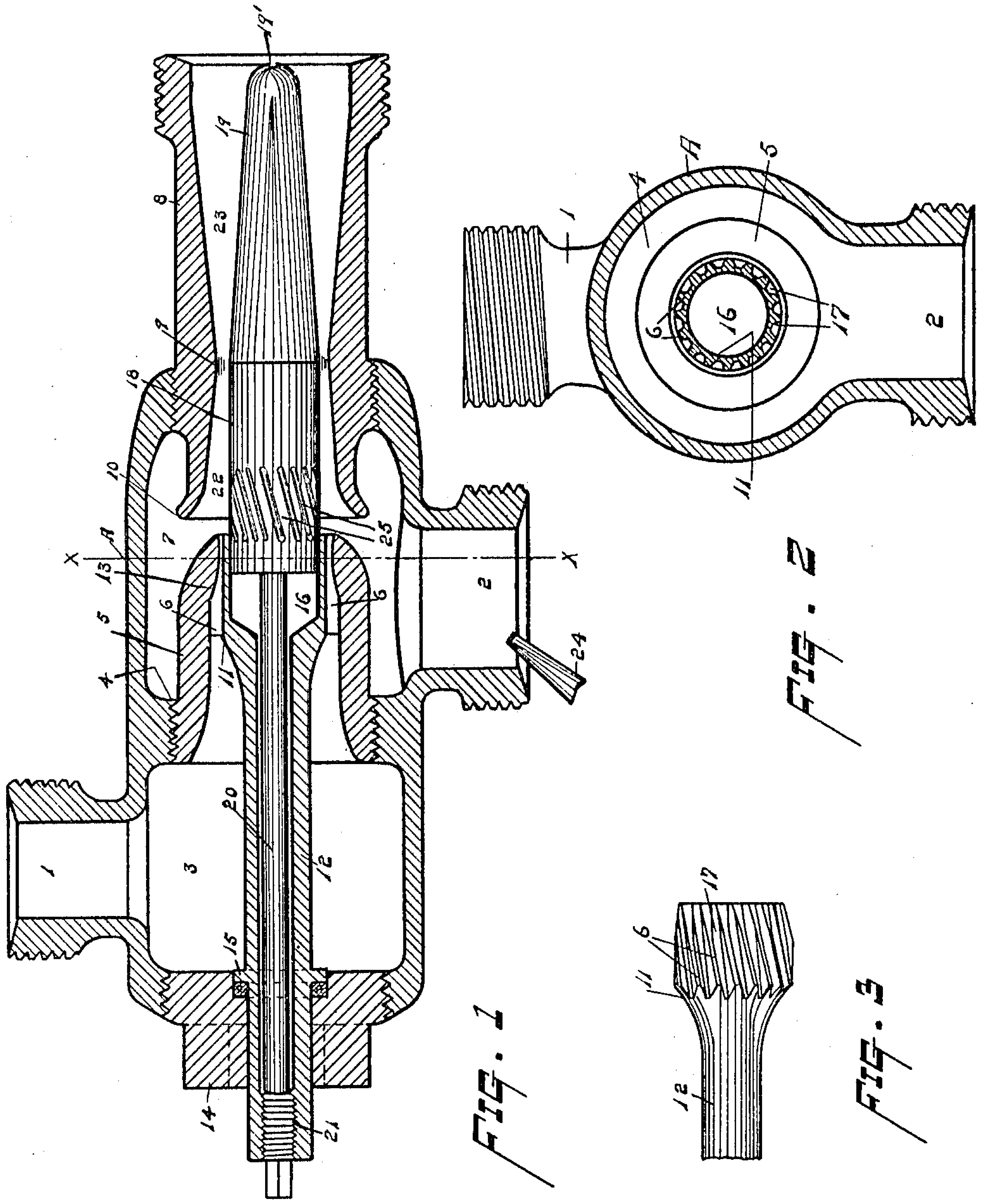
G. C. McFARLANE.

SPIRAL JET INJECTOR.

APPLICATION FILED APR. 1, 1909.

950,598. Patented Mar. 1, 1910.



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SPIRAL-JET INJECTOR.

950,598. Specification of Letters Patent. Patented Mar. 1, 1910.

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To all whom it may concern:

Be it known that I, GEORGE C. McFARLANE, a citizen of the United States, residing at Saginaw, in the county of Saginaw and State of Michigan, have invented certain new and useful Improvements in Spiral-Jet Injectors; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

My invention relates to injectors and is more particularly directed to what I may term a constricting spiral jet injector.

One object of my invention is the provision of an injector which increases the efficiency of this class of jet pumps at least one hundred per cent.

