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COMBUSTION CHAMBER

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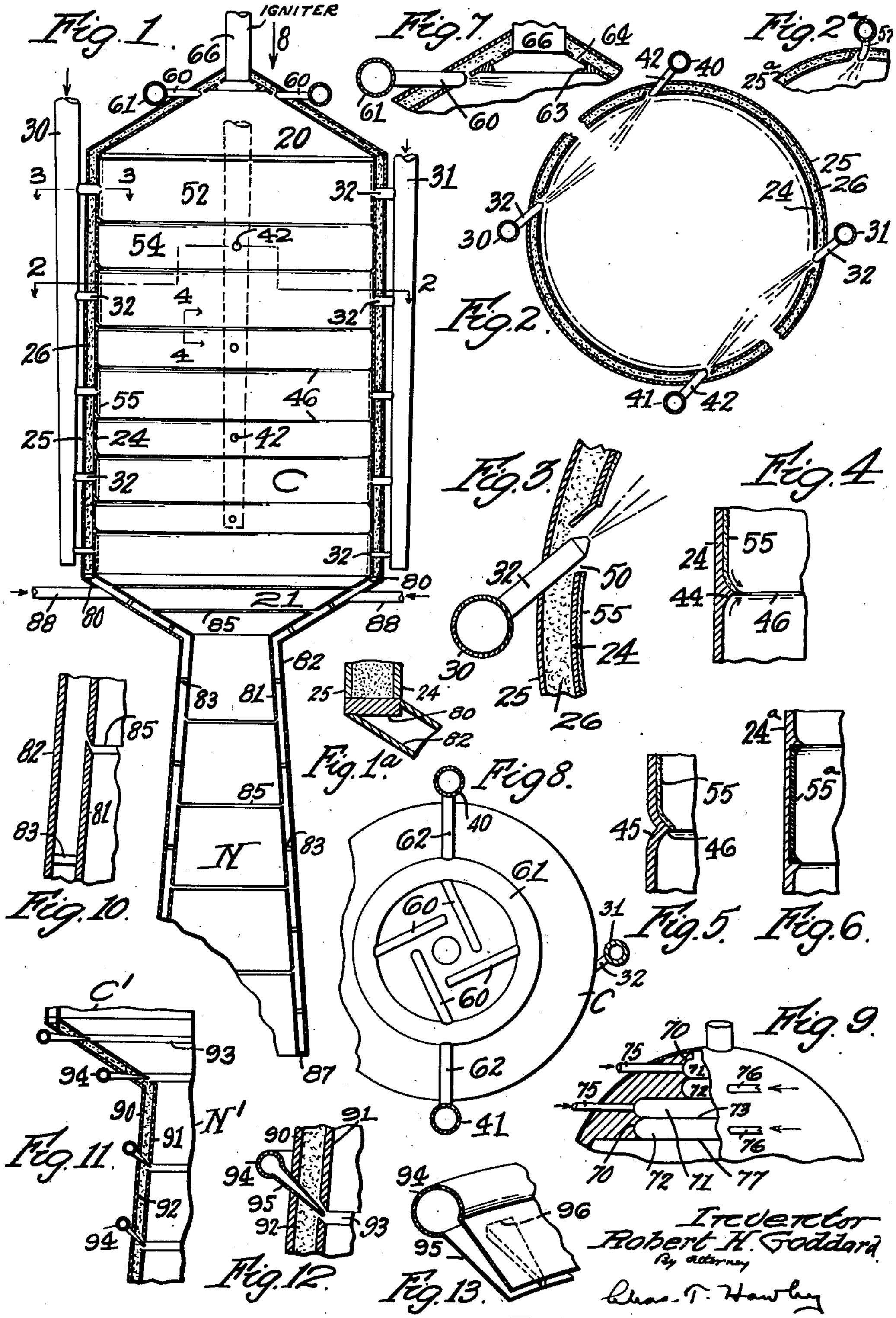

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COMBUSTION CHAMBER

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This invention relates to a combustion chamber particularly adapted for use in the propulsion of rockets or rocket craft. Such chambers are frequently used for combustion of a mixture of liquids, such as gasoline and liquid oxygen, which combustion develops an extremely high temperature, sometimes in excess of 4,000° F.

It is the general object of my present invention to provide an improved construction in a combustion chamber, by which reliable and efficient operation under extreme conditions is assured. I also provide a combustion chamber which is of simple construction and of relatively light weight and which is thereby well adapted for aircraft purposes.

My invention further relates to arrangements and combinations of parts which will be hereinafter described and more particularly pointed out in the appended claims.

A preferred form of the invention is shown in the drawing, in which

Fig. 1 is a sectional elevation of my improved combustion chamber;

Fig. 1^a is a fragmentary sectional elevation of a portion of the combustion chamber;

Fig. 2 is a sectional plan view, taken along the irregular line **2**—**2** in Fig. 1;

Fig. 2^a is a detail sectional view, showing a modification of certain structure found in Fig. 2;

Fig. 3 is an enlarged detail sectional view, taken along the line **3**—**3** in Fig. 1;

Fig. 4 is an enlarged detail sectional elevation, taken along the line **4**—**4** in Fig. 1;

Fig. 5 is a view similar to Fig. 4 but showing a modified construction;

Fig. 6 is a similar view showing an additional modification;

Fig. 7 is an enlarged sectional elevation of certain parts appearing in the upper portion of Fig. 1;

Fig. 8 is a plan view, looking in the direction of the arrow **8** in Fig. 1;

Fig. 9 is a partial front elevation, partly in section, and showing a modified construction;

Fig. 10 is an enlarged sectional view of a portion of the combustion chamber nozzle;

Fig. 11 is a partial sectional front elevation showing a modification of the discharge nozzle structure;

Fig. 12 is an enlarged sectional elevation of certain parts shown in Fig. 11; and

Fig. 13 is a partial perspective view of an annular feeding member.

Referring to the drawing, I have shown a combustion chamber C having a general cylindrical shape but with an upper conical portion **20**, a lower conical portion **21**, and a discharge nozzle N.

The combustion chamber and the conical end portions **20** and **21** all have an inner metal wall **24** and an outer metal wall **25**, which walls are spaced apart by a porous non-combustible filling material **26**, such as loosely packed asbestos.

Feed pipes **30** and **31** supply an oxidizing liquid, such as oxygen, to the chamber C through short branch pipes or tubes **32**, which have small feed openings at their inner ends and which are spaced apart vertically as shown in Fig. 1, but are placed progressively nearer together toward the lower end of the combustion chamber.

Similar feed pipes **40** and **41** supply a combustible liquid, as gasoline, through branch pipes or tubes **42** which are similarly spaced apart vertically but which alternate in vertical position with the tubes **32**, as clearly shown in Fig. 1.

Hereafter in this application the terms "oxygen" and "gasoline" will be understood to include equivalent oxidizing and combustible liquids.

The thin inner wall **24** of the combustion chamber is preferably formed of copper or of some other metal of high heat conductivity. The inner surface of the wall **24** is upset, as shown at **44** in Fig. 4, or offset, as shown at **45** in Fig. 5, to provide internal ribs **46** having sharp or linear inner edges.

Each rib **46** is axially positioned between a pair of gasoline tubes **42** and a pair of oxygen tubes **32**. The ribs **46** thus divide the wall **24** into an axial series of annular zones which alternately receives gasoline and liquid oxygen.

The branch pipes or tubes **32** and **42** are tangentially disposed, as indicated in Figs. 2 and 3, so that the liquids injected through the tubes spread out circumferentially over their respective zones of the combustion chamber wall **24** and thus effectively cool said wall.

Each tube **32** or **42** is welded or otherwise firmly secured in the outer chamber wall **25**, as indicated in Fig. 3, and the inner end of each tube projects freely into an opening **50** in the inner wall **24**. In Fig. 2^a I have shown a curved tube **57**, which shape facilitates welding or brazing in the outer wall **25**^{a}.

The delivery openings in the ends of the branch pipes or tubes **32** and **42** should be proportionate in cross section to the ratio of gasoline and oxygen required to provide complete combustion. Furthermore, the widths of the oxygen zones **52** and the gasoline zones **54** are to be proportioned to the amount of liquid to be delivered to each zone, so that the protecting liquid film may be of uniform thickness.

It is necessary that the wall **24** in the oxygen zones **52** be protected by a non-oxidizing lining **55** (Fig. 4) of porcelain or other suitable refractory material. In Fig. 6, I have shown the metal wall **24**^{a} as recessed to receive a band of porcelain **55**^{a}, while in Figs. 4 and 5 the lining **55** forms a coating on the inner wall of the chamber.

All of the zones are reduced in width toward the discharge nozzle N, since the time required for the ignited gases to pass from the lower zones to the nozzle is less than the time required from the upper zones. The combustion should therefore be made more rapid in the lower zones by using narrower zones and correspondingly smaller feed openings, thus providing a more intimate mixture of gasoline and oxygen for more rapid combustion.

In the upper conical portion **20**, gasoline feed tubes **60** enter tangentially from an annular pipe **61** (Fig. 8) which is connected by pipes **62** to the gasoline feed pipes **40** and **41**. The gasoline thus injected flows circumferentially downward and outward over the conical inner wall of the chamber portion **20**, but upward flow of the gasoline is retarded by a rib or ledge **63** overlying the nozzle openings. Pressure is equalized by providing openings **64**, in addition to the feed tube openings.

Any suitable igniter **66** may be provided at the extreme upper end of the chamber.

With the construction thus described, the gasoline and oxygen flow around the cylindrical walls of their respective zones and spread out in the directions of the arrows shown in Fig. 4, after which they intermingle along the sharp inner lines or edges of the ribs **46**. As the liquids thus intermingle to form a combustible mixture, they naturally flow inward away from the sharp edges of the ribs, so that the ribs are not melted by the high combustion temperature. Any vapors produced also circulate close to the chamber wall, as they are more dense than the hot combustion gases. The cool liquids are supplied near the middle of each narrow zone, so that no part of the inner wall is far removed from the point of cool liquid supply.

The wall **24** is protected from the heat of combustion, not only by the liquid film of gasoline or oxygen overlying its various zones, but also by the fact that the wall **24** is relatively thin and of high heat conductivity, so that heat passes readily through the wall and through the porous filling material **26** to the outer wall **25**, where the heat is rapidly dissipated.

Furthermore, the construction is such that the inner wall **24** is not subject to any substantial difference in pressure on its inner and outer faces, as the openings **50** around the ends of the branch pipes or tubes **32** and **42** cause the pressures on the two sides of the wall **24** to be maintained substantially equal.

The porous filling material **26** between the walls **24** and **25** permits the pressure to be thus equalized, but retards free flow between openings in adjacent zones, so that no explosive mixture will be formed in this insulating space.

If the combustion chamber is of such large size that the conical end portion **20** should be subdivided into successive zones, it is necessary to adopt a special construction, as centrifugal force would prevent the maintenance of adjacent circumferential zones on an internal conical surface.

Where such zones are required, the set-back construction shown in Fig. 9 may be used, with a series of annular shoulders **70** each provided with a pair of grooves **71** and **72**, separated by a sharp rib **73**. Tangential feed pipes or tubes **75** for gasoline and **76** for oxygen communicate with the grooves **71** and **72** respectively, and circumferential flow in the grooves takes place, with a combustible mixture forming along the separating ribs **73** as previously described. Additional combustion may also take place along the lower edge **77** of each lower groove **72**.

This construction is more complicated than that shown in Figs. 1 and 7 and is only required for combustion chambers of unusually large size.

A close fitting ring **80** (Fig. 1^a) is preferably interposed between the lower end of the cylindrical body portion and the upper end of the conical portion **21**.

This latter portion, together with the discharge nozzle N, is constructed with inner walls **81** and outer walls **82**, held apart by spacing pins **83**.

A non-oxidizing liquid enters the conical portion **21** and the nozzle N through circumferential slits **85**, axially spaced lengthwise of the cone and nozzle. These slits are directed downward, as clearly shown in Fig. 10, so that the injected liquid will flow axially outward along the interior wall **81** and will not interfere with the outward flow of combustion gases.

A ring **87** closes the space between the outer ends of the nozzle walls **81** and **82**. As the pressure in the nozzle N decreases toward the open end, the slits **85** may be correspondingly reduced in width.

Gasoline or other cooling liquid is supplied to the space between the inner and outer walls by pipes **88** which may be connected to the gasoline feed pipes **40** and **41** previously described, if gasoline is used as the non-oxidizing cooling liquid.

If the temperatures within the cone and nozzle are not too high, water may be substituted for gasoline as the cooling liquid, in which case the pipes **88** will be connected to a separate source of water supply. Water should not be used, however, if the temperature in the nozzle is high enough to disassociate the elements in the water and free the oxygen, which would then have a destructive effect on the inner metal wall **81**.

An alternative nozzle construction is shown in Figs. 11, 12 and 13, in which the conical end portion of the combustion chamber C′ and the nozzle N′ are formed with a metal outer wall **90**, a liner **91** formed of some refractory material having a very high melting point, and a filling **92** which constitutes a rigid but porous mass and which may be formed from the same material as the liner **91**.

For extremely high temperatures, a mixture of four parts tantalum carbide to one part of hafnium carbide is found satisfactory, as this material has a melting point above 4200° Kelvin.

Annular sheets of gasoline are introduced through slits **93** in the liner **91** from tubes **94** having flattened annular delivery parts **95** which project through the outer wall **90** and extend loosely into the slits **93**.

The parts **95** are formed with upper and lower flat rings or bands, held in spaced relation by wedge-shaped spacing members **96** interposed at intervals between said upper and lower bands. The air spaces provided by the slits **93** are sufficient to prevent the gasoline from becoming too hot as it leaves the annular flat feed members, thus avoiding gas choke and the deposit of carbon.

With this modified construction, the temperature of the inner wall or liner **91** may be quite high, as the gasoline film provides a reducing atmosphere and the liner material has an external high melting point.

