No. 737,734. PATENTED SEPT. 1, 1903.

J. W. GRAYDON.

TURBINE ACTUATED BY STEAM.

APPLICATION FILED JULY 8, 1901.

NO MODEL. 3 SHEETS—SHEET 1.

FIG 1.

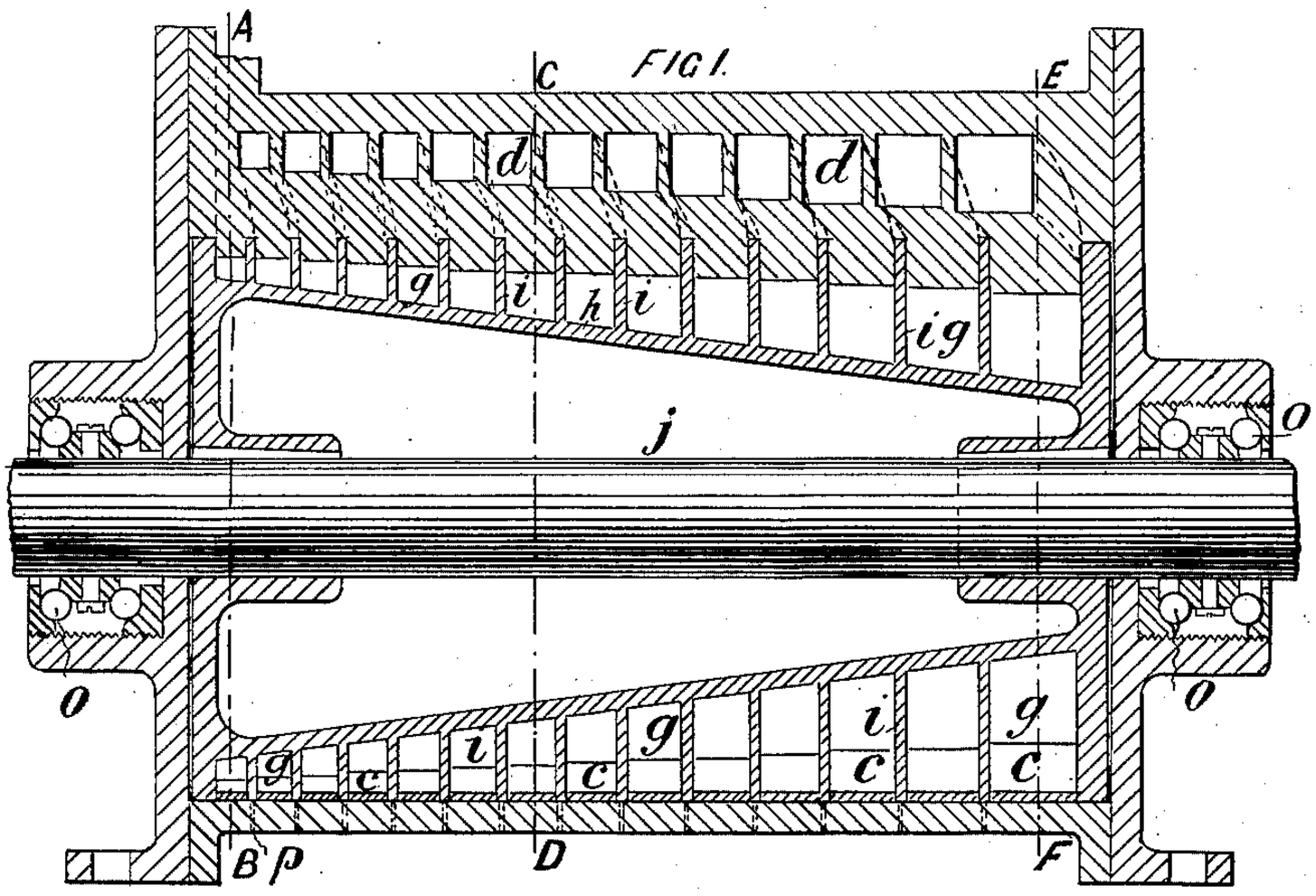
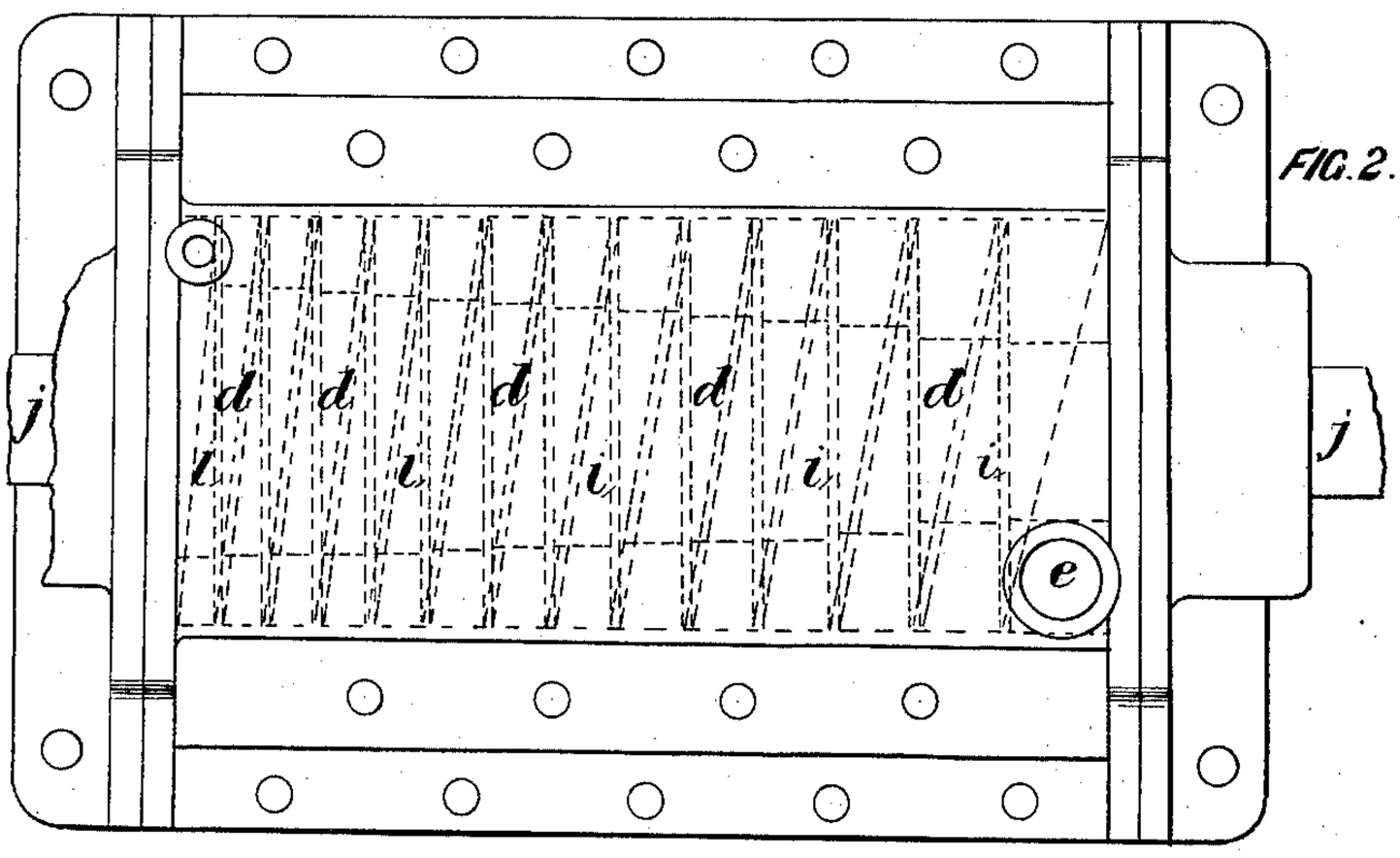


