United States Patent

Helmrich

[15] **3,684,186**

[45] **Aug. 15, 1972**

[54] **AERATING FUEL NOZZLE**

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[22] Filed: **June 26, 1970**

[21] Appl. No.: **50,112**

[52] **U.S. Cl.** **239/400,** 239/403, 239/422, 239/423

[51] **Int. Cl.** **B05b 7/10**

[58] **Field of Search**......239/400, 403, 404, 405, 406, 239/422, 423; 60/39.74 R

[56] **References Cited**

UNITED STATES PATENTS

3,533,558	10/1970	Masters	239/404
1,881,359	10/1932	Jones	239/400
1,510,039	9/1924	Canfield	239/403
2,612,405	9/1952	Kirschbaum	239/404
3,310,240	3/1967	Grunoman	239/404
3,153,438	10/1964	Brzozowski	239/405 X
2,703,260	3/1955	Olson et al	239/404
3,026,048	3/1962	Gascoigne et al	239/404 X
3,498,059	3/1970	Grandon et al.	239/400 X
2,595,759	5/1952	Buckland et al.	60/39.74 R
3,483,699	12/1969	Harvey	60/39.74 R
3,530,667	9/1970	Bryan	60/39.74 R
3,576,384	4/1971	Peczeli	239/405 X

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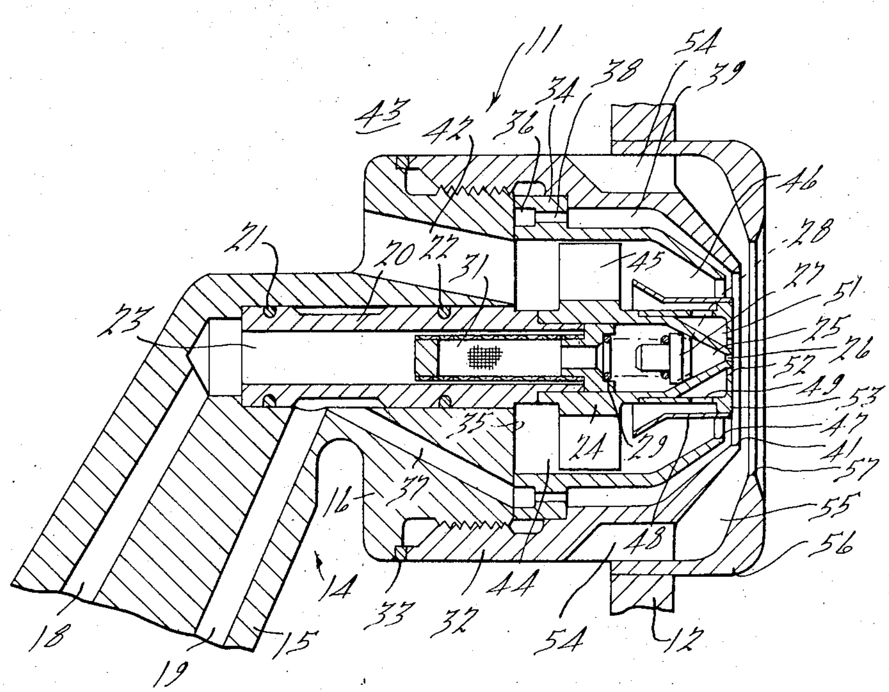
[57] **ABSTRACT**

An aerating fuel nozzle for a gas turbine engine combustion chamber. The nozzle has an annular fuel swirl chamber from which the fuel issues in a spray cone, blending with inner and outer layers of swirling air. Air from the engine compressor is mixed with the fuel to obtain a high degree of air-fuel blending close to the nozzle, thus promoting cleaner and more complete combustion.

