O. D. H. BENTLEY.

TURBINE.

APPLICATION FILED MAY 20, 1909.

944,839.

Patented Dec. 28, 1909.

2 SHEETS—SHEET 1.

FIG. 1.

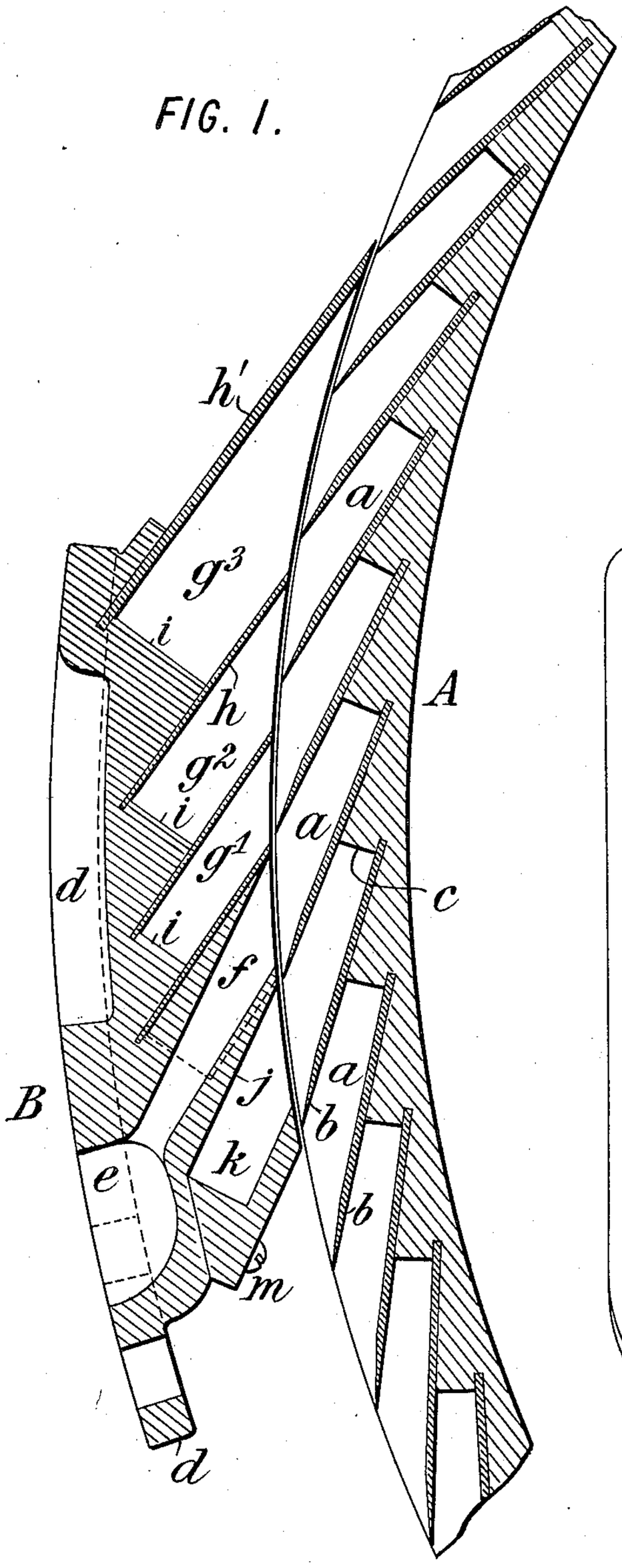
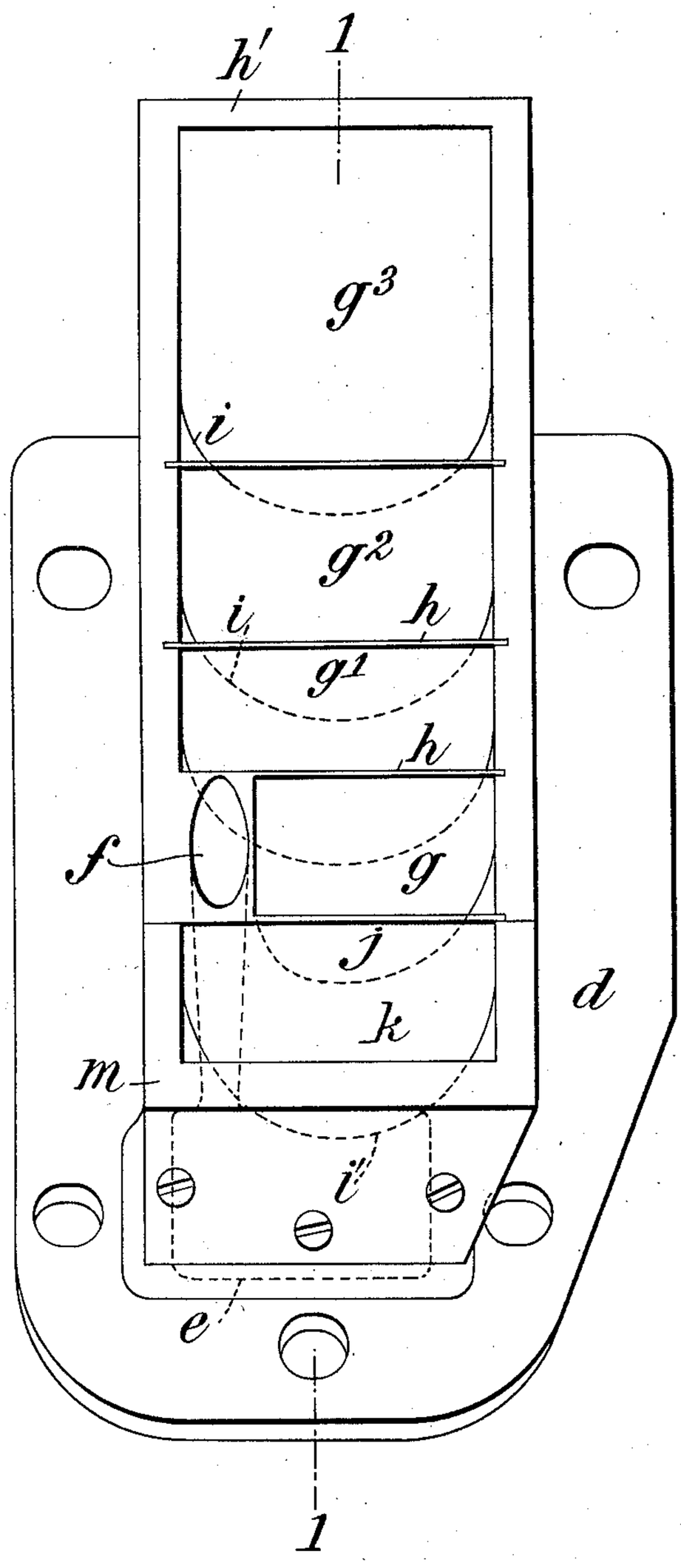



