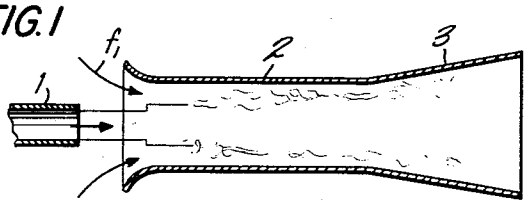
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JET OPERATED DEVICE FOR CIRCULATING OR COMPRESSING A FLUID

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FIG. 1



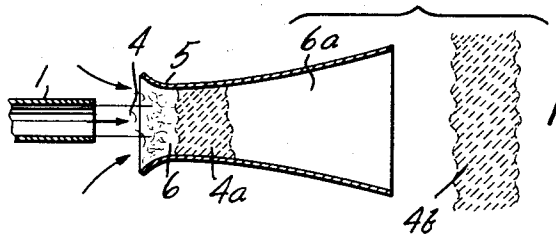
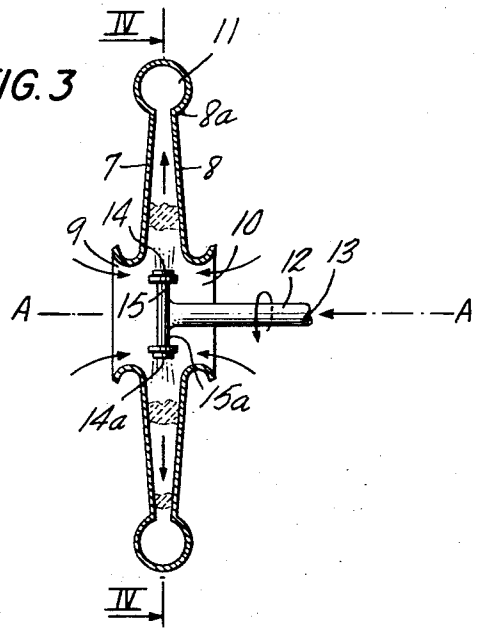


FIG. 2

FIG. 3



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FIG. 4

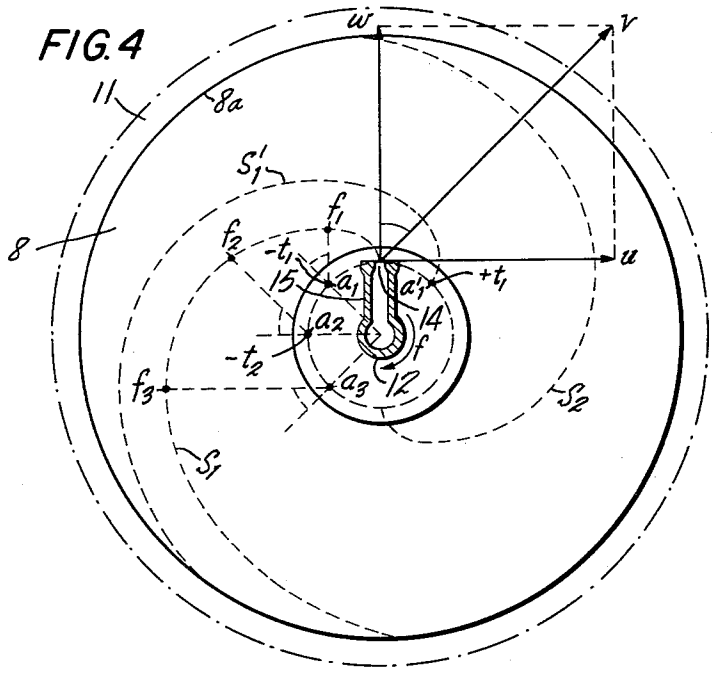
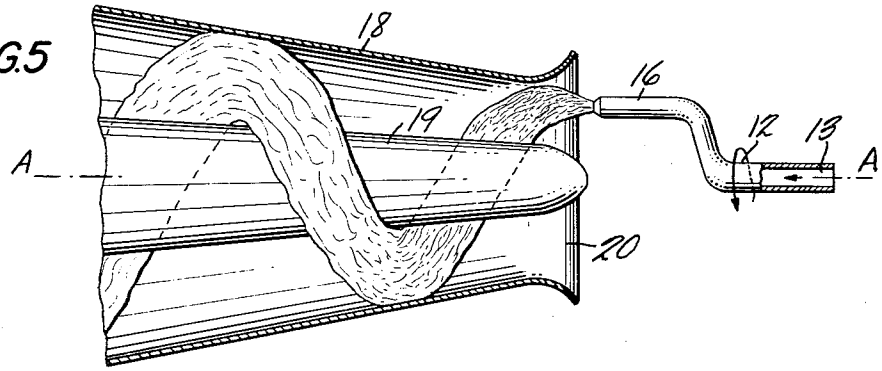