9 Claims, 2 Drawing Figures



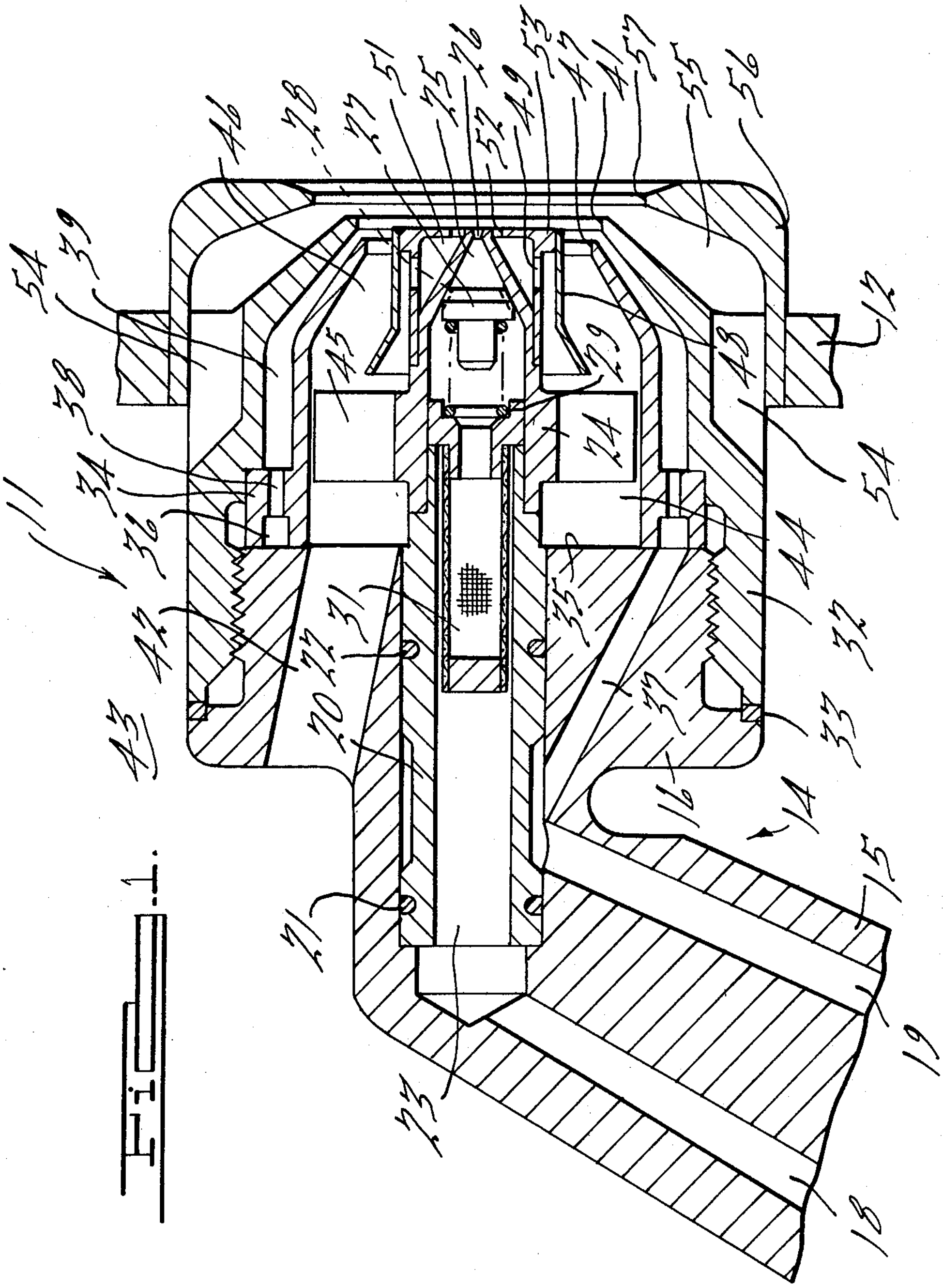


Fig. 1

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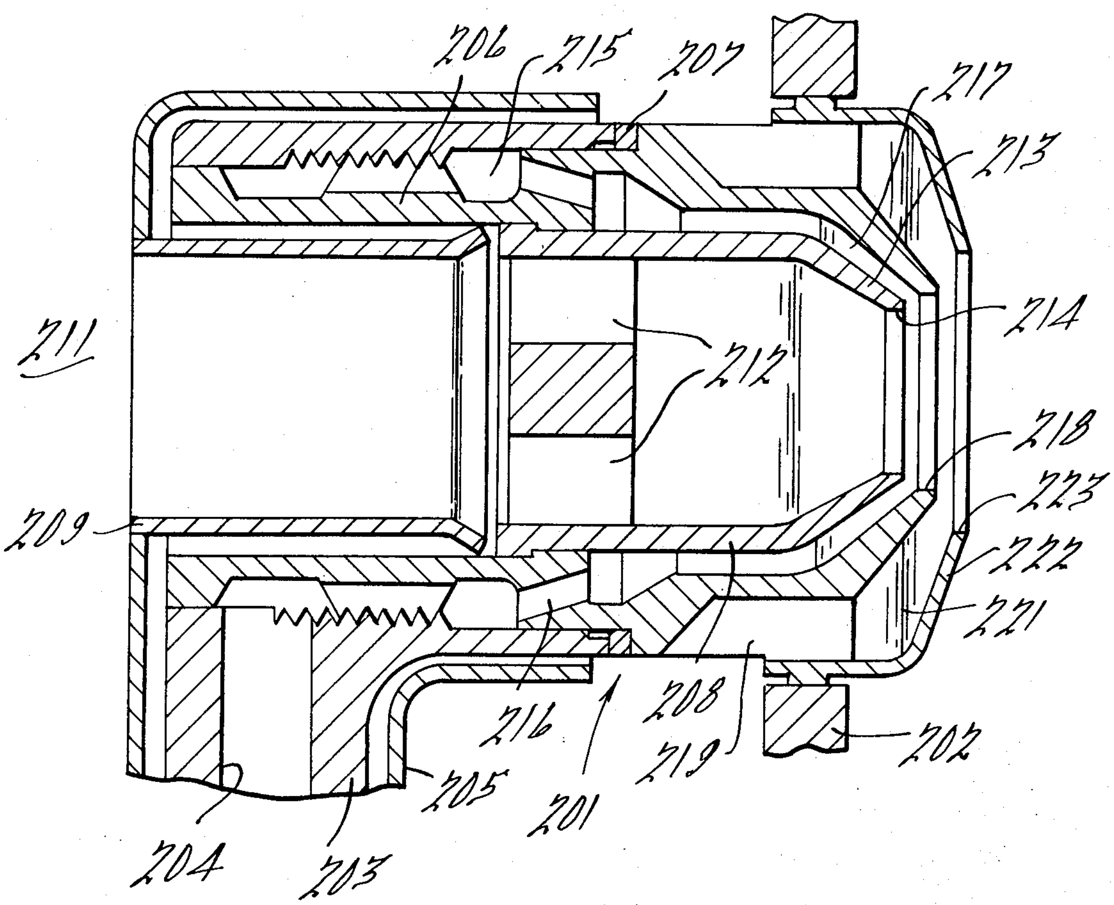
FIG. 2.



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AERATING FUEL NOZZLE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to gas turbine engines, and more particularly to aerating nozzles which deliver fuel to the combustion chambers of such engines. The invention is particularly useful in the newer types of gas turbine engines which operate at higher temperatures, but the principles of the invention are also applicable to all types of gas turbine engines to achieve more even temperature distribution around the combustion chamber and improved performance, as well as smoke reduction because of clearer and more complete burning.

2. Description of the Prior Art

The prior art is exemplified by Grundman U.S. Pat. No. 3,310,240 and Gradon et al. U.S. Pat. No. 3,489,059. The Grundman nozzle is of the air atomizing type using relatively high air pressure, and furthermore does not teach swirl chamber configurations which achieves the very high degree of air-fuel blending of the present invention. The Gradon nozzle is not of the aerating or air atomizing type, and is therefore even less pertinent.