FIG. 2.



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NO MODEL. 3 SHEETS—SHEET 2.

FIG. 3.

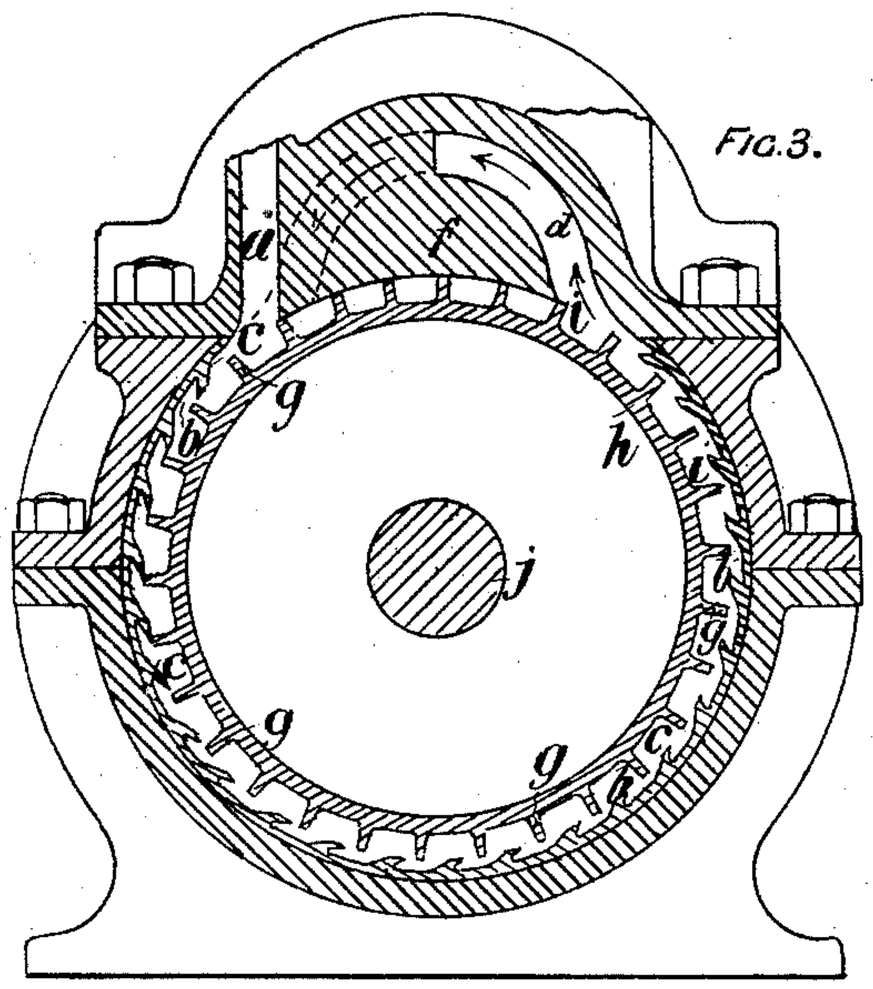


FIG. 4.

