July 31, 1945. A. J. POOLE 2,380,463

FLUENT FUEL BURNER

Filed June 23, 1942

Fig. 1

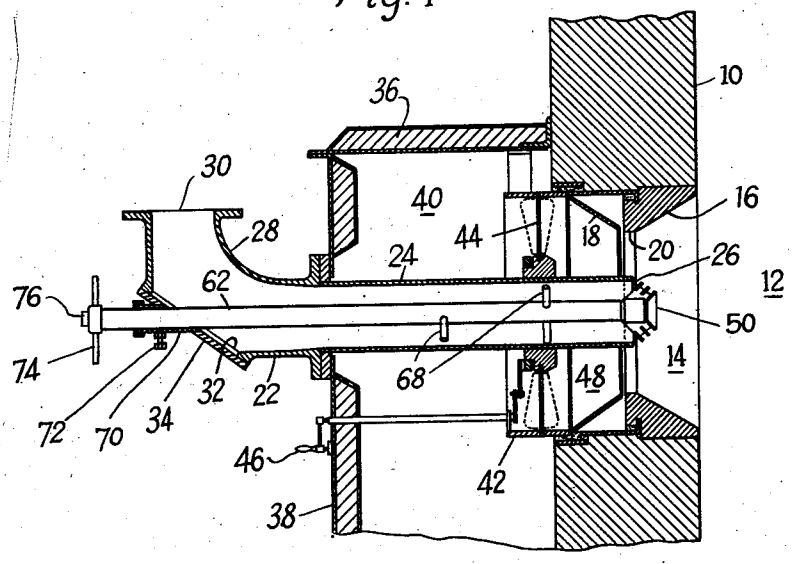


Fig. 2

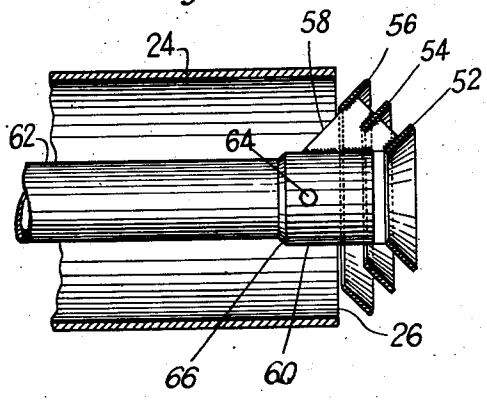
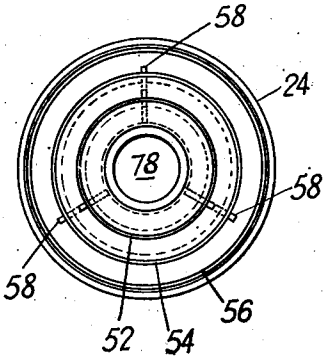


Fig. 3



INVENTOR.

BY Arthur J. Poole

ATTORNEY

Patented July 31, 1945 2,380,463

UNITED STATES PATENT OFFICE

2,380,463

FLUENT FUEL BURNER

Arthur J. Poole, Belleville, N. J., assignor to The Babcock & Wilcox Company, Jersey City, N. J., a corporation of New Jersey

Application June 23, 1942, Serial No. 448,061

11 Claims. (Cl. 110—104)

The invention disclosed herein relates particularly to burners utilizing a fuel which is capable of being projected into the combustion zone in a fluent stream. A specific application of the invention is in connection with pulverized fuel burners of the circular type arranged to discharge a fluent mixture of solid fuel particles and primary air from a central burner pipe or nozzle, and to discharge additional, secondary air annularly of the pipe, the fuel-air mixture being mingled with the secondary air in suitable proportions to insure complete combustion.

An important consideration, as is well known, is to provide even distribution of the fuel particles throughout the mixture entering the furnace, and to provide sufficient dispersion of the entering fuel-air stream to promote thorough mingling with the supply of secondary air. In circular pulverized fuel burners, as heretofore constructed, it has been common practice to employ a bladed member opposite the nozzle outlet for dividing the fuel-air mixture circumferentially while imparting a rotational deflection, thus tending to cause the solid fuel particles to be thrown outwardly by centrifugal force into the surrounding body of secondary air.