The invention relates to that class of injectors known as lift injectors, wherein a jet of fluid under pressure is employed to lift or raise a body of fluid, the invention being capable of use as an air compressor, a water pump, and a condenser, as well as being adapted for employment in other arts.

Heretofore, so far as I am aware, the pressure jet has been caused to issue from a restricted or conical nozzle in a single column, and it is well known that such injectors, except where used for feeding water to steam boilers through the action of a jet of steam, are far from economical and possess an efficiency of but from 20% to 30%. My invention is designed primarily to increase this efficiency to at least 60% or more and I have ascertained that by dividing the single jet into a plurality of smaller jets arranged annularly and adapted to discharge what might be termed an annular column under pressure, I attain this increased efficiency. This annular series of jets may be arranged to discharge in a direction parallel to the longitudinal axis of the combining chamber, or spirally relative thereto and in the present instance I have shown such jets arranged to discharge a hollow spiral column.

The term "annular" or "hollow column" will be used to indicate a series of jets spaced apart from each other.

While the cross-sectional configuration of the individual jets may be of any desired contour, I prefer that such jets shall each issue from nozzles having a substantially trapezoidal shape with rounded corners, as being that shape best adapted to give the most efficient results.

Another object of my invention is the provision of means located within the combining or suction tube and extending preferably into the forcing tube, such means being arranged within and concentric relative to the annular jet column and adapted to convert the area of the combining tube into an annular chamber, constricted as it nears the juncture of the combining and forcing tube members. In the simplest form this means as a plug or cone may be formed integral with the nozzle member and remain fixed. In a more advanced construction, the plug or cone will be adapted for adjustment to vary the size of the annular opening between the combining and forcing tube members to increase or decrease the load carried inversely as the pressure against which such load moves increases or decreases.

Another object of my invention is the provision of an injector air compressor of simple design and much more compact and portable than the present style.

To these and other ends, therefore, my invention consists in certain novel features and combinations of parts such as will be more fully described hereinafter and particularly pointed out in the claims.

In the accompanying drawings, Figure 1 is a longitudinal cross-sectional view through an injector embodying one form of my invention, Fig. 2 is a cross-sectional view on line *x*—*x* of Fig. 1, and Fig. 3 is a side view of the nozzle construction disassembled from the device.

This invention broadly consists of a series of circularly arranged passages, preferably restricted at their discharge ends and conveniently rifled. These passages separate the pressure fluid into a plurality of jets discharging into an annular combining or suction chamber, such chamber being formed by a constricted tube and an axially disposed spindle, the chamber being provided with a lateral communication to a source of gas or liquid. The chamber at its point of greatest constriction opposite the pressure inlet merges into a flaring forcing tube.

The fluid to be injected is sucked in through the space between the mouth of the combining chamber and the discharge ends of the passages, and passes through the interstices between the jets into the space between the annular jet column and the axial spindle, the fluid traveling in such space toward the forcing tube until it is gripped between the streams or jets as they spread and converge into the throat or point of greatest constriction of the combining tube chamber. The commingled fluids are caused to pass through the throat into the forcing tube which itself constitutes an expanding chamber wherein the velocity head is converted into a pressure head.

Referring to the drawings, A indicates a tubular casing provided with an inlet 1 for the propelling fluid, and an inlet 2 for the inducted fluid, which inlets are preferably offset from each other. The inlet 1 may, in some instances, be located at one end of the casing, as in the usual form of injectors. The inlet 1 communicates with a chamber 3 in the casing, such casing having an interiorly projecting threaded ring 4 located between the inlet and the outlet. One end of a nipple 5 is removably screwed into the internal ring and projects preferably over the inlet 2. The ring 4 and nipple 5 divide the casing into a pressure receiving chamber 3 and a suction chamber 7, the nipple projecting into the suction chamber. A combining and forcing tube 8 is removably received in the outer end of the casing, the inner flared end of the combining tube projecting into the suction chamber in longitudinal alinement with the free end of the nipple 5. The combining and forcing tube is provided with a bore flaring at opposite ends and gradually constricting as it approaches the median portion of the tube, the construction of the bore of the combining end of the tube merging into the constriction of the bore of the forcing tube and forming at that point the throat or *vena contracta* 9. The inner end or mouth of the combining and forcing tube is preferably outwardly flanged as shown at 10, such flange being spaced apart from the free end of the nipple to permit access of the inducted fluid to the combining tube. A filling member is received in the nipple 5, such filling member comprising a peripherally slotted head 11 and a stem 12. By slotting the head, a series of ribs 6 are formed which are preferably gradually reduced in height toward the free end of the nipple, the bore of which nipple is contracted as at 13, to conform to the channeled periphery of the head. Preferably the ribs extend substantially spirally of the head. The stem of the filling member, which stem in the present instance is hollow, extends rearwardly through a cap 14. This cap closes the rear end of the casing A, and its inner face surrounding the stem is countersunk to receive packing material held in place by an annular flange 15 on the stem. The head is recessed as at 16, concentric with the annularly arranged channels 17 between the ribs, to adjustably receive the cylindrical rear end 18 of a conoidal spindle 19 provided with a kerf 19′ at its apex to receive a screw driver. A rod 20 extends rearwardly from the end 18 and is received in the hollow stem 12, a portion of the rod being threaded to engage an internally threaded portion 21 of the stem. The outer end of the rod projects beyond the stem and may be squared to receive a wrench.

In operation, the fluid under pressure is admitted to the receiving chamber 3 through inlet 1, whence it passes through the circularly arranged series of nozzles in a number of fine jets, which discharge into the flaring mouth of the combining tube. It will be observed that the spindle lies in the combining and forcing tube and converts the area thereof into a hollow frusto-conical combining chamber 22 which merges into a similarly shaped forcing chamber 23. The discharge of the fluid under pressure into the larger end of the combining chamber operates in the usual manner common to injectors, to suck in fluid through the inlet 2, such fluid being drawn into the combining chamber, commingled with the motive fluid and discharged into the forcing chamber through the throat 9.

In the adjustment of parts shown in the drawing, the spindle is approximately at its farthest limit in one direction, the line of juncture of the cylindrical portion 18 with the conoidal portion 19 lying concentric relative to the *vena contracta* 9. When in this position, the injector discharges the combined fluid at the highest velocity, against a high pressure by retracting the spindle so that the tapered face lies within the *vena contracta*, a greater amount of inducted fluid will be discharged into the expanding or forcing chamber, at a lower velocity.

More in detail, the operation is as follows: The channels formed between the ribs 6 constitute a circular series of nozzles slightly inclined or reduced at their discharge ends and arranged spirally of the head 11. The outer faces of these channels or grooves are closed by the inner periphery of the nipple 5 whose contracted portion 13 follows the incline or restriction of the nozzles. The channeled or rifled head is received and fits closely in the bore of the nipple. The provision of these channels converts the solid stream usually employed in an injector, into a plurality of smaller jets which discharge into the flaring mouth of the constricted combining chamber, the opening into which is larger than the diameter of the hollow column defined by the jets, it being so arranged that the jets impinge on the tapered wall of the combining tube at a point partway between the flaring mouth and the *vena contracta*.

The jets are approximately rectangular or trapezoidal in cross-section, with rounded corners, the longitudinal axes of the jets being inclined laterally relative to the longitudinal axis of the combining tube and forcer. The jets emerging form a slightly flaring circular grating of fluid and as they impinge against the tapering wall of the combining tube, they spread laterally and unite into a single spirally moving gradually constricted hollow stream.

The fluid to be injected is sucked in through the space between the mouth of the combining tube and the nipple or nozzle ring and passes through the interstices between the jets into the annular space between the circular grid of jets and the centrally disposed spindle. This inducted fluid is gripped between the jets as they spread and converge in the throat and is carried thereby into the forcing or expanding chamber formed by the tapered outer portion of the tube 8 and the oppositely tapered spindle 19. In this chamber the velocity head is converted into a pressure head.

The efficiency of this injector is increased because, as the inducted fluid rushes through the interstices between the jets, a portion of such fluid forms a film or skin, completely surrounding each jet, which film attaches itself instantly, owing to molecular adhesion. Furthermore, a comparatively small portion of the inducted fluid is drawn in between the wall of the combining tube and the grid of jets, but by far the larger portion passes through the interstices of the grid of jets as described.

As the jets spread out and converge into the throat, two sets of currents are generated, one, a longitudinally forwardly traveling spiral current and the other, a series of eddy currents, set up by the wedging action of the motive fluid in the throat. The eddy currents are in the minority and the waves thoroughly commingle the motive and inducted fluids.

The great increase in efficiency of this form of injector over former constructions, jet pumps, or elevators, ejectors and the like, is due to the fact, first, that the motive fluid is subdivided into a plurality of jets preferably arranged to form a circular grid of fluid. Secondly, in the provision of a spindle, projecting into and reducing the area of the combining tube. As a result, the motive jets are caused to pass through and then surround and constrict the induced fluid and in the final stages, when the partially commingled fluids approach the throat, the motive jets roll against the contracting walls of the combining tube, forming eddies which roll forwardly, breaking along the cylindrical portion of the spindle and forcing the inducted liquid into the throat.

In the common type of injector with a solid motive stream discharging in the axial center of the column of fluid entering the throat, the eddies generated, set up a strong back suction of pull along the walls of the throat.

My injector may be used with any motive fluid such as air, steam, water and the like, and may be employed to inject either liquid or gas. It creates a very high vacuum and its efficiency, when using water as a motive fluid to inject water, is 62% as against 30% for the best types of large jet elevators used in placer mining and in the mines of the Comstock lode.

It will be observed that the cylindrical portion of the spindle is smaller in diameter than the diameter of the grid of jets, in order to afford a space for the reception of the inducted liquid and the efficiency of the injector may be increased by fluting the center spindle by means of shallow short grooves 25 preferably arranged under and in line with the jets, and being deepest at a point directly under the orifice of the nozzle, the grooves gradually becoming shallower and finally merging into the cylindrical surface of the spindle. By virtue of these grooves, the streams of inducted fluid passing between the jets, strike the grooves and are shunted up into the motive fluid, commingling therewith and being carried thereby into the expanding chamber.

The cross-sectional area of the annular space inclosed between the grid of jets and the cylindrical portion of the spindle should equal about one-half the area of the throat, or even more, in case the injector is used to force fluid against very high pressures. The rifling of the head 11 constituting the nozzles, should be such that the inner wall of the rifling if prolonged, would intersect the wall of the combining tube at a point in rear of the *vena contracta*. This insures that each jet will spread or be rolled down to the centrally disposed spindle before the stream passes the *vena contracta*, otherwise the injector would not create a high vacuum.

When steam or air under high pressure is used as the motive fluid, the discharge orifice of each nozzle should be slightly flared and in such case the grooves or rifling should be deepened toward the discharge orifice so as to give the orifices an area of from, say, 1.3 to 1.7 greater than the throat of the nozzle. This flare will permit a great increase in the velocity head during its passage from the choke of the nozzle to the discharge orifice and at the same time the fluid has sufficient expansive force left to permit it to expand laterally after emerging and grip the inducted fluid. With a non-expansive fluid as water, the nozzles can have a straight or a choke orifice.

Owing to its high efficiency, this injector may be used as an air compressor, using steam as the motive fluid or water under pressure. In case steam is used, it is necessary to direct a jet of water under good pressure into the suction inlet or chamber, such jet being arranged to impinge against a wall and break into spray, which is sucked in with the air and operates to condense the steam before the latter reaches the throat of the combining and forcing tube. To attain this end, I have shown the suction inlet 2 as equipped with a nozzle 24, adapted to discharge a stream of water across the inlet, the stream impinging against the flange 10 which breaks it into spray. By this means, the steam is condensed without any appreciable loss of its velocity head and the inducted air is more thoroughly commingled with the condensed steam, thereby effecting a greater efficiency.

It is evident that changes might be made in the form and arrangement of the several parts described without departing from the spirit and scope of my invention.

Having thus fully disclosed my invention, what I claim as new is—

1. An injector comprising a casing provided with inlets for the motive and for the inducted fluids respectively, a combining tube in communication with the inducted fluid inlet, a nozzle member provided with a seat surrounded by a series of nozzles, and a spindle adjustably received in the seat and projecting into the combining tube.

2. An injector comprising a casing having inlets for the motive fluid and for the inducted fluid respectively, a combining tube contracted intermediate its ends, the inner end being in communication with the inlet for the inducted fluid, a nozzle member comprising a suitably supported recessed head adapted to discharge a series of jets of motive fluid arranged annularly, into the combining tube, a spindle seated in the recess in the head and projecting into the combining tube, the spindle inclosed within the annular series of jets which are spaced apart therefrom, and an adjustably supported rod connected to the spindle, the juncture of the tapered and cylindrical portions of the spindle adapted to coöperate with the contracted portion of the tube.

3. An injector comprising a casing having inlets for the motive fluid and for the inducted fluid respectively, a nipple connected with the casing intermediate the inlets and dividing the casing into receiving and suction chambers respectively, a combining tube, a filling member, the head of which is received in the nipple, the filling member being apertured to discharge a series of jets into the combining tube, a hollow stem extending rearwardly from the head across the receiving chamber, a cap closing the rear end of the casing, the stem passing through the cap, a spindle projecting forwardly from the head into the combining tube, and a rod adjustably received in the stem and connected to the spindle.

4. In an injector, the combination with a casing having inlets for the motive and inducted fluids respectively, an apertured head suitably received in the casing between the inlets, the head provided with a hollow stem, a spindle movable relative to the head, a rod on the spindle receivable in the hollow stem, the rod projecting beyond the casing, the apertures in the head surrounding the spindle and spaced apart therefrom.

In testimony whereof, I affix my signature in presence of two witnesses.

GEORGE C. McFARLANE.

Witnesses:
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