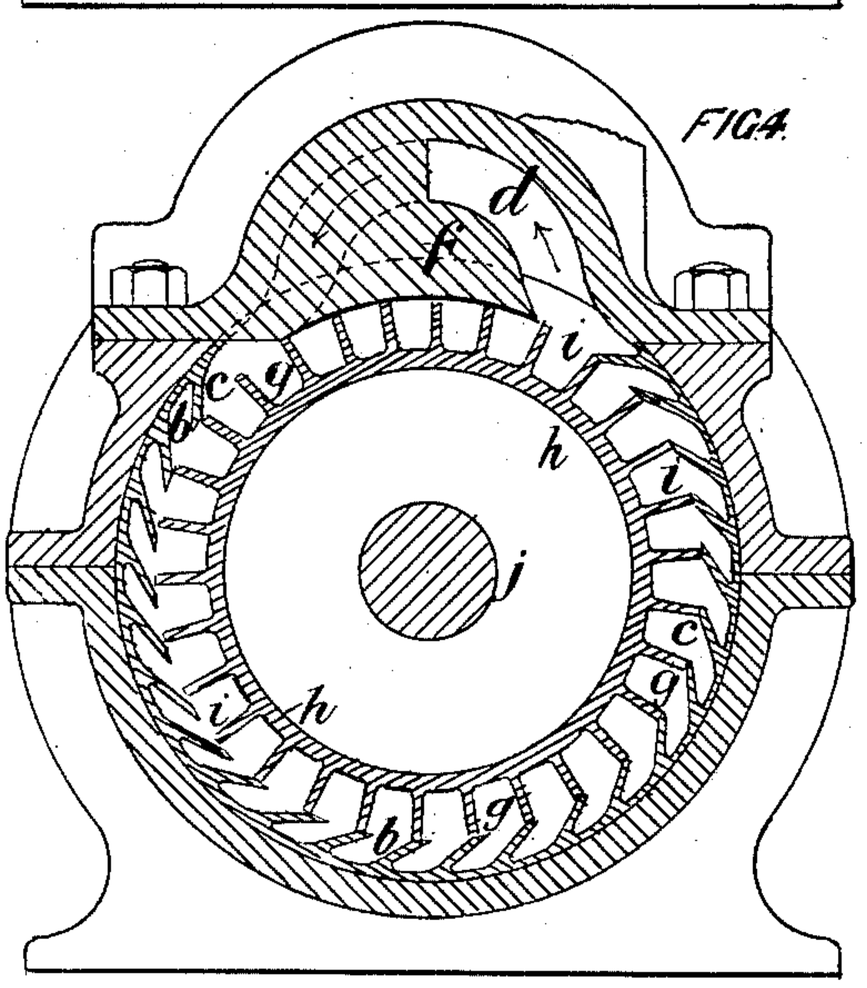
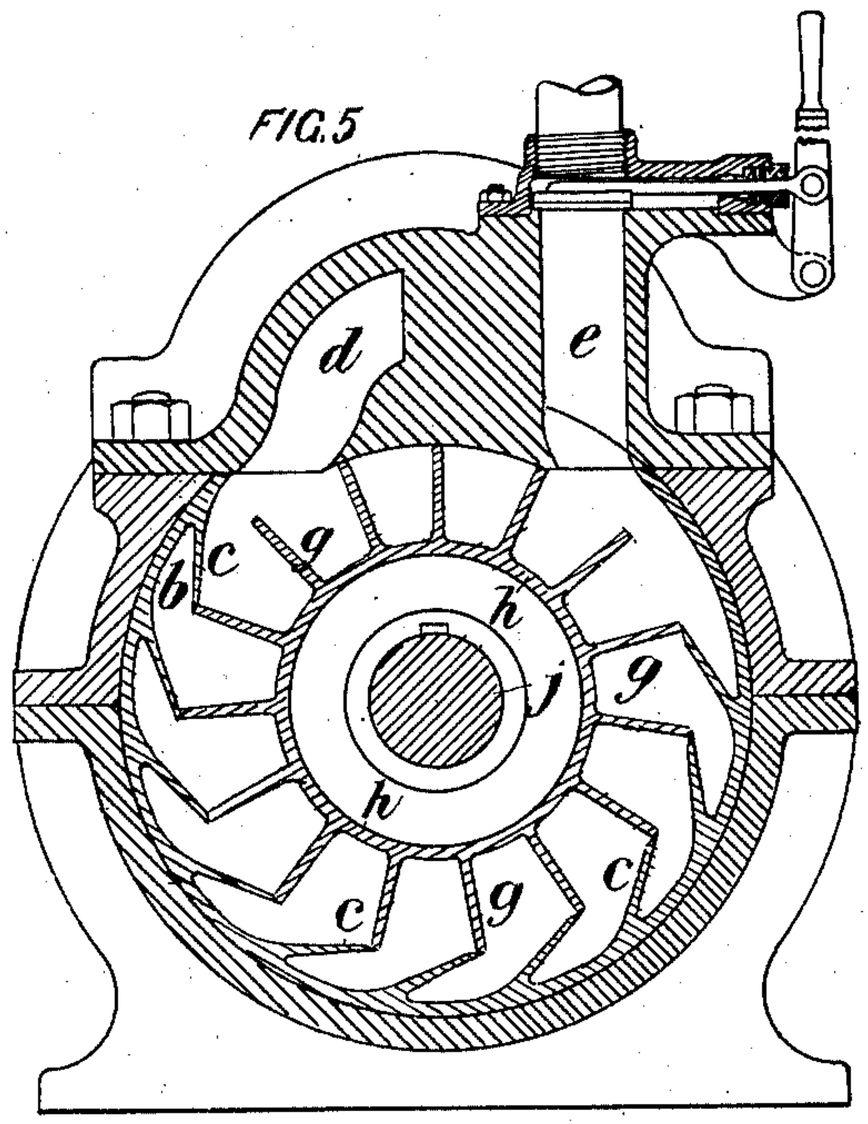


FIG. 5



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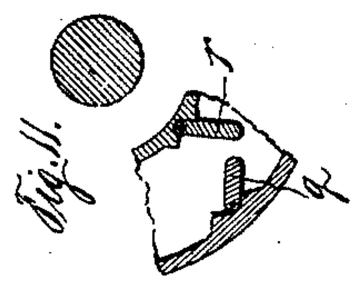
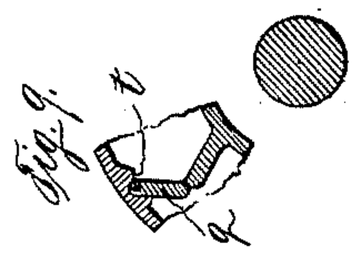
TURBINE ACTUATED BY STEAM.

APPLICATION FILED JULY 8, 1901.

NO MODEL. 3 SHEETS—SHEET 3.