The present invention has for an object an improvement in circular fuel burners wherein dispersion of the fluent fuel stream is effected directly by deflecting portions outwardly into the secondary air stream. Since the fuel is discharged from the burner at a considerably higher velocity than the surrounding annulus of secondary air, the deflection is made from a zone of relatively high pressure to a zone of relatively lower pressure, so that there is penetration of the deflected fuel into the combustion air to produce turbulence, thereby promoting thorough mixing without the supplemental whirling action inherent in other burner constructions.

Another object contemplates improved distribution of fuel throughout the entering fuel-air mixture as contributory to thorough mixing of the fuel with the total combustion air supply, for improved ignition and complete combustion.

In view of the abrasive character of pulverulent fuels, and of pulverized coal in particular, a more specific object pertains to an improved dispersing means, herein termed an impeller, capable of providing the desired deflection of the fuel into the surrounding combustion air with minimum erosion of the impeller structure.

It is further proposed to utilize an impeller having annular components concentrically arranged so that annular divisions of the fluent stream are provided, and each division separately deflected and dispersed, such components being of a form facilitating economical manufacture and assembly, and being so arranged that they may be protected from overheating as a result of their exposure to radiant heat from the furnace.

Other objects and advantages will be apparent as the description proceeds in more detail, particularly when read in conjunction with the accompanying drawing, in which:

Fig. 1 is a sectional assembly view of fuel burning apparatus embodying various features of the invention;

Fig. 2 is a fragmentary enlargement of parts shown in Fig. 1; and,

Fig. 3 is an end projection of Fig. 2.

In detail, according to Fig. 1 of the drawing, a fuel burner is shown in association with a furnace wall 10 forming a boundary for a combustion zone 12 at one side, the burner being arranged to deliver fuel and air through a burner opening or port 14 having circumferential wall surfaces 16 and 18 converging inwardly to form a venturi-like passage providing a burner throat 20 of restricted diameter at an intermediate location.

The burner includes a fuel pipe or tube 22 having a cylindrical nozzle portion 24 mounted axially of the opening 14 with its circular fuel discharge outlet 26 positioned adjacent the throat portion 20, a portion 28 being formed as an elbow to provide a fuel inlet 30 for connection with a source of fluent fuel such as a pulverulent fuel suspended in air or other gaseous carrier medium. An access opening 32 fitted with a flat cover plate 34 is provided at the outside bend of the elbow portion. In the form shown, the axis of flow through the fuel inlet 30 is at right angles to the axis of flow through the straight cylindrical nozzle portion 24, so that the entering fuel striking the inclined inner surface of the cover plate 34 at an angle of about 45° or more tends to produce a turbulence which effects a redistribution of the fuel particles throughout the mixture to provide a substantially uniform supply of fuel and primary air through the outlet 26.

A casing 36 completely surrounding the burner opening 14 and pipe portion 24, and having a wall 38 spaced from the furnace wall 10, provides a compartment 40 to which secondary air is supplied in known manner by a fan or other suitable means. Secondary air from the compartment 40 is directed toward the burner opening 14 through a cylindrical casing 42 in which movable vanes 44 are arranged, preferably uniformly distributed in

an annular series, for regulating the supply of secondary air delivered to and through the burner throat 20, the vanes 44 being suitably mounted for angular adjustment about radially extending axes, as indicated by the broken lines, whereby in addition to effecting regulation of the amount of secondary air supplied, the vanes impart a degree of rotation to the annular air stream. The extent of adjustment of the vanes 44 is under control of the handle 46 located exteriorly of the casing 36 and forming part of a suitable operating mechanism.

The mixture of fuel and air as it is discharged from the circular outlet 26 is deflected and simultaneously dispersed into intimate mingling relation with the supply of secondary air entering the combustion zone through the annular passage 48 formed between the cylindrical burner pipe portion 24 and the surrounding converging wall portion of the burner opening 14.

The deflecting-dispersing device 50, which for convenience may be termed an impeller, is mounted axially of the discharge outlet 26 and comprises a series of annular vanes, in the present embodiment three vanes 52, 54 and 56 being utilized, each formed substantially as the frustum of a hollow cone having its vertex at the side toward the fuel outlet 26. The vanes are supported in concentric spaced relation by means of ribs 58 arranged radially which are circumferentially spaced about the hub 60 to which they are secured, as indicated, the hub 60 being open at both ends and telescoping over the outlet end of a tubular supporting member 62 to which it is adjustably secured as by one or more set screws 64. The hub 60 is preferably beveled as at 66 to minimize resistance to the flow of the fuel-air mixture. Pins 68 extending outwardly from the member 62 bear against the inner wall of the pipe 24 and serve to support the member and thereby the impeller 50 in centralized relation to the pipe. The member 62 also has a bearing in the extension 70 on the cover plate 34, a handle 74 being provided at the outer end of the member for convenience in moving the impeller 50 longitudinally of the pipe 24 into and out of position relative to the outlet 26, and a set screw 72 provided for holding the member in the desired position of adjustment.

