No. 808,709. PATENTED JAN. 2, 1906.

E. J. WOOD.

TURBINE ENGINE.

APPLICATION FILED JAN. 25, 1905.

2 SHEETS—SHEET 1.

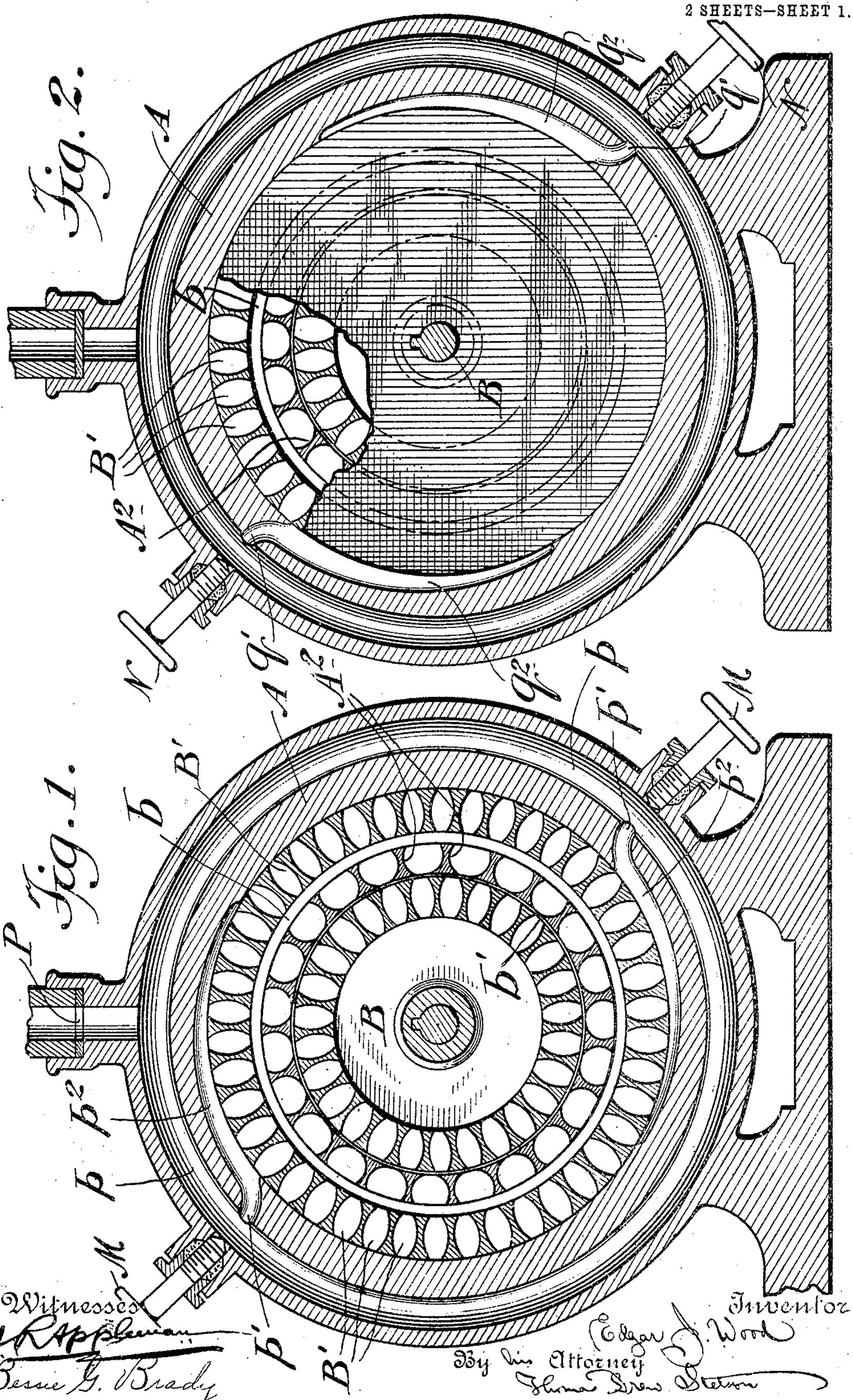

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Fig. 5.