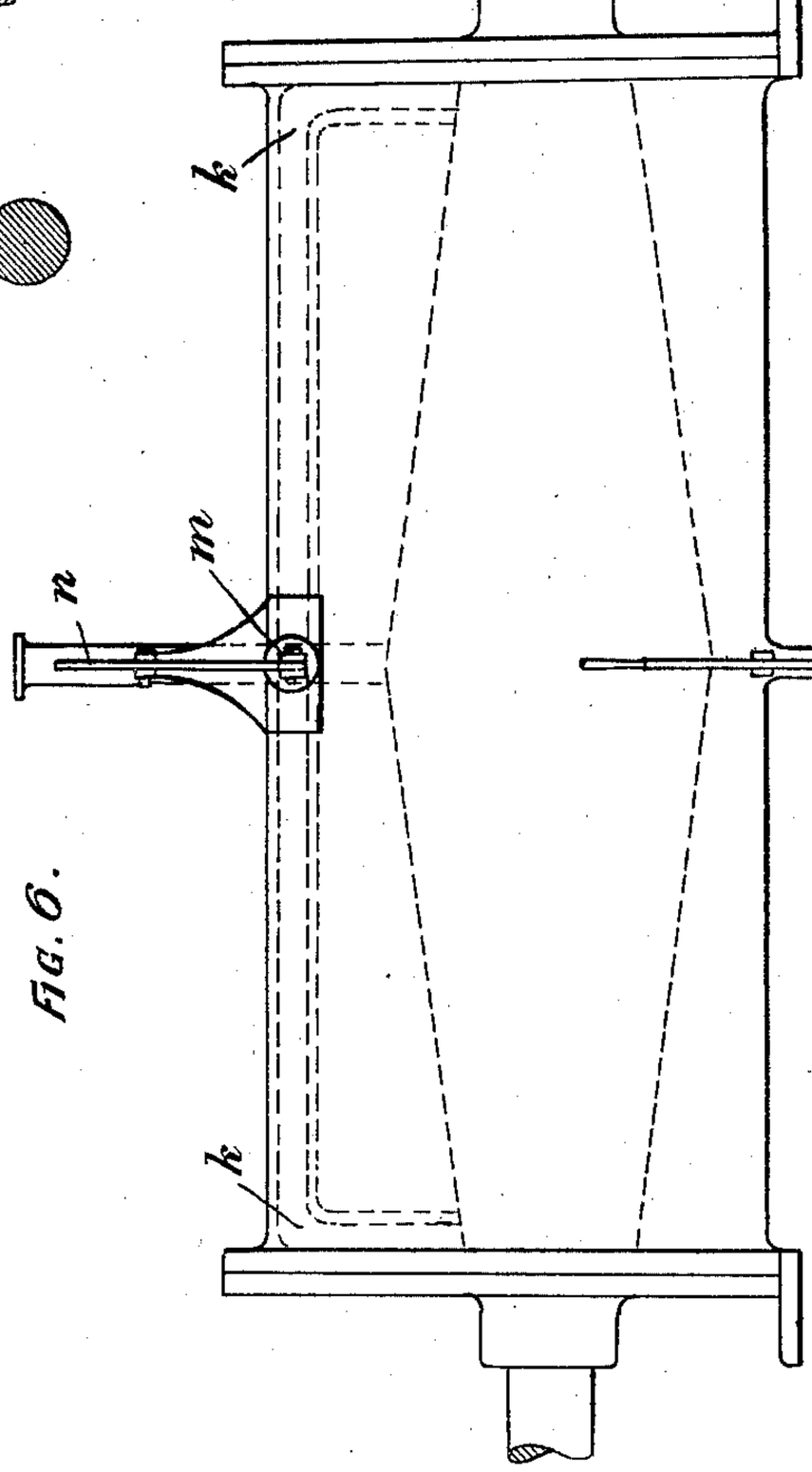


FIG. 6.

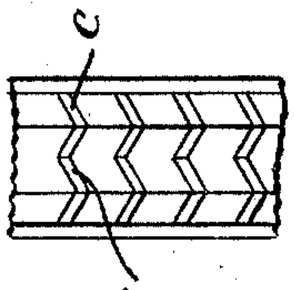


FIG. 8.

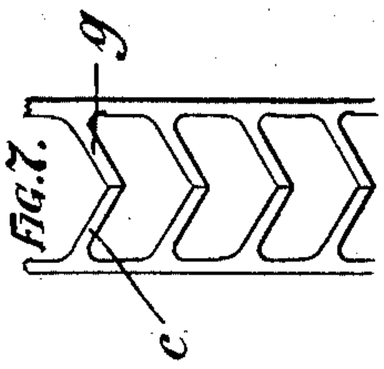


FIG. 7.

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No. 737,734. Patented September 1, 1903.

UNITED STATES PATENT OFFICE.

