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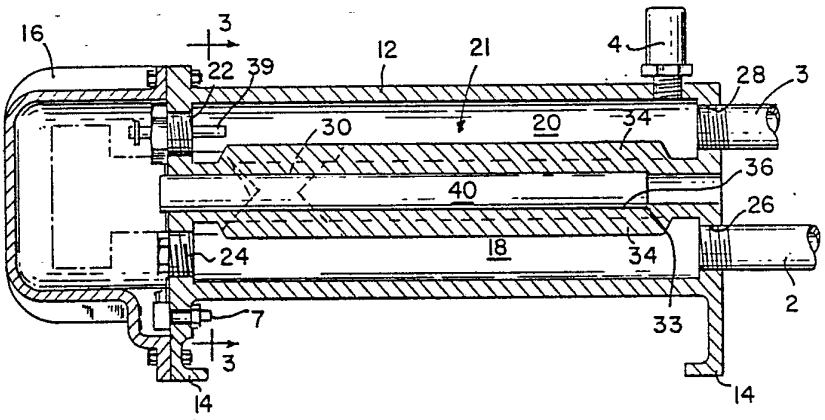
(54) Title: ELECTRIC LIQUEFIED PETROLEUM GAS VAPORIZER



(57) Abstract

A compact, economical electrically heated vaporizer (10) having a fast response time and capable of vaporizing liquified petroleum gas at a rate of 37.85 to 151.41 liters or more per hour with safety and without excessive superheating and/or cracking of the liquified petroleum gas utilizes a metal casting (12) having a closed internal cavity separated into two chambers (18 and 20) by an integral barrier (21). The casting (12) serves as a pressure vessel and heat sink as well as providing a heated interface between electric resistance heaters (40) received in passageways (36) in the barrier (21) and the liquified petroleum gas. The heat generated by the heaters (40) is disseminated uniformly throughout the casting (12) surrounding the chambers (18 and 20). A liquified petroleum gas inlet (26) at one end of the casing connects with the end of one chamber (18). Multiple small passageways (30 and 32) in the barrier (21) at the other end of the casting connect the other end of the one chamber (18) to the adjacent end of the other chamber (20). The passageways (30 and 32) are configured to create a turbulent flow which improves heat transfer. An outlet (28) connects with the other end of the other chamber (20) for discharge of the vaporized gas. The electrical and temperature controls for controlling the operation of the heaters (40) and the flow of liquified petroleum gas through the chambers (18 and 20) are housed within an enclosed chamber formed by an end cover (16) on the other end of the casting. The temperature sensors for the temperature controls are received in passageways (38) in the barrier (21).

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TITLE

ELECTRIC LIQUEFIED PETROLEUM GAS VAPORIZER

Technical Field

This invention relates to an apparatus for uniformly and economically vaporizing liquefied petroleum gas.

Background Art

Electric vaporizers for vaporizing liquefied petroleum gas are known. Such units employ electric resistance heaters which are directly immersed in storage tanks for the liquefied petroleum gas or which are immersed in a liquid bath to heat the liquid bath which in turn, heats the liquefied petroleum gas to vaporize the same. U.S. Patent Nos. 2,166,922; 2,193,006; and 2,775,-683; all disclose the use of electric resistance heaters for vaporizing liquefied petroleum gas, the resistance heaters enclosed directly in the storage tank holding the liquefied petroleum gas. U.S. Patent No. 2,348,546 discloses an electric vaporizer in an installation adjacent the liquefied petroleum gas tank through which the liquefied petroleum gas is fed. Direct heating of liquefied petroleum gas described by the above references creates a safety hazard. Additionally, the high temperature of a heating element directly in contact with the liquefied gas causes excessive cracking of the liquefied petroleum gas.

Indirect heating of liquefied petroleum gas by water baths, oil baths or other such means performs well when high vaporization capacity is needed; however, for low or medium vaporization capacities such units are both uneconomical and inefficient.

DISCLOSURE OF INVENTION

The primary object of this invention is to provide an electric liquefied petroleum gas vaporizer unit which is compact, economical and safe.