BRIEF SUMMARY OF THE INVENTION

According to the present invention, the fuel nozzle uses a larger volume of burner inlet air to provide fuel atomization without any auxiliary air pressure increasing device. In one embodiment of the invention, a central primary fuel orifice is located at the exit of a swirl chamber while an annular secondary fuel swirl chamber and orifice are located outwardly of the primary orifice. An air swirl chamber surrounds the primary fuel chamber, and two air swirl chambers are disposed inwardly and outwardly of the secondary fuel chamber. The exit portions of all chambers are of frustoconical shape to increase the velocity of the air or fuel swirling therein, and the exits are so located as to create a very high degree of blending of the air and fuel. In another embodiment of the invention, the primary fuel delivery system is omitted, since the degree of air-fuel blending has been found so complete in some cases as to make unnecessary the provisions of a primary fuel system for starting or high altitude operation. The air swirl chambers are in communication with the space surrounding the nozzle, which receives air from the engine compressor. The ratio of inner to outer air surrounding the secondary fuel spray cone, as well as the relative axial positioning of the orifices are selected so as to obtain optimum mixing efficiency and fuel-air ratios, thus making possible a complete burning close to the nozzle, rather than downstream as in previous constructions.

The nozzle of this invention has been proven to give improved combustion performance because of the cleaner and more complete burning which imparts more even temperature distribution around the combustion chamber. The gas turbine engine can thus be operated at relatively higher temperatures without the use of more expensive or exotic materials. Even fuel distribution thus results in a higher engine efficiency. Another advantage of the invention is the significant reduction of smoke (unburned hydrocarbons) issuing from the engine, and contributing to air pollution.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross-sectional view in elevation of one embodiment of the invention having both primary and secondary fuel systems, the tangential passages being shown in full for purposes of clarity; and

FIG. 2 is a view similar to FIG. 1 of another embodiment of the invention having only one fuel system.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring first to the embodiment of FIG. 1, the nozzle is generally indicated at **11** and is mounted in a gas turbine engine combustion chamber partially indicated at **12**. The nozzle is secured to a nozzle support generally indicated at **14** and comprising two sections **15** and **16**. Section **15** has a primary fuel passage **18** and a secondary fuel passage **19**, and an adaptor insert **20** is brazed at spaced locations **21** and **22** to sections **15** and **16** respectively. Insert **20** has a central passage **23** connected to passage **18**.

A primary body **24** is welded to the outer end of insert **20** and has a primary fuel swirl chamber **25** of frustoconical shape, ending in an orifice **26**. A primary insert **27** having tangential slots **28** is mounted in chamber **25**, being held in position by a spring **29**. The primary fuel will flow from passage **23** through a screen filter assembly **31** to slots **28** and chamber **25**, being sprayed from orifice **26**.

A secondary body **32** is threadably mounted on support section **16** and welded thereto at **33**. This body holds an insert **34** against the face **35** of section **16** to form a metal-to-metal seal. An annular passage **36** in insert **34** receives secondary fuel from a plurality of circumferentially spaced passages **37** in section **16** leading from passage **19**. A series of circumferentially spaced tangential secondary fuel ports **38** lead from annular chamber **36** to a secondary swirl chamber **39** formed between body **32** and insert **34**. Ports **38** are of a predetermined size whereby the fuel will flow at certain rates depending upon the pressure so as to follow a desired fuel flow curve. The first portion of annular chamber **39** is cylindrical in shape and the latter portion is frustoconical, a lip **41** being formed on body **32** over which the fuel will flow to form a spray cone.

A plurality of circumferentially spaced air passages **42** extend through support section **16** from the chamber **43** surrounding nozzle **11** to an annular passage **44** between inserts **20** and **34**. Chamber **43** receives air from the gas turbine compressor which flows toward combustion chamber **12**. The air in chamber **44** flows past a plurality of inner air swirl vanes **45** formed on and extending outwardly from primary body **24**. A portion of this air flows into a frustoconical chamber **46** formed at the outer end of insert **34** and past a lip **47** on this insert. It will be observed that lip **47** is disposed axially inwardly of secondary fuel lip **41** so that the air flowing past lip **47** will intermix with the spray cone issuing from secondary swirl chamber **39**. Another portion of the air flowing past swirl vanes **45** will be diverted by a deflector **48** into a series of apertures **49** from where it will pass into a primary air chamber **51**, flowing past a lip **52** to intermix with the primary fuel spray cone. Deflector **48** is supported by a heat shield **53** which is mounted on primary body **24** and forms chamber **51**.