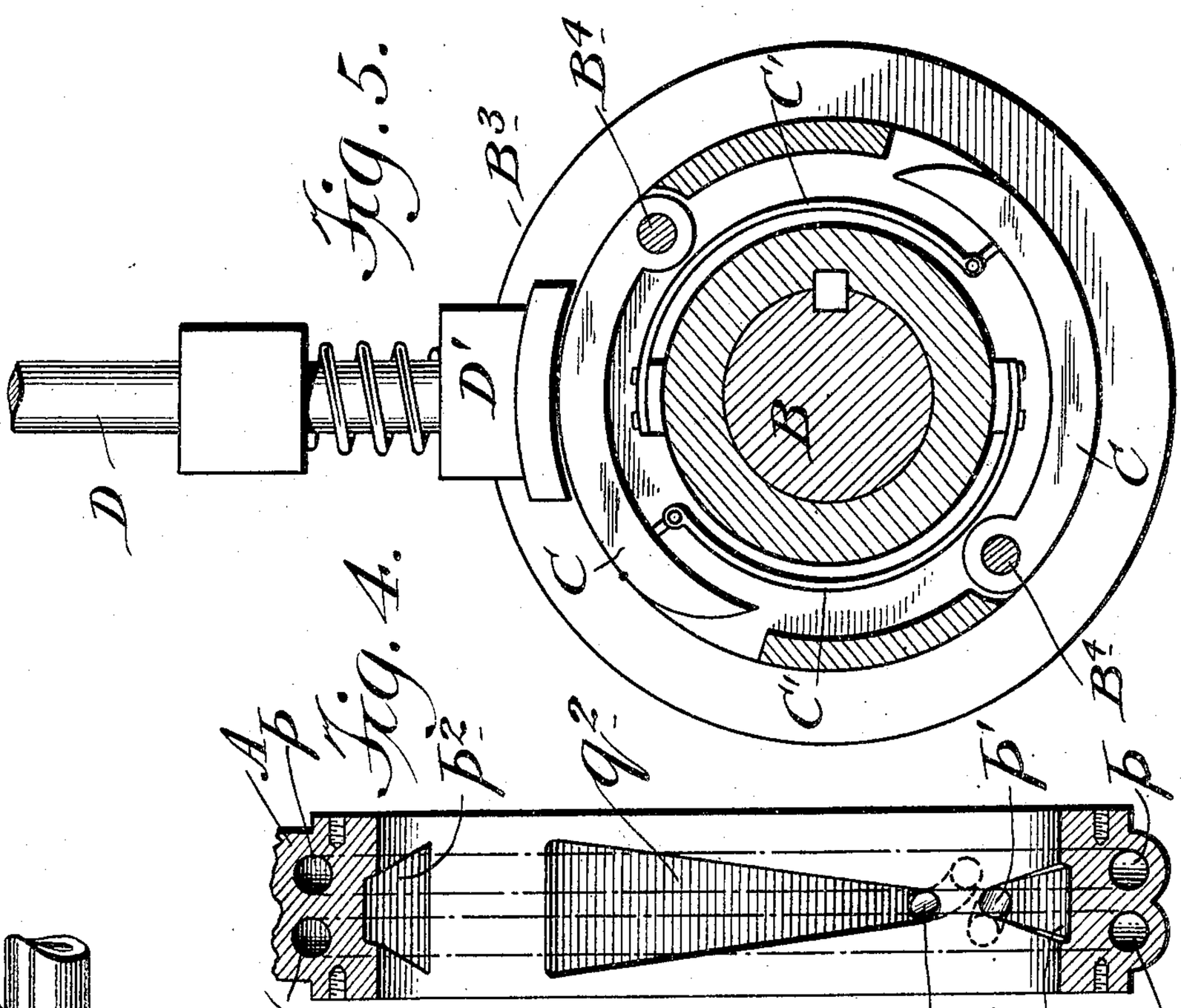