FIG. 2.

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2 SHEETS—SHEET 2.

FIG. 3.

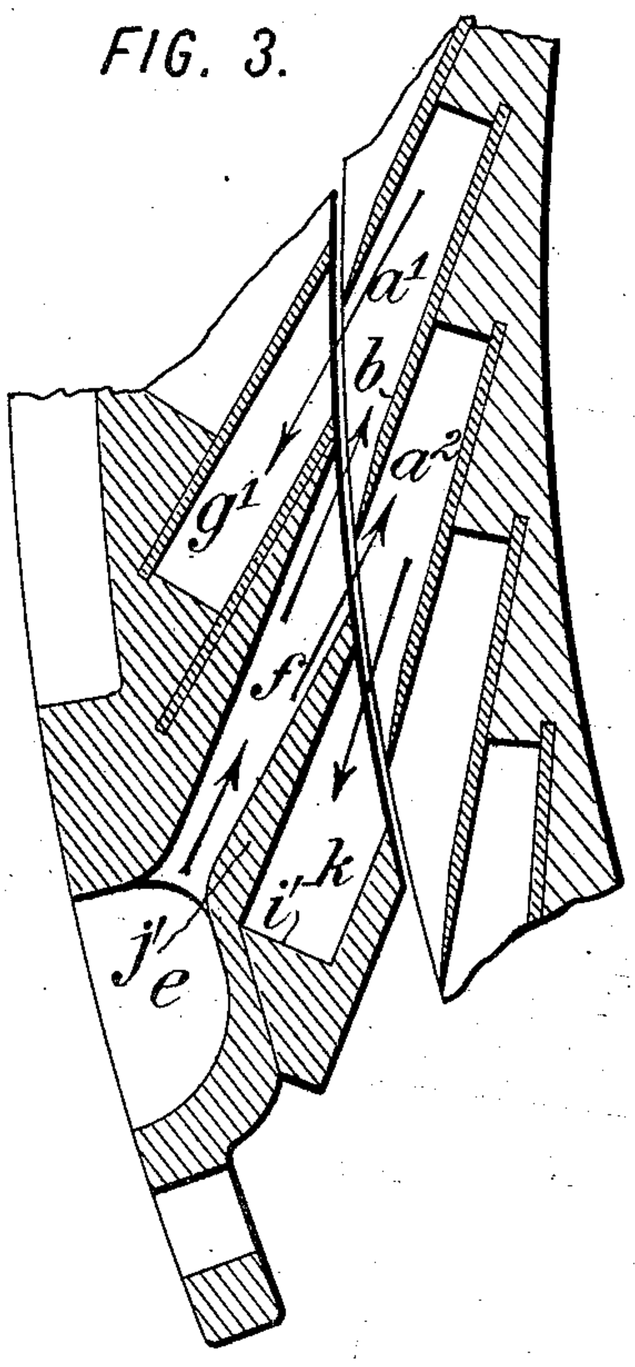



FIG. 4.