JAMES WEIR GRAYDON, OF STOCKWELL, ENGLAND.

TURBINE ACTUATED BY STEAM.

SPECIFICATION forming part of Letters Patent No. 737,734, dated September 1, 1903.

Application filed July 8, 1901. Serial No. 67,518. (No model.)

To all whom it may concern:

Be it known that I, JAMES WEIR GRAYDON, late lieutenant in the United States Navy, a citizen of the United States, at present residing at No. 35 Lingham road, Stockwell, in the county of Surrey, England, have invented new and useful Improvements in Turbines Actuated by Steam or other Fluid Under Pressure, of which the following is a specification.

The objects of these improvements in engines of the turbine class actuated by steam or other fluid under pressure are to reduce the quantity of fluid used therein, to reduce the weight and size of same, and generally to simplify and improve its mechanical efficiency.

Figure 1 of the accompanying drawings represents in sectional elevation a simple form of compound turbine constructed according to this invention. Fig. 2 is a plan thereof. Fig. 3 is a section on the line A B, Fig. 1. Fig. 4 is a section on the line C D, Fig. 1; and Fig. 5 is a section on the line E F, Fig. 1. Fig. 6 shows a double compound turbine, and Figs. 7, 8, 9, 10, and 11 represent details of vane constructions.

According to this invention and as shown in Figs. 1 to 5 the steam or other fluid under pressure enters at *a* and passes circumferentially around the axis for a portion of the inner circumference of an annular compartment *b* of the turbine-casing, which compartment is provided with a number of vanes or projections *c*, and then passes by one or more slanting passages *d* into another adjoining annular compartment, and so on. Having thus traversed several such compartments, the steam at a reduced pressure may be passed into another similar turbine, and if the initial pressure were high I may employ more than two turbines in succession in order to utilize the expansive force to the utmost, or, as shown, each succeeding annular chamber is made of larger area. Finally, the exhaust goes off at *e* into the condenser, (or it might escape into the open air.) As indicated, the turbine-casing compartments are furnished with deflecting blades or vanes *c* throughout a portion, in some cases the greater portion, of the inner circumference, but in any case not at or near that part where the slanting exit-passage or communicating passage is formed to the next adjoining compartment. At this part I provide a cover piece or plate *f*, forming the inner side of the aforesaid slanting passage and having the same inner radius as the outer circumference of the blades or vanes *g* on the wheel *h*.

Within the casing, which is suitably made in two halves longitudinally, I provide a series of wheels *h* with vanes or blades *g* all around, each set corresponding to a set of vanes in one compartment of the casing. These vanes or blades are, by preference, made with "lap" relatively to the vanes in the casing. In the casing or on the wheels *h* I provide ring flanges *i*, that separate the sets of vanes thus forming the compartments.

The aforesaid cover-piece *f* is made with curved slanting ends for directing the actuating fluid gently upward and then downward from one compartment to the next by the communicating passage *d*. Moreover, it is made sufficiently wide to cover several—say four or more—of the vanes *g* in the wheel, which latter vanes thus capture and carry along a certain portion of steam—that is, the steam contained between the four vanes—so that the said portion of steam is made to enter the same ring compartment again, commingling with the fresh steam which has meanwhile entered that ring of compartments. This portion of steam will thus be made to do work once more therein. This operation is repeated in each ring compartment.

From the above it will be understood that the arrangement of sets of adjoining annular compartments *b*, joined by the slanting communicating passages *d* over the cover-plates *f*, practically comes to the same as if they formed one continuous helical passage. The steam therefore travels in annular zones one after the other around the axis or shaft *j* of the engine.

I have stated that I use two or more such turbines if I desire to utilize to the full the expansive force of the fluid. There is a great advantage resulting from this, because the shaft *j* is well supported by a bearing between each two such comparatively short turbines, and I thus avoid the necessity for providing elastic bearings, as in the well-known Parson's turbine and others, where the great

length of the turbine at the great speed produces gyrations of the shaft.

The vanes *c* in the casing and the vanes *g* on the wheels *h*, mounted on the shaft *j*, may be of various forms and be variously arranged. In the form shown in Figs. 1 to 5 the vanes *g* on the wheel extend right across the parallel channels *b* between the rings *i* at right angles to them, but in depth, say, two-thirds of the said channels. In that case the vanes *c* in the casing extend into the parallel channels the other third of the depth of the channels, the vanes both in the wheel and in the casing having their faces beveled to the required angle to throw the steam onto the wheel-vanes, or vice versa. In this case the aforesaid inclined communicating passage is of the full width of the parallel passage just named; but it is evident that the proportions and inclinations of the vanes *g* on the wheels *h* and those marked *c* on the casing may be varied without departing from my invention.