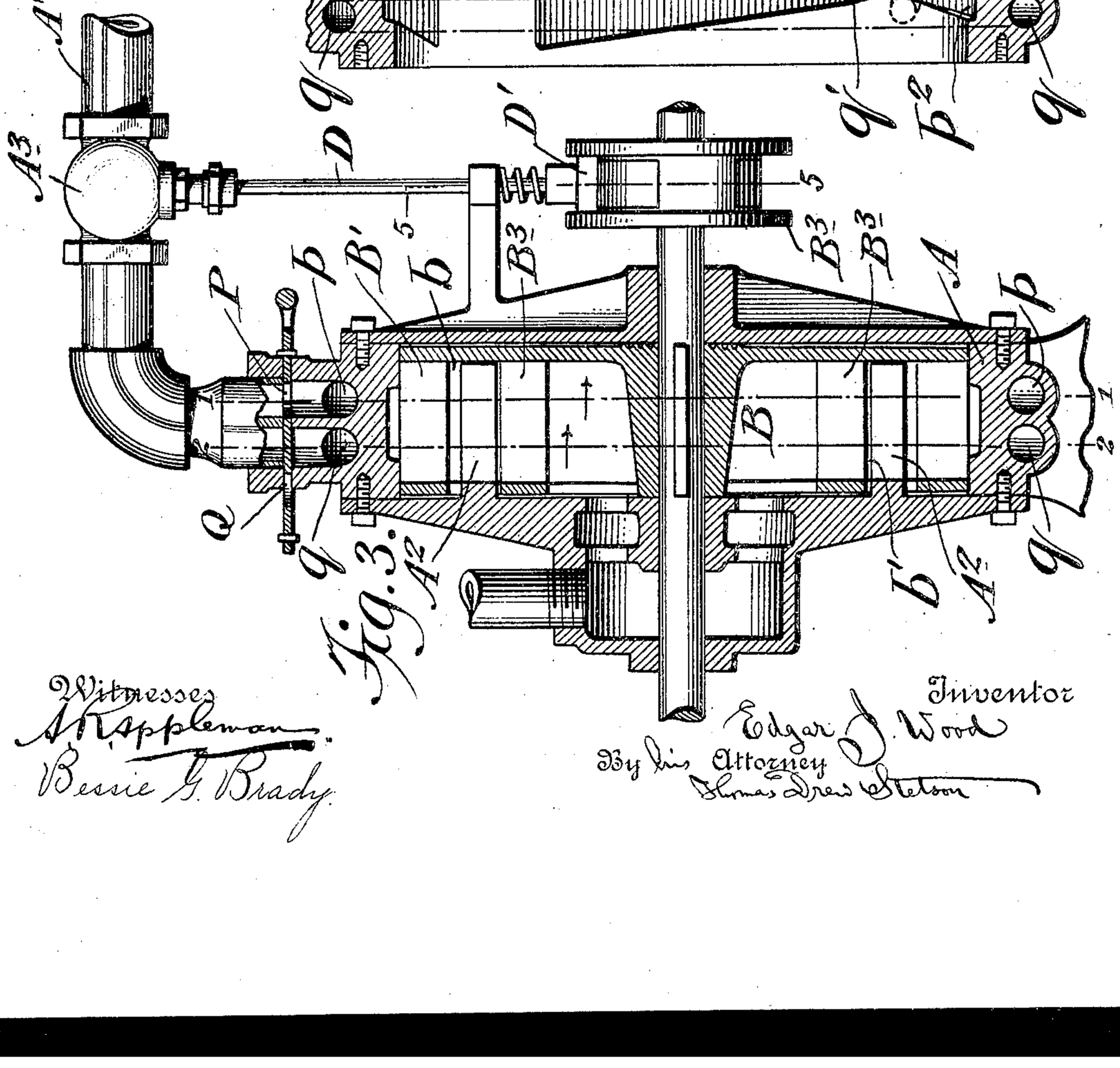