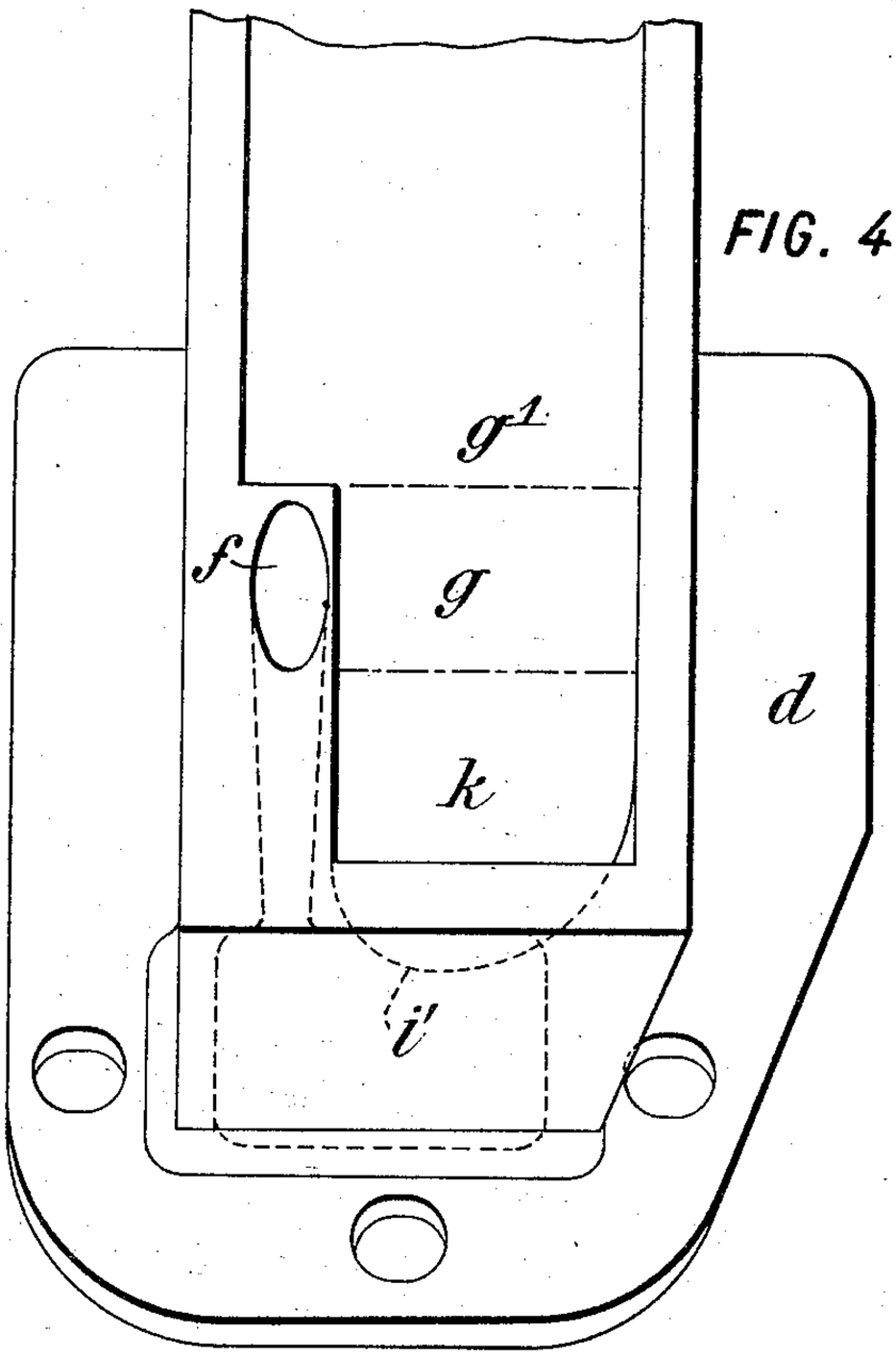