FIG. 5



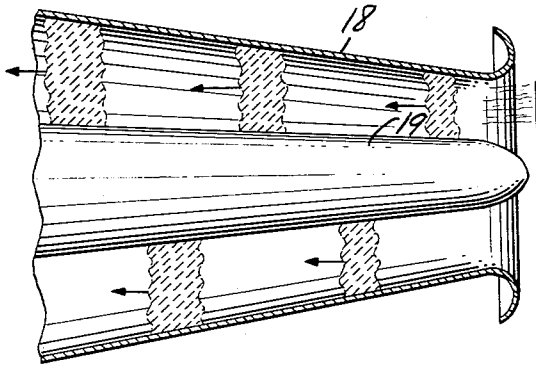
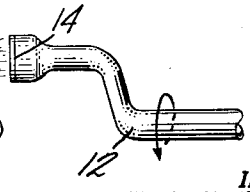


FIG. 6



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FIG.7

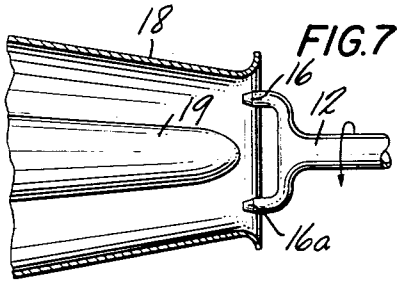


FIG.8

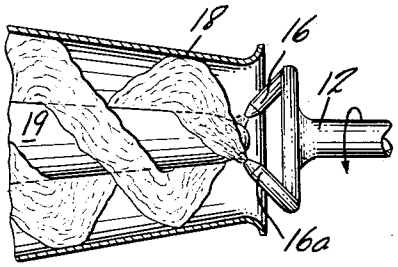


FIG.9

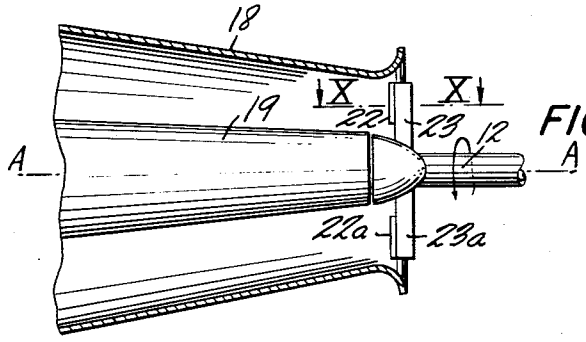
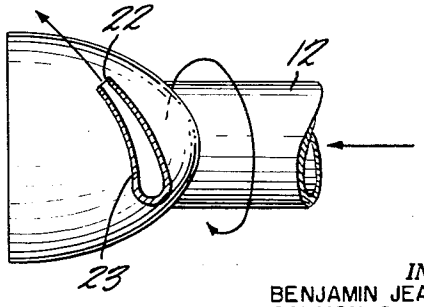


FIG.10



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JET OPERATED DEVICE FOR CIRCULATING OR COMPRESSING A FLUID

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2 Claims. (Cl. 230—108)

The transfer of energy from a primary or energizing flow to a secondary or induced flow to drive the latter flow, can be carried out in two different well known ways: (*a*) by tangential action and mixture, in continuous operation, or (*b*) by thrust or "sandwiching," in intermittent flow.

The conventional jet ejector illustrated in FIG. 1 of the accompanying drawings in an example of (*a*) and comprises a mixing chamber **2** following the nozzle **1** discharging the primary or energizing jet; the induced fluid is entrained, as shown by the arrows f_1, into this chamber which is extended by a diffuser **3** opening into the zone to be fed.

This operation takes place with very poor efficiency owing to the losses due to the formation of the mixture and to the unavoidable vortices.

In the case of (*b*), primary flow is no longer in the form of a continuous jet but in the form of a succession of puffs which push in front of them, as would a piston, slices of secondary fluid enclosed between the puffs.

FIG. 2 of the accompanying drawings illustrates a device of this kind.

A puff of primary fluid is shown at **4** as it issues from the nozzle **1**. It drives in front of it, through the convergent-divergent duct **5**, a slice of secondary fluid **6** behind the previous puff **4***a* which itself pushes before it the previous slice of secondary fluid **6***a*, which lies behind an earlier puff **4***b*, and so on. Discharge takes place in the system to be fed, which is the atmosphere in the illustrated example, the device being then used to augment the thrust of the hot gaseous flow generated in a pulsatory combustion chamber.

This pulsatory drive, acting normally or perpendicularly to the sections of induced fluid, yields high efficiences, but may lead to technical difficulties.