Fig. 4.



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EDGAR J. WOOD, OF NEW YORK, N. Y.

TURBINE-ENGINE.

No. 808,709. Specification of Letters Patent. Patented Jan. 2, 1906.

Application filed January 25, 1905. Serial No. 242,585.

To all whom it may concern:

Be it known that I, EDGAR J. WOOD, a citizen of the United States, residing in the borough of Brooklyn, in the county of Kings, city and State of New York, have invented a new and useful Improvement in Turbine-Engines to be Used with Steam or Gas; and I do hereby declare that the following is a full and exact description thereof.

My turbine can be worked either single or compound. I will describe the compound form. All that is necessary to make the single form is to omit portions which will require no drawing or detailed description. The compound form may be constructed with separate wheels for the successive actions; but I will show and describe the construction as having two wheels on the same shaft receiving the fluid first in the largest and immediately after in a smaller wheel mounted concentrically within it. I will refer to the fluid as "steam." I make the buckets and the stationary casing of peculiar form and peculiarly arranged. I provide two stop-valves arranged to control two steam-passages connected to bring steam as required. It may be both passages leading from the same boiler. Where one of these valves is opened the steam flows without any considerable loss of pressure past such valve and is discharged, a high velocity through contracted passages reaching the wheels with high velocity in an approximately tangential direction from the right. When this valve is closed and the other is opened, the steam flows in other channels in its approach to the wheels and in a sense in other directions as it passes through spaces between the buckets and revolves the wheel in the opposite direction. I provide two substantially annular reservoirs for the strong steam, each extending continuously around the periphery of the largest series of buckets, and provide two valves, each capable of being tightly closed, arranged to control these passages. There may be two or more of the tangential induction-passages receiving the steam from these annular passages, and a corresponding number of equally-separated or varingly-separated portions of the wheel which receive the action of the jets. The buckets are double-faced, receiving impact and a quickly-curved flow of the steam on the left face of each bucket of the wheel, and the right face of each deflecting-plate, sometimes termed "fixed buckets," of the fixed casing when the steam is received from the left, all these conditions being reversed when the steam is received in the reverse direction. I make the several series of buckets and the series of fixed blades between them narrower than the spaces provided and arrange them so that there is a clear annular space extending quite around both on the outer and inner sides of each series.

The following is a description of what I consider the best means of carrying out the invention.

The accompanying drawings form a part of this specification.

Figure 1 is a section on the line 1 1 in Fig. 3. Fig. 2 is a section on the line 2 2 in Fig. 3, only a portion of the wheel being shown. Fig. 3 is a vertical section of the main portion in the plane of the axis. Fig. 4 is an interior view of the casing with the wheel removed. Fig. 5 is on a larger scale, showing the governor. It is on the line 5 5 in Fig. 3.

Similar letters of reference indicate like parts in all the figures where they appear.

A is a fixed casing of cast-iron or other suitable material, preferably a material and construction adapted to give a slow conduction of heat. Supernumerals will be used when required to distinguish special portions thereof.

B indicates the shaft, wheel, and buckets, the revolving parts, all of which are rigidly secured together—supernumerals, as B′, being used when necessary to designate special portions.

B′ is a series of buckets in the periphery of the wheel. The form of the buckets will be described farther on.

If the parts are cast-iron, I make the quality and shapes so related that the conduction of heat from the parts exposed to high-pressure steam to the parts bathed in the lower pressure, and consequently cooler, steam shall induce no serious difficulties and that the expansion and contraction by heating and cooling and the springing due to the steam imposed by the high-pressure steam and the intense centrifugal force to which the revolving parts are subjected under some conditions shall have as little influence as possible on the closeness of the joints between the moving and the fixed parts, which require to run steam-tight, or nearly so.

P and Q are slide-valves moved as required by the attendant.

I have shown the exhaust as allowed to

discharge freely into the atmosphere. It will be understood that this is not a necessary condition. The escaping steam may be led by a sufficiently liberal casing, as shown, to any desired point, and where condensing-water or other means of cooling are available it may be led to a condenser, so as to attain by a nearly complete vacuum the extreme tenuity of the steam and the extremely high velocity of the flow thereof, which is found desirable in steam-turbines.

I provide two continuous spaces or passages *p* and *q* around the wheel and admit the steam at as high pressure as may be from the steam-pipe A′ to one or the other, according as the valves P and Q are thrust in or drawn not. There may be provisions for governing by hand or automatically by means of these valves when for any reason governing becomes desirable; but the adjustment must always have only one valve in the open position at any one time. I will refer to these annular channels *p* and *q* (each a complete endless passage distinct from the other in which the steam at full pressure distributes itself) as "belts," which term may aid to distinguish them from the several smooth channels to be described below, in which the steam reduced in pressure moves at high velocity partially or completely around the wheel. At points in the inner side of each belt are perforations *p′* and *q′*, respectively arranged to allow small streams of steam to be projected at a high velocity through passages nearly tangential to the series of buckets B′. These passages p^2 and q^2 are each curved and extended partially around the periphery, being widened and flattened, as shown, so that the steam is expanded and used at a high velocity, and that each stream of the steam is caused to strike and act effectively on a number of the buckets B′. Confining attention first to one valve and to the flow of steam controlled thereby, the opening of the valve P fills the belt *p* with strong steam, which rushes through the small apertures *p′* and moves with the highest velocity attainable through the passages p^2. The faces of the retreating buckets B′ which are presented thereto are properly curved and polished to receive and deflect backward the streams of steam, and the steam issues from the inner edges of the series of buckets B′ with a backward motion relatively to the motion of the wheel and escapes into an annular space *b*, which extends quite around. There is a constant flow of the steam in this annular passage in the direction opposite to the motion of the wheel; but it is less violent than the earlier motion of the same in the primary passage p^2, because the steam has imparted much of its momentum to the wheel in its sweep along the presented hollow faces of the several rapidly-retreating buckets B′