Another object of this invention is to provide an electric liquefied petroleum gas vaporizer utilizing a highly heat-conductive metal casting heated by electric resistance heaters, the casting functioning as a pressure vessel and heat interface between the heat source and the liquefied petroleum gas, as well as a heat sink to uniformly vaporize liquefied petroleum gas.

A further object of this invention is to provide an electric liquefied petroleum gas vaporizer capable of uniformly vaporizing the liquefied petroleum gas without excessive superheating and/or cracking of the liquefied petroleum gas and which gives superior response time.

A further object of this invention is to provide an electric liquefied petroleum gas vaporizer which is capable of vaporizing liquefied petroleum gas to the full capacity of the unit within minutes after it is started.

These and other objects are accomplished by a compact, economical vaporizer employing a heat-conductive casting having a closed internal cavity bridged by an integral divider dividing the cavity into two separate chambers. The chambers are interconnected at the end opposite the point of entry of the liquefied petroleum gas by multiple passageways of considerably reduced dimension relative to the dimensions of each of the chambers. The passageways increase the efficiency of the unit by creating turbulence which promotes heat exchange for more efficient vaporization. An inlet opening in the casting for liquefied petroleum gas communicates with one of the chambers and an outlet opening in the casting adjacent the inlet opening communicates with the other chamber. Passageways in the integral divider are provided for installing electric resistance heater units which allow close control of the system. The heat generated by these units is uniformly disseminated by conduction over the

surface area of the casting surrounding each of the chambers. Temperature sensing means are included in the casting for maximum control of the power delivered to the electric resistance heaters to maintain the temperature of the casting uniform.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a perspective view of the vaporizer unit in relation to a storage tank for liquefied petroleum gas;

Fig. 2 is a vertical cross section through the vaporizer of Fig. 1 along section line 2-2 of Fig. 1;

Fig. 3 is a cross section of the vaporizer unit along section line 3-3 of Fig. 2.; and

Fig. 4 is a wiring diagram of the vaporizer unit employing three resistance heaters.

BEST MODE FOR CARRYING OUT THE INVENTION

Referring to Fig. 1, the vaporizer unit 10 is shown in relation to a storage tank for liquefied petroleum gas 1. An inlet liquid gas line 2 of sufficient size to supply the vaporizer unit at full flow capacity and accommodate rapid flow changes in or out of the unit with minimum pressure drop extends from the storage tank to the vaporizer unit. Generally the liquefied petroleum gas may be pumped from the storage tank to the unit by a pump (not shown).

The vaporizer unit 10 may be an integral metal casting 12 which is of a highly heat conductive material such as aluminum. The casting may be jacketed with one or more layers of a heat insulating material if desired. The casting is supported on legs 14 which are secured to a concrete pad or other suitable support. Liquefied gas enters the vaporizer unit through line 2 and is heated during its passage through the casting and exits the unit as a gas vapor through outlet line 3 which is directly above the inlet line 2. If desired, the inlet and outlet to the casting can be reversed. The casting may be

mounted horizontally or vertically. A pressure relief valve 4 is threaded through the casting 12 to communicate with the interior of the vaporizer unit for safety purposes.

An outlet solenoid valve 5 connects to gas vapor outlet line 6 as illustrated. This outlet valve acts as a safety device and prevents vapor flow from the outlet line beyond the valve until the unit is properly operating. The valve closes if the unit functions improperly. The electrical wiring for the solenoid is operatively connected to the controls for the unit through a conduit (not shown). Other types of control valves may be used if desired.

All of the electrical components for control of the unit as well as the wiring therefor are housed within end cover 16 located at the opposite end of the casting from the liquid gas inlet and gas vapor outlets 2 and 3. In this way all of the wiring is enclosed and is totally out of contact with any liquid gas or gas vapor. The start and stop push buttons 7 and 8 for the unit are located within the support leg 14 adjacent the end of the casting where the electrical controls are located. By locating all of the wiring and electrical controls internally in the unit the end cover 16 can be readily removed for servicing of the unit without having to cut or remove any wiring.