The present invention has for its object to combine the normal action with the tangential action and to allow, starting with a permanent energizing jet and requiring but a relatively simple mechanical device, transfer to the induced flow of an important fraction of the available energy, by normal or frontal action.

In the accompanying drawings:

FIGS. 1 and 2 are explanatory diagrams which have been referred to above.

FIG. 3 is an axial section of an embodiment of the invention.

FIG. 4 is a section on an enlarged scale taken along the line IV—IV of FIG. 3, illustrating the generation of spirals formed by the energizing fluid.

FIG. 5 is an axial section of another embodiment with a helical jet.

FIGS. 6 to 9 are similar sections of four additional embodiments.

FIG. 10 is a section of a detail of FIG. 9, on an enlarged scale, taken along line X—X of this figure.

In the embodiment of FIGS. 3–4, a stationary casing is formed by two flanges **7** and **8** which converge slightly towards the periphery, i.e. whose spacing gradually decreases from the axis A—A of the machine to the periphery, so as to keep a roughly constant radial passage area, as in a compressor. The flanges comprise, along the axis, one or two inlets **9**, **10** for sucking induced fluid and, at

their periphery, the flanges are connected to a volute **11** adapted to collect the compressed fluid. A hollow shaft **12** rotates about axis A—A. This shaft is driven by a motor (not shown) and its bore **13** is fed with energizing fluid under pressure. This fluid issues from slot-like nozzles **14**, **14***a*, which are directed parallel to the axis A—A and which are located at the end of radial arms **15**, **15***a* which are fast with the shaft **12**. The energizing fluid is discharged by the slots **14**, **14***a* in the form of two flat opposite jets which, during the continuous rotation of shaft **12**, sweep the space comprised between the flanges **7** and **8** and extending around axis A—A.

FIG. 4 illustrates this operation. Only one of the arms **15**, rotating in the direction of arrow *f*, and the corresponding slot **14** extending perpendicularly to the plane of the figure, have been drawn. One of the flanges **8**, and the circle **8***a* corresponding to the connection of this flange with the volute **11**, are seen. Owing to the composition of the tangential velocity *u* at which the slot **14** moves, with the velocity *w* of the ejected primary fluid relatively to the slot, the fluid issues with an oblique absolute velocity *v* and moves at this velocity through the space comprised between flanges **7** and **8**. (The velocities are not drawn to scale on the figure because they are much too high and may reach several hundreds of meters per second.)

If the origin of time, or zero time, is taken as corresponding to the position of the members shown in FIG. 4, at the time $-t_1$, slot **14** was at a_1. The fluid then ejected has reached f_1 at zero time, the distance a_1f_1 being equal to the product of *v* by the time difference t_1. At the time $-2t_1$, slot **14** was at a_2 and the fluid it has ejected has reached f_2 at zero time, the distance a_2f_2 being equal to the product of *v* by $2t_1$, and so on. Therefore, at zero time, the fluid previously ejected by the slot **14** lies on a spiral S_1. This spiral moves through the space between flanges **7** and **8**. At the time $+t_1$, slot **14** reaches a'_1 and the fluid spiral at S'_1, pushes in front of it, towards volute **11**, the primary fluid which has entered through inlets **9** and **10**.

The opposite slot **14***a* (not shown in FIG. 4) operates similarly: at zero time, the fluid ejected by this slot lies on a spiral S_2 which moves in like manner.

The device thus constitutes a sort of centrifugal compressor with fluid vanes. As the spirals move, they exert a frontal action on the induced fluid and this frontal action is a cause of good efficiency.

The above explanation is, of course, theoretical since the inducing jet issuing from the slots is assumed to maintain it velocity. However, as the inducing fluid moves away from the slots, the jet formed at the outlet of the slots loses its stiffness, and it spreads out and deteriorates through tangential action and vortical mixture with the induced fluid. This action entails unavoidable losses, but the efficiency is higher than that which is obtainable with a purely tangential action as in the case of FIG. 1. On the other hand, it is convenient to be able to use a continuous inducing jet, contrary to the device of FIG. 2 which requires a pulsating jet.

In the embodiment of FIG. 5, the nozzle **16** forming the inducing jet, rotates about axis A—A which is parallel to the axis of said nozzle but is shifted radially, and is disposed at the inlet of a convergent-divergent duct **18** of revolution about axis A—A and comprising a central body **19**, so that the axis of the nozzle describes the medial line of an annular orifice **20** bounded by body **19** and the wall **18**.

Referring to the analysis shown in FIG. 4 (although in this case the flow is rather more complex since it does not lie in a plane), it will be observed that the flow of inducing fluid has a helical shape and propagates through the space comprised between the duct **18** and the central

body, driving before it, by frontal and tangential action, the induced fluid entering the orifice **20**. Duct **18** and central body **19** must be so shaped that the helical inducing jet sweeps the space between these members while remaining tangential to them. Theoretically, the mean stream-line of the jet ought to describe (neglecting velocity retardation) a single-sheet revolution hyperboloid about axis A—A. In practice, the spreading out of the jet and its retardation will be taken experimentally into account, in order to determine more accurately the adequate wall outlines.