A² is a series of fixed deflecting-plates or fixed buckets which are rigidly and skilfully set to constitute portions of the casing. They present hollowed faces adapted to receive the backwardly-moving current of steam from the annular space *b* and to again reverse the direction of its circumferential motion. These surfaces not retreating do not subtract much from the velocity of the steam. I provide a second annular space *b′*, which extends around within the series of fixed buckets A². In this space there is a motion of the steam traveling around in the same direction as the motion of the wheel. This is utilized by causing it to sweep swiftly inward along sharply-hollowed and finely-polished faces presented by a second series of buckets B³. The steam is discharged from the inner edges of these buckets B³ in a condition substantially at rest. It has a lively backward motion relatively to the wheel; but its velocity being only about equal to the velocity of the wheel it is delivered motionless. The steam is now dead—it is "exhaust." It flows out leisurely through the left side of the casing near the center. This repeated action of the steam is common to many of our long-approved steam-turbines. The buckets and the arrangements of the valves, belts, and passages are peculiar; but the mode of operation of the steam is old, first impelling the wheel by its useful forward pressure on the presented hollow faces of the series of swiftly-moving buckets B′, then being turned forward again by its idle backward pressure against the presented hollow faces of the fixed buckets A², and then being caused to act again by its second useful forward pressure against the adjacent faces of the second series of moving buckets B³. The action is improved by the liberty allowed the steam to freely flow around in the annular spaces *b* and *b′* to the next series of buckets, and thereby better apply itself uniformly to the whole series; but there is great practical advantage in the points now to be further studied.

I have described the steam as acting against smoothly-hollowed surfaces presented toward the incoming current without directing any attention to the forms of the opposite faces of the several buckets. It is the practice in ordinary turbines to make such opposite faces swelled. I do not. I make both faces hollowed and hollow them to an exactly equal amount. One face of each bucket in the outer series of moving buckets B′ is a counterpart of the other face thereof, and similarly each of the buckets in the intermediate fixed series A² has both faces hollowed, care being taken to make the form and spacing just right. The drawings show these forms as well as yet determined. The wheel and the fixed buckets are equally adapted to receive steam in the direction to revolve from right to left or from left to

right, and the wheel can turn with equal freedom and efficiency in one direction or the other. If my turbine is used on a vessel or automobile, it backs with the same ease and force as it can go forward and without requiring any change of position of any parts except the valves P and Q. Now the importance of having two valves—the valve Q as well as the valve P—and two annular spaces—the space or belt *q*, as well as the space or belt *p*—becomes apparent. The perforations P and Q and the connected approximately tangential passages *p'* and *q'*, controlled thereby, being entirely independent, may be fixed integral, strong, durable, and every way reliable. In case of accident or a necessity for attention or adjustment from any cause each is independent, and a change of one does not affect another. The provisions for supplying the steam make it practicable to deliver it with its full force and economy in either direction, and the provisions for utilizing it adapt it for doing this without any changes whether the wheel is to revolve in one direction or the other.

I attach importance to the smooth annular space *b*, because it allows the steam to be received continuously from the other bucket B', notwithstanding the intermittent or rather the stepped presentation of the apertures between the fixed buckets A^2 for receiving it, and because it allows the fixed buckets to receive the action continuously, notwithstanding the intermittent or stepped character of its delivery from the moving buckets B', and I attach importance to the corresponding annular space *b'* because it similarly allows the steam to be delivered and received in its transfer from the fixed buckets to the second set of revolving buckets B^2. These passages provide separately for the motion in either direction.

The area of the apertures or perforations *p'* and *q'* should be such as will give all the steam required to develop the full power of which the engine is capable. A throttle-valve acting in a valve-casing A^3 in the steam-pipe A' controls the speed by reducing the pressure maintained in the belt P or Q. In cases where much less than the full power is required I can shut off one of the apertures *p'* or *q'*, leaving the work to be done by the steam from the other or others (or where there are more than two) the remainder of such passages. This completely putting out of action a part of the passages is more economical of steam than to very greatly reduce the pressure and keep all at work.

M and N show in outline hand-wheels which operate ordinary tight-fitting stop-valves by which any one of the several passages can be closed without interfering with the other or others. These valves M and N may be controlled automatically; but I propose usually to arrange for operating them by the hand-wheels shown according to the judgment of the attendant. Each should be set fully open when opened at all.

