to receive fluid from the impeller which has inclined walls, producing a change of area in the direction of flow and has such position and dimensions that it will guide the fluid in its passage from the impeller in substantially the direction of the movement imparted to it by the impeller, the rate of change of area being so proportioned to the movement and elasticity of the fluid that a considerable portion or all of the velocity of the fluid will be converted into pressure during its passage through the nozzle.

35. In an elastic fluid compressor, the combination with a rotary impeller with outward flow and having curved buckets which discharge at a forward angle, thereby producing velocity by centrifugal action, of a nozzle adapted to receive fluid from the impeller which has inclined walls, producing a change of area in the direction of flow and has such position and dimensions that it will guide the fluid in its passage from the impeller in substantially the direction of the movement imparted to it by the impeller, the rate of change or area being so proportioned to the movement and elasticity of the fluid that a considerable portion of all of the velocity of the fluid will be converted into pressure during its passage through the nozzle.

36. In an elastic fluid compressor, the combination with a rotary impeller with outward flow, of a means for converting velocity into pressure, into which said impeller discharges, the said means consisting of a reversed expansion nozzle.

37. In an elastic fluid compressor, the combination with a rotary impeller with outward flow, of a nozzle adapted to receive fluid from the impeller which has inclined walls, producing a change of area in the direction of flow and has such position and dimensions that it will guide the fluid in its passage from the impeller in substantially the direction of the movement imparted to it by the impeller, the rate of change of area being so proportioned to the movement and elasticity of the fluid that a considerable portion or all of the velocity of the fluid will be converted into pressure during its passage through the nozzle.

38. In an elastic fluid compressor, the combination with a velocity producing wheel, of a nozzle adapted to receive fluid from the wheel which has inclined walls, producing a change of area in the direction of flow and has such position and dimensions that it will guide the fluid in its passage from the wheel in substantially the direction of the movement imparted to it by the wheel, the rate of change of area being so proportioned to the movement and elasticity of the fluid that a considerable portion or all of the velocity of the fluid will be converted into pressure during its passage through the nozzle.

39. In an elastic fluid compressor, the combination with means for producing velocity, of a means for converting velocity into pressure into which said velocity producing means discharges, the said velocity converting means consisting of a reversed expansion nozzle.

40. In an elastic fluid compressor, the combination with means for producing velocity, of a nozzle adapted to receive fluid from the velocity producing means, which has inclined walls, producing a change of area in the direction of flow and has such position and dimensions that it will guide the fluid in its passage from the velocity producing means in substantially the direction of the movement imparted to it by the said means, the rate of change of area being so proportioned to the movement and elasticity of the fluid that a considerable portion or all of the velocity of the fluid will be converted into pressure during its passage through the nozzle.

This specification signed and witnessed this 30th day of July 1896.

CHARLES G. CURTIS.

Witnesses:
EUGENE CONRAN,
JNO. R. TAYLOR.

**Copies of this patent may be obtained for five cents each, by addressing the "Commissioner of Patents, Washington, D. C."**