The conical vanes 52, 54, 56 in their assembled concentric relation may be spaced apart, as shown, at approximately equal distances measured in a direction normal to the conical vane surfaces, and the vane 56 nearest the fuel outlet 26, at approximately the same distance from the inner end of the nozzle 24. The space between blades and from the end of the nozzle may be adjusted to suit particular operating conditions and/or the characteristics of the fuel being used; for example, when the fuel is a gas, it will probably be found more desirable to reduce the amount of spacing, as compared with the amount used with the usual fluent mixture of pulverized coal and air. The vanes may be of equal widths, as shown, and of equal angularity with respect to their common central axis, a suitable angularity having been found to be about 45°, as illustrated in Fig. 2, although other values of angularity may be utilized, either higher or lower.

The vanes are of progressively decreasing diameters, inside and outside, advancing from the outlet 26 of nozzle 24, the inner circumferential edge being shown of uniformly decreasing diameters and thus lying at the surface of a cone having its vertex at the side remote from the outlet; the innermost vane 52 having an inside diameter approximately equal to the outside diameter of the hub 60 and its inner circumferential edge spaced longitudinally from the end of the hub; the outermost vane 56 having an outside diameter less than the inside diameter of the nozzle outlet 26 to provide a clearance space permitting withdrawal of the impeller 50 through the nozzle 24 into the elbow 28 for removal through the access opening 32. The outer edges of the vanes may also lie at the surface of a cone having its vertex at the side remote from the outlet 26, and with vanes of equal widths, at equal spacings, the angularity of the cones containing the inner and outer edges is approximately 45° with respect to the central axis, the same as the angularity of the cones determining the conical surfaces of the vanes. The vanes are also so proportioned and arranged as to provide a small amount of overlap longitudinally and radially between adjacent vanes, the radial overlap being usually the smaller and an amount not exceeding 5 one-hundredths of an inch for diameters up to about 12 inches generally being sufficient to assure deflection of the entire fuel stream.

Successive vanes may be of different widths, if desired, and may vary to a certain extent from an exact conical formation, that is, while identified generally as conoidal, their surfaces of revolution may be generated by curvilinear elements, instead of by straight lines, to provide surfaces concave for example on the side remote from the central axis.

In the operation of the burner described, the fluent mixture of fuel and primary air is discharged in an annular stream from the nozzle outlet 26, and is successively divided into concentric annular portions, first by the outermost vane 56 which removes the outer layer from the annular fuel-air column and deflects that portion outwardly in the form of a hollow cone into the supply of secondary air entering through the throat 20. The remaining central portion of the fuel-air stream is then further divided by the next smaller vane 54 providing additional annular layers which are similarly deflected outwardly into the secondary air stream in the form of hollow cones by the conical vanes 54 and 52, respectively.

With the vane surfaces inclined at an angle of about 45°, for example, to the axial flow of the fuel-air stream, the resulting angularity of flow is sufficiently abrupt in relation to the flow of secondary air to produce turbulence, and since each vane deflects a separate annular division of the stream in the direction of a different zone of secondary air, such turbulence assures intimate mingling of each unit of fuel with the required proportion of combustion air. Thus, the successive dividing and deflecting of the fuel-air mixture is effective in providing the degree of dispersion and turbulence essential for complete combustion of individual divisions, and thereby of the entire fuel supply, and moreover accomplishes these results by a direct expansion of the perimeter of successive portions without relying on centrifugal force to throw the fuel particles outwardly as in the case of blades which in deflecting the fuel circumferentially tend to impart a swirling movement to the discharging fuel. Furthermore, after extended periods of use, it has been indicated that there is less erosion of the conical deflector vanes than of other forms of deflector elements, with the result that the serviceable life of such parts has been substan-

tially prolonged, and the cost of impeller maintenance accordingly reduced. The conical form of the vanes also has the advantage of resisting deformation due to heat, while if a slight warp should occur there would ordinarily be no difficulty in withdrawing the impeller through and from the pipe 22 for inspection or replacement due to the receding inclination of the vane surfaces.

The outer open end of the tubular member 62 may be closed by a plug 76, for example, or the end left open to the atmosphere so as to provide an additional supply of combustion air axially of the impeller 50 from the inner open end 78 of the member, some of the air being discharged axially within the vane 52 and some mingling with fuel passing between the vanes 52 and 54. Air admitted through member 62 in this manner serves as a coolant for the vanes and for the exposed end of the hub, and has also been found beneficial in certain instances and with certain coals in obviating or at least minimizing minor coke formations within the member 62 or on the innermost vane 52 where the tendency for such formations might sometimes occur.

If desired, an oil atomizer of suitable type may be assembled within the tubular member 62, with its tip adjacent the end of hub 60, similar to the arrangement disclosed in U. S. Patent 1,994,461, E. L. Boland, for burning oil, either alone or in combination with the fuel discharged through the nozzle 24.

While in accordance with the provisions of the statutes I have illustrated and described herein the best forms of my invention now known to me, those skilled in the art will understand that changes may be made in the form of the apparatus disclosed without departing from the spirit of the invention covered by my claims, and that certain features of my invention may sometimes be used to advantage without a corresponding use of other features.

I claim:

1. In a burner arranged to discharge fluent fuel and air through a furnace wall opening, said opening being of circular cross-section throughout and of tapering cross-section inwardly from its ends to provide an intermediate throat portion of restricted diameter, a burner nozzle having an outlet at one end adjacent said throat portion for discharging said fuel in an annular stream axially of said opening, said burner nozzle and the surrounding wall portion of said opening defining an annular passage for combustion air of gradually decreasing diameter and cross-section, said annular passage having its outlet substantially within said throat portion, means for regulating the flow of combustion air through said passage while imparting a whirling motion to said air flow, and an impeller opposite said nozzle outlet for dispersing said fuel into intimate mingling relation with said combustion air, said impeller comprising means for successively dividing said stream of fuel into concentric annular currents and for directing said currents outwardly at substantially equal angles oblique to the axial direction of flow from said nozzle outlet, said last named means comprising a series of stationary axially spaced annular vanes terminating in free inner and free outer circumferential edges of which said free inner edges are of diameters less than the diameter of said outlet and of progressively decreasing diameters at progressively increasing distances from said outlet.

2. In a burner arranged to discharge fluent fuel and air through a circular furnace wall opening having an intermediate throat portion of restricted diameter, a burner nozzle having an outlet at one end for discharging said fuel in an annular stream axially of said throat portion, means for discharging combustion air through said throat portion annularly of said fuel discharge outlet, an impeller opposite said fuel discharge outlet for dispersing said fuel into said combustion air, said impeller comprising stationary vanes of substantially frusto-conical form arranged concentrically in spaced nested relation for dividing and directing the flow of fuel from said outlet to provide expanding annular streams, a tubular member telescoped within said burner nozzle for supporting said impeller and for making adjustments in the position of said impeller vanes relative to said nozzle outlet and throat portion, successive vanes terminating in inner edges of progressively decreasing diameters in the direction of flow from said outlet, the innermost of said nested vanes having its inner edge spaced from the exposed end of said member while in substantial alignment with the perimeter thereof, and means for inducing a flow of air through the interior of said member for cooling the exposed adjacent surfaces of said member and innermost vane.

3. In a fluent fuel burner, a burner tube having a fuel discharge outlet of annular formation at one end, means for directing combustion air longitudinally of said tube and past said outlet end in an annular stream uniformly distributed about said tube, and means arranged concentrically with said tube for successively dividing the discharging fuel into concentric annular streams and for directing each of said streams outwardly with respect to the central axis of said tube into intersecting relation with said annular stream of combustion air, said last named means comprising a series of spaced annular vanes each having a free inner and a free outer circumferential edge and being of continuously flaring formation from its inner circumferential edge to its outer, said inner edges being of progressively decreasing diameters at progressively greater distances from said outlet, each of said vanes being relatively narrow with respect to its mean diameter and successive vanes being arranged in longitudinally overlapping relation to form a compact series of said vanes extending longitudinally from said outlet a distance less than the mean diameter of said outlet.

4. In a fluent fuel burner, a burner tube having an outlet at one end arranged to discharge fuel in an annular stream, fuel dispersing means arranged coaxially with said outlet for successively dividing the discharging fuel into concentric annular streams and for directing each of said streams outwardly with respect to the central axis of said tube in the form of a hollow cone, said means comprising a series of concentric annular vanes successively spaced from said outlet, said vanes terminating in free inner and free outer circumferential edges and each being formed in the nature of a truncated cone having its apex at the side toward said tube to provide a vane of continuously flaring formation from its inner circumferential edge to its outer, said inner and said outer circumferential edges being of progressively decreasing diameters at progressively greater distances from said outlet, each of said vanes being relatively narrow by several times with respect to its mean diameter and successive vanes being ar-

ranged in longitudinally overlapping relation to form a compact series of said vanes extending longitudinally from said outlet a distance less than the mean diameter of said outlet, and means for supplying combustion air in an anular column uniformly distributed about said outlet and said series of vanes.

5. In combination with a furnace wall having a fuel burner opening therein, a burner tube arranged axially of said opening for discharging fluent fuel therethrough, said burner tube terminating in an outlet within said opening and having internal displacer means for causing said fuel to be discharged in an annular stream, means for dispersing said fuel upon discharge from said outlet, and means for supplying combustion air through said opening annularly of said dispersing means, said dispersing means comprising a series of conically formed rings arranged in concentric nested relation for successively dividing said stream of fuel into concentric annular layers and for directing said layers outwardly into said annulus of combustion air each in the form of a hollow cone, successive rings terminating in free inner circumferential edges of progressively decreasing diameters at locations progressively farther from said outlet, the ring of minimum diameter having its free inner edge substantially coincident with the periphery of said displacer means and said series of rings terminating short of the furnace end of said fuel burner opening.

6. In combination with a furnace wall having a fuel burner port of circular cross section therein, a fuel burner nozzle disposed axially of said port and terminating in an annular outlet within said port for discharging fluent fuel therethrough, said burner nozzle being of a diameter less than the diameter of said port to provide a surrounding annular passage for combustion air, and means opposite said nozzle outlet and within said port for dispersing said fuel into the surrounding annular body of said combustion air, said dispersing means comprising a series of spaced rings of truncated conical form arranged concentrically in nested relation, said rings being formed relative to vertices at the side toward said nozzle and terminating in free inner and free outer circumferential edges, said free inner edges having diameters less than the maximum diameter of said annular outlet and lying at the surface of a cone having its vertex at the side remote from said nozzle, said series of nested rings extending axially from said nozzle outlet a distance less than the distance between said outlet and the furnace end of said fuel burner port

7. In combination with a furnace wall having a fuel burner port of circular cross section therein, said port having a circumferential wall portion tapering inwardly from its outer end to provide an opening of reduced cross section intermediate the ends of said port, a fuel burner nozzle disposed axially of said port and terminating in an annular outlet adjacent said opening of reduced cross section for discharging fluent fuel through said port, said nozzle being of a diameter less than the diameter of said port and opening to provide a surrounding annular passage, means for supplying combustion air through said passage for discharge through said opening annularly of said outlet, and means for dispersing said fuel into said combustion air comprising a series of vanes of substantially frusto-conical formation arranged axially of said outlet in longitudinally spaced relation, said vanes terminating in free inner and free outer circumferential edges of progressively decreasing diameters at progressively increasing longitudinal distances from said outlet, said free inner edges having diameters less than the maximum diameter of said outlet, each vane being relatively narrow in relation to its mean diameter and successive vanes being arranged in longitudinally overlapping relations to provide a series of vanes disposed wholly between said outlet and the furnace end of said fuel burner port.

8. In combination with a furnace wall having a fuel burner port of circular cross section therein, a fuel burner nozzle disposed axially of said port for discharging fluent fuel therethrough, said nozzle terminating within said port in an annular outlet spaced from the furnace end of said port, said nozzle being of a diameter less than the diameter of said port to provide a surrounding passage for supplying combustion air annularly of said outlet, and means for directing said fuel into said annularly supplied combustion air comprising a series of annular vanes arranged concentrically in longitudinally spaced succession from said outlet, successive vanes terminating in free inner and free outer circumferential edges of progressively decreasing diameters advancing from said outlet, each vane being relatively narrow in relation to its mean diameter and being of continuously flaring formation from its inner to its outer circumferential edge with said outer edge leading said inner edge, said vanes being spaced from each other and from the periphery of said outlet in substantially equal amounts in a direction normal to said vanes, successive vanes being arranged in overlapping relation radially and longitudinally to an extent providing a lesser amount of overlap in the radial direction, said series of vanes extending axially from said outlet a distance less than the diameter of said outlet and terminating short of the furnace end of said fuel burner port.

9. In a fluent fuel burner, a burner tube having an outlet at one end arranged to discharge fuel in an annular stream, fuel dispersing means arranged coaxially with said outlet for dividing the discharging fuel into concentric annular portions and for directing each of said portions outwardly with respect to the central axis of said outlet in the form of a hollow cone, said means comprising a series of concentric inner and outer annular vanes successively spaced from said outlet and axially adjustable as a group relative to said outlet, said series including at least one outer vane terminating in free inner and outer circumferential edges and being formed in the nature of a truncated cone having its apex at the side toward said outlet to provide a vane of continuously flaring formation throughout its width from the inner of said edges to the outer, said inner edge being of diameter less than the maximum diameter of said outlet, said series including a single inner vane longitudinally displaced from said outlet a greater distance than any outer vane of said series and presenting an exterior surface of truncated conical formation toward said outlet for deflecting the innermost of said annular fuel portions, said inner vane terminating in a free outer circumferential edge and its said deflecting surface flaring outwardly to said edge from an inner circumference substantially equal to the inner circumference of said annular stream of discharging fuel, said outer edges of said vanes being of progressively decreasing diameters at progressively increasing distances from said outlet, each of said vanes being rela-

tively narrow with respect to its mean diameter and successive vanes being arranged in overlapping relation to form a compact series of said vanes extending longitudinally a distance less than the mean diameter of said outlet, and means for supplying combustion air in an annular column about said outlet and said series of vanes.

10. In combination with a furnace wall having a fuel burner port of circular cross section therein, a fuel burner nozzle disposed axially of said port and terminating in an annular outlet within said port for discharging fluent fuel therethrough, said burner nozzle being of a diameter less than the diameter of said port to provide a surrounding annular passage for combustion air, and means opposite said nozzle outlet and within said port for dispersing said fuel into the surrounding annular body of said combustion air, said dispersing means comprising a series of spaced inner and outer annular vanes of frustoconical formation arranged concentrically in nested relation, each of said vanes being formed relative to a vertex at the side toward said nozzle and terminating in a free outer circumferential edge at the side remote from said nozzle, said series including outer annular vanes terminating in free inner circumferential edges at the side toward said nozzle, said free inner edges having diameters less than the maximum diameter of said annular outlet and progressively smaller at progressively greater distances from said outlet, said series including a single inner vane longitudinally displaced from said outlet a greater distance than any outer vane of said series and extending in width inwardly toward the central axis of said series at least to a circumference substantially equal to the inner circumference of said annular outlet, said series of nested vanes extending axially from said nozzle outlet a distance less than the distance between said outlet and the furnace end of said fuel burner port.

11. In a fluent fuel burner, a burner tube having an end outlet symmetrically formed about the longitudinal axis of said tube and arranged to discharge fuel in a hollow stream, means for directing combustion air longitudinally of said tube in a hollow stream surrounding said outlet, and means for dispersing said fuel into said air comprising concentric inner and outer vanes coaxially arranged with respect to said outlet and successively spaced therefrom, each of said vanes being of continuous formation about said axis and flaring outwardly to a free outer edge of a perimeter corresponding in configuration and symmetry to the outer perimeter of said outlet, said free outer edges being disposed at progressively decreasing distances from said axis at progressively increasing distances from said outlet, said vanes including at least one outer vane terminating in a free inner edge of smaller perimeter than the outer perimeter of said outlet for dividing said fuel stream into concentric portions, said inner vane extending inwardly toward said axis to a perimeter substantially equal in size and shape to the inner perimeter of said outlet, each of said vanes being relatively narrow with respect to its average transverse dimension and successive vanes being arranged in overlapping relation to form a compact group extending longitudinally a distance less than than the average transverse dimension of said outlet.

ARTHUR J. POOLE.