

June 23, 1953

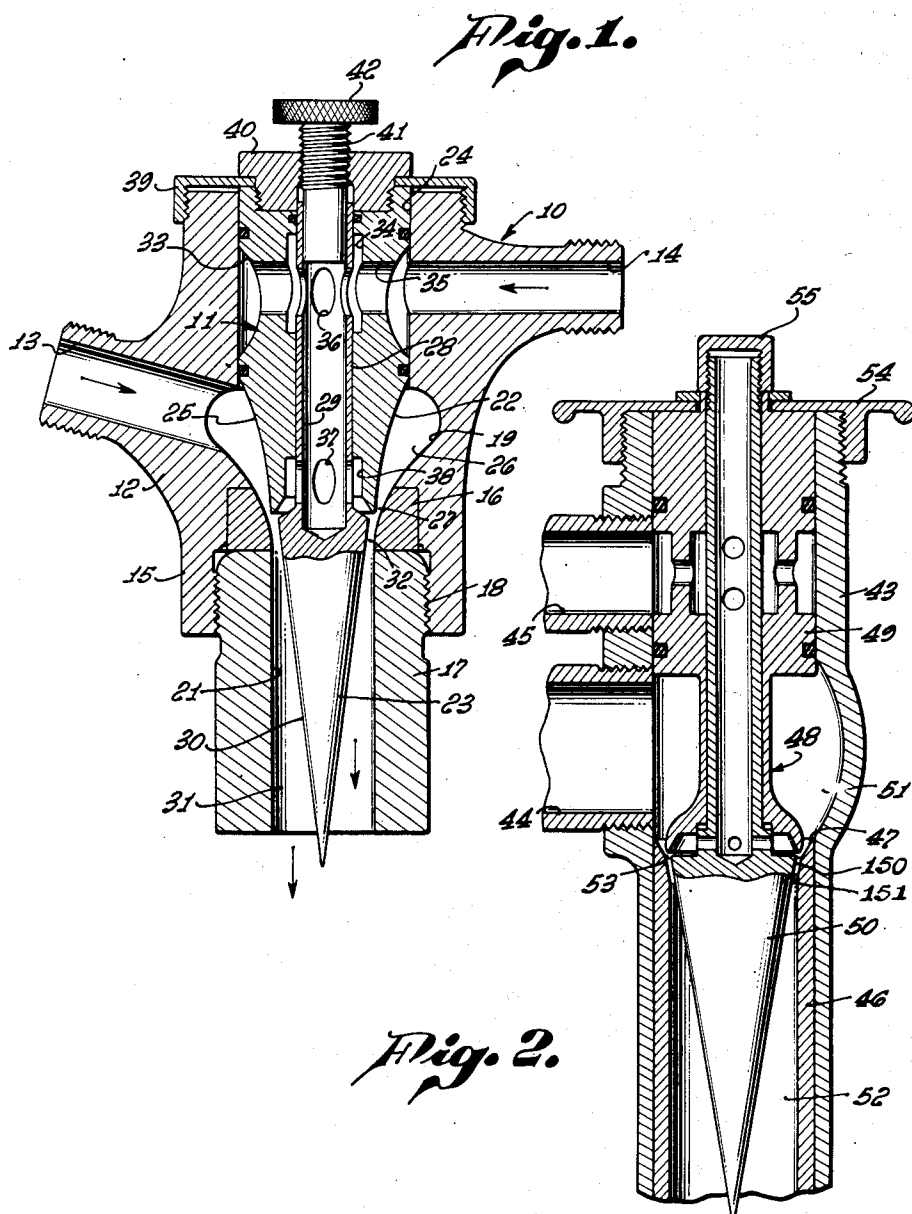
L. B. WOODRUFF ET AL

2,642,813

ASPIRATOR

Filed Feb. 13, 1950

2 Sheets-Sheet 1



JAMES D. ALCORN,
LEE B. WOODRUFF,
HENRY H. HAMMERSTROM,
INVENTOR.

BY *Marlin White*

ATTORNEY.