Fig. 2 illustrates a vertical cross section of casting 12. The casting is cylindrical and may be symmetrical about its vertical and horizontal axes. The shape of the casting is not critical, however, and may be of any desired configuration. The casting has an internal cavity separated into two chambers 18 and 20 by an integral divider 21. As illustrated the chambers 18 and 20 are of equal size although this is not critical. The openings 22 and 24 at the end of the casting adjacent the end cover 16 are plugged with a suitable material so that

no gas flow can escape the casting. Liquid gas inlet pipe 2 is threaded into the lower opening 26 and gas vapor outlet pipe 3 is threaded into the upper vapor outlet 28 of the casting as illustrated in Fig. 2. The two compartments 18 and 20 within the casting are interconnected by passages 30 and 32 which are of considerably reduced size relative to the size of the compartments 18 and 20. The passages 30 and 32 are configured to create a turbulent flow of the gas or gas-liquid mixture in the casting to aid in heat transfer from the walls of the casting to the liquefied gas. As illustrated in Fig. 2 each of the passageways is wedge-shaped.

The integral divider 21 separating the internal cavity of the casting into the two compartments 18 and 20 includes integral multiple fins 34 extending from the divider respectively into the chambers 18 and 20. The fins 34 expose a greater amount of the surface area of the casting to the liquefied gas being introduced into the internal cavity of the casting to aid in heat transfer. The integral divider 21 also includes multiple bore openings 36 extending the length of the casting between the passageways 30 and 32 interconnecting the chambers 18 and 20. These passageways are designed to receive electric resistance heaters as will be described. One or more additional bore openings 38 are provided in the integral divider of the casting between the passageways 36. These passageways 38 are designed to receive temperature sensing means, the temperature sensing means connected to control means for controlling power to the electric resistance heaters. A liquid gas carryover sensor 39 extends into the upper chamber 20 through the plug in opening 22 to sense, by measurement of temperature, liquefied gas carryover from the unit.

One or more electric resistance heater units 40 enclosed in a sheath of the same diameter as the diameter of passageways 36 is inserted in the passageways as il-

lustrated in Fig. 2. A close fit of the electric resistance heater in the casting is desired to insure maximum heat transfer between the resistance heater and the casting. The close fit also plugs each of the passageways 36 to maintain the explosion-proof condition of the electrical system of the unit. A ledge 33 at the end of each passageway 36 keeps the resistance heater from being projected from the casting, should an explosion occur.

The vaporizing unit is capable of readily meeting the demand for vaporization capacities ranging from 37.85 to 151.41 or more liters per hour. The same casting can be used for vaporization of 37.85 liters per hour as for 151.41 liters per hour. The only difference in the units is in the number and size of electrical resistance heaters utilized. For example, a unit capable of vaporizing 37.85 liters per hour utilizes one 2.5 kw element. A unit vaporizing 75.71 liters per hour utilizes two 2.5 kw elements and a unit vaporizing 113.56 liters per hour utilizes three 2.5 kw elements. A 151.41 liters per hour unit would employ three 3.25 kw elements, etc.

Each of the electrical resistance heaters 40 is connected to a source of electrical power through control and safety relays which are interconnected with the temperature sensing means to insure proper operation of the unit. Fig. 4 illustrates a wiring diagram for the vaporizer unit. Resistance heaters 40 are connected through contacts 41, 42 and 43 of control relay 44 and contacts 45, 46, 47 and 48 of safety relay 49 to a source of suitable voltage such as a source of single phase 240V, 50/60 Hz power or three phase power. The unit is started by allowing liquefied gas to flow into the lower chamber 18 of the unit and depressing switch 7 until the unit has warmed to operating temperature (about 43.33°C.). When the switch 7 is released solenoid outlet valve 5 is actuated to allow vapor flow through line 6. Temperature sensing means connected to operating temperature switch

51 retains the switch in closed position until the maximum operating temperature (about 98.89°C.) is reached. When the switch 51 closes it deactivates control relay 44 to open contacts 41, 42 and 43 to disrupt current flow to the resistance heaters 40. A high temperature sensing means is positioned in the casting and set at a predetermined temperature (such as about 148.89°C.). If the temperature of the casting exceeds the predetermined temperature safety switch 52 opens, interrupting current to safety relay 49, resulting in opening of contacts 45, 46, 47 and 48 to interrupt power to the heaters 40. When any of the safety limits are reached, solenoid valve 5 closes. Manual restart of the unit is required. A liquefied gas carryover switch 53 connected to sensor 39 in the casting remains open until it senses the absence of liquid. The safety switch 53 is manually bypassed during startup.