A plurality of tangential outer air swirl slots **54** are formed in the outer portion of secondary body **32** and lead to a secondary air swirl chamber **55** formed by the frustoconical portion of a shroud **56**. This shroud is mounted on secondary body **32**. The lip **57** formed on shroud **56** at the exit of chamber **55** is spaced axially outwardly of secondary fuel lip **41** and is so located that the air issuing from chamber **55** will intermix with the secondary fuel. It will be observed that the frustoconical portions of all the swirl chambers will increase the velocity and therefore the centrifugal forces on the air or fuel flowing therethrough.

In operation, primary fuel will issue past lip **52** and secondary fuel past lip **41**, the fuel forming hollow spray cones. The air issuing past lip **52** will intermix with the primary fuel spray cone while the secondary fuel will be intermixed with air issuing from chambers **46** and **55**. The volume of air flowing, the ratio of inner and outer air to the secondary fuel, and the relative axial locations of the fuel and air lips will be so chosen as to achieve optimum fuel/air mixing, thus obtaining a proper fuel-air ratio and relatively complete combustion very close to the nozzle. The configuration of the nozzle chambers and lips is such as to obtain near perfect blending of air and fuel.

FIG. **2** shows a modification of the invention in which the primary fuel system is omitted. Normally the primary fuel system is needed during starting of the engine, when relatively low fuel flow is required, and also at high altitudes, in which case thinner air is being fed to the engine. However, because of the excellent action of this aerating nozzle it has been found that in some cases the engine can be started, and operated at high altitudes, using only the secondary fuel system.

Accordingly, FIG. **2** shows a nozzle generally indicated at **201** mounted in a combustion chamber indicated partially at **202**. The nozzle has a support member **203** with a fuel passage **204** and a heat shield **205**. A body is indicated at **206** and is threadably mounted on support **203** as well as being welded thereto at **207**. The body holds an insert **208** in alignment with a heat shield **209** through which air will flow from the space **211** surrounding the combustion chamber. Insert **208** has a plurality of inner swirl vanes **212** and a frustoconical portion **213**, the air flowing past the lip **214**.

The fuel from passage **204** is fed through an annular chamber **215** to a plurality of tangential metering apertures **216** in body **206**. A fuel swirl chamber **217** is formed between body **206** and insert **208**, the outer portion of this chamber being frustoconical in shape and having a lip **218** formed on member **206** past which the fuel will flow to form a spray cone.

A plurality of circumferentially spaced outer air swirl slots **219** are formed in body **206** and lead to an outer air swirl chamber **221** formed by an air shroud **222**. This shroud is mounted on body **206**. Chamber **221** is frustoconical in shape and leads to a lip **223** on shroud **222** past which the air will flow to intermix with the fuel spray cone. It will be noted that, as in the previous embodiment, lip **223** of the outer air swirl chamber is located axially outwardly of secondary fuel lip **218** whereas lip **214** of the inner air chamber is axially inwardly of the fuel lip.

What is claimed is:

1. In a gas turbine engine having a burner and a chamber receiving compressor discharge air and feeding said air to the burner, an aerating nozzle using burner inlet air only to obtain optimum fuel atomization without any auxiliary air pressure increasing device, comprising an annular fuel swirl chamber having a first lip at its outer end past which the fuel will flow to form a spray cone entering the burner, an inner air chamber inwardly of said fuel chamber, means swirling the air entering the inner air chamber, an annular outer air chamber surrounding said fuel chamber, second and third lips at the outer ends of said air chambers separate from said first lip past which air will flow to intermix with said fuel spray cone, whereby fuel and air mixing will occur externally of said lips, and a plurality of circumferentially spaced passages having their entrances leading from said compressor discharge chamber and conducting engine compressor discharge air to each of said air chambers in sufficient volume to achieve the optimum fuel-air mixing.

2. The combination according to claim **1**, the lip of said inner air chamber being axially inwardly of said fuel lip and the lip of said outer air chamber being axially outwardly of the fuel lip.