A construction similar to that shown in Figs. 11 and 12 may be substituted for the construction shown in the upper conical end portion **20**, if so desired.

Having thus described my invention and the advantages thereof, I do not wish to be limited to the details herein disclosed, otherwise than as set forth in the claims, but what I claim is:

1. A combustion chamber comprising an inner metal wall, an outer metal wall spaced from said inner wall, non-combustible porous material filling the space between said walls, said inner wall having inner ribs dividing the inner surface of said wall into an axial series of annular zones, and means to deliver a combustible liquid tangentially to a set of zones comprising every second zone, and means to deliver an oxidizing liquid to the intervening zones.

2. The combination in a combustion chamber as set forth in claim 1, in which the zones vary in width in proportion to the relative amounts of the combustible and oxidizing liquids required for complete combustion.

3. The combination in a combustion chamber as set forth in claim 1, in which the zones vary in width in proportion to the relative amounts of the combustible and oxidizing liquids required for complete combustion, and in which both sets of zones decrease in relative width toward the discharge end of said combustion chamber.

4. The combination in a combustion chamber as set forth in claim 1, in which the inner ribs have sharp linear inner edges and concave approach surfaces.

5. A combustion chamber comprising an inner metal wal', an outer metal wall spaced from said inner wall, a non-combustible porous material filling the space between said walls, and a plurality of feed tubes mounted in said outer wall and extending loosely into openings in said inner wall and effective to deliver combustible and oxidizing liquids to axially alternating zones of the internal surface of said inner wall, said zones being separated by sharp-edged internal ribs and the zones which receive the oxidizing liquid having a non-oxidizable refractory lining.

6. A combustion chamber comprising an inner metal wall, an outer metal wall spaced from said inner wall, a non-combustible porous material filling the space between said walls, and a plurality of feed tubes mounted in said outer wall and extending loosely into openings in said inner wall and effective to deliver streams of combustible and oxidizing liquids to axially alternating zones of the internal surface of said inner wall, the tubes which deliver the combustible liquid discharging in one circumferential direction and the tubes which deliver the oxidizing liquid discharging in the opposite circumferential direction, the liquids on the inner surfaces of axially adjacent zones rotating in opposite directions over the zone surfaces, and avoiding impingement on each other on entering said chamber and each liquid thereafter spreading over and cooling the wall surface of the zones which are axially adjacent to its feeding tubes.

7. A combustion chamber comprising an inner metal wall, an outer metal wall spaced from said inner wall, a non-combustible porous material filling the space between said walls, and a plurality of feed tubes mounted in said outer wall and extending loosely into openings in said inner wall and effective to deliver combustible and oxidizing liquids to axially alternating zones of the internal surface of said inner wall, said zones being separated by sharp-edged internal ribs and the zones which receive the oxidizing liquid having non-oxidizable refractory lining bands seated in annular recesses in said inner wall.

8. A combustion chamber having a substantially cylindrical body portion, a nozzle, a conical discharge portion communicating with said nozzle, and an opposite end portion gradually reduced in diameter axially away from said body portion and having set-back shoulders on its inner surface each provided with two annular grooves separated by a sharp-edged rib and tangentially receiving combustible and oxidizing liquids respectively.

9. A combustion chamber having its inner wall formed in axially successive zones, means to supply a film of combustible liquid over alternate zones, and means to supply an oxidizing liquid over each remaining zone, each liquid forming a cooling film over the surface of its associated zone.

10. A combustion chamber having its inner wall formed in axially successive zones alternately having non-reducible and non-oxidizable surfaces respectively, means to admit a supply of combustible liquid to produce a film over each non-reducible zone, and means to admit a supply of an oxidizing liquid to produce a film over each non-oxidizable zone.

11. A combustion chamber having its inner wall formed in axially successive zones alternately having non-reducible and non-oxidizable surfaces respectively, means to admit a supply of combustible liquid to produce a film over each non-reducible zone, and means to admit a supply of an oxidizing liquid to produce a film over each non-oxidizable zone, said means for admitting combustible liquid being disposed at a substantial angle to the means for admitting oxidizing liquid and thereby causing the liquids on adjacent zones to impinge in relatively oblique directions along their adjacent edges.

12. A combustion chamber having its inner wall formed in axially successive zones alternately having non-reducible and non-oxidizable surfaces respectively, means to admit a supply of combustible liquid to produce a film over each non-reducible zone, and means to admit a supply of an oxidizing liquid to produce a film over each non-oxidizable zone, said means for admitting combustible liquid being disposed at a substantial angle to the means for admitting oxidizing liquid and thereby causing the liquids on adjacent zones to impinge in relatively oblique directions, said intermingled liquids thereafter advancing away from the inner wall of said zones and toward the longitudinal axis of said chamber for combustion.

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