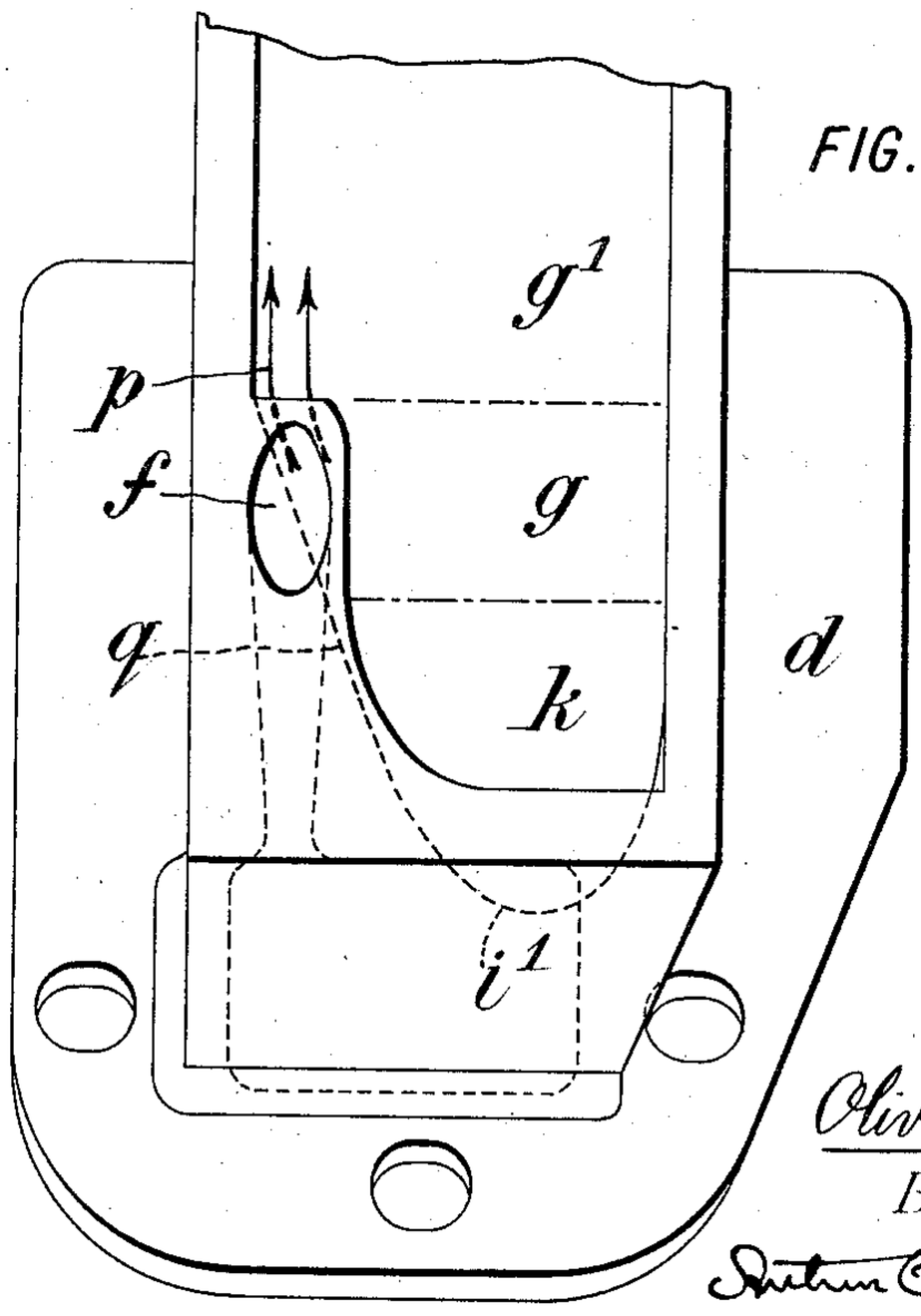