3. The combination according to claim **2**, said nozzle being provided with tangential passages leading to said fuel chamber comprising swirl vanes.

4. The combination according to claim **1**, portions of said chambers being frustoconical in shape to increase the velocity of the air or fuel therein.

5. The combination according to claim **4**, the lip of said inner air chamber being axially inwardly of said fuel lip and the lip of said outer air chamber being axially outwardly of the fuel lip.

6. The combination according to claim **1**, the diameters of said lips being substantially greater than their axial dimensions whereby the space within said lips is in non-confining relation with the fuel passing therethrough.

7. In a gas turbine engine, an aerating nozzle using burner inlet air only to obtain optimum fuel atomization without any auxiliary air pressure increasing device, comprising an annular fuel swirl chamber having a lip at its outer end past which the fuel will flow to form a spray cone, an inner air chamber inwardly of said fuel chamber, an annular outer air chamber surrounding said fuel chamber, lips at the outer ends of said air chambers past which air will flow to intermix with said fuel spray cone, passages conducting engine compressor discharge air to said air chambers in sufficient volume to achieve the optimum fuel-air mixing, said fuel chamber being part of a secondary fuel system, a primary fuel system comprising a frustoconical primary fuel chamber inwardly of said inner air swirl chamber, a primary air chamber between said primary fuel chamber and said inner air swirl chamber, and means for deflecting a portion of the air flowing through said inner air swirl chamber to said primary air chamber, the latter chamber having a lip surrounding the outlet orifice of said primary fuel chamber.

8. In a gas turbine engine, an aerating nozzle using burner inlet air only to obtain optimum fuel atomization without any auxiliary air pressure increasing device, comprising an annular fuel swirl chamber having a lip at its outer end past which the fuel will flow to form a spray cone, an inner air swirl chamber inwardly of said fuel chamber, an annular outer air swirl chamber surrounding said fuel chamber, portions of said chambers being frustoconical in shape to increase the velocity of the air or fuel swirling therein, lips at the outer ends of said air chambers past which air will flow to intermix with said fuel spray cone, passages conducting engine compressor discharge air to said air swirl chambers in sufficient volume to achieve the optimum fuel-air mixing, said fuel chamber being part of a secondary fuel system, a primary fuel system comprising a frustoconical primary fuel chamber inwardly of said inner air swirl chamber, a primary air chamber between said primary fuel chamber and said inner air swirl chamber, and means for deflecting a portion of the air flowing through said inner air swirl chamber to said primary air chamber, the latter chamber having a lip surrounding the outlet orifice of said primary fuel chamber.

9. In an aerating nozzle for gas turbine engines, an annular fuel swirl chamber having a lip at its outer end past which the fuel will flow to form a spray cone, an inner air swirl chamber inwardly of said fuel chamber, an annular outer swirl chamber surrounding said fuel chamber, portions of said chambers being frustoconical in shape to increase the velocity of the air or fuel swirling therein, lips at the outer ends of said air chambers past which air will flow to intermix with said fuel spray cone, passages conducting air to said air swirl chambers in sufficient volume to achieve the optimum fuel-air mixing, said fuel chamber being part of a secondary fuel system, a primary fuel system comprising a frustoconical primary fuel chamber inwardly of said inner air swirl chamber, a primary air chamber between said primary fuel chamber and said inner air swirl chamber, and means for deflecting a portion of the air flowing through said inner air swirl chamber to said primary air chamber, the latter chamber having a lip surrounding the outlet orifice of said primary fuel chamber.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,684,186 Dated August 15, 1972

Inventor(s) William F. Helmrich

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 14, the word "clearer" should be --cleaner--; after line 25, the following paragraph should be inserted:

--Two other patents in the prior art are Masters, Patent No. 3,533,558, and Jones, Patent No. 1,881,359. Neither of these patents is directed to an aerating nozzle. The device of Masters is intended for use with a highly viscous fluid and the Jones burner nozzle is for oil fuel. These patents lack important features of the invention as set forth below.--;

line 46, the word "provisions" should be --provision--.

Signed and sealed this 6th day of February 1973.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents