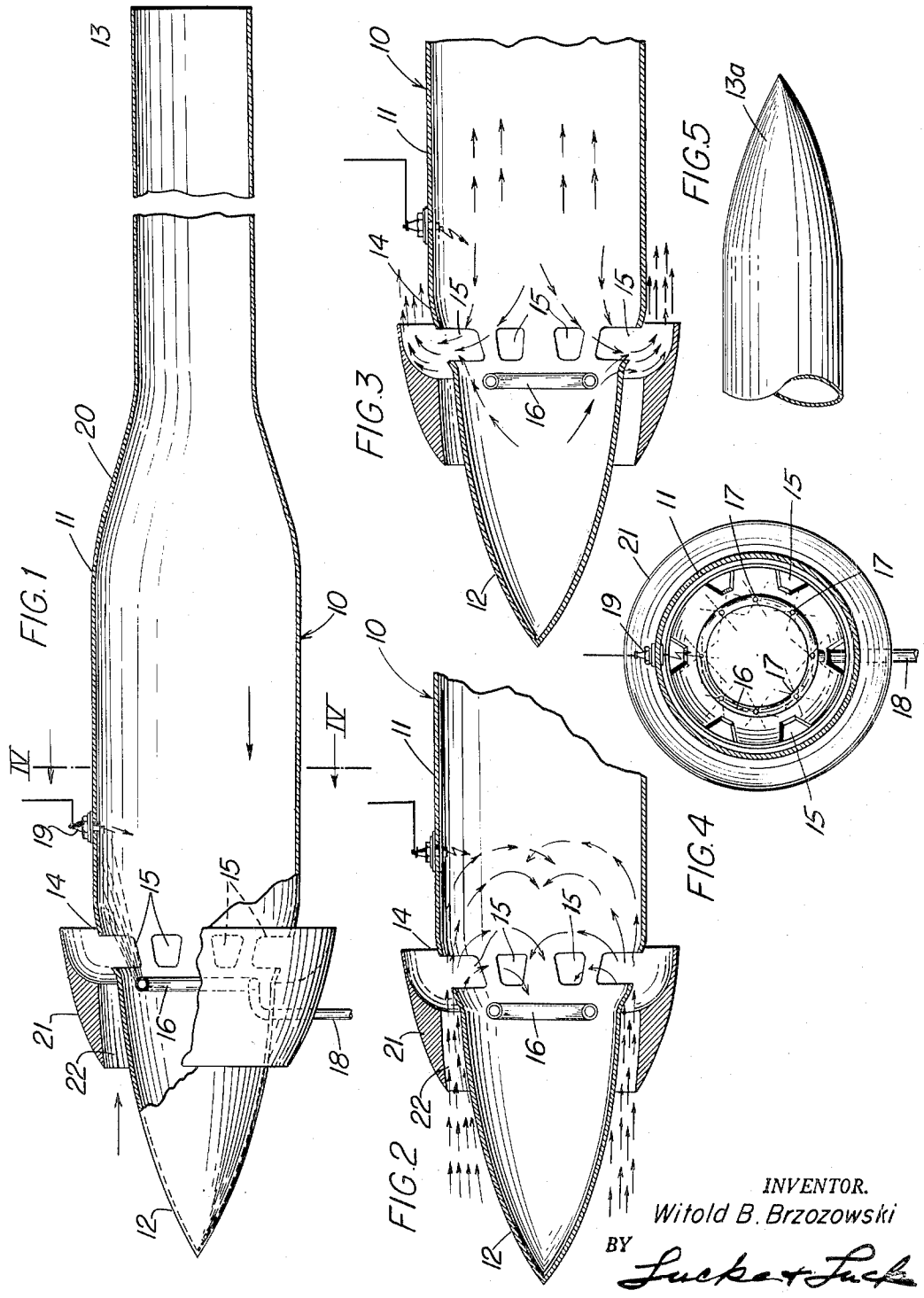
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VALVELESS INTERMITTENT COMBUSTOR
WITH AUTOMATIC FLOW CONTROL
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VALVELESS INTERMITTENT COMBUSTOR WITH AUTOMATIC FLOW CONTROL

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This invention relates to an intermittent combustor, and more particularly a valveless intermittent combustor. The invention is especially useful in its application to jet propulsion, to which use, however, it is not restricted.