June 23, 1953

L. B. WOODRUFF ET AL

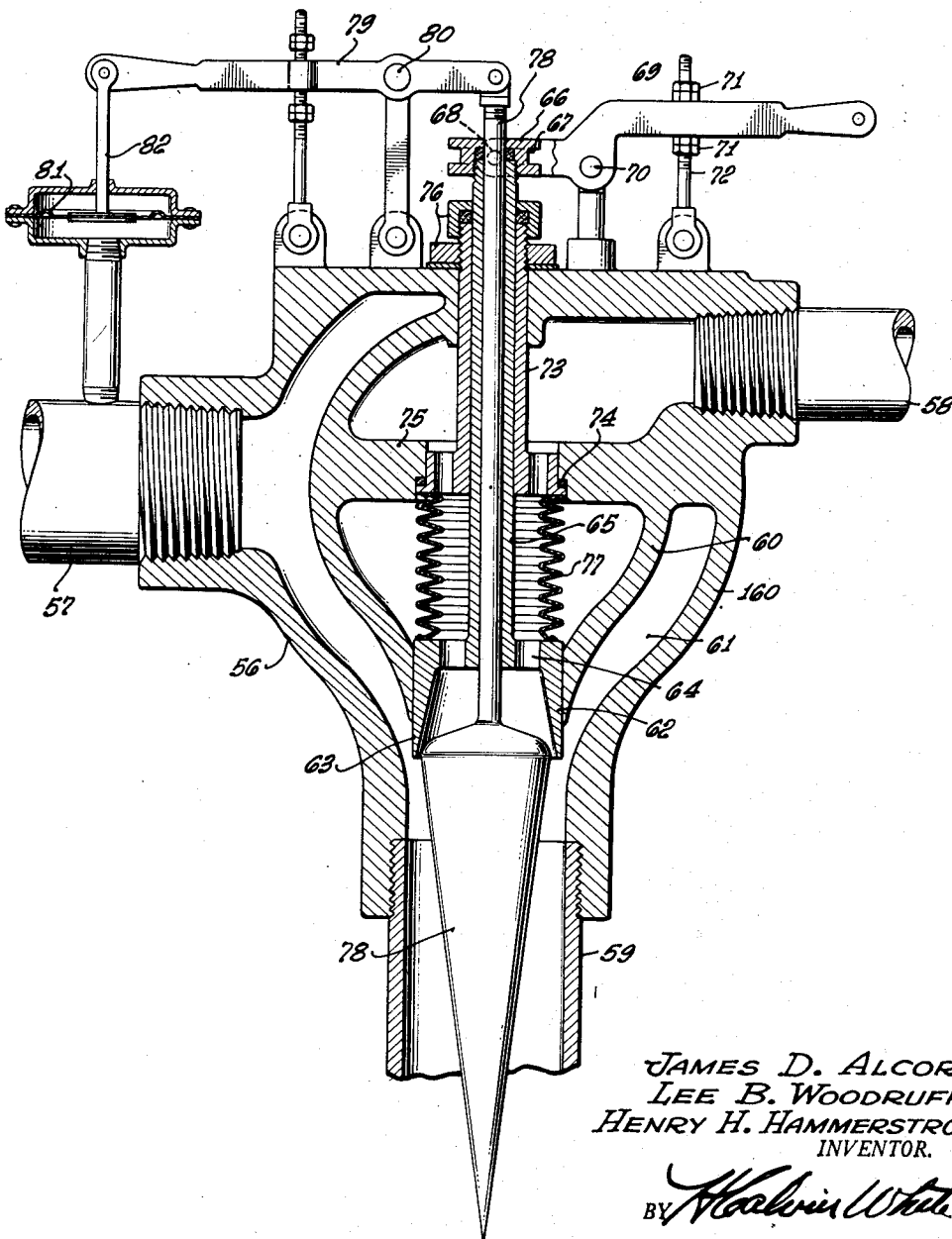
2,642,813

ASPIRATOR

Filed Feb. 13, 1950

2 Sheets-Sheet 2

Fig. 3.



JAMES D. ALCORN,
LEE B. WOODRUFF,
HENRY H. HAMMERSTROM,
INVENTOR.

BY *Maxwell White*

ATTORNEY.

UNITED STATES PATENT OFFICE

2,642,813

ASPIRATOR

Lee B. Woodruff, Los Angeles, James D. Alcorn,
South Pasadena, and Henry H. Hammerstrom,
Los Angeles, Calif.