The vaporizer is started by allowing liquefied petroleum gas to flow into the lower chamber 18 of the vaporizer unit through the inlet line 2. The vaporizer unit is warmed up to minimum operating temperature by pressing the "start" switch 7 as previously mentioned and holding it for two to three minutes. When the start button is released the outlet solenoid valve 5 opens to allow gas vapor to exit the vaporizer unit through gas vapor line 6. The flow of gas vapor at full capacity of the unit is generally available five minutes after the start switch is initially depressed. Should, for some reason, the temperature of the unit exceed the preset temperature of the high temperature switch which is generally about 148.89°C. the power will be disconnected to the electric resistance heaters. The liquid carryover switch 53, previously described, provides an extra safety measure. Should liquefied gas be sensed, solenoid valve 5 closes, power to the electric resistance heaters is disrupted and manual restart is required.

The liquefied petroleum gas enters the lower chamber as a liquid and is heated to its vaporization point. The passageways 30 and 32 between the upper and lower chambers are small enough to create turbulence and disperse the liquefied gas into small droplets which rapidly flash to gas vapor as the liquefied gas flows through the passageways. The upper chamber further heats the vaporized gas to a proper superheated condition. The unit is stopped by pressing switch 8 to deactivate relays 49 and 44, outlet valve 5 and heaters 40.

The unit as described is a compact versatile unit for vaporizing liquefied petroleum gas employing a heat sink in the form of a highly heat conductive metal casting also serving as a pressure vessel and heat interface between a source of heat and the liquefied petroleum gas. Flow surges can be readily accommodated. Excessive superheating of the liquefied petroleum gas is prevented by the relatively low temperature of the heat sink in contrast to direct contact of the liquefied petroleum gas with a heat source which causes cracking of the gas, resulting in polymerization, tarry residues and undesired components to form. The unit can go from no load to full load almost instantaneously -- a matter of seconds and can thus quickly respond to load changes.

CLAIMS:

1. A compact economical electric vaporizer unit for vaporizing liquefied petroleum gas comprising:

a heat-conductive casting having an internal cavity bridged by an integral divider dividing the cavity into separate chambers,

multiple passageways through one end of the divider interconnecting the separate chambers, the passageways of considerably reduced dimension relative to the dimension of each of the chambers,

a liquefied petroleum gas inlet opening in the casting spaced from the multiple passageways and communicating with one of the chambers,

a gas outlet opening in the casting adjacent the inlet opening and spaced from the multiple passageways communicating with the other chamber,

one or more passageways in the integral divider holding electric resistance heater units,

one or more temperature sensing ports in the casting including temperature sensing means,

electric power means connected to the electric resistance heaters, and

control means operatively connected to the sensing means and electric power means for maintaining the temperature of the casting uniform.

2. The vaporizer of claim 1 wherein the interior surface of each of the chambers includes fins to increase the overall surface area to which the liquefied petroleum gas entering the chambers is exposed.

3. The vaporizer of claim 1 wherein the casting is symmetrical about its vertical and horizontal axes.

4. The vaporizer of claim 1 including an end cover sealing the exposed ends of the electric resistance heater units and control means therefor.

5. The vaporizer of claim 1 wherein the cast-

ing is an aluminum casting.

6. The vaporizer of claim 1 wherein contact of the electric resistance heaters with the casting is such as to insure maximum heat transfer between the electric resistance heater units and the casting.

7. The vaporizer of claim 1 wherein the temperature sensing port and sensing means are located between the electric resistance heater units.