Fig. 6 shows a double-ended turbine in which the steam or other fluid enters at the inlet *a* past the valve *l*, whence it flows off on both sides and performs work until it escapes at each end by the exhaust-pipes *k k*, which meet together at the single exhaust-pipe *e*, and the speed of the escaping exhaust, and consequently of the engine, may be quickly regulated by a valve *m*, having a lever *n* or other suitable means for operating same.

In another form, as shown in Fig. 7, the wheel-vanes *g* occupy only one side of the parallel passages and the vanes *c* in the casing occupy the other side. In this case the aforesaid inclined communicating passage is of the width of vanes in the casing, but may be of greater depth to make up the required area.

In yet another form, as shown in Fig. 8, the wheel-vanes *g* are in the center of the parallel passage and V-shaped, so as to throw the steam to the right and left upon the vanes *c* in the casing. In this case there are two inclined communicating passages, and the width of each of them is the width of the spaces occupied by the vanes in the casing on each side of the parallel passages; but they may have a greater depth to make up the required area.

Instead of admitting the steam at one part of the circumference steam may be admitted at two opposite sides, the steam from one inlet traversing the upper halves of the compartments and the steam from the other inlet traversing the lower halves of the compartments.

The lubrication of the working parts is effected by forcing the lubricant into the ball or other bearings *o*, Fig. 1, and other parts and back to a cooling apparatus from whence the pump draws its supply, so as to circulate the lubricant again and again. If the turbine itself is to be lubricated in its interior vane parts, (and without depending upon the lubricant that may be introduced in the steam itself in the usual manner with steam-engines,) then I pump lubricating material through small pipes or passages *p*, leading to the grooves in the ring flanges, which flanges divide the turbine into compartments. There are projections between the pipes and extending into the groove, so that one carries the lubricant around the ring flange and brings it back to the other pipe, the projection between the pipes serving to stop the lubricant there and to divert it into the second pipe, which leads it to the cooling apparatus.

The shaft works in grooved or ball bearings, as shown, to counteract a small end pressure; but it will be noticed that the action of the steam is mainly in a circumferential direction. The engine may, however, also be mounted on its bed-plate in a longitudinal groove or grooves and on rollers, if desired, so that the whole engine may move longitudinally. For ship-propelling purposes the ordinary thrust-bearings will be used for taking the propeller-thrust, as usual.

The turbines need not be placed end for end or work on the same shaft. The casing and the wheels may be cylindrical or of a gradually or stepwise increasing diameter, as has been illustrated, or the ring compartments may be made of increasing widths or both of increasing diameters and widths. A governor will in some cases be needed and may be applied in the ordinary way or between any two compartments or between two turbines if more than one is used.

The engine when applied to a locomotive may be in connection with one shaft only, or I may use one in connection with each of two or three wheel-axles, the steam after being used in one turbine passing into the next, or each turbine may be independent or work with high-pressure steam and exhaust direct.

My invention is applicable for driving purposes generally.

Reversing-gear, whereby, for instance, the steam for the time being enters at the exit or exhaust end and leaves by the inlet end, is provided where required, and in order to secure an efficient working during such reversal it is made possible to reverse the inclination of one or of both sets of vanes. This is accomplished by pivoting the vanes—as, for instance, the vanes on the interior casing, as shown at *q* in Fig. 9, or the vanes upon the rotary wheel or drum, as shown at *r* in Fig. 10, or by pivotally mounting both sets of vanes, as shown at *q r* in Fig. 11. These vanes are preferably supported in their inclined positions by the inclined side walls of the recesses *t*, in which the vanes are hinged.

Although I have only shown turbines of the compound type in which the cells formed by the vanes in the casing and on the shaft become larger the nearer they are to the exhaust, I wish it to be distinctly understood that I may make the turbines high-pressure turbines, in which case the area of the cells

at the exhaust end is no larger than those at the end where the motive fluid enters.

What I claim as my invention, and desire to secure by Letters Patent, is—

1. In a turbine, the combination of a casing, a plurality of vanes or projections arranged to form a plurality of partial rings of cells extending around the greater part of the inner circumference of the casing, a tangential steam-admission port and a tangential exhaust-port, a shaft supported in suitable bearings at both ends of the casing, a plurality of vanes or projections arranged in a plurality of rings on and concentric with said shaft, curved ports or passages arranged above the rings of cells each passage communicating at its ends tangentially with adjoining rings of cells whereby the steam is exhausted from each ring and efficiently delivered to the adjoining ring, substantially as set forth.