FIG. 5.

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# UNITED STATES PATENT OFFICE.

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## TURBINE.

944,839. Specification of Letters Patent. Patented Dec. 28, 1909.

Application filed May 20, 1909. Serial No. 497,205.

*To all whom it may concern:*

Be it known that I, OLIVER D. H. BENTLEY, a citizen of the United States, residing in the borough of Brooklyn, county of Kings, city and State of New York, have invented certain new and useful Improvements in Turbine-Engines, of which the following is a specification.

This invention relates to turbine engines for steam, compressed air, or other fluid.

In certain well known forms of steam turbines, the rotor is formed with recesses or buckets with rounded bottoms, and the jet nozzle is arranged to direct the jet of steam into these buckets to one side thereof, so that the steam entèring the buckets executes a half turn therein whereby its direction is reversed, and emerges therefrom at the opposite side of the bucket as a stream flowing tangentially backward. The reversed stream is caught in one or more stationary cavities or reversing chambers which commonly are formed in the same casting with the jet nozzle. These chambers have rounded bottoms, so that the steam projected into them from the rotor buckets is given another half turn so that it is caused to again impinge upon the rotor, in the buckets of which its direction may be again reversed so that it may be once more returned to the stationary reversing chambers, wherein it may be again turned back to exert a further impact against the rotor. Thus the steam after emerging from the jet nozzle may make several successive turns, moving forward each time with the rotor buckets, whereby, and because of its expansion, its path will constitute approximately a helix of rapidly increasing pitch.

It is to a turbine of this type that my invention is especially applicable. Heretofore the stationary reversing chambers appurtenant to the nozzle have been located either entirely in advance of the jet nozzle, or both one side thereof and in advance thereof. I have found that with these arrangements there is a waste of energy which it is the object of my invention to economize.

According to my invention I provide a supplemental reversing chamber (one or more) in the rear of the jet nozzle so as to catch such part of the return flow from the rotor buckets as has heretofore escaped behind the jet. This simple addition to the nozzle has the practical effect of attaining a desirable economy whereby the efficiency of the turbine is materially increased.

The accompanying drawings show embodiments of the invention.