The governor which controls the flow through the pipe A' is shown in Fig. 5. B^3 is a wheel on the shaft B, carrying pivots B^4, on which freely turn levers C curved to match the motion, and C' are springs curved to work freely in the space available and of sufficient length to give a proper action. Each is attached to the hub of the wheel. Each is adjusted by setting the screw B^5 in or out, as required, to draw the lever C inward toward the axis with just sufficient force. D' is a foot on a freely-movable rod D, connected to an easily-moved throttle-valve inclosed in the casing A^3. So long as the speed is properly moderate there is no action; but the moment the speed much exceeds the proper limit the centrifugal force of the levers C overcomes the tension of the springs C', so that they move outward and act at each revolution on the under face of the foot D' and lift the rod D and partially close the valve. This reduces the pressure of the steam which is received in the belt *p* or *q*, as the case may be. The engine is slowed to proper limit, and the springs C' again draw inward the levers C, and the valve in A^3 is thereby opened either to its full extent or partially, as required, and the engine revolved at the right speed, as at first.

Modifications may be made by any good mechanic without departing from the principle or sacrificing the advantages of the invention. The number of the orifices *p'* and *q'* may be increased, taking care to shorten the passages p^2 and q^2. The number may be reduced to one of each; but I esteem it preferable to have two or four of each and to arrange them so that the two which are in use at once shall be opposite each other.

I have shown the annular space *b*, which is exterior to the series of fixed buckets, deeper radially than the space *b'*, which is interior to such fixed buckets. These conditions may be reversed, or there may be an equal depth to each.

Parts of the invention may be used with some advantage without others. Thus the annular spaces *b* and *b'* may be used without the provisions for reversing, or the provisions for reversing may be used without the annular spaces. The engine may be used with a different construction of governor or without any governor. The faces of the several buckets may be hollowed more or less than shown. The depth or radial dimensions of the several series of buckets may be greater or less than shown relatively to the diameter of the wheel and to the breadth of the buckets.

I have shown the grooves as carried on the shaft B, and this may be desirable for sim-

plicity and for inducing extremely quick response when the speed becomes too high or too low; but it will be obvious that the slight frictional resistance will be less if the governor is mounted on a slower shaft. In cases where there is a reduction of speed by gearing or belting for other purposes the governor may be preferably carried on a slower shaft, the tension of the springs C′ being adjusted to be correspondingly less.

I have shown the outer space *b* as deeper than the inner space *b′*. These proportions can be reversed or either or both can be increased or diminished or one or both can be omitted without entirely defeating the success of the engine.

I claim as my invention—

1. The steam-turbine described having its buckets hollow-faced on each side and two independent belts, *p* and *q*, arranged side by side in the periphery with connections for keeping them filled with steam, adapted to serve substantially as herein specified.

2. The steam-turbine described having two or more annular series of buckets hollow-faced on each side in combination with fixed buckets hollow on each face arranged annularly between with a clear space for the same to traverse around in each of the spaces thus provided and with a casing having provisions for discharging jets of steam to act on either face.

3. The steam-turbine described having hollow-faced buckets adapted to receive the current in either direction in combination with two valves and connected passages or belts extending separately quite around the wheel arranged to supply steam at full pressure and having contracted discharges from each arranged for driving in either direction at will all substantially as herein specified.

4. In a steam-turbine having moving buckets delivering steam into fixed buckets and fixed buckets delivering steam into moving buckets the deep annular spaces *b* adapted to allow a continuous rearward current of steam between the delivery edges of the buckets B′ and the receiving edges of the fixed buckets A^2 two continuous channels or belts *p* and *q*, arranged independently around, the perforations *p′*, and passages p^2, leading from each in opposite directions, and valves Q arranged to control the admission of steam into the belts, and valves M arranged to control the flow of steam from such belts through such perforations and connected passages beyond adapted to serve substantially as herein specified.

5. In a steam-turbine having moving buckets delivering steam into fixed buckets delivering steam into moving buckets, the deep annular spaces *b* adapted to allow a continuous rearward current of steam between the delivery edges of the buckets B′ and the receiving edges of the fixed buckets A^2 and also the deep annular spaces *b′* adapted to allow a continuous forward current of steam between the delivery edges of the fixed buckets and the receiving edges of the moving buckets all substantially as herein specified.

Signed at New York, in the county of New York and State of New York, this 21st day of January, A. D. 1905.

EDGAR J. WOOD.

Witnesses:
THOMAS DREW STETSON,
BESSIE G. BRADY.