2. In a turbine, the combination of a casing, a plurality of vanes or projections arranged to form a plurality of partial rings of cells extending around the greater part of the inner circumference of the casing, a tangential steam-admission port, and a tangential exhaust-port, a shaft supported in suitable bearings at both ends of the casing, a plurality of vanes or projections arranged in a plurality of rings on and concentric with said shaft, a cover for the casing, curved ports or passages arranged in said cover, said ports or passages being above the rings of cells and each passage communicating at its ends tangentially with adjoining rings of cells whereby the steam is exhausted from each ring and efficiently delivered to the adjoining ring, substantially as set forth.

3. In a turbine, the combination with a casing, a plurality of vanes or projections arranged to form partial rings of cells and extending around the greater part of the inner circumference of said casing, annular grooves between adjoining rings of vanes, a steam-admission port, an exhaust-port, a valve to regulate the opening of the exhaust-port, a shaft supported in suitable bearings at both ends of the casing, a plurality of vanes or projections on the said shaft, a ring flange between each two adjoining sets of vanes and projecting into the said annular grooves so as to form rings of cells and a plurality of holes for the supply of lubricant to the said ring flanges; of a plurality of curved ports or passages in the upper part of the casing arranged in such manner as to convey and guide the steam as nearly tangentially as may be out of one ring of cells and into the adjoining ring of cells, substantially as set forth.

4. In a turbine, the combination with a casing, a plurality of vanes or projections arranged to form partial rings of cells and extending around the greater part of the inner circumference of said casing, annular grooves between adjoining rings of vanes, a steam-admission port, an exhaust-port, a shaft supported in suitable bearings at both ends of the casing, a plurality of vanes or projections on the said shaft, a ring flange between each two adjoining sets of vanes and projecting into the said annular grooves so as to form rings of cells and a plurality of holes for the supply of lubricant to the said ring flanges; of a plurality of curved ports or passages in the upper part of the casing arranged in such manner as to convey and guide the steam as nearly tangentially as may be out of one ring of cells and into the adjoining ring of cells, substantially as set forth.

5. In a turbine the combination with a casing and a plurality of vanes or projections arranged to extend partially around the inner circumference of the said casing; of a shaft supported in suitable bearings at both ends of the said casing, a plurality of movable vanes or projections arranged to form rings on the said shaft, a ring flange or partition extending radially between each two coinciding sets of vanes, to form a number of cells or chambers, a cover-piece extending from at or near one end of the casing to the other end of the said casing, a port for the inlet of the motive fluid, ports or passages leading from one ring of vanes to the next ring of vanes and an exhaust-port, substantially as set forth.

6. In a turbine, the combination with a casing and a plurality of movable vanes arranged to extend partially around the inner circumference of the said casing; of a shaft supported in suitable bearings at both ends of the said casing, a plurality of vanes arranged to form rings on the said shaft, a ring flange or partition extending radially between each two coinciding sets of vanes to form a number of cells or chambers, a cover-piece extending from at or near one end of the casing to the other end of the said casing, a port for the inlet of the motive fluid, ports or passages leading from one ring of vanes to the next ring of vanes and an exhaust-port, substantially as set forth.

7. In a turbine, the combination with a casing and a plurality of movable vanes arranged to extend partially around the inner circumference of the said casing, a plurality of movable vanes arranged to form rings on the said shaft, a ring flange or partition extending radially between each two coinciding sets of vanes so as to form a number of cells or chambers, a cover-piece extending from at or near one end of the casing to the other end of the said casing, a port for the inlet of the motive fluid, ports or passages leading from one ring of vanes to the next ring of vanes and an exhaust-port, substantially as set forth.

8. In a turbine, the combination with a casing, inlet and exhaust pipes for motive fluid, a shaft and a wheel thereon; of movable vanes on said wheel and coöperating movable vanes on the casing, substantially as set forth.

9. In a turbine, the combination with a casing, inlet and exhaust pipes for motive fluid, a shaft and a wheel thereon; of vanes hinged

to the casing and coöperating vanes hinged to the wheel, substantially as set forth.

10. In a turbine, the combination with a casing provided with recesses having inclined side walls, inlet and exhaust pipes for motive fluid, a shaft and a wheel thereon also provided with recesses having inclined side walls; of vanes hinged in the recesses in said casing and similar coöperating vanes hinged in the recesses in said wheel, substantially as set forth.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

JAMES WEIR GRAYDON.

Witnesses:

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WALTER J. SKERTEN.