It is advantageous to replace the cylindrical jet by a jet of rectangular shape or, better still, by a sheet-like jet issuing from a thin slot-like nozzle, as in FIGS. 3 and 4. The delimitation of the boundary between the inducing and induced flows is then effected in a more regular way, the separating surfaces having, at the start, rectilinear directrices (FIG. 6).

As in the case of FIG. 3, it is possible to use two or more nozzles **16**, **16***a* (FIG. 7) rotating synchronously, to generate two or more inducing jets.

In the arrangement of FIG. 8, the nozzles **16**, **16***a* generating the inducing jets are inclined with respect to the axis A—A of the system, in a direction opposite to the direction of rotation so as to reduce the magnitude of the tangential component. This arrangement may be particularly useful in the case where the ejection velocity of the inducing jet is too small in comparison with the tangential linear velocity of the nozzles.

The same arrangement is easily applicable to the case of FIGS. 3 and 4, by imparting to the relative velocity w a tangential component, i.e. by using a nozzle whose blowing slot **14** is inclined with respect to the radius.

In the embodiment of FIGS. 9 and 10, the inducing jets in the form of flat sheets are generated by radial slots **22**, **22***a* extending on hollow radial arms **23**, **23***a* which are fast with the hollow rotary shaft **12**. As shown in FIG. 10, the slots **22**, **22***a* may be inclined in order to impart to the injection velocity of the inducing sheet a tangential component which, according to the direction of inclination, is subtracted from the rotation velocity of the nozzle, or is added thereto.

This inclination of the nozzles, such as that of the nozzles shown in FIG. 8, may be used to insure, by reaction, rotation of the shaft **12** carrying them, thus avoiding the use of a motor for driving this shaft.

The radial arms may, of course, be more numerous, for instance there may be 3 or 4 of them. They will preferably be so shaped as to reduce resistance to the induced fluid and possibly to have a favorable interaction with this fluid. Thus, reaction of the fluid on the arms may contribute to their rotation, provided they are shaped as motive vanes similar to turbine vanes, or else, the driving of the arms by a motor or by reaction of the inducing flows may contribute directly to driving the induced flow, provided the arms are shaped as compressor vanes or screw blades. This latter case is illustrated in FIG. 10.

A similar arrangement may be applied to the device of FIGS. 3 and 4, by fixing on shaft **12**, close to the inlets **9** and **10**, vanes or screw blades having a motive or compressive action as set forth above.

All the above-described devices may be operated both with liquid and gaseous flows. Mixed solutions can also be considered, with one of the flows being liquid and the other gaseous.

The applications of the invention are numerous.

The embodiment of FIGS. 3 and 4 is specifically directed to the case of a compressor or fan, whereas the other embodiments may be operated either as compressors or fans, or as jet propulsion units, or as aircraft sustainers or lift producers, the mixture of inducing fluid and induced air in that case issuing into the atmosphere. According to the particular application, the axis A—A will be horizontal or vertical.

What we claim is:

1. An ejector device comprising, in combination, a longitudinally-extending duct having a peripheral wall with said wall defining a convergent inlet end for said duct and said duct being generally divergent away from said convergent inlet end, a hollow rotary shaft coaxial with said duct and disposed at said inlet end, a plurality of hollow vane-shaped arms integral with and extending radially from said hollow shaft toward said wall at said inlet end but the ends of said arms terminating short of said wall and the trailing edges of said vane-shaped arms extending substantially in the transverse plane of smallest cross-section of said duct wherein the convergent portion of said wall is connected to the divergent portion thereof, the interior of said hollow arms communicating with the interior of said hollow shaft, slot-like nozzles formed on said arms and extending along the trailing edges thereof, said nozzles communicating with the interior of said hollow arms, said shaft being adapted to be connected to a supply of fluid under pressure for supplying pressure fluid to said nozzles through the interior of said shaft and said arms, whereby the fluid in issuing from said nozzles forms thin laminar jets directed to move along said duct in a generally helical path.

2. An ejector device as defined in claim 1, wherein each slot-like nozzle is oriented in a direction which is inclined with respect to the radial plane of its arm.

References Cited in the file of this patent

UNITED STATES PATENTS

1,067,883	Skiffington	July 22, 1913
1,653,189	Oliphant	Dec. 20, 1927
1,842,940	Jannin	Jan. 26, 1932
1,900,898	Christie	Mar. 14, 1933

FOREIGN PATENTS

561,787	France	Aug. 17, 1923