In constructing intermittent combustors, as for use in jet propulsion, attempts have been made to design air inlet valves which are small, compact, efficient and durable, and which offer a minimum resistance to the air when the unit is in motion. Such attempts however, have not given satisfactory results. Consequently attempts have been made to provide intermittent combustors without air inlet valves. In designing valveless intermittent combustors, however, attention has heretofore been focused upon offering the least possible resistance to the in-flow of air through the inlet passage while, at the same time, offering the greatest possible resistance to reverse flow of the products of combustion through that passage. Tests upon such combustors heretofore provided have indicated that their efficiency is so low as to make the apparatus impractical.

I have now found it possible to construct a valveless intermittent or pulse combustor in accordance with a different principle. This combustor is simple and efficient; and it has met practical tests proving its superior effectiveness.

In accordance with the invention, a minimum resistance is offered to the flow of air into the burner, but a minimum resistance is also offered to reverse movement of the products of combustion outwardly of the burner. By suitably changing the direction of the reversely flowing products of combustion they may be directed to move in the same direction as that of the air entering the burner, and their passage out of the burner may be utilized to give additional propulsive impulse to the unit where jet propulsion is contemplated.

The invention is illustrated by way of example in the accompanying drawing; wherein—

Fig. 1 is an elevation of an intermittent combustor constructed in accordance with the invention, shown partly in longitudinal mid-section;

Fig. 2 is a broken longitudinal mid-section through the burner shown in Fig. 1 illustrating one phase of its cycle of operation;

Fig. 3 is a similar broken longitudinal mid-section through the same burner illustrating a subsequent phase of its cycle of operation;

Fig. 4 is a cross section taken on the line IV—IV of Fig. 1; and

Fig. 5 is a broken elevation illustrating a variant form of the rear end of the burner.

In the embodiment of the invention which is illustrated in Figs. 1 to 4 inclusive, there is shown a valveless intermittent combustor **10** comprising a tube **11** having a closed forward end **12**, of smaller diameter than that of its main portion, and an open rear end **13**. The tube **11** has a short transition section or shoulder **14** formed

thereon by gradually or progressively reducing the diameter of its main portion toward its closed forward end **12**. Angular openings **15** are thus provided in the tube **11** at its recessed shoulder **14** for admission of air into the tube. Thus, air moving from left to right as illustrated in Figs. 1, 2 and 3, relatively to the combustor, and about the closed forward end **12** of the tube **11** will readily enter the tube through the openings **15** therein.

A fuel ring **16** is positioned transversely of the tube **11** a short distance ahead of the openings **15** therein, being fixed in place in any known or convenient manner (not illustrated). The fuel ring **16** has spray orifices **17** extending through it and directed toward the rear of the tube **11**. A fuel supply pipe **18** is connected to the fuel ring **16** to supply a fluid fuel thereto under pressure. Thus, the fuel ring **16** sprays fluid fuel into the tube **11** where the fuel mixes with air entering the tube through the openings **15** to form a combustible mixture. Igniting means, here illustrated as a spark plug **19** projecting through the tube **11**, ignites the combustible mixture therein.

When the fuel-air mixture in the tube **11** is ignited it burns and expands. Thereupon the pressure in the tube **11** forces the products of combustion out of the tube. One portion of the products of combustion leaves the tube through the open rear end **13** exerting a reaction upon the combustor tending to move it in the opposite direction, that is to say to the left as viewed in the drawing. In order to employ this force effectively the tube **11** is reduced rearwardly in cross section as illustrated at **20** and the rear part of the tube is extended for an appreciable distance behind this point, as illustrated in Fig. 1.