Figure 1 is a section in a plane perpendicular to the axis of rotation, being cut mainly along the line 1—1 in Fig. 2, except that the plate of the section is diverted to pass through the jet nozzle. This figure shows both the stationary nozzle and a fragment of the rotor. Fig. 2 is an elevation of the nozzle alone viewed from the interior. Fig. 3 is a fragment of Fig. 1 showing the parts in a different position. Fig. 4 is a view answering to Fig. 2 but showing a modification. Fig. 5 is a similar view to Fig. 4 showing another modification.

Let A designate the rotor and B the nozzle as a whole. In Fig. 1 the rotor is shown as having peripheral buckets *a a* separated by partitions *b b* which are best sharpened at their outer edges after the manner of chisel blades. The particular construction of the buckets is immaterial, but they should be made with rounded or semi-circular bottoms *c*.

The nozzle B in the construction shown is adapted to coact with the peripheral buckets of the rotor A. Hence it is arranged exterior to the rotor. It is shown with an outer flange *d* having bolt holes whereby it may be fastened to the shell or casing of the turbine. It has a cavity *e* which communicates with the steam inlet passage of the casing. From this cavity it has as usual a jet nozzle *f*, which may be of any usual form and location. In addition to the jet nozzle, the nozzle is shown as having stationary reversing chambers or cavities $g$, $g^1$, $g^2$, $g^3$ of greater or less number. The chamber $g$ is shown as arranged with its opening at one side of the opening of the jet nozzle; the chambers $g^1$, $g^2$, $g^3$ are shown as arranged successively in advance of the nozzle and chamber *f g*. These successive chambers should be made of successively greater width in order to accommodate the expanding steam which is thrown back into them from the rotor buckets. The construction of the chambers may be varied, that shown being of the same character as the rotor buckets, that is to say, the cavities are separated from one another by intervening plates or partitions *h h*. A final partition $h'$ closes the last chamber of the series. It is common in nozzles of this char-

acter to employ instead of the successive chambers $g$ $g^1$ etc., a single cavity to the same effect as if the partitions $h$ $h$ were omitted, and this construction also may be availed of in applying my present invention, which is independent of the detail as to whether the nozzle has successive subdivided chambers, or a single cavity. In either case the bottom of the cavity or the bottoms of the successive chambers at $i$, are rounded, being preferably semi-circular in form as shown by the dotted lines in Fig. 2.

So far as described there is no novelty in the construction. In operation, the steam entering through the jet nozzle $f$ impinges upon the rotor, entering the buckets thereof as they successively present themselves in the path of the jet. The nozzle being located at one side, the jet enters the buckets close to one side thereof, and impinging upon the rounded bottoms thereof is given a half turn and emerges toward the opposite sides of the buckets, being thus projected backwardly with somewhat diminished velocity. The lateral expansion of the steam is limited by the centrifugal effect of the whirling jet. The reversed flow of steam thus directed backwardly from the successive buckets, enters one or another of the stationary reversing chambers of the nozzle, partly in the chamber $g$ but mainly in the more advanced chambers $g^1$ etc., and because of the rounded bottoms of these chambers the steam is whirled through another half turn and is again projected forwardly and tangentially against the rotor buckets on the same side thereof as the original jet. Thus the steam whirls first through a rotor bucket, then through one or more of the reversing chambers (or stator buckets), and then again through a succeeding rotor bucket, and so on, until its velocity is so reduced that its energy is substantially exhausted, whereupon it escapes into the casing of the turbine. This is the usual operation, and is here explained only in order that my invention may be fully understood.

The operation thus described would occur precisely as stated, if the relative positions of the jet nozzle $f$ and rotor buckets shown in Fig. 1 could be preserved. In Fig. 1 one of the rotor buckets is shown in exact coincidence with the jet nozzle. In Fig. 3 the rotor is shown as advanced the space of half the width of a bucket compared with Fig. 1, so that the partition $b$ between two buckets stands opposite the middle of the jet nozzle and divides the jet. Obviously if the parts remained stationary in this position, the portion of the jet entering the more advanced bucket $a^1$ would be directed back thereby into the chambers $g$ $g^1$; while that entering the following bucket $a^2$ would only partly return into the chamber $g$, a portion of the steam being wasted by escaping to the rear of the back wall $j$ of the nozzle. But by reason of the extremely rapid rotation of the rotor, the steam is carried forward so rapidly that by far the greater part of it is caught in the reversing chambers of the nozzle, and the small amount of steam escaping to the rear of the nozzle has either not been observed, or has been treated as a negligible quantity. I have discovered, however, that even in high velocity turbines, the loss from this source amounts to a serious impairment of the efficiency of the turbine.

According to my invention I apply to the nozzle B a supplemental reversing chamber $k$, which is arranged just in the rear of the jet nozzle, and is preferably of a width equal to that of the rotor buckets. This supplemental chamber I have shown as constructed by screwing to the ordinary bucket a supplemental shell $m$, although it may as well be formed integrally with the main portion of the nozzle. Like the other chambers, it is preferably made with a semi-circular bottom as shown at $i'$.

I have found by repeated tests that the addition of this supplemental chamber $k$ adds at least six per cent. to the efficiency of the turbine, all other conditions being equal. This result I believe to be due to the fact that the backward flow of steam heretofore occurring from the rotor buckets is caught in the supplemental chamber $k$, and the steam therein is given a half turn or whirled as in the more advanced chambers, so that instead of escaping uselessly, its remaining velocity is utilized to impart a second forward impact to the rotor.

My invention may be somewhat modified without departing from its essential features. For example, the supplemental chamber $k$ instead of being separated from the more advanced chambers by the partition $j$, may be merged therewith as indicated in Fig. 4, where also the partitions $h$ $h$ are shown as omitted, so that the chambers $g$ $g^1$ etc. are also merged together. Nevertheless the functions of these respective chambers are performed without the intervention of the partitions, to nearly the same effect as if the partitions were present. The chamber $k$ may either be made of the full width of the chambers $g^1$ etc., (as shown in Fig. 2), or of the narrower width of the chamber $g$ (as shown in Fig. 4).

In Fig. 5 is shown a modification wherein the reversing chamber $k$ (which may or may not be merged with the chambers $g$, $g^1$ etc.) is made to discharge the reversed stream of fluid in advance of the nozzle $f$, as shown by the arrows $p$. For this purpose the rounded bottom of the chamber $k$ communicates with an under-cut portion $q$ which underlies the jet nozzle $f$. The result is that the reversed jet returned to the rotor impinges upon the latter at a point in advance

of the nozzle instead of at a point in the rear of the nozzle.

What I claim is:—

1. In a fluid turbine, the combination of a rotor having cup-shaped buckets adapted to receive the fluid jet at one side, reverse it and project it backwardly, with a nozzle adapted to direct the jet into one side of the buckets for its first impact, and a stationary reversing chamber located in the rear of the jet nozzle, adapted to receive the backward flow from the rotor buckets and reverse it and return it toward the rotor for a second impact.

2. In a fluid turbine, the combination of a rotor having cup-shaped buckets adapted to receive the fluid jet at one side, reverse it and project it backwardly, with a nozzle adapted to direct the jet into one side of the buckets for its first impact, having a reversing chamber adapted to receive the backward flow from the rotor, reverse it and return it toward the rotor for a second impact, and a supplemental reversing chamber located in the rear of the jet nozzle, adapted to receive such backward flow from the rotor in the rear of the jet nozzle.

3. In a fluid turbine, the combination of a rotor having cup-shaped buckets adapted to receive the fluid jet at one side, reverse it and project it backwardly, with a nozzle adapted to direct the jet into one side of the buckets for its first impact, stationary reversing chambers adapted to receive the backward flow from the rotor, reverse it and return it toward the rotor for a second impact, one of said reversing chambers located in the rear of the jet nozzle.

In witness whereof, I have hereunto signed my name in the presence of two subscribing witnesses.

OLIVER D. H. BENTLEY.

Witnesses:
CHAS. A. HOWARD,
ARCHIE S. MCLUNDIS.