8. The vaporizer of claim 1 wherein the chambers are of equal volume and wherein the multiple passageways are configured to minimize liquid petroleum gas carry-over and create turbulent flow of the liquefied petroleum gas as it passes from one chamber to the other.

9. The vaporizer of claim 1 wherein the central cavity provides a labrinyth passageway leading to the outlet opening for vaporizing liquefied petroleum gas introduced into the inlet opening.

10. A compact economical vaporizer having a vaporization capacity of ten to forty gallons of liquefied petroleum gas per hour or more, comprising:

a heat-conductive aluminum casting having an enclosed central cavity bridged by an integral divider dividing the central cavity into at least two separate vaporization chambers,

multiple passageways interconnecting the two chambers, the passageways of considerably reduced dimension relative to the dimension of each of the vaporization chambers,

a liquefied petroleum gas inlet opening in the casting at the opposite end of the casting from the multiple passageways communicating with one of the chambers,

a gas outlet opening in the casting adjacent the inlet opening communicating with another of the chambers,

passageways in the integral divider, each holding an electric resistance heater unit,

temperature sensing passageways in the casting adjacent the electric resistance heaters including temperature sensing means,

electric power means connected to the electric resistance heater units at the end of the casting opposite the inlet and outlet openings,

control means at the end of the casting opposite the inlet and outlet openings operatively connected to the sensing means and electric power means for maintaining the temperature of the casting uniform, and

an end cover sealing the exposed ends of the electric resistance heaters and control means.

FIG. 1

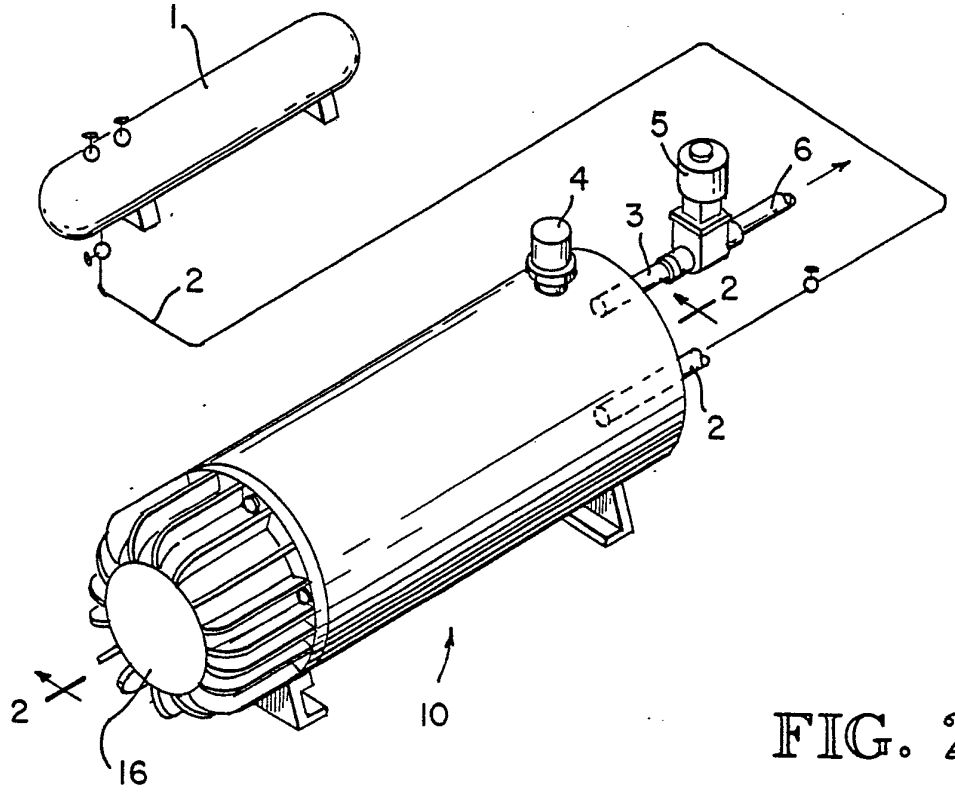


FIG. 2

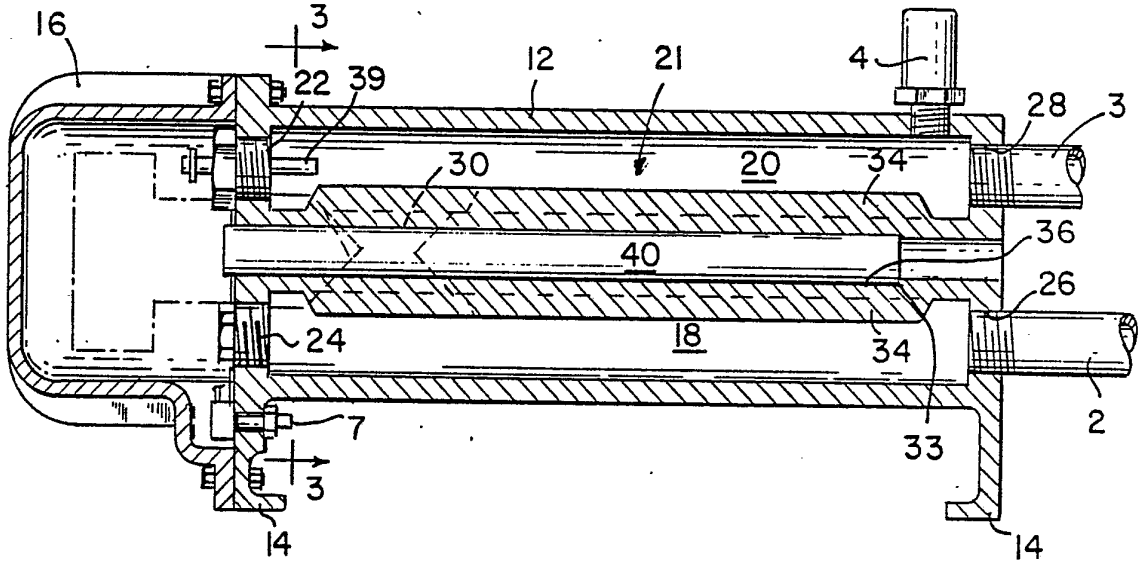
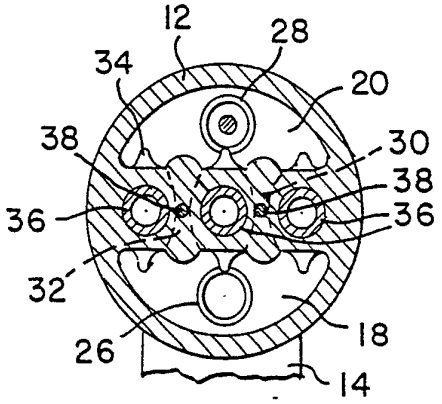


FIG. 3



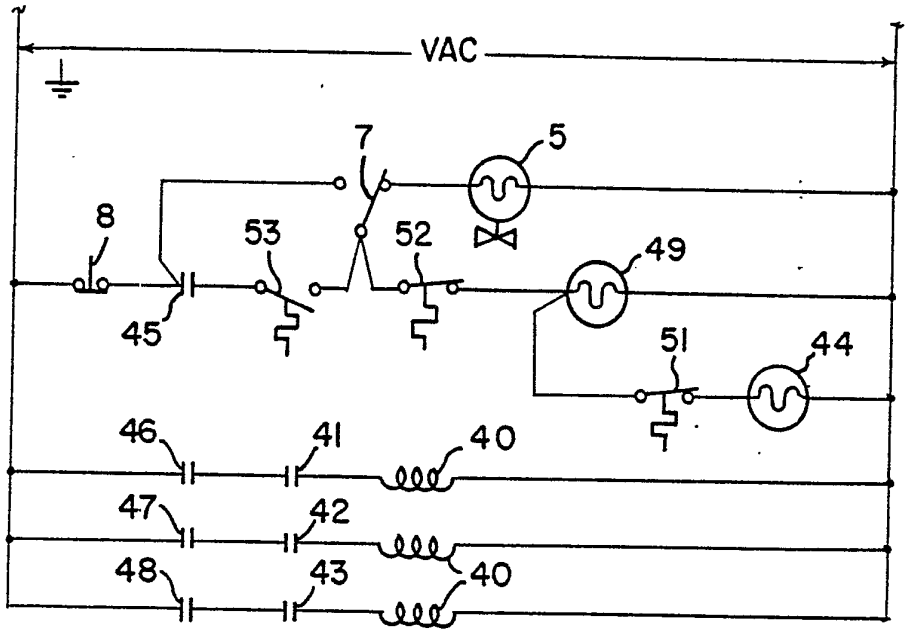


FIG. 4

INTERNATIONAL SEARCH REPORT

International Application No PCT/US79/00124

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [3]

According to International Patent Classification (IPC) or to both National Classification and IPC

INT. CL. - F17C 7/02; B05B 1/24; F22B 1/28; F23D 1/44; C10G 9/24.
U.S. CL. - 219/275; 48/103; 62/52; 122/208; 137/341; 219/302; 239/136; 431/208

II. FIELDS SEARCHED

Minimum Documentation Searched [4]

Classification System	Classification Symbols
U.S.	219/271-276,280,296-299,302-306,314,328;48/103;122/4,5,40,41,208; 62/50,52;137/341;239/133-137;222/146R,146H,146HE; 431/11,36,41,207,208;128/186,192;43/129,130;123/122R,122E,122F

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [5]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No. [18]
A	GB, A, 915,826, PUBLISHED 16 JANUARY 1963 Evans	1-10
X	US, A, 2,010,331, PUBLISHED 06 AUGUST 1935 see page 2, col. 1, lines 12-70, Starrick.	1-10
X	US, A, 3,477,644, PUBLISHED 11 NOVEMBER 1969 see col. 2, line 71 to col. 3, line 47, Bablouzian, et. al.	1-10
A	US, A, 2,228,315, PUBLISHED 14 JANUARY 1941 see Figs. 2-4 and 6, Hutton.	1-10
X	US, A, 3,175,075, PUBLISHED 23 MARCH 1965 see col. 3, line 42 to col. 4, line 60, Nord et al.	1-10
X	US, A, 2,592,568, PUBLISHED 15 APRIL 1952 see 25 and 49 in Fig. 4, Hill.	2
A	US, A, 1,594,564, PUBLISHED 03 AUGUST 1926 Rosier.	1-10
A	US, A, 2,266,046, PUBLISHED 16 DECEMBER 1941 see page 1, col. 2, lines 6-12, Kanter et al.	1-10
X	US, A, 2,907,176, PUBLISHED 06 OCTOBER 1959 see Figs. 2-5, Tsunoda et al.	1-10
X	US, A, 2,980,099, PUBLISHED 18 APRIL 1961 see col. 3, lines 2-33, Klemm.	1-10

(CON'T ON SUPPL. SHEET 2)

* Special categories of cited documents: [15]

"A" document defining the general state of the art
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"X" document of particular relevance

IV. CERTIFICATION

Date of the Actual Completion of the International Search [2]	Date of Mailing of this International Search Report [2]
30 APRIL 1979	18 MAY 1979
International Searching Authority [1]	Signature of Authorized Officer [20]
ISA/US	A. BARTIS

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

X	US, A, 3,012,129; PUBLISHED 05 DECEMBER 1961 see col. 3, lines 35-68, Wehl.	4,10
X	US, A, 2,272,341; PUBLISHED 10 FEBRUARY 1942 see vaporizing chambers 14 and 16, Holzapfel.	1-10
X	US, A, 2,039,892, PUBLISHED 05 MAY 1936 see Figs. 2-4, Dowinsky.	1-10

V. ☐ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE [10]

This international search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons:

1. ☐ Claim numbers....., because they relate to subject matter [12] not required to be searched by this Authority, namely:

2. ☐ Claim numbers....., because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out [13], specifically:

VI. ☐ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING [11]

This International Searching Authority found multiple inventions in this international application as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.

2. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:

3. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:

Remark on Protest

☐ The additional search fees were accompanied by applicant's protest.

☐ No protest accompanied the payment of additional search fees.