Another portion of the expanding products of combustion leaves the tube **11** through the openings **15**, moving reversely with respect to the entrance of air into the tube through these openings.

In order to direct air effectively into the tube **11**, and in order to realize the objects of the invention with respect to reverse flow of the products of combustion through the openings **15**, an annular collar **21** is disposed to surround the tube **11** between its closed end **12** and the shoulder **14** formed thereon. The annular collar is conveniently fixed in place by fins or other conventional means (not shown). The annular collar **21** is streamlined to offer a minimum resistance to the air upon movement of the air relatively to the combustor **10** from left to right as illustrated in Fig. 1. Thus the annular collar is bowl-shaped having an axial passage therethrough of a diameter slightly less than that of the larger or main section of the tube **11** and having an interior bell-shaped space between the passage and the larger end of the collar **21**. The annular collar is disposed to surround the forward end section of the tube, and the bell-shaped expansion of its bore surrounds the transition section of the tube and faces rearwardly thereof. Accordingly, an annular passage **22** is provided between the collar **21** and the tube, this annular passage narrowing slightly from front to rear and serving to direct air passing therethrough toward the openings **15**. See Fig. 2. Thus, upon movement of the combustor to the left as shown in the drawing, or upon movement of air to the right, air enters the tube **11** through the openings **15** therein rearwardly of the fuel ring **16** where it mixes with the fluid fuel which is projected through the spray orifices **17**. Upon ignition of the resulting combustible mixture, as by the spark plug **19**, a sudden expansion of the mixture results and the products of combustion leave the tube **11** as previously described.

It is noted however, that the force of the expanding mixture as it burns causes the products adjacent the openings **15** to be projected through these openings sub-

stantially radially of the tube **11**. The annular collar **21** is formed to take advantage of this action and to change the direction of flow of the products of combustion through the openings **15** to give additional propulsive impulse to the burner.

In order to obtain the result just described the rear portion of the annular collar **21** is bell-shaped and surrounds the openings **15** in the shoulder **14** in a manner to cause the products of combustion impinging thereon to be deflected rearwardly of the burner. See Fig. 3. Thus, where the invention is applied to jet propulsion, a reaction is exterted upon the annular collar **21** which gives a propulsive impulse to the unit tending to move the combustor **10** in the same direction as does the reaction to the products of combustion leaving the open rear end **13**.

Clearly air cannot enter and leave the openings **15** at the same time. Consequently, the action of the combustor is intermittent. First air passes through the annular passage **22** between the collar **21** and the tube **11** and is directed into the tube through the openings **15** to mix with the fluid fuel spray projected through the spray orifices **17**. See Fig. 2. A combustible mixture being thus formed, the spark plug **19** ignites it. Thereupon pressure builds up in the tube **11**. In consequence the products of combustion leave the burner through the open rear end **13** and, in a jet propulsive unit, impart a propulsive impulse to the burner. At the same time the built up pressure in the tube **11** expels another portion of the products of combustion through the openings **15**. The flow of such portion of the products of combustion is substantially radially of the tube **11** and impinges upon the bell shaped after portion of the annular collar **21** to be deflected rearwardly of the burner. See Fig. 3. Thus in a jet propulsive unit, an additional propulsive impulse is applied to the combustor.

The invention also contemplates, in one form, applying the entire propulsive impulse of the combusting gases to the burner through the annular collar **21**. There may accordingly be no ejection of the products of combustion through an open rear end **13**, but the combustor may have a closed rear end **13***a* as shown in Fig. 5. In this modification, the internal pressure against rear end **13***a* is nullified by similar pressure against forward end **12**. These internal forces represent no significance in the operation of the combustor shown in Fig. 5. The only external force (except air resistance) taking place during the combustion period is produced by the deflected expulsion of combustion products passing through the rearwardly facing bell-shaped exit portion of collar **21**.

The present invention provides a valveless intermittent or pulse combustor which is simple, efficient and practical. A minimum resistance is offered to the flow of air into the burner, and a minimum resistance is also offered to reverse movement of the products of combustion out of the burner. The direction of the reversely flowing products of combustion is advantageously changed to direct the products of combustion in the same direction as that of the air entering the burner. In the case of a jet propulsive unit, an additional propulsive impulse is thus given the unit.

The forms of the invention here described and illustrated in the accompanying drawing are presented as examples of how the invention may be applied. Other forms, embodiments and applications of the invention, coming within the scope of the appended claims, will of course, suggest themselves to those skilled in the art.

I claim:

1. A valveless combustor comprising a tube having a closed end and an open end, a shoulder connecting the body of said tube with said closed end, said shoulder being provided with openings therein, a separate annular collar substantially coaxial therewith and spaced from said tube surrounding said shoulder openings, said collar comprising a forward entrance passage constructed and arranged to intermittently admit air into and withhold air from said tube and a rearwardly disposed exhaust passage constructed and arranged to eject deflected combustion products, said shoulder openings constructed and arranged to intermittently channel air into said combustion tube from said collar entrance passage and direct combustion products from said tube against said exhaust passage for propulsive expulsion.

2. A valveless combustor comprising a tube having a closed end and an open end, a shoulder connecting the body of said tube with said closed end, said shoulder being provided with openings therein, a fuel supply element in said tube for spraying fuel into the air in said tube, igniting means for fuel-air mixture in said tube, a separate annular collar substantially coaxial therewith and spaced from said tube surrounding said shoulder openings, said collar comprising a forward entrance portion constructed and arranged to intermittently admit air into and withhold air from said tube and a rearwardly disposed bell-shaped exhaust portion constructed and arranged to eject deflected combustion products therefrom, said shoulder openings constructed and arranged to intermittently channel air into said combustion tube from said collar entrance portion and direct combustion products from said tube against said bell-shaped exit portion for propulsive expulsion.

3. A valveless intermittent combustor comprising: a tube of circular cross-section, said tube having a closed forward end section, a main section of larger diameter than said forward end section, and a transition section of progressively increasing diameter between the forward end section and the main section of said tube, the transition section of said tube having openings therein for admitting air to said tube and permitting combustion products to leave said tube therethrough; and a bowl-shaped collar having an axial passage therethrough of a diameter slightly less than that of the main section of said tube and having an interior bell-shaped space between the passage and the larger end of said collar; said collar being disposed to surround the forward end section of said tube, being spaced therefrom with the inner edge of its bell-shaped interior substantially surrounding the junction of the forward end section and the transition section of said tube, and the rear edge of said bowl-shaped collar surrounding the main section of said tube beyond the openings formed in the transition section thereof; whereby air moving along said tube axially thereof from its forward section toward the main section will pass between said collar and said tube to enter the main section through the openings in the transition section of said tube, and whereby pressure in said tube will leave the openings in its transition section substantially radially and will be turned in the bell-shaped space of said collar to move rearwardly of said tube.

4. A valveless intermittent combustor comprising: a tube of circular cross-section, said tube having a closed forward end section, a main section of larger diameter than said forward end section, and a short transition section of progressively increasing diameter between the forward end section and the main section of said tube, the transition section of said tube having openings therein for admitting air to said tube and permitting combustion products to leave said tube therethrough; and a bowl-shaped collar having a bore therethrough larger than the greatest external diameter of the forward end section of said tube and a bell-shaped expansion of the bore therein extending to the larger end of said collar; said collar being fixed with the bore therethrough symmetrically surrounding the forward end section of said tube and the bell-shaped expansion of its bore surrounding the transition section of said tube; whereby air moving along said tube axially thereof from its forward end section toward the main section will pass between said collar and said tube to enter the main section through the openings in the transition section of said tube, and whereby pressure

in said tube will leave the openings in its transition section substantially radially and will be turned in the bell-shaped space of said collar to move rearwardly of said tube.

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