Application February 13, 1950, Serial No. 143,936

9 Claims. (Cl. 103—271)

1

This invention relates generally to improved fluid aspirators, that is, devices in which two or more fluids are brought together in such relation that the motive power of one acts to entrain and transfer the other in intimate mixtures.

Aspirators or ejectors of the conventional Venturi type have long been widely used as pumps, condensers, aerators, mixers and the like, and their uses are continually expanding in a wide variety of fields. This popularity is due primarily to the ruggedness and simplicity of such ejectors and in certain instances to the fact that a particular result cannot be achieved as well or at all by other means. However, all prior ejectors with which we are acquainted have had at least one common disadvantage which has materially decreased their effectiveness in most situations and has entirely prevented their use in other instances. Specifically, the underlying theory of operation of the Venturi type ejector is such as to preclude any possibility of adjustment or regulation of the device to operate satisfactorily under varying or unpredictable inlet and outlet pressure or temperature conditions. For reasons that need not be discussed in detail at this point, such a device must be constructed for operation at predetermined pressures and to handle a predetermined rate of flow, and any appreciable deviation from design conditions immediately decreases the operating efficiency of the ejector often to an extent rendering the device virtually useless.

The extreme importance of this limitation of the conventional ejector is apparent from a realization of the fact that, in a large majority of the situations in which ejectors are used, the fluid pressures do not remain constant, but vary considerably over a relatively wide range. Consequently, the ejector operates effectively only a very small percentage of the time, that is, only during those periods when the pressures happen to be approximately at the rated values.

A major object of the present invention is to provide an aspirator having all of the advantages of the conventional Venturi type ejector and yet which is so designed that adjustments may be quickly and easily made to compensate for changes in operating pressures and flow conditions. As a result, the device may be set to function at peak efficiency under any conditions within a relatively wide range. As will appear, this adjustment may be manual or effected by an automatic control apparatus responsive to changes in such conditions as the pressures of either or both fluid inlet stream.

2

Further contemplated is the provision of an aspirator type device in which the intermixture of the primary and secondary fluids is more complete and rapid than in prior arrangements.

Another major disadvantage of the conventional Venturi type ejector lies in its inherent inability to function effectively in any relatively large size. As is well known in the art, when the attempt is made to enlarge the passages of such an ejector, the effectiveness of the device drops off rapidly and soon reaches a point at which the ejector will not serve its intended purpose. This of course narrowly limits or prevents the use of the ejector for such purposes as the aeration of sewage where large volumes of fluid must be handled to attain any appreciable result. A particular object of the present invention is therefore to provide an aspirator which is so designed as to function in any size or capacity which might be desired. Aspirators embodying the invention have been constructed in sizes up to several feet in diameter and have functioned in those sizes with little or no decrease in efficiency.

To achieve the above and other objects, devices embodying the invention direct the primary and secondary fluids through separate annular inlet passages of progressively decreasing sectional area to form two concentric annular streams of increased velocity and decreased static pressure. These streams impinge together at or near the point of maximum velocity of each to thoroughly intermix and then discharge as an expanding annular stream eventually converting to a solid stream of decreased velocity and increased pressure. Adjustment of the device to operate at maximum efficiency under any particular pressure and volume flow conditions is attained by regulation of the dimensions of the two annular inlet passages and of the common passage through which the mixed fluids discharge together.

Structurally, an aspirator embodying the invention includes a tubular body containing an inner flow controlling unit about which the primary fluid passes in traveling between a body inlet and outlet. The flow controlling unit may comprise a pair of sections, one of which forms with the inner body wall a restricted primary fluid passage, and the other of which forms with the body wall a fluid discharge passage of expanding sectional area. The secondary fluid is introduced by passage annularly outwardly between these two sections and into the primary stream. Axial movement of the sections relative to each other and to the body effects a varia-

3

tion in the dimensions of the inlet and outlet passages to permit adjustment of the apparatus for most efficient operation under any prevailing pressure conditions.

The above and further features and objects of the present invention will be better understood from the following detailed description of the typical embodiments illustrated in the accompanying drawings, in which:

Fig. 1 is a central longitudinal section through a first form of flow controlling device embodying the invention and particularly designed for use as a sewage aerating aspirator;

Fig. 2 is a similar view of a second form of device which we have found to be especially well suited for proportioning gas and air being supplied to a burner; and

Fig. 3 shows a third form of flow control device in which adjustment of the apparatus is effected automatically in response to changes in the fluid inlet pressures.

Referring first to Fig. 1, the aspirator there shown comprises essentially an outer tubular body generally indicated at 10 and an inner two-section flow controlling unit 11 extending axially within the body. The body is formed sectionally, and includes an upper tubular main section 12 having a pair of side inlets 13 and 14 and having a downwardly extending tubular outlet portion 15. The body also includes an annular replaceable fluid directing insert 16 received within the depending discharge portion 15 of the main body section, and a tubular downwardly extending discharge section 17 threadedly mounted to the main body section at 18 to retain insert 16 in position. Beneath fluid inlet 13, main body section 12 and insert 16 form together an annular downwardly converging inner wall 19 merging at its lower end with the inner cylindrical wall 21 of lower body section 17.

The inner flow controlling unit 11 includes two sections 22 and 23. The first of these sections is slidably guided for axial movement by reception of its upper end within bore 24 of body section 12. Opposite end beneath inlet 13, section 22 of the flow controlling unit has an outer smoothly curved and slightly converging annular surface 25 forming with the inner surface 19 of the body an annular passage 26 of progressively decreasing transverse section into which fluid from inlet 13 usually the primary or motive fluid is directed. As this fluid flows through passage 26, its velocity increases to a maximum at the most restricted portion 27 of the passage. As will appear later, the second dry fluid is introduced into the annular stream of this first fluid substantially at or near this location of maximum velocity to thus assure a highly effective aspirator action.

Section 23 of the flow controlling unit has an upper tubular portion 28 guided for axial movement by reception in the central bore 29 of section 22. Section 23 also includes at its lower end a fluid directing portion 30 tapering downwardly to a point to form with the inner cylindrical surface 21 of the body a fluid discharge passage 31 of progressively increasing transverse section. The upper narrowest portion 32 of this discharge passage is of somewhat greater sectional area than the narrowest portion 27 of the primary fluid inlet passage 26 since both fluids discharge together through this passage.

The secondary fluid is directed inwardly into section 23 from inlet 14 through outer annular passage 33, radial passage 35, and inner annular

4

passage 34 of section 22, and through openings 36 of section 23. This fluid then flows downwardly within section 23 and outwardly through lower openings 37 into counterbore 38 of section 22, to pass outwardly between the two sections in the form of an annular stream entering the stream of the first fluid. It is particularly noted that the path of the secondary fluid progressively decreases in sectional area as the fluid passes outwardly and is most constricted at the point of introduction of the secondary fluid into the primary stream. Consequently, the secondary fluid attains its maximum velocity at that point.

Axial adjustment of the flow controlling unit is effected by rotation of adjusting nut 39, which is axially fixed relative to section 22 by retaining nut 40. Independent axial adjustment of section 23 is effected by rotation of threaded plug 41 through knob 42, the plug being suitably secured in any manner to section 23, as by forced reception within its upper tubular portion.

In using the form of aspirator shown in Fig. 1, a first or primary fluid under considerable pressure would ordinarily be introduced into the body through inlet 13 to flow downwardly about the flow controlling unit through passages 26 and 31. The maximum velocity and consequently the lowest pressure attained in passage 26 would be reached at the portion 27 of that passage having the smallest sectional area. A second fluid, usually under relatively low pressure, is introduced into the body through inlet 14 to flow downwardly within the flow controlling unit and to pass outwardly in an annular stream between the two sections of that unit. The high velocity annular stream of the primary fluid serves to carry along with it the secondary fluid, and these fluids then flow together through passage 31 in which their velocity slowly decreases and the pressure increases.

As will be appreciated, the operation of the apparatus must be materially affected by the minimum dimensions of passages 26 and 31 as well as by the minimum annular spacing between the two sections at the point of introduction of the secondary fluid into the primary stream. It has been discovered that, for any particular set of inlet and discharge pressures, there is a corresponding optimum setting for the two sections of the inner flow controlling unit. Consequently upon initial installation, nut 39 and knob 42 are manually adjusted to vary the dimensions of these various passages until the most satisfactory operation is attained under the prevailing pressure conditions. If one of the pressures subsequently changes, the position of one or both of the sections of the flow controlling unit may be varied to compensate for that change. For instance section 23 may be moved axially to increase or decrease the size of the secondary fluid passage while also altering the discharge passage dimension, or the unit as a whole may be moved to change the size of the primary fluid and discharge passages. As will be appreciated, means may of course be provided for adjusting section 22 independently of section 23 where that adjustment might be desirable. Thus, an infinite variety of adjustments is possible to meet virtually any operating condition which may arise. As brought out in the introduction, no prior aspirator with which we are acquainted has been adjustable in this manner to operate effectively under different pressure conditions, and this advantage is considered to be one of the most important features of the present invention.

5

The device shown in Fig. 2 is generally the same as that shown in Fig. 1, differing primarily only in the shapes of the various fluid passages. The contours of the passage forming surfaces in Fig. 2 are of a design found especially effective for the mixing of gas and air flowing to a burner.

The device of Fig. 2 comprises essentially a tubular body 43 having lateral inlets 44 and 45 and adapted to discharge downwardly as in Fig. 1. A tubular insert 46 is received within the lower portion of body 43, and has at its upper end a tapering or converging surface 47 corresponding to surface 19 of Fig. 1. The upper portion of surface 47 preferably extends at a greater angle than its lower portion, as this arrangement has been found most satisfactory for the present purpose.

The inner flow controlling unit 48 comprises a pair of sections 49 and 50 forming with the inner wall of the body a primary fluid inlet passage 51 of decreasing transverse section and an annular discharge passage 52 of increasing section. The secondary fluid is introduced through inlet 45 to pass inwardly and then downwardly within the sections of the flow controlling unit and to then pass outwardly at 53 in an annular stream joining with the stream of the primary fluid at approximately the instant of maximum velocity of both. Axial adjustment of the flow controlling unit is effected by rotation of adjusting nut 54, and adjustment of section 50 separately is effected by rotation of nut 55. Operation of this second form of the invention corresponds to the operation of the Fig. 1 form, and will not be discussed in detail.

Increased efficiency is attained by directing the two fluids, after their combination into a single stream, through a relatively restricted guiding passage formed by a pair of radially opposed parallel and tapering surfaces. In Fig. 2, the upper end of section 50 forms one of these opposed parallel surfaces, designated at 150, and the other surface is the lower portion 151 of surface 47 on the body insert. Preferably, these parallel surfaces are frusto-conical, as shown, and positioned directly adjacent and downstream from the point at which the primary and secondary fluids are combined. To assure most effective control of the combined fluid stream, the parallel-sided passage should be of substantial axial extent, and preferably has greater axial than radial extent.

Fig. 3 illustrates a third form of aspirator and one in which the adjustment of the sections of the flow controlling unit is effected automatically in accordance with changes in the fluid inlet pressures. In this form as in the others, the device includes a body 56 having a pair of lateral inlets 57 and 58 and having downwardly extending discharge 59. The body itself includes an inner annular wall 60 spaced from the outer wall 160 of the body and forming with that wall a downwardly converging annular passage 61 through which fluid entering inlet 57 is directed. As will be appreciated this inner body wall, in forming with the outer wall an annular passage of decreasing transverse section, performs one of the functions of the inner flow controlling unit in the other two forms.

The adjustable portions of the flow controlling unit in this form include an upper section 62 guided for axial movement within a bore formed in the lower end of annular wall 60 and having a lower end 63 forming with the outer wall of the body the narrowest portion of the primary

6

fluid inlet passage. Section 62 has a transverse upper wall 64 containing fluid passing openings and carrying at its center an upwardly extending tubular control rod 65. At its upper end, rod 65 rigidly carries a circular head 66 having an annular groove 67 in its outer surface within which a pair of inwardly directed pins 68 carried by lever arm 69 are received. This lever is pivotable about a fulcrum 70 to adjust the vertical position of section 62 of the flow controlling unit and may be set in any condition by nuts 71 carried by bolts 72 extending upwardly from the body.

Rod 65 is guided for axial movement by passage through a tubular member 73, whose lower perforated flange end 74 bears upwardly against transverse wall 75 of the body and whose upper end carries tightening and packing nuts 76. Flexible pressure responsive bellows 77 extends vertically between the lower surface of member 73 and the upper surface of section 62 of the flow controlling unit. Fluid entering inlet 58 passes downwardly through the openings in flange 74 of member 73, then through bellows 77, and finally through the openings in member 62 to pass outwardly between the two sections of the flow controlling unit.

The lower section 78 of the flow controlling unit is of the same general tapering configuration as in previous forms, and has an upwardly extending control shaft 79 guided for axial movement by passage through rod 65. Lever 79, fulcrummed at 80, regulates the axial positions of section 78, and is itself automatically actuated in response to changes in fluid pressure at inlet 57. For this purpose, we provide a pressure responsive diaphragm 81 in communication at one side with the fluid at inlet 57 and mechanically connected through arm 82 to lever 79.

In the operation of the apparatus shown in Fig. 3, a first fluid enters inlet 57 to pass downwardly through converging passage 61 and to attain its highest velocity upon passing the lower end of section 62 of the flow controlling unit. The second fluid enters inlet 58 and passes downwardly through the bellows to flow annularly outwardly into the stream of the primary fluid and to discharge with that fluid through the lower end of the body. Upon variation of the pressure at inlet 57, diaphragm 81 responds to correspondingly displace section 78 of the flow controlling unit to thereby compensate for the change in pressure in a manner such that peak efficiency of the apparatus is maintained. Similarly, upon variation of the pressure at inlet 58, bellows 77 responds to displace section 62 (assuming that the section has not been preset in a desired position by tightening of nuts 71 against lever 69).

We claim:

1. An aspirator comprising a tubular fluid passing body having a fluid inlet and an outlet spaced axially therefrom, said body having an inner wall with an annular tapering portion, an inner flow controlling unit within said body and about which fluid passing between said inlet and outlet flows, said unit including a first section having an annular outer surface forming with the inner wall of said body an annular relatively restricted first passage into which a first fluid is directed from said inlet, said unit including a second section having an annular outer surface downstream from said outer surface of the first section and forming with said body wall a discharge passage of progressively increasing transverse section leading to the out-

let end of the body, said first passage and said discharge passage each having a most restricted portion of minimum cross-sectional area, said sections having proximate annular outer portions in annularly spaced relation on which said outer surfaces are formed, said unit containing a passage communicable with a supply of a second fluid and leading said second fluid into the space between said outer portions of the sections for discharge through said space in an annular stream into the stream of said first fluid, said outer surfaces of the sections having annular portion near the point of introduction of said second fluid and opposite said tapering portion of the body wall and forming therewith said most restricted portions of the passages between said outer surfaces respectively and the body wall, and means mounting both of said sections for axial movement relative to each other and to said tapering portion of the body wall to vary the sectional area of said most restricted passage portions, and two individual control units operable to vary the positions of said two sections in accordance with the pressures of said two fluids respectively.

2. An aspirator comprising a tubular fluid passing body having a fluid inlet and an outlet spaced axially therefrom, said body having an inner wall with an annular tapering portion, an inner flow controlling unit within said body and about which fluid passing between said inlet and outlet flows, said unit including a first section having an annular outer surface forming with the inner wall of said body an annular relatively restricted first passage into which a first fluid is directed from said inlet, said unit including a second section having an annular outer surface downstream from said outer surface of the first section and forming with said body wall a discharge passage of progressively increasing transverse section leading to the outlet end of the body, said first passage and said discharge passage each having a most restricted portion of minimum cross-sectional area, said sections having proximate annular outer portions in annularly spaced relation on which said outer surfaces are formed, said unit containing a passage communicable with a supply of a second fluid and leading said second fluid into the space between said outer portions of the sections for discharge through said space in an annular stream into the stream of said first fluid, said outer surfaces of the sections having annular portion near the point of introduction of said second fluid and opposite said tapering portion of the body wall and forming therewith said most restricted portions of the passages between said outer surfaces respectively and the body wall, and means mounting both of said sections for axial movement relative to said tapering portion of the body wall to vary the sectional area of said most restricted passage portions.

3. An aspirator comprising a tubular fluid passing body having a fluid inlet and an outlet spaced axially therefrom, said body having an inner wall with an annular tapering portion, an inner flow controlling unit within said body and about which fluid passing between said inlet and outlet flows, said unit including a first section having an annular outer surface forming with the inner wall of said body an annular relatively restricted first passage into which a first fluid is directed from said inlet, said unit including a second section having an annular outer surface downstream from said

outer surface of the first section and forming with said body wall a discharge passage of progressively increasing transverse section leading to the outlet end of the body, said first passage and said discharge passage each having a most restricted portion of minimum cross-sectional area, said sections having proximate annular outer portions in annularly spaced relation on which said outer surfaces are formed, said unit containing a passage communicable with a supply of a second fluid and leading said second fluid into the space between said outer portions of the sections for discharge through said space in an annular stream into the stream of said first fluid, said outer surfaces of the sections having annular portion near the point of introduction of said second fluid and opposite said tapering portion of the body wall and forming therewith said most restricted portions of the passages between said outer surfaces respectively and the body wall, and means mounting said sections for axial movement relative to said tapering portion of the body wall to vary the sectional area of said most restricted portions of the passages, and for relative axial movement to vary the distance between said outer portions thereof to thereby vary the flow of said second fluid.

4. An aspirator comprising a tubular fluid passing body having a fluid inlet and an outlet spaced axially therefrom, a flow controlling unit extending axially within said body and about which a first fluid flows in passing between said inlet and outlet, said unit including a first section having an outer surface spaced from the body and forming therewith a passage through which said first fluid flows, said unit including a second section having an outer surface downstream from said outer surface of the first section and spaced from the body, said unit containing a passage communicable with a supply of a second fluid and directing said second fluid from within the unit into the stream of said first fluid at a location between said outer surfaces of the sections, said outer surface of the second section and an inner surface of the body wall having radially opposed substantially parallel and tapering portions of substantial axial extents between which both fluids flow toward said outlet, and said outer surface of the second section having downstream from said parallel surfaces a tapering portion forming with the opposed body wall a discharge passage of progressively increasing transverse section leading toward said outlet.

5. An aspirator as recited in claim 4, in which said parallel surface portions are located directly adjacent and downstream from the point of introduction of the second fluid into the stream of the first fluid.

6. An aspirator comprising a tubular fluid passing body having a fluid inlet and an outlet spaced axially therefrom, a flow controlling unit extending axially within said body and about which a first fluid flows in passing between said inlet and outlet, said unit including a first section having an outer surface spaced from the body and forming therewith a passage through which said first fluid flows, said unit including a second section having an outer surface downstream from said outer surface of the first section and spaced from the body, said unit containing a passage communicable with a supply of a second fluid and directing said second fluid from within the unit into the stream of said first

9

fluid at a location between said outer surfaces of the sections, said outer surface of the second section and an inner surface of the body wall having radially opposed substantially parallel and tapering portions between which both fluids flow toward said outlet and forming therebetween a parallel-sided passage having a greater axial than radial extent, and said outer surface of the second section having downstream from said parallel surfaces a tapering portion forming with the opposed body wall a discharge passage of progressively increasing transverse section leading toward said outlet.

7. An aspirator as recited in claim 6, including means mounting said sections for axial adjusting movement relative to each other and to the body.

8. An aspirator as recited in claim 6, in which said body has a converging annular wall radially

10

opposite said outer surface of the first unit section.

9. An aspirator as recited in claim 4, in which said parallel surface portions are substantially frusto-conical and of sufficient extent to form therebetween a converging parallel-sided passage having a greater axial than radial extent.

LEE B. WOODRUFF.

JAMES D. ALCORN.

HENRY H. HAMMERSTROM.

References Cited in the file of this patent

UNITED STATES PATENTS

15 Number	Name	Date
207,827	Starbuck -----	Sept. 10, 1878
571,692	Schneible -----	Nov. 17, 1896
950,598	McFarlane -----	Mar. 1, 1910
1,555,030	Schmidt -----	Sept. 29, 1925