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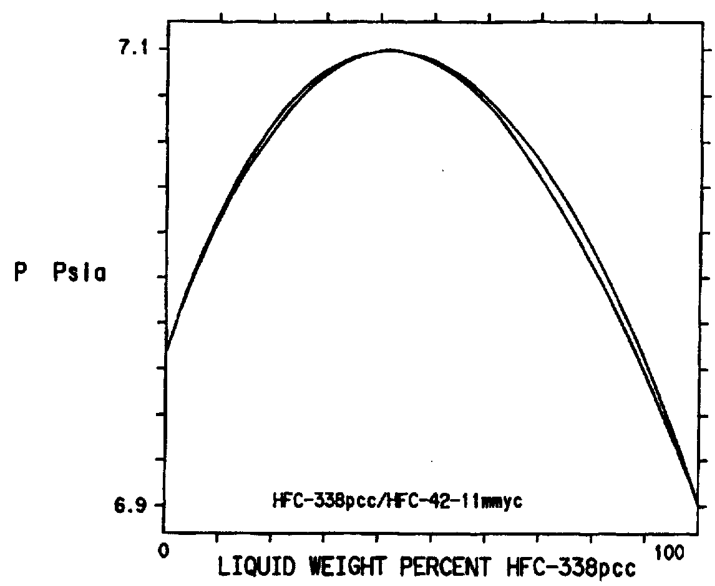


(57) Abstract

Compositions of 1,1,2,2,3,3,4,4-octafluorobutane and a compound of the formula selected from the group consisting of a 4-6 carbon linear or a cyclic hydrofluorocarbon or fluorocarbon, a 3-5 carbon fluoroether, a fluorinated alcohol, perfluoro-n-methylmorpholine, and an ether are disclosed. These compositions, which may be azeotropic or azeotrope-like, may be used as refrigerants, in small turbine high speed compressors. They may also be used as refrigerants, cleaning agents, expansion agents for polyolefins and polyurethanes, aerosol propellants, heat transfer media, gaseous dielectrics, fire extinguishing agents, power cycle working fluids, polymerization media, particulate removal fluids, carrier fluids, buffing abrasive agents, displacement drying agents or as an anesthetic.

TITLE

1,1,2,2,3,3,4,4-OCTAFLUOROBUTANE COMPOSITIONS

FIELD OF THE INVENTION

This invention relates to compositions that include an octafluorobutane. More specifically, this invention relates to binary compositions containing 1,1,2,2,3,3,4,4-octafluorobutane and a compound selected from the group consisting of a 4-6 carbon linear or a cyclic hydrofluorocarbon (HFC) or fluorocarbon (FC), a 3-5 carbon fluoroether, a fluorinated alcohol, perfluoro-n-methylmorpholine, and an ether. These compositions are useful as refrigerants, cleaning agents, expansion agents for polyolefins and polyurethanes, aerosol propellants, refrigerants, heat transfer media, gaseous dielectrics, fire extinguishing agents, power cycle working fluids, polymerization media, particulate removal fluids, carrier fluids, buffing abrasive agents, displacement drying agents and as an anesthetic.

BACKGROUND OF THE INVENTION

Fluorinated hydrocarbons have many uses, one of which is as a refrigerant. Such refrigerants include trichlorofluoromethane (CFC-11) and chlorodifluoromethane (HCFC-22).

In recent years it has been pointed out that certain kinds of fluorinated hydrocarbon refrigerants released into the atmosphere may adversely affect the stratospheric ozone layer. Although this proposition has not yet been completely established, there is a movement toward the control of the use and the production of certain chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs) under an international agreement.

Accordingly, there is a demand for the development of refrigerants that have a lower ozone depletion potential than existing refrigerants while still achieving an acceptable performance in refrigeration applications. Hydrofluorocarbons (HFCs) have been suggested as replacements for CFCs and HCFCs since HFCs have no chlorine and therefore have zero ozone depletion potential.

In refrigeration applications, a refrigerant is often lost during operation through leaks in shaft seals, hose connections, soldered joints and broken lines. In addition, the refrigerant may be released to the atmosphere during maintenance procedures on refrigeration equipment. If the refrigerant is not a pure component or an azeotropic or azeotrope-like composition, the refrigerant composition may change when leaked or discharged to the atmosphere from the refrigeration equipment, which may cause the refrigerant to become flammable or to have poor refrigeration performance.

Accordingly, it is desirable to use as a refrigerant a single fluorinated hydrocarbon or an azeotropic or azeotrope-like composition that includes one or more fluorinated hydrocarbons.

Fluorinated hydrocarbons may also be used as a cleaning agent or solvent to clean, for example, electronic circuit boards. It is desirable that the cleaning agents be azeotropic or azeotrope-like because in vapor degreasing operations the cleaning agent is generally redistilled and reused for final rinse cleaning.

Azeotropic or azeotrope-like compositions that include a fluorinated hydrocarbon are also useful as blowing agents in the manufacture of closed-cell polyurethane, phenolic and thermoplastic foams, as propellants in aerosols, as heat transfer media, gaseous dielectrics, fire extinguishing agents, power cycle working fluids such as for heat pumps, inert media for polymerization reactions, fluids for removing particulates from metal surfaces, as carrier fluids that may be used, for example, to place a fine film of lubricant on metal parts, as buffing abrasive agents to remove buffing abrasive compounds from polished surfaces such as metal, as displacement drying agents for removing water, such as from jewelry or metal parts, as resist developers in conventional circuit manufacturing techniques including chlorine-type developing agents, or as strippers for photoresists when used with, for example, a chlorohydrocarbon such as 1,1,1-trichloroethane or trichloroethylene.

It has become increasingly important to identify compositions to replace CFC-113 in small high speed turbine compressors. Small high speed turbine compressors have become part of an emerging new technology for air conditioning systems that operate at low pressures. Target applications include air conditioning of automobiles, buses, trains, recreational vehicles, roof top and residential window units. Potential advantages include low emission rates, small size, light weight, and higher energy efficiency with variable speed control. The azeotropic or azeotrope-like compositions disclosed herein, have been identified as providing suitable performance in these systems. As discussed above, these compositions, may also be useful in other applications, particularly as cleaning agents and blowing agents.

SUMMARY OF THE INVENTION

The present invention relates to the discovery of refrigerant compositions of 1,1,2,2,3,3,4,4-octafluorobutane (HFC-338pcc) and a compound selected from the group consisting of a 4-6 carbon linear or a cyclic HFC or FC, a 3-5 carbon fluoroether, a fluorinated alcohol, perfluoro-n-methylmorpholine and an ether. These compositions are particularly useful as refrigerants, particularly in small, high speed turbine compressors, or cleaning agents. These compositions are also useful as expansion agents for polyolefins and polyurethanes, aerosol propellants, heat transfer media, gaseous dielectrics, fire extinguishing agents, power cycle working fluids, polymerization media, particulate removal fluids, carrier fluids, buffing abrasive agents, and displacement drying agents. Further, the invention relates to the discovery of binary azeotropic or azeotrope-like compositions comprising effective amounts of 1,1,2,2,3,3,4,4-octafluorobutane and a compound selected from the group consisting of a 4-6 carbon linear or cyclic HFC or FC, a 3-5 carbon fluoroether, a fluorinated alcohol, perfluoro-n-methylmorpholine and an ether to form an azeotropic or azeotrope-like composition.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a graph of the vapor/liquid equilibrium curve for mixtures of HFC-338pcc and HFC-42-11mmyc at 25°C;

Figure 2 is a graph of the vapor/liquid equilibrium curve for mixtures of HFC-338pcc and HFC-42-11p at 25°C;

Figure 3 is a graph of the vapor/liquid equilibrium curve for mixtures of HFC-338pcc and HFC-43-10mf at 25°C;

Figure 4 is a graph of the vapor/liquid equilibrium curve for mixtures of HFC-338pcc and HFC-449mmzf at 25°C;

Figure 5 is a graph of the vapor/liquid equilibrium curve for mixtures of HFC-338pcc and HFC-c354cc at 25°C;

Figure 6 is a graph of the vapor/liquid equilibrium curve for mixtures of HFC-338pcc and HFC-c51-12c at 25°C;

Figure 7 is a graph of the vapor/liquid equilibrium curve for mixtures of HFC-338pcc and HFC-c429 at 25°C;

Figure 8 is a graph of the vapor/liquid equilibrium curve for mixtures of HFC-338pcc and HFC-c52-11 at 25°C;

Figure 9 is a graph of the vapor/liquid equilibrium curve for mixtures of HFC-338pcc and 245caEαβ at 25°C;

Figure 10 is a graph of the vapor/liquid equilibrium curve for mixtures of HFC-338pcc and 245eaE at 25°C;

Figure 11 is a graph of the vapor/liquid equilibrium curve for mixtures of HFC-338pcc and 338meeEβγ at 25°C;

Figure 12 is a graph of the vapor/liquid equilibrium curve for mixtures of HFC-338pcc and 338peEγδ at 25°C;

Figure 13 is a graph of the vapor/liquid equilibrium curve for mixtures of HFC-338pcc and 347mcfEβγ at 25°C;

Figure 14 is a graph of the vapor/liquid equilibrium curve for mixtures of HFC-338pcc and 347mcfEgδ at 25°C;

Figure 15 is a graph of the vapor/liquid equilibrium curve for mixtures of HFC-338pcc and 347mmzEβγ at 25°C;

Figure 16 is a graph of the vapor/liquid equilibrium curve for mixtures of HFC-338pcc and 356mecEgδ at 25°C;

Figure 17 is a graph of the vapor/liquid equilibrium curve for mixtures of HFC-338pcc and 356mecE2aβγδ at 25°C;

Figure 18 is a graph of the vapor/liquid equilibrium curve for mixtures of HFC-338pcc and 356mmzEβγ at 25°C;

Figure 19 is a graph of the vapor/liquid equilibrium curve for mixtures of HFC-338pcc and 365mcEγδ at 25°C;

Figure 20 is a graph of the vapor/liquid equilibrium curve for mixtures of HFC-338pcc and 374pcEβγ at 25°C;

Figure 21 is a graph of the vapor/liquid equilibrium curve for mixtures of HFC-338pcc and 383mEβγ at 25°C;

Figure 22 is a graph of the vapor/liquid equilibrium curve for mixtures of HFC-338pcc and 467mmyEβγ at 25°C;

Figure 23 is a graph of the vapor/liquid equilibrium curve for mixtures of HFC-388pcc and 467sfEγδ at 25°C;

Figure 24 is a graph of the vapor/liquid equilibrium curve for mixtures of HFC-388pcc and $C_4F_9OCH_3$;

Figure 25 is a graph of the vapor/liquid equilibrium curve for mixtures of HFC-388pcc and $(CF_3)_3COH$;

Figure 26 is a graph of the vapor/liquid equilibrium curve for mixtures of HFC-388pcc and $C_5F_{11}NO$;

Figure 27 is a graph of the vapor/liquid equilibrium curve for mixtures of HFC-388pcc and dimethoxymethane;

Figure 28 is a graph of the vapor/liquid equilibrium curve for mixtures of HFC-388pcc and diethylether;

Figure 29 is a graph of the vapor/liquid equilibrium curve for mixtures of HFC-388pcc and diethoxyethane; and

Figure 30 is a graph of the vapor/liquid equilibrium curve for mixtures of HFC-388pcc and HFC-43-10mcf.

DETAILED DESCRIPTION

The present invention relates to azeotropic or azeotrope-like compositions of 1,1,2,2,3,3,4,4-octafluorobutane (HFC-338pcc) and a compound selected from the group consisting of a 4-6 carbon linear or a cyclic HFC or FC, a 3-5 carbon fluoroether, a fluorinated alcohol, perfluoro-n-methylmorpholine and an ether. Examples of these compositions include:

(a) HFC-338pcc and 1,1,1,2,3,3,4,4-octafluoro-2-(trifluoromethyl)butane (HFC-42-11mmyc); 1,1,1,2,2,3,3,4,4,5,5-undecafluoropentane (HFC-42-11p); 1,1,1,2,2,3,3,5,5,5-decafluoropentane (HFC-43-10mf); 1,1,1,2,2,4,4,5,5,5-decafluoropentane (HFC-43-10mcf); and 1,1,1,4,4,4-hexafluoro-2-(trifluoromethyl)butane (HFC-449mmzf); or

(b) HFC-338pcc and 1,1,2,2-tetrafluorocyclobutane (HFC-c354cc); perfluorocyclohexane (FC-c51-12c); 1,1,2,2,3,3,4,4,5-nonafluorocyclopentane (HFC-c429); and 1,1,2,2,3,3,4,4,5,5,6-undecafluorocyclohexane (HFC-c52-11); or

(c) HFC-338pcc and 1-(difluoromethoxy)-1,1,2-trifluoroethane $CHF_2OCF_2CH_2F$, (245caEαβ); 1-(difluoromethoxy)-1,2,2-trifluoroethane $CHF_2OCHFCHF_2$, (245eaE); 1,1'-oxybis(1,2,2,2-tetrafluoro)ethane $CF_3CHFOCHFCF_3$, (338 meeEβγ); 3-difluoromethoxy-1,1,1,2,2,3-hexafluoropropane $CHF_2OCHFCF_2CF_3$, (338peEγδ); 1,1,2,2-tetrafluoro-1-(2,2,2-trifluoroethoxy)ethane $CHF_2CH_2OCF_2CF_3$, (347mcfEβγ); 3-difluoromethoxy-1,1,1,2,2-pentafluoropropane $CHF_2OCH_2CF_2CF_3$, (347mcfEγδ); 1,1,1,3,3,3-hexafluoro-2-fluoromethoxypropane $CH_2FOCH(CF_3)_2$, (347mmzEβγ); 1,1,1,2,3,3-hexafluoro-3-methoxypropane $CH_3OCF_2CHFCF_3$, (356mecEγδ); 1,1,2-trifluoro-1-methoxy-2-(trifluoromethoxy)ethane $CH_3OCF_2CHFOCF_3$, (356mecE2αβγδ); 1,1,1,3,3,3-hexafluoro-2-methoxypropane $(CF_3)_2CHOCH_3$, (356mmzEβγ); 1,1,1,2,2-pentafluoro-3-methoxypropane $CF_3CF_2CH_2OCH_3$, (365mcEγδ); 1-ethoxy-1,1,2,2-tetrafluoroethane

$C_2H_5OCF_2CHF_2$, (374pcEβγ); 2-ethoxy-1,1,1-trifluoroethane $C_2H_5OCH_2CF_3$ (383mEβγ); 2-ethoxy-1,1,1,2,3,3,3-heptafluoropropane $C_2H_5OCF(CF_3)_2$, (467mmyEβγ); 3-ethoxy-1,1,1,2,2,3,3-heptafluoropropane $C_2H_5OCF_2CF_2CF_3$, (467sfEγδ); $C_4F_9OCH_3$; or $(CF_3)_3COH$; or

(d) HFC-338pcc and nonafluoro-*tert*-butanol $(CF_3)_3COH$; or

(e) HFC-338pcc and perfluoro-n-methylmorpholine ($C_5F_{11}NO$); or

(f) HFC-338pcc and dimethoxymethane; diethylether or diethoxyethane.

Examples of these compounds include the following:

1. 1,1,2,2,3,3,4,4-octafluorobutane ($CHF_2CF_2CF_2CHF_2$, HFC-338pcc, boiling point = 44.4°C);
2. 1-(difluoromethoxy)-1,1,2-trifluoroethane ($CHF_2OCF_2CH_2F$, 245caEab, boiling point = 40°C);
3. 1-(difluoromethoxy)-1,2,2-trifluoroethane ($CHF_2OCHFCHF_2$, 245eaE, boiling point = 53.0°C);
4. 1,1'-oxybis(1,2,2,2-tetrafluoro)ethane ($CF_3CHFOCHFCF_3$, 338meeEbg, boiling point = 50.0°C);
5. 3-(difluoromethoxy)-1,1,1,2,2,3-hexafluoropropane ($CHF_2OCHFCF_2CF_3$, 338peEgd, boiling point = 44.5°C);
6. 1,1,2,2-tetrafluoro-1-(2,2,2-trifluoroethoxy)-ethane ($CHF_2CH_2OCF_2CF_3$, 347mcfEbg, boiling point = 45.4°C);
7. 1,1,2-trifluoro-1-methoxy-2-(trifluoromethoxy)ethane ($CH_3OCF_2CHFOCF_3$, 356mecE2abgd, boiling point = 58.0°C);
8. 1,1,1,2,3,3-hexafluoro-3-methoxypropane ($CH_3OCF_2CHFCF_3$, 356mecEgd, boiling point = 56.0°C);
9. 1,1,1,3,3,3-hexafluoro-2-methoxypropane ($(CF_3)_2CHOCH_3$, 356mmzEbg, boiling point = 50.0°C);
10. 1-ethoxy-1,1,2,2-tetrafluoroethane ($C_2H_5OCF_2CHF2$, 374pcEbg, boiling point = 56.0°C);
11. 2-ethoxy-1,1,1-trifluoroethane ($C_2H_5OCH_2CF_3$, 383mEbg, boiling point = 49.9°C);

12. 3-ethoxy-1,1,1,2,2,3,3-heptafluoropropane ($C_2H_5OCF_2CF_2CF_3$, 467sfEgd, boiling point = 51.5°C);
13. 2-ethoxy-1,1,1,2,3,3,3-heptafluoropropane ($C_2H_5OCF(CF_3)_2$, 467mmyEbg, boiling point = 45.5°C);
14. 1,1,2,2-tetrafluorocyclobutane (cyclo-$CF_2CF_2CH_2CH_2$-, c354cc, boiling point = 50.0°C);
15. 1,1,1,2,3,3,4,4-octafluoro-2-(trifluoromethyl)butane ($(CF_3)_2CFCF_2CHF_2$, HFC-42-11mmyc, boiling point = 45.5°C);
16. 1,1,1,2,2,3,3,4,4,5,5-undecafluoropentane ($CHF_2CF_2CF_2CF_2CF_3$, HFC-42-11p, boiling point = 45.0°C);
17. 1,1,1,2,2,3,3,5,5,5-decafluoropentane ($CF_3CH_2CF_2CF_2CF_3$, HFC-43-10mf, boiling point = 47.0°C);
18. 1,1,1,2,2,4,4,5,5-decafluoropentane ($CF_3CF_2CH_2CF_2CF_3$, HFC-45-10mcf, boiling point = 50.0°C).
19. perfluorocyclohexane (cyclo-C_6F_{12}, c51-12c, boiling point = 52.8°C);
20. 3-difluoromethoxy-1,1,1,2,2-pentafluoropropane ($CHF_2OCH_2CF_2CF_3$, 347mcfEgd, boiling point = 45.9°C);
21. $C_4F_9OCH_3$ isomers including 1,1,1,2,2,3,3,4,4,-nonafluoro-4-methoxy-butane ($CH_3OCF_2CF_2CF_2CF_3$), 1,1,1,2,3,3,-hexafluoro-2-(trifluoromethyl)-3-methoxy-propane ($CH_3OCF_2CF(CF_3)_2$), 1,1,1,3,3,3-hexafluoro-2-methoxy-2-(trifluoromethyl)-propane ($CH_3OC(CF_3)_3$), and 1,1,1,2,3,3,4,4,4-nonafluoro-2-methoxy-butane ($CH_3OCF(CF_3)CF_2CF_3$), approximate isomer boiling point = 60°C;
22. perfluoro-n-methylmorpholine ($C_5F_{11}NO$, boiling point = 50.0°C);
23. nonafluoro-tert-butanol ($(CF_2)_3COH$, boiling point = 45.0°C);
24. 1,1,1,4,4,4-hexafluoro-2-(trifluoromethyl)butane ($(CF_3)_{32}CHCH_2CF_3$, HFC-449mmzf, boiling point = 52.5°C);
25. 1,1,2,2,3,3,4,4,5-nonafluorocyclopentane (cyclo-$(CF_2)_4CHF$-, HFC-c429, boiling point = 50°C);
26. 1,1,2,2,3,3,4,4,5,5,6-undecacyclohexane (cyclo-$(CF_2)_5CHF$-, HFC-c52-11, boiling point = 63.0°C);
27. 1,1,1,3,3,3-hexafluoro-2-fluoromethoxypropane ($CH_2FOCH(CF_3)_2$, 347mmzEbg, boiling point = 58.1°C);
28. 1,1,1,2,2-pentafluoro-3-methoxypropane ($CF_3CF_2CH_2OCH_3$, 365mcEgd, boiling point = 48.4°C);
29. Dimethoxymethane ($CH_3OCH_2OCH_3$, boiling point = 45.5°C);

30. Diethylether ($CH_3CH_2OCH_2CH_3$, boiling point = 34.6°C);
31. Diethoxyethane ($C_2H_5OCH_2OC_2H_5$, boiling point = 121.0°C).

1,1,2,2,3,3,4,4-octafluorobutane, $CF_2HCF_2CF_2CF_2H$, HFC-338pcc, may be made by refluxing the potassium salt of perfluoroadipic acid in ethylene glycol as reported by Hudlicky, et. al. in J. Fluorine Chemistry, Vol. 59, pp. 9-14 (1992).

1-(difluoromethoxy)-1,1,2-trifluoroethane (245caEab, $CHF_2OCF_2CH_2F$, CAS Reg. No. [69948-24-9]) has been prepared by hydrogenation of 2-chloro-1,1,2-trifluoroethyl difluoromethyl ether at 200°C over a palladium catalyst as disclosed by Bagnall, et al. in J. Fluorine Chem., Vol. 13 pages 123-140 (1979).

1-(difluoromethoxy)-1,2,2-trifluoroethane (245eaE, $CHF_2OCHFCHF_2$, CAS Reg. No. [60113-74-8]) has been prepared by hydrogenation of 1,2-dichloro-1,22-trifluoroethyl difluoromethyl ether at a temperature range of 200-250°C using a palladium on charcoal catalyst as disclosed by Bell, et al. U. S. Patent 4,149,018.

1,1'-oxybis(1,2,2,2-tetrafluoro)ethane (338meeEbg, $CF_3CHFOCHFCF_3$, CAS Reg. No. [67429-44-1]) has been prepared by the reaction of diethylaminosulfur trifluoride with trifluoroacetaldehyde as disclosed by Siegemund Ger. Offen. 2,656,545.

3-(Difluoromethoxy)-1,1,1,2,2,3-hexafluoropropane (338peEgd, $CHF_2OCHFCF_2CF_3$, CAS Reg. No. [60598-11-0]) may be prepared from pentafluoropropanol, chlorodifluoromethane, chlorine, and cobalt(III)fluoride by a process similar to that used for $CHF_2OCHFCF_2CHF_2$ and disclosed by Bagnall, et al. in J. Fluorine Chem., Vol. 11, pp. 93-107 (1978).

3-Difluoromethoxy-1,1,1,2,2-pentafluoropropane (347mcfEgd, $CHF_2OCH_2CF_2CF_3$, CAS Reg. No. [56860-81-2]) has been prepared by the reaction of 2,2,3,3,3-pentafluoro-1-propanol with chlorodifluoromethane in the presence of aqueous sodium hydroxide as disclosed by Regan in U.S. Patent 3,943,256.

1,1,2-trifluoro-1-methoxy-2-(trifluoromethoxy)ethane (356mecE2abgd, $CH_3OCF_2CHFOCF_3$, CAS Reg. No. [996-56-5]) may be prepared by the reaction of trifluoromethyl trifluorovinyl ether with methanol as disclosed by Tumanova, et al. in Zh. Obshch. Khim., Vol. 35, pp. 399-400 (1965).

1,1,1,2,3,3-hexafluoro-3-methoxypropane (356mecEgd, $CH_3OCF_2CHFCF_3$, CAS Reg. No. [382-34-3]) has been prepared by the reaction of methanol with hexafluoropropene as disclosed by England, et. al. in J. Fluorine Chem., Vol. 3, pp. 63-8 (1973/74).

1,1,1,3,3,3-hexafluoro-2-methoxypropane (356mmzEbg, $(CF_3)_2CHOCH_3$, CAS Reg. No. [13171-18-1]) has been prepared by the reaction of 1,1,1,3,3,3-

hexafluoroisopropanol with dimethyl sulfate in the presence of aqueous sodium hydroxide as disclosed by Gilbert, et. al. in U. S. Patent 3,346,448.

1-ethoxy-1,1,2,2-tetrafluoroethane (374pcEbg, $C_2H_5OCF_2CHF_2$, CAS Reg. No. [512-51-6]) has been prepared by the reaction of ethanol with tetrafluoroethylene as reported by Park, et. al. in J. Am. Chem. Soc., Vol.73, pp. 1329-1330 (1951).

2-ethoxy-1,1,1-trifluoroethane (383mEbg, $C_2H_5OCH_2CF_3$, CAS Reg. No. [461-24-5]) has been prepared by reaction of sodium trifluoroethoxide with ethyl bromide as disclosed by Henne, et al. in J. Am. Chem. Soc., Vol. 72, pp. 4378-4380 (1950).

3-ethoxy-1,1,1,2,2,3,3-heptafluoropropane (467sfEgd, $C_2H_5OCF_2CF_2CF_3$, CAS Reg. No. [22052-86-4]) has been prepared by reaction of pentafluoropropionyl fluoride with potassium fluoride and diethyl sulfate in N,N-dimethylformamide as disclosed by Scherer, et. al. in Ger. Offen. 1,294,949.

2-ethoxy-1,1,1,2,3,3,3-heptafluoropropane (467mmyEbg, $C_2H_5OCF(CF_3)_2$, CAS. Reg. No. [22137-14-0]) may be prepared by the reaction of ethyl iodide with a mixture of hexafluoroacetone and potassium fluoride as disclosed in French Patent 1,506,638.

1,1,2,2-tetrafluorocyclobutane (HFC-c-354cc, cyclo-$CF_2CF_2CH_2CH_2$-, CAS Reg. No. [374-12-9]) has been prepared by reacting ethylene and tetrafluoroethylene at 150°C as disclosed by Coffman, et. al. in J. Am. Chem. Soc., Vol. 71, pp. 490-496 (1949).

1,1,1,2,3,3,4,4-octafluoro-2-(trifluoromethyl)butane (HFC-42-11mmyc, $(CF_3)_2CFCF_2CHF_2$, CAS Reg. No. [1960-20-9]) has been prepared by reducing 1-iodo-1,1,2,2,3,4,4,4-octafluoro-3-(trifluoromethyl)butane with zinc in the presence of sulfuric acid as disclosed by Chambers, et. al. in Tetrahedron, Vol. 20, pp. 497-506 (1964).

1,1,1,2,2,3,3,4,4,5,5-undecafluoropentane (HFC-42-11p, $CHF_2CF_2CF_2CF_2CF_3$, CAS Reg. No. [375-61-1]) has been prepared by treating 1-iodo-1,1,1,2,2,3,3,4,4,5,5-undecafluoropentane with alcoholic potassium hydroxide at elevated temperature as disclosed by Haszeldine in J. Chem. Soc. pp. 3761-3768 (1953).

1,1,1,2,2,3,3,5,5,5-decafluoropentane (HFC-43-10mf, $CF_3CH_2CF_2C_2F_5$, CAS Reg. No. [755-45-3]) has been prepared by the reaction of antimony dichlorotrifluoride with 1-iodo-1,1,3,3,4,4,5,5,5-nonafluoropentane (prepared in turn from vinylidene fluoride and 1-iodo-heptafluoropropane) as disclosed by Hauptschein, et al. in J. Am. Chem. Soc., Vol. 82, pp. 2868-2871 (1960).

1-99 wt.% of each of the components of the compositions can be used as refrigerants or cleaning agents. Further, the present invention also relates to the discovery of azeotropic or azeotrope-like compositions of effective amounts of each of the above mixtures to form an azeotropic or azeotrope-like composition.

By "azeotropic" composition is meant a constant boiling liquid admixture of two or more substances that behaves as a single substance. One way to characterize an azeotropic composition is that the vapor produced by partial evaporation or distillation of the liquid has the same composition as the liquid from which it was evaporated or distilled, that is, the admixture distills/refluxes without compositional change. Constant boiling compositions are characterized as azeotropic because they exhibit either a maximum or minimum boiling point, as compared with that of the non-azeotropic mixtures of the same components.

By "azeotrope-like" composition is meant a constant boiling, or substantially constant boiling, liquid admixture of two or more substances that behaves as a single substance. One way to characterize an azeotrope-like composition is that the vapor produced by partial evaporation or distillation of the liquid has substantially the same composition as the liquid from which it was evaporated or distilled, that is, the admixture distills/refluxes without substantial composition change. Another way to characterize an azeotrope-like composition is that the bubble point vapor pressure and the dew point vapor pressure of the composition at a particular temperature are substantially the same.

It is recognized in the art that a composition is azeotrope-like if, after 50 weight percent of the composition is removed such as by evaporation or boiling off, the difference in vapor pressure between the original composition and the composition remaining after 50 weight percent of the original composition has been removed is less than 10 percent, when measured in absolute units. By absolute units, it is meant measurements of pressure and, for example, psia, atmospheres, bars, torr, dynes per square centimeter, millimeters of mercury, inches of water and other equivalent terms well known in the art. If an azeotrope is present, there is no difference in vapor pressure between the original composition and the composition remaining after 50 weight percent of the original composition has been removed.

Therefore, included in this invention are compositions of effective amounts of:

(a) HFC-338pcc and 1,1,1,2,3,3,4,4-octafluoro-2-(trifluoromethyl)butane (HFC-42-11mmyc); 1,1,1,2,2,3,3,4,4,5,5-undecafluoropentane (HFC-42-11p); 1,1,1,2,2,3,3,5,5,5-decafluoropentane (HFC-43-10mf);

1,1,1,2,2,4,4,5,5,5-decafluoropentane (HFC-43-10mcf); and 1,1,1,4,4,4-hexafluoro-2-(trifluoromethyl)butane (HFC-449mmzf); or

(b) HFC-338pcc and 1,1,2,2-tetrafluorocyclobutane (HFC-c354cc); perfluorocyclohexane (FC-c51-12c); 1,1,2,2,3,3,4,4,5-nonafluorocyclopentane (HFC-c429); and 1,1,2,2,3,3,4,4,5,5,6-undecafluorocyclohexane (HFC-c52-11); or

(c) HFC-338pcc and 1-(difluoromethoxy)-1,1,2-trifluoroethane $CHF_2OCF_2CH_2F$, (245caEαβ); 1-(difluoromethoxy)-1,2,2-trifluoroethane $CHF_2OCHFCHF_2$,.(245eaE); 1,1'-oxybis(1,2,2,2-tetrafluoro)ethane $CF_3CHFOCHFCF_3$, (338 meeEβγ); 3-difluoromethoxy-1,1,1,2,2,3-hexafluoropropane $CHF_2OCHFCF_2CF_3$, (338peEγδ); 1,1,2,2-tetrafluoro-1-(2,2,2-trifluoroethoxy)ethane $CHF_2CH_2OCF_2CF_3$, (347mcfEβγ); 3-difluoromethoxy-1,1,1,2,2-pentafluoropropane $CHF_2OCH_2CF_2CF_3$, (347mcfEγδ); 1,1,1,3,3,3-hexafluoro-2-fluoromethoxypropane $CH_2FOCH(CF_3)_2$, (347mmzEβγ); 1,1,1,2,3,3-hexafluoro-3-methoxypropane $CH_3OCF_2CHFCF_3$, (356mecEγδ); 1,1,2-trifluoro-1-methoxy-2-(trifluoromethoxy)ethane $CH_3OCF_2CHFOCF_3$, (356mecE2αβγδ); 1,1,1,3,3,3-hexafluoro-2-methoxypropane $(CF_3)_2CHOCH_3$, (356mmzEβγ); 1,1,1,2,2-pentafluoro-3-methoxypropane $CF_3CF_2CH_2OCH_3$, (365mcEγδ); 1-ethoxy-1,1,2,2-tetrafluoroethane $C_2H_5OCF_2CHF_2$, (374pcEβγ); 2-ethoxy-1,1,1-trifluoroethane $C_2H_5OCH_2CF_3$ (383mEβγ); 2-ethoxy-1,1,1,2,3,3,3-heptafluoropropane $C_2H_5OCF(CF_3)_2$, (467mmyEβγ); 3-ethoxy-1,1,1,2,2,3,3-heptafluoropropane $C_2H_5OCF_2CF_2CF_3$, (467sfE γδ); $C_4F_9OCH_3$; or $(CF_3)_3COH$; or

(d) HFC-338pcc and nonafluoro-*tert*-butanol $(CF_3)_3COH$; or

(e) HFC-338pcc and perfluoro-n-methylmorpholine ($C_5F_{11}NO$); or

(f) HFC-338pcc and dimethoxymethane; diethylether or diethoxyethane.

such that after 50 weight percent of an original composition is evaporated or boiled off to produce a remaining composition, the difference in the vapor pressure between the original composition and the remaining composition is 10 percent or less.

For compositions that are azeotropic, there is usually some range of compositions around the azeotrope point that, for a maximum boiling azeotrope, have boiling points at a particular pressure higher than the pure components of the composition at that pressure and have pure components of the composition at that temperature, and that, for a minimum boiling azeotrope, have boiling points at a particular pressure lower than the pure components of the composition at that pressure and have vapor pressures at a particular temperature higher than the pure components of the composition at that temperature. Boiling temperatures and vapor pressures above or below that of the pure components are caused by unexpected intermolecular forces between and among the molecules of the compositions, which can be a combination of repulsive and attractive forces such as van der Waals forces and hydrogen bonding.

The range of compositions that have a maximum or minimum boiling point at a particular pressure, or a maximum or minimum vapor pressure at a particular temperature, may or may not be coextensive with the range of compositions that have a change in vapor pressure of less than about 10% when 50 weight percent of the composition is evaporated. In those cases where the range of compositions that have maximum or minimum boiling temperatures at a particular pressure, or maximum or minimum vapor pressures at a particular temperature, are broader than the range of compositions that have a change in vapor pressure of less than about 10% when 50 weight percent of the composition is evaporated, the unexpected intermolecular forces are nonetheless believed important in that the refrigerant compositions having those forces that are not substantially constant boiling may exhibit unexpected increases in the capacity or efficiency versus the components of the refrigerant composition.

The components of the compositions of this invention have the following vapor pressures at 25°C.

COMPONENTS	PSIA	KPA
HFC-338pcc	6.88	47.4
HFC-42-11mmyc	6.97	48.1
HFC-42-11p	7.09	48.9
HFC-43-10mf	6.64	45.8
HFC-449mmzf	5.42	37.4
HFC-c354cc	6.36	43.9
FC-c51-12c	5.67	39.1
HFC-c429	9.22	63.6

HFC-c52-11	3.93	27.1
245caEαβ	8.51	58.7
245eaE	5.22	36.0
338meeEβγ	5.80	40.0
338peEγδ	7.12	49.1
347mcfEβγ	6.91	47.6
347mcfEγδ	6.79	46.8
347mmzEβγ	4.32	29.8
356mecEγδ	5.09	35.1
356mecE2αβγδ	4.22	29.1
356mmzEβγ	5.73	39.5
365mcEγδ	6.33	43.6
374pcEβγ	4.77	32.9
383mEβγ	5.98	41.2
467mmyEβγ	6.93	47.8
467sfEγδ	5.56	38.3
$C_4F_9OCH_3$	4.07	28.1
$(CF_3)_3COH$	6.36	43.9
$C_5F_{11}NO$	5.98	41.2
dimethoxymethane	6.91	47.6
diethylether	10.5	72.4
diethoxyethane	0.38	2.6
HFC-43-10mcf	5.96	41.1

Substantially constant boiling, azeotropic or azeotrope-like compositions of this invention comprise the following (all compositions are measured at 25°C):

COMPONENTS	WEIGHT RANGES (wt.%/wt/%)	PREFERRED (wt.%/wt.%)
HFC-338pcc/HFC-42-11mmyc	1-99/1-99	20-80/20-80
HFC-338pcc/HFC-42-11p	1-99/1-99	20-80/20-80
HFC-338pcc/HFC-43-10mf	1-99/1-99	20-80/20-80
HFC-338pcc/HFC-449mmzf	1-99/1-99	40-99/1-60
HFC-338pcc/HFC-c354cc	1-99/1-99	40-99/1-60
HFC-338pcc/FC-c51-12c	1-99/1-99	40-99/1-60
HFC-338pcc/HFC-c429	1-99/1-99	20-99/1-80
HFC-338pcc/HFC-c52-11	1-99/1-99	1-60/40-99
HFC-338pcc/245caEαβ	1-99/1-99	40-99/1-60
HFC-338pcc/245eaE	1-99/1-99	50-99/1-50
HFC-338pcc/338meeEβγ	1-99/1-99	40-99/1-60
HFC-338pcc/338peEγδ	1-99/1-99	40-90/1-60
HFC-338pcc/347mcfEβγ	1-99/1-99	40-90/1-60
HFC-338pcc/347mcfEγδ	1-99/1-99	40-90/1-60

HFC-338pcc/347mmzEβγ	1-99/1-99	50-99/1-40
HFC-338pcc/356mecEγδ	1-99/1-99	60-99/1-40
HFC-338pcc/356mecE2αβγδ	1-99/1-99	60-99/1-40
HFC-338pcc/356mmzEβγ	1-99/1-99	60-99/1-40
HFC-338pcc/365mcEγδ	1-99/1-99	60-99/1-40
HFC-338pcc/374pcEβγ	1-99/1-99	60-99/1-40
HFC-338pcc/383mEβγ	1-99/1-99	50-99/1-50
HFC-338pcc/467mmyEβγ	1-99/1-99	40-99/1-60
HFC-338pcc/467sfEγδ	1-99/1-99	50-99/1-50
HFC-338pcc/$C_4F_9OCH_3$	1-99/1-99	50-99/1-40
HFC-338pcc/$(CF_3)_3COH$	1-88/12-99	40-80/20-60
HFC-338pcc/$C_5F_{11}NO$	1-99/1-99	40-99/1-60
HFC-338pcc/dimethoxymethane	1-95/5-99	60-95/5-40
HFC-338pcc/diethylether	1-86/14-99	40-86/14-60
HFC-338pcc/diethoxyethane	83-99.9/0.1-17	83-99.9/0.1-17
HFC-338pcc/HFC-43-10mcf	1-99/1-99	30-99/1-70

For purposes of this invention, "effective amount" is defined as the amount of each component of the inventive compositions which, when combined, results in the formation of an azeotropic or azeotrope-like composition. This definition includes the amounts of each component, which amounts may vary depending on the pressure applied to the composition so long as the azeotropic or azeotrope-like compositions continue to exist at the different pressures, but with possible different boiling points.

Therefore, effective amount includes the amounts, such as may be expressed in weight percentages, of each component of the compositions of the instant invention which form azeotropic or azeotrope-like compositions at temperatures or pressures other than as described herein.

For the purposes of this discussion, azeotropic or constant-boiling is intended to mean also essentially azeotropic or essentially-constant boiling. In other words, included within the meaning of these terms are not only the true azeotropes described above, but also other compositions containing the same components in different proportions, which are true azeotropes at other temperatures and pressures, as well as those equivalent compositions which are part of the same azeotropic system and are azeotrope-like in their properties. As is well recognized in this art, there is a range of compositions which contain the same components as the azeotrope, which will not only exhibit essentially equivalent properties for refrigeration and other applications, but which will also exhibit essentially equivalent properties to the true azeotropic composition in terms of constant boiling characteristics or tendency not to segregate or fractionate on boiling.

It is possible to characterize, in effect, a constant boiling admixture which may appear under many guises, depending upon the conditions chosen, by any of several criteria:

* The composition can be defined as an azeotrope of A, B, C (and D...) since the very term "azeotrope" is at once both definitive and limitative, and requires that effective amounts of A, B, C (and D...) for this unique composition of matter which is a constant boiling composition.
* It is well known by those skilled in the art, that, at different pressures, the composition of a given azeotrope will vary at least to some degree, and changes in pressure will also change, at least to some degree, the boiling point temperature. Thus, an azeotrope of A, B, C (and D...) represents a unique type of relationship but with a variable composition which depends on temperature and/or pressure. Therefore, compositional ranges, rather than fixed compositions, are often used to define azeotropes.
* The composition can be defined as a particular weight percent relationship or mole percent relationship of A, B, C (and D...), while recognizing that such specific values point out only one particular relationship and that in actuality, a series of such relationships, represented by A, B, C (and D...) actually exist for a given azeotrope, varied by the influence of pressure.
* An azeotrope of A, B, C (and D...) can be characterized by defining the compositions as an azeotrope characterized by a boiling point at a given pressure, thus giving identifying characteristics without unduly limiting the scope of the invention by a specific numerical composition, which is limited by and is only as accurate as the analytical equipment available.

The azeotrope or azeotrope-like compositions of the present invention can be prepared by any convenient method including mixing or combining the desired amounts. A preferred method is to weigh the desired component amounts and thereafter combine them in an appropriate container.

Specific examples illustrating the invention are given below. Unless otherwise stated therein, all percentages are by weight. It is to be understood that these examples are merely illustrative and in no way are to be interpreted as limiting the scope of the invention.

EXAMPLE 1

Phase Study

A phase study shows the following compositions are azeotropic. The temperature is 25°C.

Composition	Weight Percents	Vapor Press. psia	Vapor Press. kPa
HFC-338pcc/HFC-42-11mmyc	41.6/58.4	7.14	49.2
HFC-338pcc/HFC-42-11p	34.2/65.8	7.22	49.8
HFC-338pcc/HFC-43-10mf	51.5/48.5	7.52	51.8
HFC-338pcc/HFC-449mmzf	73.3/26.7	7.10	49.0
HFC-338pcc/HFC-c354cc	62.3/37.7	7.72	53.2
HFC-338pcc/FC-c51-12c	68.4/31.6	7.10	49.0
HFC-338pcc/HFC-c429	68.4/31.6	6.18	42.6
HFC-338pcc/HFC-c52-11	12.5/87.5	3.88	26.8
HFC-338pcc/245caEαβ	49.1/50.9	9.06	62.5
HFC-338pcc/245eaE	81.0/19.0	7.50	51.7
HFC-338pcc/338meeEβγ	80.1/19.9	7.15	49.3
HFC-338pcc/338peEgδ	59.0/41.0	7.54	52.0
HFC-338pcc/347mcfEβγ	64.1/35.9	7.53	51.9
HFC-338pcc/347mcfEγδ	66.4/33.6	7.48	51.6
HFC-338pcc/347mmzEβγ	93.3/6.7	6.93	47.8
HFC-338pcc/356mecEγδ	88.9/11.1	7.15	49.3
HFC-338pcc/356mecE2αβγδ	88.4/11.6	7.06	48.7
HFC-338pcc/356mmzEβγ	85.4/14.6	7.26	50.1
HFC-338pcc/365mcEγδ	81.0/19.0	7.52	51.8
HFC-338pcc/374pcEβγ	84.8/15.2	7.36	50.7
HFC-338pcc/383mEβγ	78.5/21.5	7.86	54.2
HFC-338pcc/467mmyEβγ	64.7/35.3	7.60	52.4
HFC-338pcc/467sfEγδ	81.6/18.4	7.20	49.6
HFC-338pcc/$C_4F_9OCH_3$	95.3/4.7	6.91	47.6
HFC-338pcc/$(CF_3)_3COH$	60.0/40.0	8.74	60.3
HFC-338pcc/$C_5F_{11}NO$	61.8/38.2	7.15	49.3
HFC-338pcc/dimethoxymethane	85.0/15.0	8.94	61.6
HFC-338pcc/diethylether	63.7/36.3	12.7	87.6
HFC-338pcc/diethoxyethane	98.7/1.3	6.96	48.0
HFC-388pcc/HFC-43-10mcf	64.0/36.0	7.23	49.8

EXAMPLE 2

Impact of Vapor Leakage on Vapor Pressure at 25°C

A vessel is charged with an initial liquid composition at 25°C. The liquid, and the vapor above the liquid, are allowed to come to equilibrium, and the vapor pressure in the vessel is measured. Vapor is allowed to leak from the vessel, while the temperature is held constant at 25°C, until 50 weight percent of the initial charge is removed, at which time the vapor pressure of the composition remaining in the vessel is measured. The results are summarized below.

Refrigerant Composition	0 wt% evaporated psia	kPa	50 wt% evaporated psia	kPa	0% change in vapor pressure
HFC-338pcc/HFC-42-11mmyc					
41.6/58.4	7.14	49.2	7.14	49.2	0.0
20/80	7.10	49.0	7.10	49.0	0.0
1/99	6.98	48.1	6.97	48.1	0.1
60/40	7.12	49.1	7.11	49.0	0.1
80/20	7.03	48.5	7.02	48.4	0.1
99/1	6.89	47.5	6.89	47.5	0.0
HFC-338pcc/HFC-42-11p					
34.2/65.8	7.22	49.8	7.22	49.8	0.0
15/85	7.18	49.5	7.18	49.5	0.0
1/99	7.10	49.0	7.10	49.0	0.0
60/40	7.16	49.4	7.16	49.4	0.0
80/20	7.05	48.6	7.04	48.5	0.1
99/1	6.89	47.5	6.89	47.5	0.0
HFC-338pcc/HFC-43-10mf					
51.5/48.5	7.52	51.8	7.52	51.8	0.0
20/80	7.24	49.9	7.18	49.5	0.8
1/99	6.68	46.1	6.67	46.0	0.1
80/20	7.32	50.5	7.27	50.1	0.7
99/1	6.91	47.6	6.90	47.6	0.1

HFC-388pcc/HFC-449mmzf					
73.3/26.7	7.10	49.0	7.10	49.0	0.0
85/15	7.06	48.7	7.05	48.6	0.1
99/1	6.90	47.6	6.89	47.5	0.1
40/60	6.82	47.0	6.71	46.3	1.6
20/80	6.33	43.6	6.11	42.1	3.5
10/90	5.94	41.0	5.75	39.6	3.2
1/99	5.48	37.8	5.45	37.6	0.5
HFC-338pcc/HFC-c354cc					
62.3/37.7	7.72	53.2	7.72	53.2	0.0
80/20	7.58	52.3	7.53	51.9	0.7
99/1	6.94	47.8	6.92	47.7	0.3
40/60	7.56	52.1	7.48	51.6	1.1
20/80	7.16	49.4	6.93	47.8	3.2
1/99	6.42	44.3	6.38	44.0	0.6
HFC-338pcc/FC-c51-12c					
68.4/31.6	7.10	49.0	7.10	49.0	0.0
80/20	7.07	48.7	7.06	48.7	0.1
99/1	6.89	47.5	6.89	47.5	0.0
40/60	6.92	47.7	6.86	47.3	0.9
20/80	6.51	44.9	6.37	43.9	2.2
1/99	5.73	39.5	5.70	39.3	0.5
HFC-338pcc/HFC-c429					
68.4/31.6	6.18	42.6	6.18	42.6	0.0
80/20	6.29	43.4	6.25	43.1	0.6
90/10	6.55	45.2	6.46	44.5	1.4
99/1	6.85	47.2	6.83	47.1	0.3
40/60	6.85	47.2	6.56	45.2	4.2
20/80	7.93	54.7	7.49	51.6	5.5
10/90	8.56	59.0	8.26	57.0	3.5
1/99	9.15	63.1	9.11	62.8	0.4

HFC-338pcc/HFC-c52-11					
12.5/87.5	3.88	26.8	3.88	26.8	0.0
1/99	3.92	27.0	3.92	27.0	0.0
40/60	4.19	28.9	4.07	28.1	2.9
60/40	4.86	33.5	4.47	30.8	8.0
65/35	5.09	35.1	4.63	31.9	9.0
70/30	5.33	36.7	4.82	33.2	9.6
72/28	5.44	37.5	4.90	33.8	9.9
73/27	5.49	37.9	4.95	34.1	9.8
80/20	5.86	40.4	5.33	36.7	9.0
99/1	6.84	47.2	6.80	46.9	0.6
HFC-338pcc/245caEαβ					
49.1/50.9	9.06	62.5	9.06	62.5	0.0
20/80	8.85	61.0	8.81	60.7	0.5
1/99	8.53	58.8	8.52	58.7	0.1
80/20	8.67	59.8	8.43	58.1	2.8
90/10	8.21	56.6	7.66	52.8	6.7
99/1	7.12	49.1	6.92	47.7	2.8
HFC-338pcc/245eaE					
81.0/19.0	7.50	51.7	7.50	51.7	0.0
90/10	7.43	51.2	7.38	50.9	0.7
99/1	6.99	48.2	6.93	47.8	0.9
60/40	7.27	50.1	7.12	49.1	2.1
40/60	6.76	46.6	6.41	44.2	5.2
20/80	6.06	41.8	5.72	39.4	5.6
10/90	5.65	39.0	5.45	37.6	3.5
1/99	5.27	36.3	5.24	36.1	0.6
HFC-338pcc/338meeEβγ					
80.1/19.9	7.15	49.3	7.15	49.3	0.0
90/10	7.10	49.0	7.09	48.9	0.1
99/1	6.92	47.7	6.91	47.6	0.1
60/40	7.02	48.4	6.98	48.1	0.6
40/60	6.72	46.3	6.63	45.7	1.3
20/80	6.30	43.4	6.21	42.8	1.4
1/99	5.83	40.2	5.82	40.1	0.2

HFC-338pcc/338peEγδ					
59.0/41.0	7.54	52.0	7.54	52.0	0.0
80/20	7.44	51.3	7.41	51.1	0.4
99/1	6.94	47.8	6.91	47.6	0.4
40/60	7.48	51.6	7.47	51.5	0.1
20/80	7.33	50.5	7.31	50.4	0.3
1/99	7.13	49.2	7.13	49.2	0.0
HFC-338pcc/347mcfEβγ					
64.1/35.9	7.53	51.9	7.53	51.9	0.0
80/20	7.45	51.4	7.43	51.2	0.3
99/1	6.94	47.8	6.92	47.7	0.3
40/60	7.41	51.1	7.39	51.0	0.3
20/80	7.20	49.6	7.17	49.4	0.4
1/99	6.93	47.8	6.93	47.8	0.0
HFC-338pcc/347mcfEγδ					
66.4/33.6	7.48	51.6	7.48	51.6	0.0
80/20	7.42	51.2	7.40	51.0	0.3
99/1	6.94	47.8	6.91	47.6	0.4
40/60	7.34	50.6	7.31	50.4	0.4
20/80	7.09	48.9	7.06	48.7	0.4
1/99	6.80	46.9	6.80	46.9	0.0
HFC-338pcc/347mmzEβγ					
93.3/6.7	6.93	47.8	6.93	47.8	0.0
99/1	6.90	47.6	6.89	47.5	0.1
60/40	6.44	44.4	6.21	42.8	3.6
40/60	5.86	40.4	5.50	37.9	6.1
20/80	5.14	35.4	4.84	33.4	5.8
1/99	4.37	30.1	4.35	30.0	0.5
HFC-338pcc/356mecEγδ					
88.9/11.1	7.15	49.3	7.15	49.3	0.0
99/1	6.96	48.0	6.92	47.7	0.6
60/40	6.72	46.3	6.54	45.1	2.7
40/60	6.19	42.7	5.97	41.2	3.6
20/80	5.63	38.8	5.48	37.8	2.7
1/99	5.11	35.2	5.10	35.2	0.2

HFC-338pcc/356mecE2αβγδ					
88.4/11.6	7.06	48.7	7.06	48.7	0.0
99/1	6.92	47.7	6.91	47.6	0.1
60/40	6.68	46.1	6.42	44.3	3.9
40/60	6.06	41.8	5.58	38.5	7.9
30/70	5.67	39.1	5.16	35.6	9.0
20/80	5.23	36.1	4.78	33.0	8.6
10/90	4.74	32.7	4.47	30.8	5.7
1/99	4.27	29.4	4.24	29.2	0.7
HFC-338pcc/356mmzEβγ					
85.4/14.6	7.26	50.1	7.26	50.1	0.0
99/1	6.98	48.1	6.92	47.7	0.9
60/40	6.98	48.1	6.89	47.5	1.3
40/60	6.57	45.3	6.45	44.5	1.8
20/80	6.14	42.3	6.06	41.8	1.3
1/99	5.75	39.6	5.75	39.6	0.0
HFC-338pcc/365mcEγδ					
81.0/19.0	7.52	51.8	7.52	51.8	0.0
99/1	7.04	48.5	6.93	47.8	1.6
60/40	7.34	50.6	7.29	50.3	0.7
40/60	7.02	48.4	6.94	47.8	1.1
20/80	6.66	45.9	6.61	45.6	0.8
HFC-338pcc/374pcEβγ					
84.8/15.2	7.36	50.7	7.36	50.7	0.0
99/1	6.98	48.1	6.93	47.8	0.7
60/40	7.01	48.3	6.77	46.7	3.4
40/60	6.41	44.2	5.96	41.1	7.0
30/70	6.04	41.6	5.57	38.4	7.8
20/80	5.64	38.9	5.25	36.2	6.9
1/99	4.82	33.2	4.79	33.0	0.6
HFC-338pcc/383mEβγ					
78.5/21.5	7.86	54.2	7.86	54.2	0.0
90/10	7.73	53.3	7.63	52.6	1.3
99/1	7.08	48.8	6.94	47.8	2.0
60/40	7.68	53.0	7.57	52.2	1.4
40/60	7.22	49.8	6.97	48.1	3.5
20/80	6.63	45.7	6.41	44.2	3.3
1/99	6.01	41.4	6.00	41.4	0.2

HFC-338pcc/467mmyEβγ					
64.7/35.3	7.60	52.4	7.60	52.4	0.0
80/20	7.53	51.9	7.50	51.7	0.4
99/1	6.96	48.0	6.92	47.7	0.6
40/60	7.47	51.5	7.45	51.4	0.3
20/80	7.23	49.8	7.21	49.7	0.3
1/99	6.95	47.9	6.95	47.9	0.0
HFC-338pcc/467sfEγδ					
81.6/18.4	7.20	49.6	7.20	49.6	0.0
99/1	6.93	47.8	6.91	47.6	0.3
60/40	7.03	48.5	6.96	48.0	1.0
40/60	6.66	45.9	6.51	44.9	2.3
20/80	6.15	42.4	6.02	41.5	2.1
1/99	5.60	38.6	5.59	38.5	0.2
HFC-338pcc/$C_4F_9OCH_3$					
95.3/4.7	6.91	47.6	6.91	47.6	0.0
99/1	6.89	47.5	6.89	47.5	0.0
60/40	6.31	43.5	6.02	41.5	4.6
40/60	5.66	39.0	5.27	36.3	6.9
20/80	4.89	33.7	4.60	31.7	5.9
1/99	4.11	28.3	4.09	28.2	0.5
90/10	6.89	47.5	6.88	47.4	0.1
HFC-338pcc/$(CF_3)_3COH$					
60.0/40.0	8.74	60.3	8.74	60.3	0.0
80/20	8.56	59.0	8.27	57.0	3.4
88/12	8.31	57.3	7.53	51.9	9.4
89/11	8.27	57.0	7.42	51.2	10.3
40/60	8.55	59.0	8.31	57.3	2.8
20/80	7.85	54.1	7.38	50.9	6.0
10/90	7.22	49.8	6.82	47.0	5.5
1/99	6.46	44.5	6.40	44.1	0.9
HFC-338pcc/$C_5F_{11}NO$					
61.8/38.2	7.15	49.3	7.15	49.3	0.0
80/20	7.09	48.9	7.08	48.8	0.1
99/1	6.89	47.5	6.89	47.5	0.0
40/60	7.05	48.6	7.02	48.4	0.4
20/80	6.72	46.3	6.62	45.6	1.5
1/99	6.03	41.6	6.01	41.4	0.3

HFC-338pcc/dimethoxymethane					
85.0/15.0	8.94	61.6	8.94	61.6	0.0
95/5	8.74	60.3	8.50	58.6	2.7
70/30	8.72	60.1	8.58	59.2	1.6
60/40	8.45	58.3	8.22	56.7	2.7
40/60	7.88	54.3	7.62	52.5	3.3
20/80	7.36	50.7	7.20	49.6	2.2
1/99	6.93	47.8	6.93	47.8	0.0
HFC-338pcc/diethylether					
63.7/36.3	12.7	87.2	12.7	87.2	0.0
80/20	12.4	85.8	12.1	83.4	2.7
86/14	12.2	84.1	11.1	76.2	9.4
87/13	12.2	83.8	10.7	73.8	11.9
40/60	12.3	84.8	12.0	82.5	2.8
20/80	11.6	80.0	11.0	76.0	4.9
1/99	10.5	72.4	10.5	72.2	0.3
HFC-338pcc/diethoxyethane					
98.7/1.3	6.96	48.0	6.96	48.0	0.0
99.9/0.1	6.91	47.6	6.89	47.5	0.3
90/10	6.90	47.6	6.72	46.3	2.6
83/17	6.78	46.7	6.12	42.2	9.7
82/18	6.76	46.6	6.00	41.4	11.2
HFC-338pcc/HFC-43-10mcf					
64.0/36.0	7.23	49.8	7.23	49.8	0.0
80/20	7.16	49.4	7.15	49.3	0.1
90/10	7.06	48.7	7.03	48.5	0.4
99/1	6.90	47.6	6.90	47.6	0.0
50/50	7.18	49.5	7.16	49.4	0.3
30/70	6.93	47.8	6.84	47.2	1.3
15/85	6.56	45.2	6.44	44.4	1.8
1/99	6.00	41.4	5.99	41.3	0.2

The results of this Example show that these compositions are azeotropic or azeotrope-like because when 50 wt.% of an original composition is removed, the vapor pressure of the remaining composition is within about 10% of the vapor pressure of the original composition, at a temperature of 25°C.

EXAMPLE 3

Impact of Vapor Leakage at 50°C

A leak test is performed on compositions of HFC-338pcc and HFC-272ea, at the temperature of 50°C. The results are summarized below.

Refrigerant Composition	0 wt% evaporated psia	0 wt% evaporated kPa	50 wt% evaporated psia	50 wt% evaporated kPa	0% change in vapor pressure
HFC-338pcc/HFC-43-10mf					
60.2/39.8	19.02	131	19.02	131	0.0
80/20	18.79	130	18.74	129	0.3
99/1	18.06	125	18.04	124	0.1
40/60	18.78	129	18.70	129	0.4
20/80	17.95	124	17.72	122	1.3
1/99	16.36	113	16.32	112	0.2

These results show that compositions of and are azeotropic or azeotrope-like at different temperatures, but that the weight percents of the components vary as the temperature is changed.

EXAMPLE 4

Refrigerant Performance

The following table shows the performance of various refrigerants in an ideal vapor compression cycle. The data are based on the following conditions. These conditions are typical of a high speed small turbine compressor.

Evaporator temperature	40.0°F (4.4°C)
Condenser temperature	110.0°F (43.3°C)
Liquid subcooled	10°F (5.6°C)
Return Gas	75°F (23.9°C)
Compressor efficiency is 70%.	

The refrigeration capacity is based on a compressor with a fixed displacement of 3.5 cubic feet per minute and 70% volumetric efficiency. Capacity is intended to mean the change in enthalpy of the refrigerant in the evaporator per pound of refrigerant circulated, i.e. the heat removed by the refrigerant in the evaporator per time. Coefficient of performance (COP) is intended to mean the ratio of the capacity to compressor work. It is a measure of refrigerant energy efficiency.

Refrig. Comp.	Evap. Press. Psia	Evap. Press. kPa	Cond. Press. Psia	Cond. Press. kPa	Comp. Dis. Temp. °F	Comp. Dis. Temp. °C	COP	Capacity BTU/min	Capacity kW
HFC-338pcc/HFC-42-11mmyc									
1/99	2.8	19	14.0	97	128.6	53.7	3.83	16.3	0.29
99/1	3.0	21	14.4	99	142.6	61.4	4.06	18.2	0.32
HFC-338pcc/HFC-42-11p									
1/99	2.8	19	14.2	98	128.5	53.6	3.83	16.5	0.29
99/1	3.0	21	14.4	99	142.6	61.4	4.06	18.2	0.32
HFC-338pcc/HFC-43-10mf									
1/99	2.6	18	13.2	91	129.6	54.2	3.86	15.5	0.27
99/1	3.0	21	14.4	99	142.6	61.4	4.06	18.2	0.32
HFC-338pcc/HFC-449mmzf									
1/99	2.1	14	10.9	75	133.6	56.4	3.94	12.9	0.23
99/1	3.0	21	14.4	99	142.7	61.5	4.06	18.2	0.32
HFC-338pcc/HFC-c354cc									
1/99	2.6	18	11.7	8	153.1	67.3	4.21	16.0	0.28
99/1	3.0	21	14.4	99	142.9	61.6	4.06	18.2	0.32
HFC-338pcc/FC-c51-12c									
1/99	2.3	16	10.9	75	120.5	49.2	3.71	12.5	0.22
99/1	3.0	21	14.4	99	142.5	61.4	4.06	18.2	0.32
HFC-338pcc/HFC-c429									
1/99	3.9	27	17.0	117	129.0	53.9	3.87	21.1	0.37
99/1	3.0	21	14.5	100	142.7	61.5	4.05	18.2	0.32
HFC-338pcc/HFC-c52-11									
1/99	1.5	10	7.7	53	124.8	51.6	3.84	8.9	0.16
99/1	3.0	21	14.4	99	142.6	61.4	4.06	18.1	0.32
HFC-338pcc/245caEαβ									
1/99	1.5	10	7.7	53	124.8	51.6	3.84	8.9	0.16
99/1	3.0	21	14.4	99	142.6	61.4	4.06	18.1	0.32
HFC-338pcc/245eaE									
1/99	1.9	13	10.4	72	167.8	75.4	4.26	13.4	0.24
99/1	3.0	21	14.5	100	143.0	61.7	4.06	18.3	0.32

HFC-338pcc/338meeEβγ									
1/99	2.2	15	11.8	81	141.8	61.0	4.04	14.2	0.25
99/1	3.0	21	14.4	99	142.8	61.6	4.06	18.2	0.32
HFC-338pcc/338peEγδ									
1/99	2.8	19	14.4	99	140.4	60.2	4.02	17.4	0.31
99/1	3.0	21	14.4	99	142.8	61.6	4.06	18.2	0.32
HFC-338pcc/347mcfEβγ									
1/99	2.7	19	13.8	95	141.9	61.1	4.04	17.0	0.30
99/1	3.0	21	14.4	99	142.8	61.6	4.06	18.2	0.32
HFC-338pcc/347mcfEγδ									
1/99	2.6	18	13.6	94	142.1	61.2	4.04	16.6	0.29
99/1	3.0	21	14.4	99	142.8	61.6	4.06	18.2	0.32
HFC-338pcc/347mmzEβγ									
1/99	1.6	11	8.8	61	145.2	62.9	4.10	10.6	0.19
99/1	3.0	21	14.4	99	142.8	61.6	4.06	18.1	0.32
HFC-338pcc/356mecEγδ									
1/99	1.8	12	9.5	66	145.8	63.2	4.12	11.7	0.21
99/1	3.0	21	14.4	99	142.8	61.6	4.06	18.1	0.32
HFC-338pcc/356mecE2αβγδ									
1/99	1.5	10	8.8	61	143.8	62.1	4.10	10.4	0.18
99/1	3.0	21	14.4	99	142.8	61.6	4.06	18.2	0.32
HFC-338pcc/356mmzEβγ									
1/99	2.3	16	11.7	81	144.3	62.4	4.09	14.5	0.26
99/1	3.0	21	14.4	99	142.8	61.6	4.06	18.2	0.32
HFC-338pcc/365mcfEγδ									
1/99	2.5	17	12.7	88	145.2	62.9	4.10	16.0	0.28
99/1	3.0	21	14.4	99	142.8	61.6	4.06	18.2	0.32
HFC-338pcc/374pcEβγ									
1/99	1.7	12	9.4	65	152.5	66.9	4.19	11.8	0.21
99/1	3.0	21	14.4	99	142.8	61.6	4.06	18.2	0.32
HFC-338pcc/383mEβγ									
1/99	2.2	15	11.6	80	152.8	67.1	4.17	14.9	0.26
99/1	3.0	21	14.5	100	142.9	61.6	4.06	18.3	0.32

HFC-338pcc/467mmyEβγ									
1/99	2.7	19	13.8	95	132.1	55.6	3.91	16.4	0.29
99/1	3.0	21	14.4	99	142.7	61.5	4.06	18.2	0.32
HFC-338pcc/467sfEγδ									
1/99	2.1	14	11.2	77	133.4	56.3	3.94	13.2	0.23
99/1	3.0	21	14.4	99	142.7	61.5	4.06	18.2	0.32
HFC-338pcc/$C_4F_9OCH_3$									
1/99	1.5	10	8.4	58	131.4	55.2	3.93	9.6	0.17
99/1	3.0	21	14.4	99	142.7	61.5	4.05	18.1	0.32
HFC-338pcc/$(CF_3)_3COH$									
1/99	2.4	17	15.1	104	140.5	60.3	3.99	16.7	0.29
99/1	3.0	21	14.5	100	142.7	61.5	4.06	18.4	0.32
HFC-338pcc/$C_5F_{11}NO$									
1/99	2.3	16	11.9	82	122.9	50.5	3.74	13.4	0.24
99/1	3.0	21	14.4	99	142.6	61.4	4.06	18.2	0.32
HFC-338pcc/dimethoxymethane									
1/99	2.6	18	13.6	94	174.8	79.3	4.37	18.6	0.33
99/1	3.1	21	15.1	104	143.9	62.2	4.10	19.3	0.34
HFC-338pcc/diethylether									
1/99	4.3	30	19.5	134	158.7	70.4	4.20	26.5	0.47
99/1	3.1	21	14.9	103	142.9	61.6	4.08	18.9	0.33
HFC-388pcc/diethoxyethane									
1/99	0.1	1	0.8	6	155.2	68.4	4.47	0.8	0.01
99/1	2.4	17	13.0	90	147.8	64.3	3.93	15.2	0.27
HFC-338pcc/HFC-43-10mcf									
1/99	2.3	16	11.9	82	130.3	54.6	3.88	14.0	0.25
99/1	3.0	21	14.4	99	142.6	61.4	4.06	18.2	0.32

EXAMPLE 5

This Example is directed to measurements of the liquid/vapor equilibrium curves for the mixtures in Figures 1-30.

Turning to Figure 1, the upper curve represents the composition of the liquid, and the lower curve represents the composition of the vapor.

The data for the compositions of the liquid in Figure 1 are obtained as follows. A stainless steel cylinder is evacuated, and a weighed amount of HFC-338pcc is added to the cylinder. The cylinder is cooled to reduce the vapor pressure of HFC-338pcc and then a weighed amount of HFC-42-11-mmyc is added to the cylinder. The cylinder is agitated to mix the HFC-388pcc and HFC-42-11mmyc, and then the cylinder is placed in a constant temperature bath until the temperature comes to equilibrium at 25°C, at which time the vapor pressure of the HFC-338pcc and HFC-41-11mmyc in the cylinder is measured. Additional samples of liquid are measured the same way, and the results are plotted in Figure 1.

The curve which shows the composition of the vapor is calculated using an ideal gas equation of state.

Vapor/liquid equilibrium data are obtained in the same way for the mixtures shown in Figures 2-30.

The data in Figures 1-6 and 9-30 show that at 25°C, there are ranges of compositions that have vapor pressures higher than the vapor pressures of the pure components of the composition at that same temperature. As stated earlier, the higher than expected pressures of these compositions may result in an unexpected increase in the refrigeration capacity or efficiency for these compositions versus the pure components of the compositions.

The data in Figures 7, 8 show that at 25°C, there are ranges of compositions that have vapor pressures lower than the vapor pressures of the pure components of the composition at that same temperature. These minimum vapor pressure compositions are useful in refrigeration, and may show an improved efficiency when compared to the pure components of the composition.

The novel compositions of this invention, including the azeotropic or azeotrope-like compositions, may be used to produce refrigeration by condensing the compositions and thereafter evaporating the condensate in the vicinity of a body to be cooled. The novel compositions may also be used to produce heat by condensing the refrigerant in the vicinity of the body to be heated and thereafter evaporating the refrigerant. These compositions may be particularly useful in high speed, small turbine compressors with speeds from about 40,000-90,000 revolutions per minute (RPM).

The compositions of the present inventions are useful as blowing agents in the production of thermoset foams, which include polyurethane and phenolic foams, and thermoplastic foams, which include polystyrene or polyolefin foams.

A polyurethane foam may be made by combining a composition of the present invention, which functions as a blowing agent, together with an isocyanate, a polyol, and appropriate catalysts or surfactants to form a poylurethane or polyisocyanurate reaction formulation. Water may be added to the formulation reaction to modify the foam polymer as well as to generate carbon dioxide as an in-situ blowing agent.

A phenolic foam may be produced by combining a phenolic resin or resole, acid catalysts, a blowing agent of the present invention and appropriate surfactants to form a phenolic reaction formulation. The formulation may be chosen such that either an open cell or closed cell phenolic foam is produced.

Polystyrene or polyolefin foams may be made by extruding a molten mixture of a polymer, such as polystyrene, polyethylene or polypropylene), a nucleating agent and a blowing agent of the present invention through an extrusion die that yields the desired foam product profile.

The novel compositions of this invention, including the azeotropic or azeotrope-like compositions, may be used as cleaning agents to clean, for example, electronic circuit boards. Electronic components are soldered to circuit boards by coating the entire circuit side of the board with flux and thereafter passing the flux-coated board over preheaters and through molten solder. The flux cleans the conductive metal parts and promotes solder fusion, but leave residues on the circuit boards that must be removed with a cleaning agent. This is conventionally done by suspending a circuit board to be cleaned in a boiling sump which contains the azeotropic or azeotrope-like composition, then suspending the circuit board in a rinse sump, which contains the same azeotropic or azeotrope-like composition, and finally, for one minute in the solvent vapor above the boiling sump.

As a further example, the azeotropic mixtures of this invention can be used in cleaning processes such as described in U.S. Patent No. 3,881,949, or as a buffing abrasive detergent.

It is desirable that the cleaning agents be azeotropic or azeotrope-like so that they do not tend to fractionate upon boiling or evaporation. This behavior is desirable because if the cleaning agent were not azeotropic or azeotrope-like, the more volatile components of the cleaning agent would preferentially evaporate, and would result in a cleaning agent with a changed composition that may become flammable and that may have less-desirable solvency properties, such as lower rosin flux solvency and lower inertness toward the electrical components being cleaned. The azeotropic character is also desirable in vapor degreasing operations because the cleaning agent is generally redistilled and employed for final rinse cleaning.

The novel compositions of this invention are also useful as fire extinguishing agents.

In addition to these applications, the novel constant boiling or substantially constant boiling compositions of the invention are also useful as aerosol propellants, heat transfer media, gaseous dielectrics, and power cycle working fluids.

ADDITIONAL COMPOUNDS

Other components, such as aliphatic hydrocarbons having a boiling point of -60 to +100°C, hydrofluorocarbonalkanes having a boiling point of -60 to +100°C, hydrofluoropropanes having a boiling point of between -60 to +100°C, hydrocarbon esters having a boiling point between -60 to +100°C, hydrochlorofluorocarbons having a boiling point between -60 to +100°C, hydrofluorocarbons having a boiling point of -60 to +100°C, hydrochlorocarbons having a boiling point between -60 to +100°C, chlorocarbons and perfluorinated compounds, can be added to the azeotropic or azeotrope-like compositions described above.

Additives such as lubricants, corrosion inhibitors, surfactants, stabilizers, dyes and other appropriate materials may be added to the novel compositions of the invention for a variety of purposes provides they do not have an adverse influence on the composition for its intended application. Preferred lubricants include esters having a molecular weight greater than 250.

CLAIMS

What is claimed is:

1. A refrigerant composition comprising octafluorobutane and a compound selected from the group consisting a 4-6 carbon linear or a cyclic hydrofluorocarbon (HFC) or fluorocarbon (FC), a 3-5 carbon fluoroether, a fluorinated alcohol, perfluoro-n-methylmorpholine, and an ether.

2. A composition according to claim 1, comprising 1,1,1,2,2,3,3,4-octafluorobutane and 1,1,1,2,3,3,4,4-octafluoro-2-(trifluoromethyl)butane (HFC-42-11mmyc); 1,1,1,2,2,3,3,4,4,5,5-undecafluoropentane (HFC-42-11p); 1,1,1,4,4,4-hexafluoro-2-(trifluoromethyl)butane (HFC-449mmzf) or 1,1,1,2,2,3,3,5,5,5-decafluoropentane (HFC-43-10mf); 1,1,1,2,2,4,4,5,5,5-decafluoropentane (HFC-43-10mcf) or 1,1,2,2,3,3,4,4-octafluorobutane and 1,1,2,2-tetrafluorocyclobutane (HFC-c354cc); perfluorocyclohexane (FC-c51-12c); 1,1,2,2,3,3,4,4,5-nonafluorocyclopentane cyclo-c $(CF_2)_4CHF$, (HFC-c429); or 1,1,2,2,3,3,4,4,5,5,6-undecafluorocyclohexane cyclo-c $(CF_2)_5CHF$ (HFC-c52-11); 1,1,2,2,3,3,4,4-octafluorobutane and 1-(difluoromethoxy)-1,2,2-trifluoroethane (HFC-245caEαβ); 1-(difluoromethoxy)-1,1,2-trifluoroethane (245eaE); (1,1'-oxybis(1,2,2,2-tetrafluoro)ethane (338 meeEβγ); 3-(difluoromethoxy)-1,1,1,2,2,3-hexafluoropropane (338peEγδ); 1,1,2,2-tetrafluoro-1-(2,2,2-trifluoroethoxy)ethane (347mcfEβγ); 3-difluoromethoxy-1,1,1,2,2-pentafluoropropane (347mcfEγδ); 1,1,1,3,3,3-hexafluoro-2-fluoromethoxypropane $CH_2FOCH(CF_3)_2$ (347mmzEβγ); 1,1,1,2,3,3-hexafluoro-3-methoxypropane (356mecEγδ); 1,1,2-trifluoro-1-methoxy-2-(trifluoromethoxy)ethane (356mecE2αβγδ); 1,1,1,3,3,3-hexafluoro-2-methoxypropane (356mmzEβγ); 1,1,1,2,2-pentafluoro-3-methoxypropane $CF_3CF_2CH_2OCH_3$ (365sfEγδ); 1-ethoxy-1,1,2,2-tetrafluoroethane (374pcEβγ); 2-ethoxy-1,1,1-trifluoroethane (383mEβγ); 2-ethoxy-1,1,1,2,3,3,3-heptafluoropropane (467mmyEβγ); 3-ethoxy-1,1,1,2,2,3,3-heptafluoropropane (467sfEγδ); $C_4F_9OCH_3$; or nonafluoro-tert-butanol $(CF_3)_3COH$; a 1,1,2,2,3,3,4,4-octafluorobutane and perfluoro-n-methylmorpholine or 1,1,2,2,3,3,4,4-octafluorobutane and dimethoxymethane; diethylether; or diethoxyethane.

3. Effective amounts of the following compounds to form an azeotropic or azeotrope-like composition: 1,1,2,2,3,3,4,4-octafluorobutane and a compound selected from the group consisting of a 4-6 carbon linear compound; a cyclic hydrofluorocarbon or fluorocarbon; a 3-5 carbon fluoroether; perfluoro-n-metylmorpholine; and an ether.

4. The azeotropic or azeotrope-like composition of Claim 2, said composition consisting essentially of 1-99 weight percent 1,1,2,2,3,3,4,4-octafluorobutane (HFC-338pcc) and 1-99 weight percent 1,1,1,2,3,3,4,4-octafluoro-2-(trifluoromethyl)butane (HFC-42-11mmyc); 1-99 weight percent 1,1,2,2,3,3,4,4-octafluorobutane (HFC-338pcc) and 1-99 weight percent 1,1,1,2,2,3,3,4,4,5,5-undecafluoropentane (HFC-42-11p); 1-99 weight percent 1,1,2,2,3,3,4,4-octafluorobutane (HFC-338pcc) and 1-99 weight percent 1,1,1,2,2,3,3,5,5,5-decafluoropentane (HFC-43-10mf); 1-99 weight percent 1,1,2,2,3,3,4,4-octafluorobutane (HFC-338pcc) and 1-99 weight percent 1,1,1,4,4,4-hexafluoro-2-(trifluoromethyl)butane (HFC-449mmzf); 1-99 weight percent 1,1,2,2,3,3,4,4-octafluorobutane (HFC-338pcc) and 1-99 weight percent 1,1,2,2-tetrafluorocyclobutane (HFC-c354cc); 1-99 weight percent 1,1,2,2,3,3,4,4-octafluorobutane (HFC-338pcc) and 1-99 weight percent perfluorocyclohexane (FC-c51-12c); 1-99 weight percent 1,1,2,2,3,3,4,4-octafluorobutane (HFC-338pcc) and 1-99 weight percent 1,1,2,2,3,3,4,4,5-nonafluorocyclopentane (HFC-c429); 1-99 weight percent 1,1,2,2,3,3,4,4-octafluorobutane (HFC-338pcc) and 1-99 weight percent 1,1,2,2,3,3,4,4,5,5,6-undecafluorocyclohexane (HFC-c52-11); 1-99 weight percent 1,1,2,2,3,3,4,4-octafluorobutane (HFC-338pcc) and 1-99 weight percent 1-(difluoromethoxy)-1,1,2-trifluoroethane $CHF_2OCF_2CH_2F$, (245caEαβ); 1-99 weight percent 1,1,2,2,3,3,4,4-octafluorobutane (HFC-338pcc) and 1-99 weight percent 1-(difluoromethoxy)-1,2,2-trifluoroethane $CHF_2OCHFCHF_2$, (245eaE); 1-99 weight percent 1,1,2,2,3,3,4,4-octafluorobutane (HFC-338pcc) and 1-99 weight percent 1,1'-oxybis(1,2,2,2-tetrafluoro)ethane $CF_3CHFOCHFCF_3$, (338 meeEβγ); 1-99 weight percent 1,1,2,2,3,3,4,4-octafluorobutane (HFC-338pcc) and 1-99 weight percent 3-difluoromethoxy-1,1,1,2,2,3-hexafluoropropane $CHF_2OCHFCF_2CF_3$, (338peEγδ); 1-99 weight percent 1,1,2,2,3,3,4,4-octafluorobutane (HFC-338pcc) and 1-99 weight percent 1,1,2,2-tetrafluoro-1-(2,2,2-trifluoroethoxy)ethane $CHF_2CH_2OCF_2CF_3$, (347mcf Eβγ); 1-99 weight percent 1,1,2,2,3,3,4,4-octafluorobutane (HFC-338pcc) and 1-99 weight percent 3-difluoromethoxy-1,1,1,2,2-pentafluoropropane $CHF_2OCH_2CF_2CF_3$, (347mcfEγδ); 1-99 weight percent 1,1,2,2,3,3,4,4-octafluorobutane (HFC-338pcc) and 1-99 weight percent 1,1,1,3,3,3-hexafluoro-2-fluoromethoxypropane $CH_2FOCH(CF_3)_2$, (347mmzEβγ); 1-99 weight percent 1,1,2,2,3,3,4,4-octafluorobutane (HFC-338pcc) and 1-99 weight percent 1,1,1,2,3,3-hexafluoro-3-methoxypropane $CH_3OCF_2CHFCF_3$, (356mecEγδ); 1-99 weight percent 1,1,2,2,3,3,4,4-octafluorobutane (HFC-338pcc) and 1-99 weight percent 1,1,2-trifluoro-1-methoxy-2-(trifluoromethoxy)ethane $CH_3OCF_2CHFOCF_3$, (356mecE2αβγδ); 1-99 weight percent 1,1,2,2,3,3,4,4-octafluorobutane (HFC-338pcc) and 1-99 weight percent 1,1,1,3,3,3-hexafluoro-2-

methoxypropane $(CF_3)_2CHOCH_3$, (356mmzEβγ); 1-99 weight percent 1,1,2,2,3,3,4,4-octafluorobutane (HFC-338pcc) and 1-99 weight percent 1,1,1,2,2-pentafluoro-3-methoxypropane $CF_3CF_2CH_2OCH_3$, (365mcEγδ); 1-99 weight percent 1,1,2,2,3,3,4,4-octafluorobutane (HFC-338pcc) and 1-99 weight percent 1-ethoxy-1,1,2,2-tetrafluoroethane $C_2H_5OCF_2CHF_2$, (374pcEβγ); 1-99 weight percent 1,1,2,2,3,3,4,4-octafluorobutane (HFC-338pcc) and 1-99 weight percent 2-ethoxy-1,1,1-trifluoroethane $C_2H_5OCH_2CF_3$ (383mEβγ); 1-99 weight percent 1,1,2,2,3,3,4,4-octafluorobutane (HFC-338pcc) and 1-99 weight percent 2-ethoxy-1,1,1,2,3,3,3-heptafluoropropane $C_2H_5OCF(CF_3)_2$, (467mmyEβγ); 1-99 weight percent 1,1,2,2,3,3,4,4-octafluorobutane (HFC-338pcc) and 1-99 weight percent 3-ethoxy-1,1,1,2,2,3,3-heptafluoropropane $C_2H_5OCF_2CF_2CF_3$, (467sfEγδ); 1-99 weight percent 1,1,2,2,3,3,4,4-octafluorobutane (HFC-338pcc) and 1-99 weight percent $C_4F_9OCH_3$; 1-88 weight percent 1,1,2,2,3,3,4,4-octafluorobutane (HFC-338pcc) and 12-99 weight percent nonafluoro-*tert*-butanol $(CF_3)_3COH$; 1-99 weight percent 1,1,2,2,3,3,4,4-octafluorobutane (HFC-338pcc) and 1-99 weight percent perfluoro-n-methylmorpholine ($C_5F_{11}NO$); 1-95 weight percent 1,1,2,2,3,3,4,4-octafluorobutane (HFC-338pcc) and 5-99 weight percent dimethoxymethane; 1-86 weight percent 1,1,2,2,3,3,4,4-octafluorobutane (HFC-338pcc) and 14-99 weight percent diethylether; 83-99.9 weight percent 1,1,2,2,3,3,4,4-octafluorobutane (HFC-338pcc) and 0.1-17 weight percent diethoxyethane; or 1-99 weight percent 1,1,2,2,3,3,4,4-octafluorobutane (HFC-338pcc) and 1-99 weight percent 1,1,1,2,2,4,4,5,5,5-decafluoropentane (HFC-43-10mcf).

5. Effective amounts of the following compounds to form a composition having a vapor pressure above or below the vapor pressure of the compounds: 1,1,2,2,3,3,4,4-octafluorobutane and a compound selected from the group consisting of 1,1,1,2,3,3,4,4-octafluoro-2-(trifluoromethyl)butane (HFC-42-11mmyc); 1,1,1,2,2,3,3,4,4,5,5-undecafluoropentane (HFC-42-11p); 1,1,1,4,4,4-hexafluoro-2-(trifluoromethyl)butane (HFC-449mmzf) or 1,1,1,2,2,3,3,5,5,5-decafluoropentane (HFC-43-10mf); 1,1,1,2,2,4,4,5,5,5-decafluoropentane (HFC-43-10mcf) or 1,1,2,2,3,3,4,4-octafluorobutane and 1,1,2,2-tetrafluorocyclobutane (HFC-c354cc); perfluorocyclohexane (FC-c51-12c); 1,1,2,2,3,3,4,4,5-nonafluorocyclopentane (HFC-c429); or 1,1,2,2,3,3,4,4,5,5,6-undecafluorocyclohexane (HFC-c52-11); 1,1,2,2,3,3,4,4-octafluorobutane and 1-(difluoromethoxy)-1,2,2-trifluoroethane (245caEαβ); 1-(difluoromethoxy)-1,1,2-trifluoroethane (245eaE); (1,1'-oxybis(1,2,2,2-tetrafluoro)ethane (338 meeEβγ); 3-(difluoromethoxy)-1,1,1,2,2,3-hexafluoropropane (338peEγδ); 1,1,2,2-tetrafluoro-1-(2,2,2-trifluoroethoxy)ethane (347mcfEβγ); 3-difluoromethoxy-1,1,1,2,2-

pentafluoropropane (347mcfEγδ); 1,1,1,3,3,3-hexafluoro-2-fluoromethoxypropane $CH_2FOCH(CF_3)_2$ (347mmzEβγ); 1,1,1,2,3,3-hexafluoro-3-methoxypropane (356mecEγδ); 1,1,2-trifluoro-1-methoxy-2-(trifluoromethoxy)ethane (356mecE2αβγδ); 1,1,1,3,3,3-hexafluoro-2-methoxypropane (356mmzEβγ); 1,1,1,2,2-pentafluoro-3-methoxypropane $CF_3CF_2CH_2OCH_3$ (365mcEγδ); 1-ethoxy-1,1,2,2-tetrafluoroethane (374pcEβγ); 2-ethoxy-1,1,1-trifluoroethane (383mEβγ); 2-ethoxy-1,1,1,2,3,3,3-heptafluoropropane (467mmyEβγ); 3-ethoxy-1,1,1,2,2,3,3-heptafluoropropane (467sfEγδ); $C_4F_9OCH_3$; or nonafluoro-tert-butanol $(CF_3)_3COH$; a 1,1,2,2,3,3,4,4-octafluorobutane and perfluoro-n-methylmorpholine or 1,1,2,2,3,3,4,4-octafluorobutane and dimethoxymethane; diethylether; or diethoxyethane.

6. A process for producing refrigeration, comprising condensing a composition of Claim 1 and thereafter evaporating said composition in the vicinity of the body to be cooled.

7. A process for producing heat comprising condensing a composition of Claim 1 in the vicinity of a body to be heated, and thereafter evaporating said composition.

8. A process for producing refrigeration, comprising condensing a composition of Claim 3 and thereafter evaporating said composition in the vicinity of the body to be cooled.

9. A process for producing heat comprising condensing a composition of Claim 3 in the vicinity of a body to be heated, and thereafter evaporating said composition.

10. A process for producing refrigeration, comprising condensing a composition of Claim 5 and thereafter evaporating said composition in the vicinity of the body to be cooled.

11. A process for producing heat comprising condensing a composition of Claim 5 in the vicinity of a body to be heated, and thereafter evaporating said composition.

12. A process for preparing a thermoset or thermoplastic foam, comprising using a composition of Claim 1 as a blowing agent.

13. A process for preparing a thermoset or thermoplastic foam, comprising using a composition of Claim 3 as a blowing agent.

14. A process for preparing a thermoset or thermoplastic foam, comprising using a composition of Claim 5 as a blowing agent.

15. A process for cleaning a solid surface comprising treating said surface with a composition of Claim 1.

16. A process for cleaning a solid surface comprising treating said surface with a composition of Claim 3.

17. A process for cleaning a solid surface comprising treating said surface with a composition of Claim 5.

18. A process to produce for atomizing a fluid comprising using a composition of Claim 1 as an aerosol propellant.

19. A process to produce for atomizing a fluid comprising using a composition of Claim 3 as an aerosol propellant.

20. A process to produce for atomizing a fluid comprising using a composition of Claim 5 as an aerosol propellant.

FIG.1

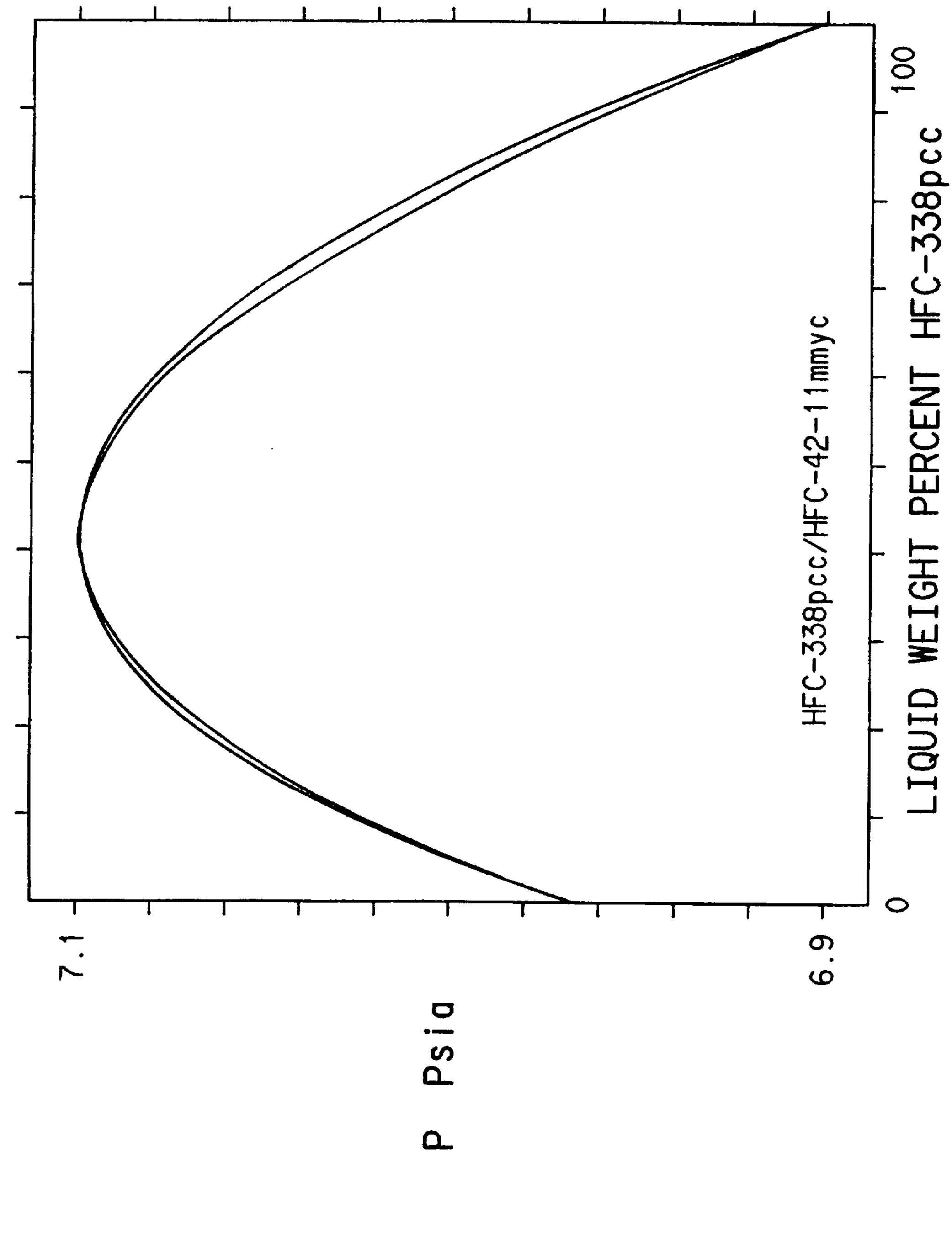

7.1
6.9
P Psia
0
100
HFC-338pcc/HFC-42-11mmyc
LIQUID WEIGHT PERCENT HFC-338pcc

FIG.2

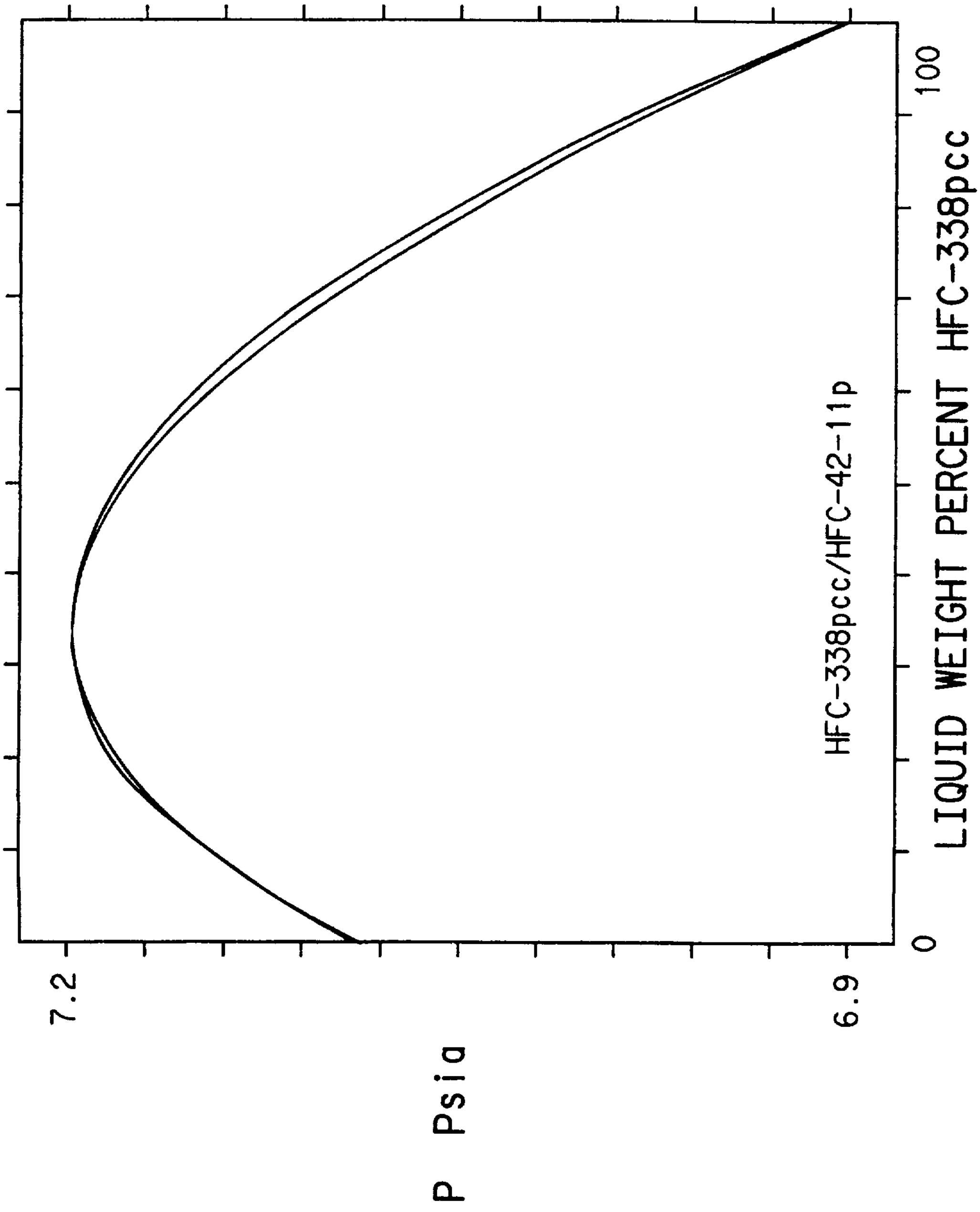

HFC-338pcc/HFC-42-11p
LIQUID WEIGHT PERCENT HFC-338pcc
P Psia
7.2
6.9
0
100

FIG. 3

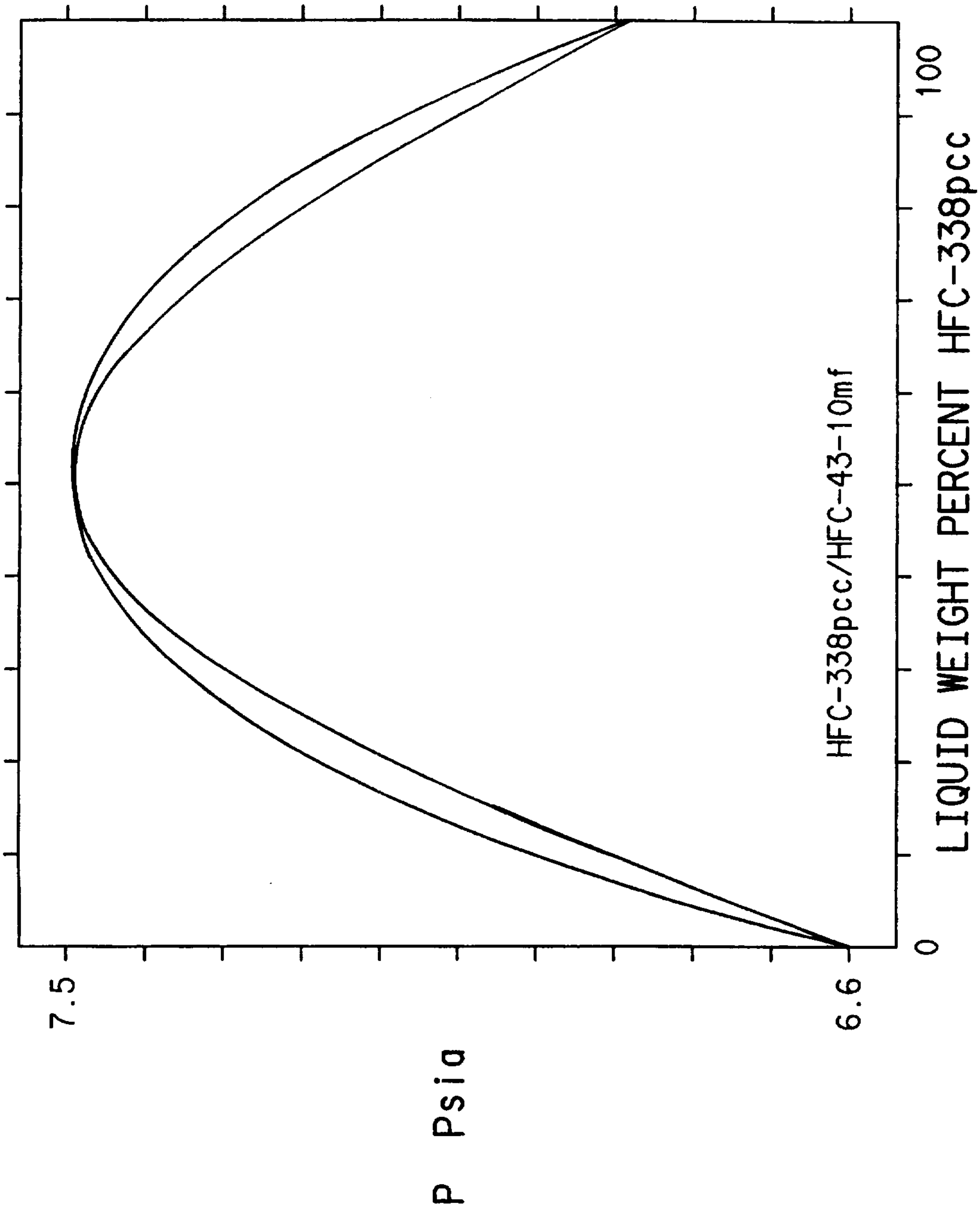

7.5
6.6
P Psia
0
100
LIQUID WEIGHT PERCENT HFC-338pcc
HFC-338pcc/HFC-43-10mf

FIG.4

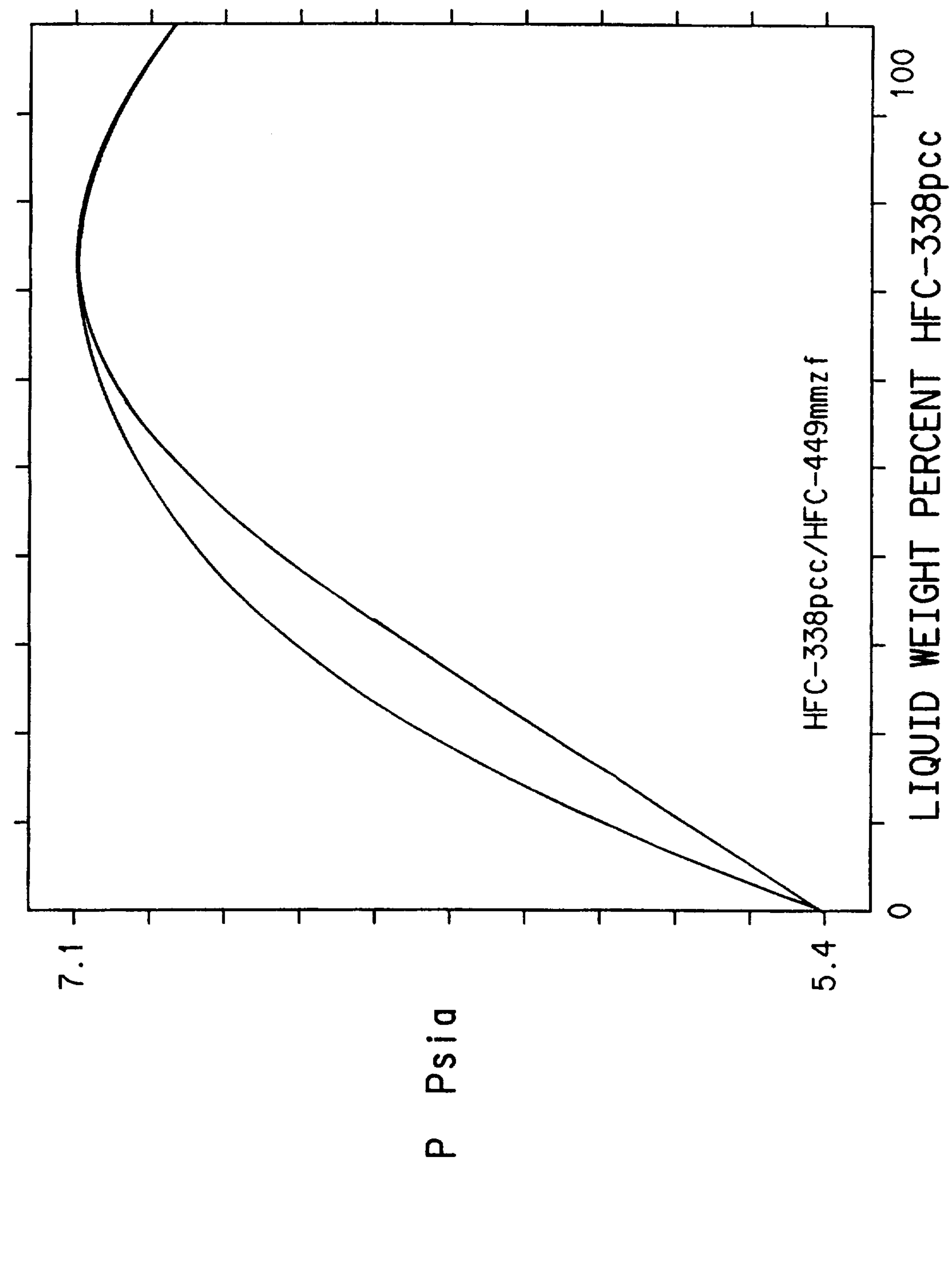

P Psia
7.1
5.4
0
100
LIQUID WEIGHT PERCENT HFC-338pcc
HFC-338pcc/HFC-449mmzf

FIG.5

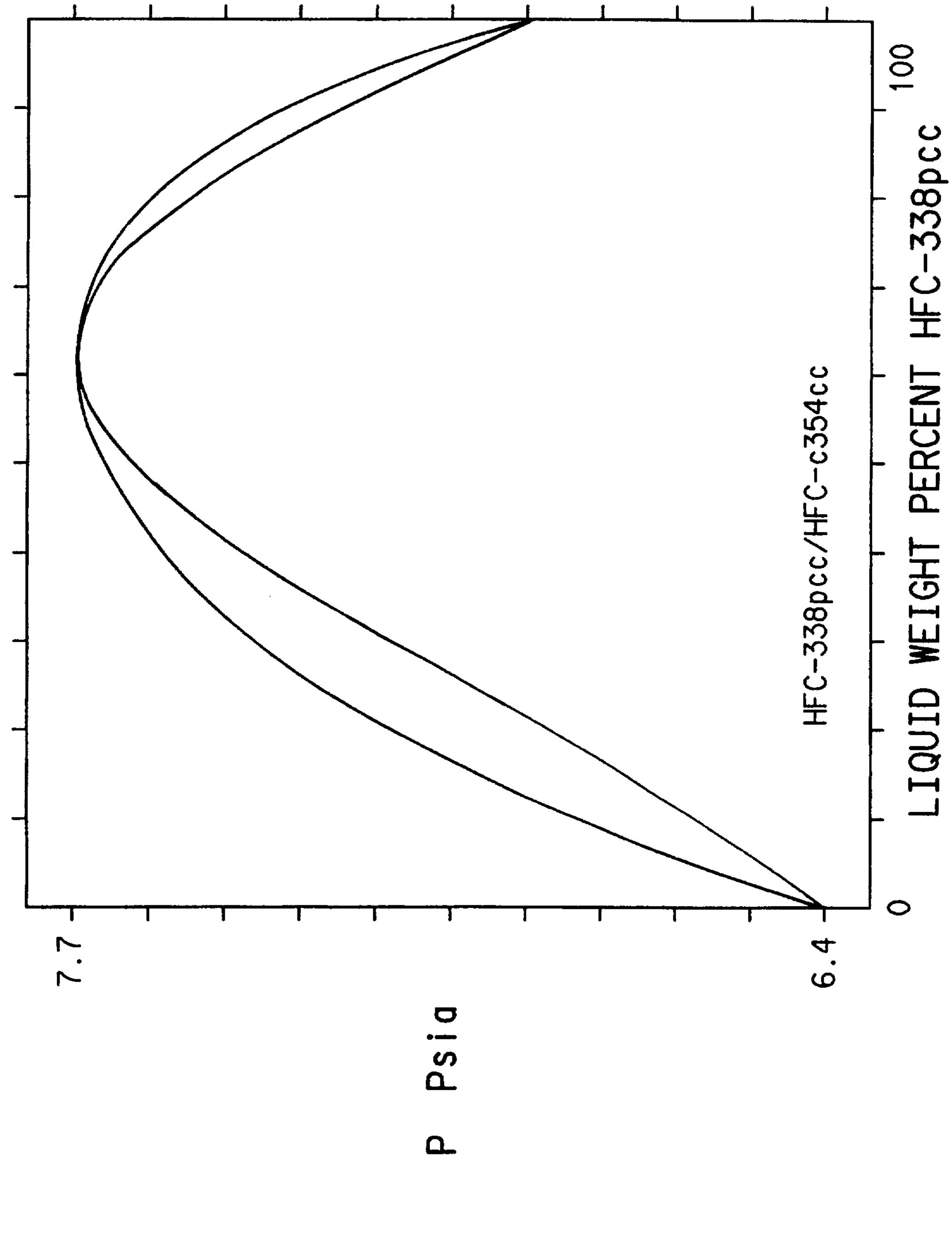

P Psia
7.7
6.4
0
100
HFC-338pcc/HFC-c354cc
LIQUID WEIGHT PERCENT HFC-338pcc

FIG.6

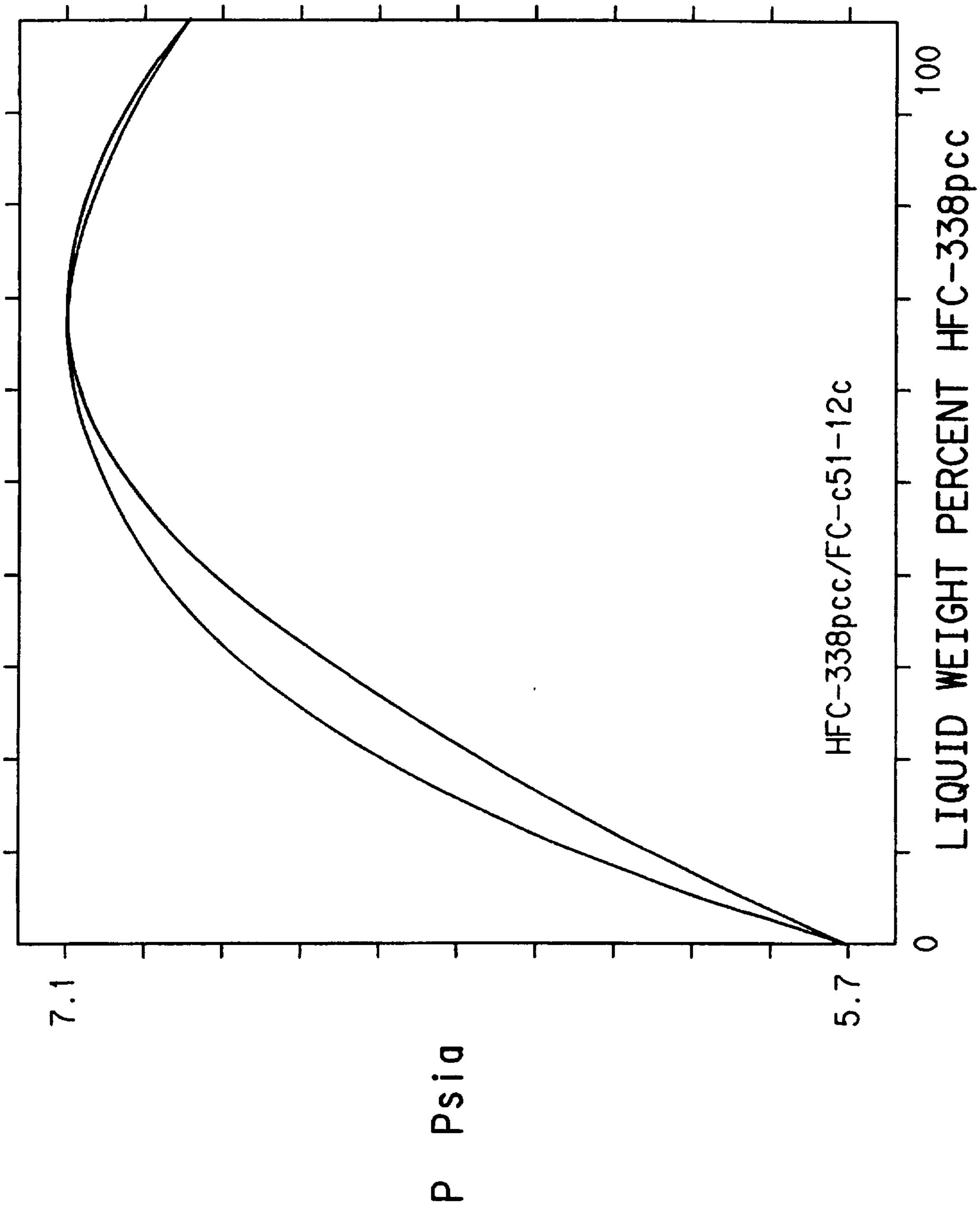

P Psia
7.1
5.7
0
100
LIQUID WEIGHT PERCENT HFC-338pcc
HFC-338pcc/FC-c51-12c

FIG.7

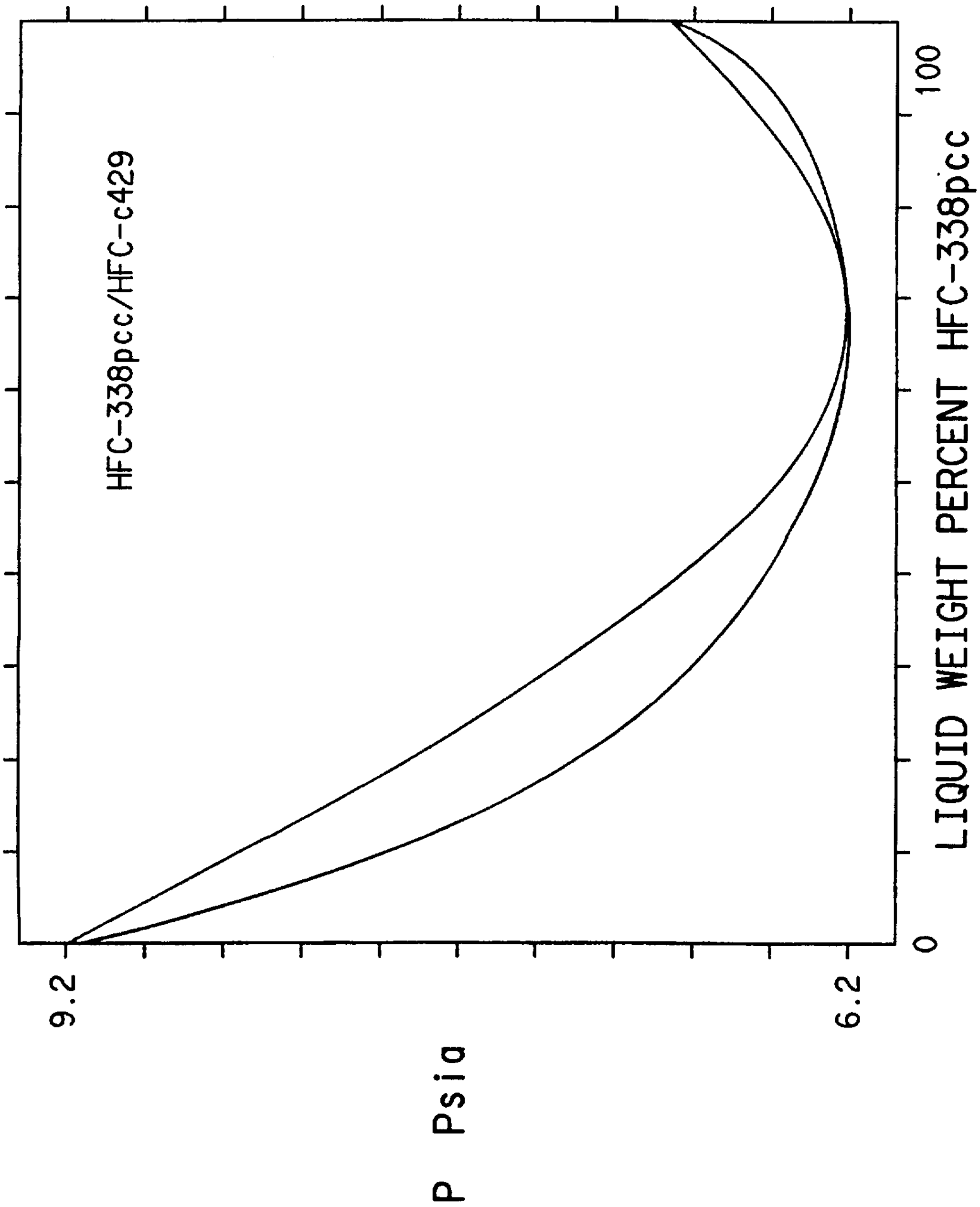

HFC-338pcc/HFC-c429
9.2
6.2
P Psia
0
100
LIQUID WEIGHT PERCENT HFC-338pcc

FIG.8

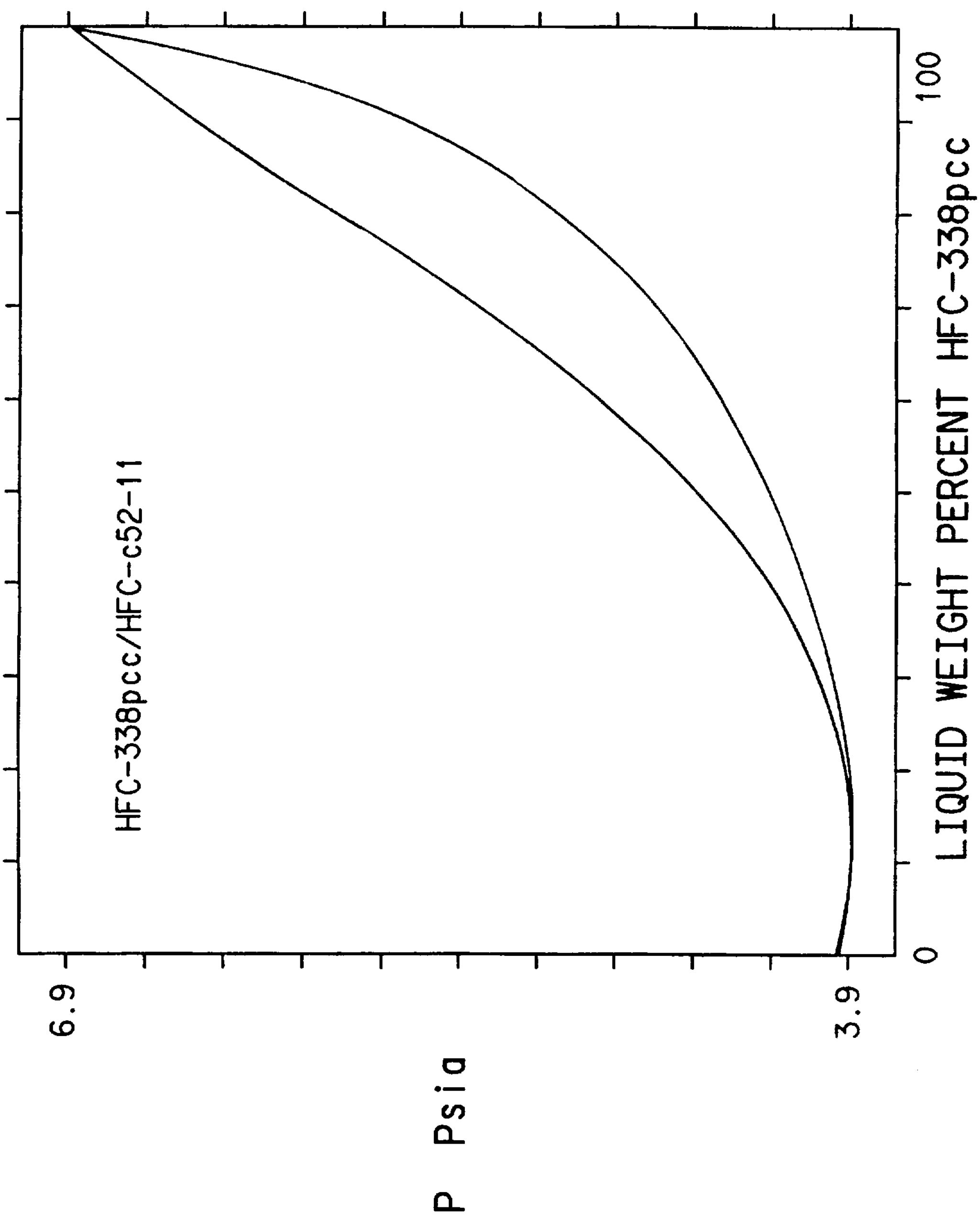
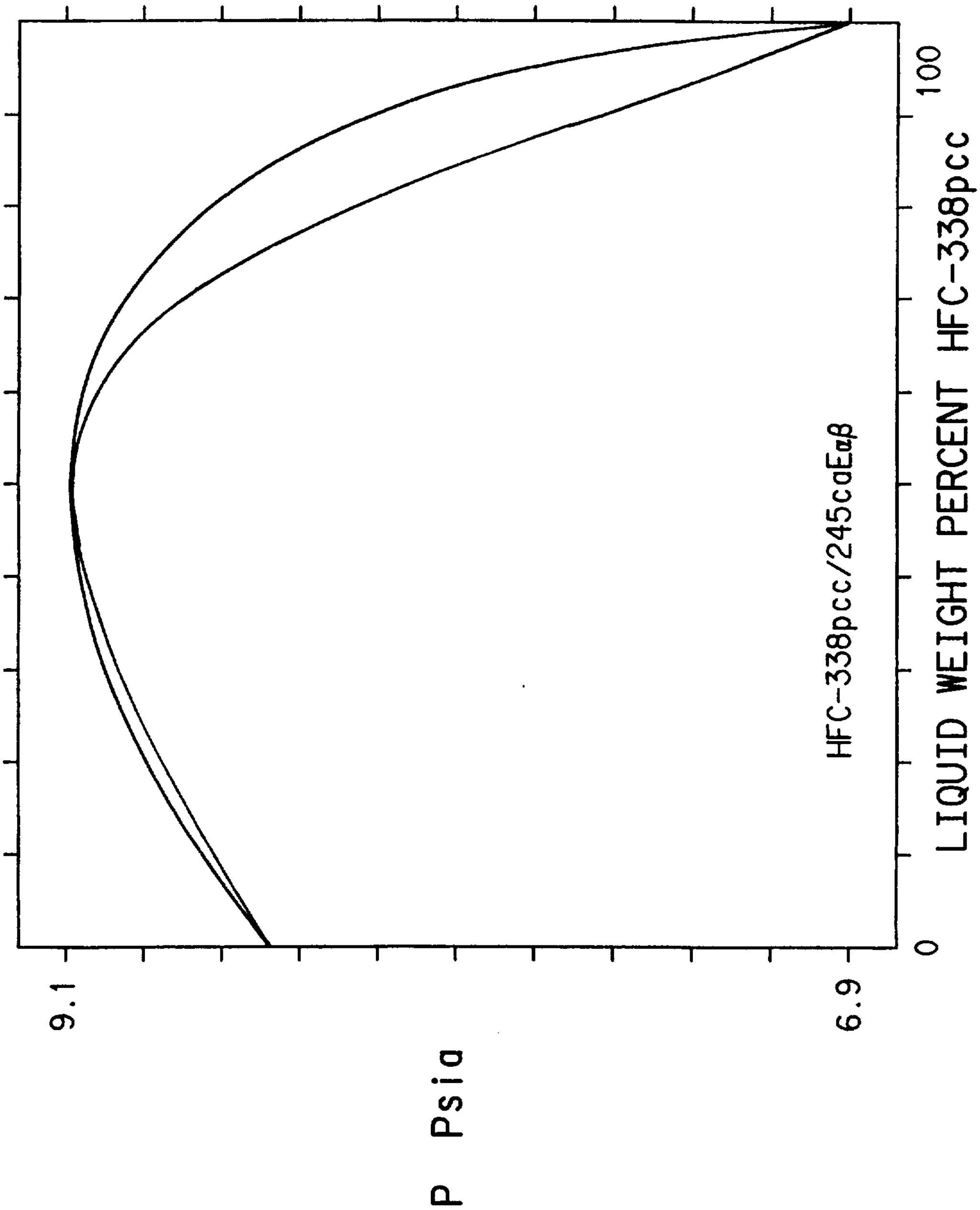

HFC-338pcc/HFC-c52-11
6.9
3.9
P Psia
0
100
LIQUID WEIGHT PERCENT HFC-338pcc

FIG.9


9.1
6.9
P Psia
0
100
LIQUID WEIGHT PERCENT HFC-338pcc
HFC-338pcc/245caEαβ

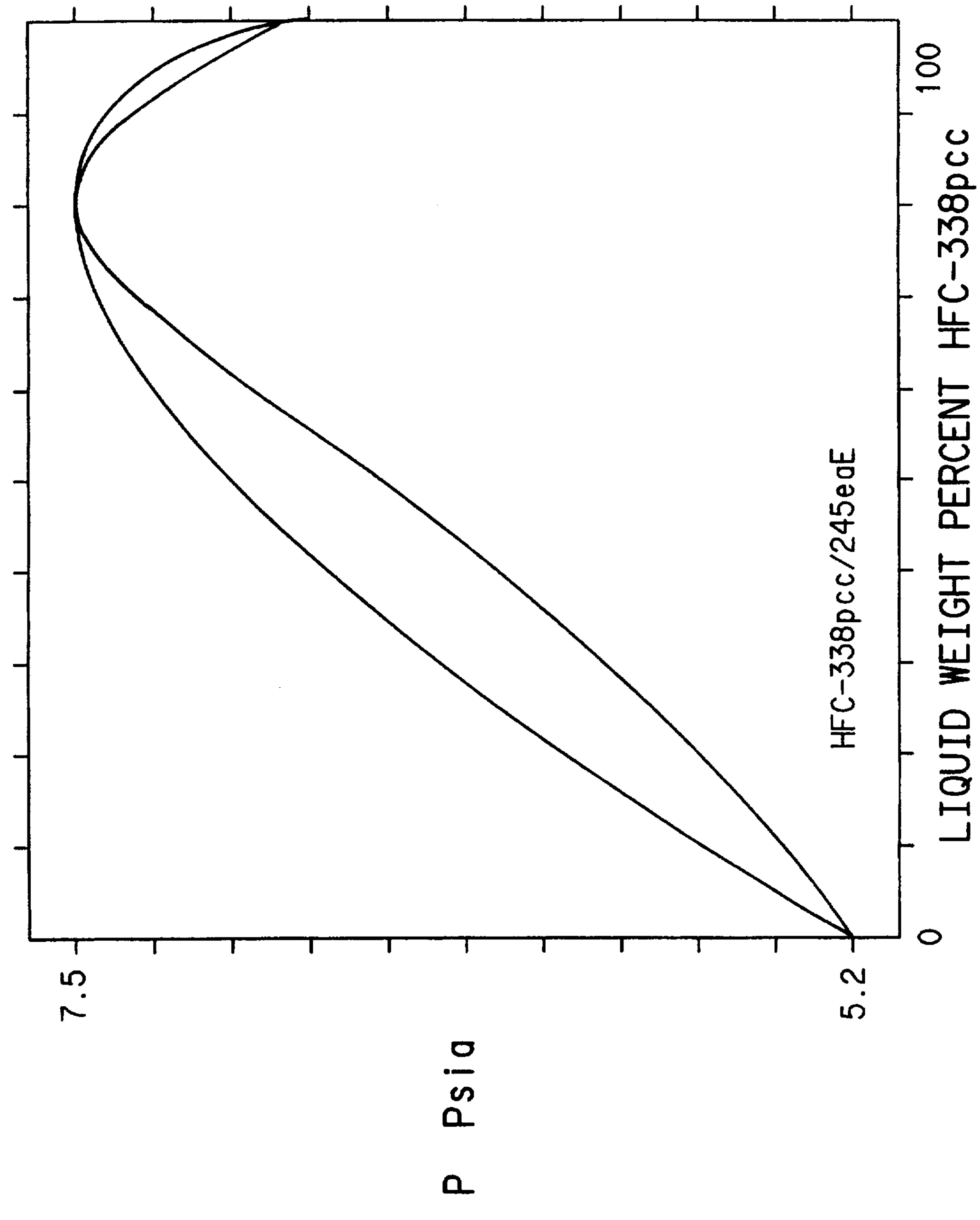

7.5
5.2
P Psia
0
100
LIQUID WEIGHT PERCENT HFC-338pcc
HFC-338pcc/245eaE

FIG.10

FIG. 11

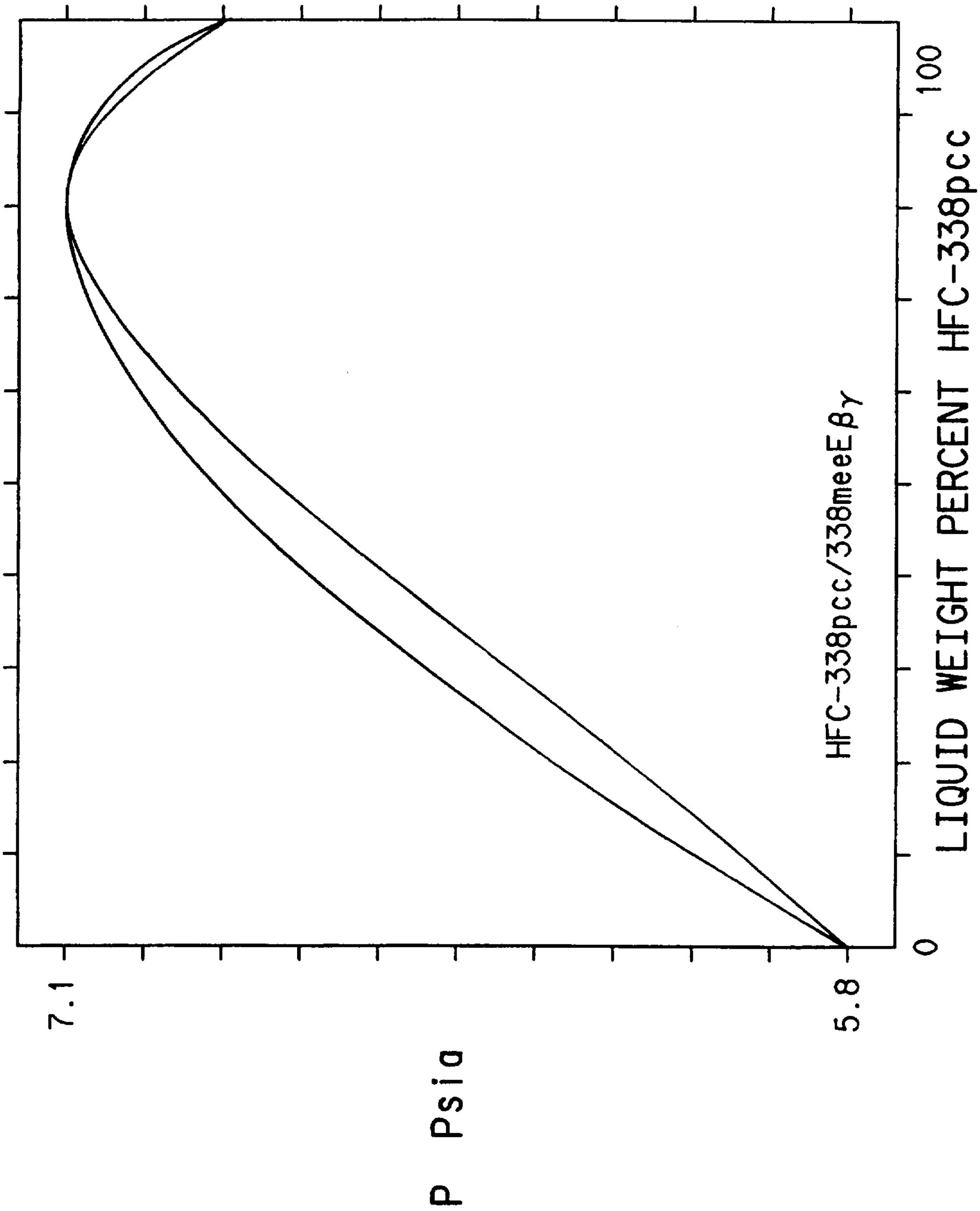

HFC-338pcc/338meeEβγ
LIQUID WEIGHT PERCENT HFC-338pcc
0
100
P Psia
7.1
5.8

FIG.12

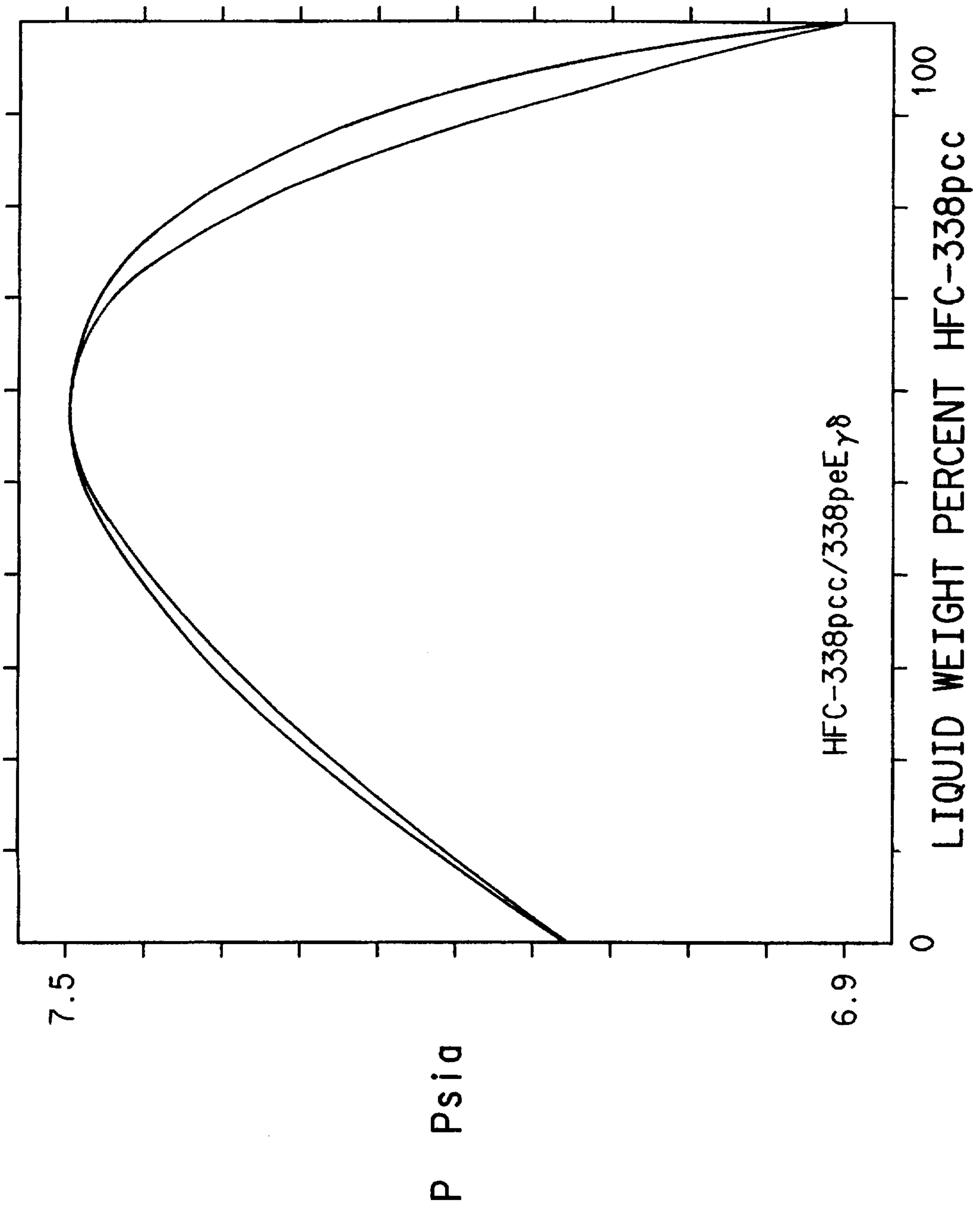

HFC-338pcc/338peEγδ
P Psia
7.5
6.9
0
100
LIQUID WEIGHT PERCENT HFC-338pcc

FIG.13

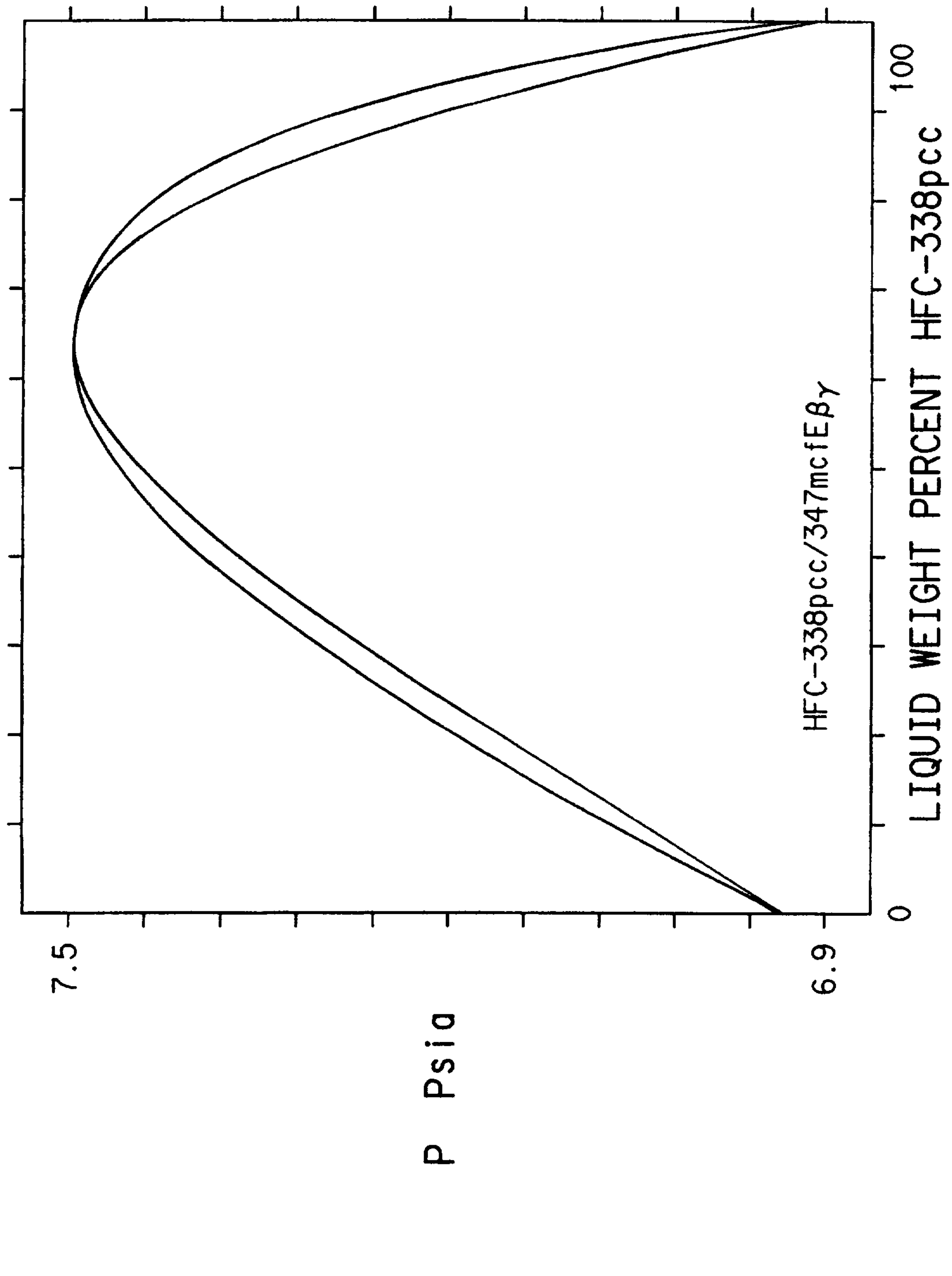

7.5
6.9
P Psia
0
100
LIQUID WEIGHT PERCENT HFC-338pcc
HFC-338pcc/347mcfEβγ

FIG. 14

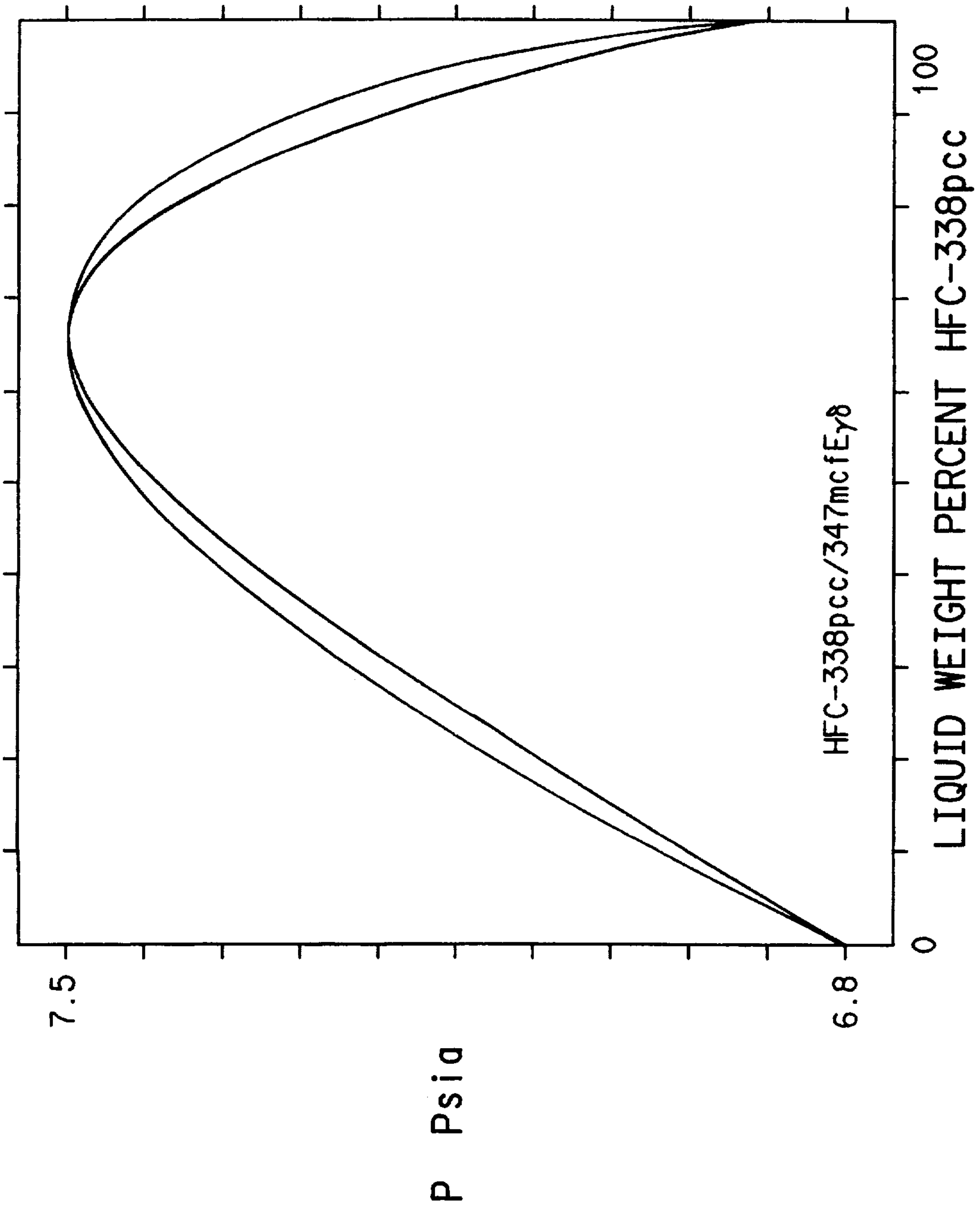

7.5
6.8
P Psia
0
100
LIQUID WEIGHT PERCENT HFC-338pcc
HFC-338pcc/347mcfEγδ

FIG.15

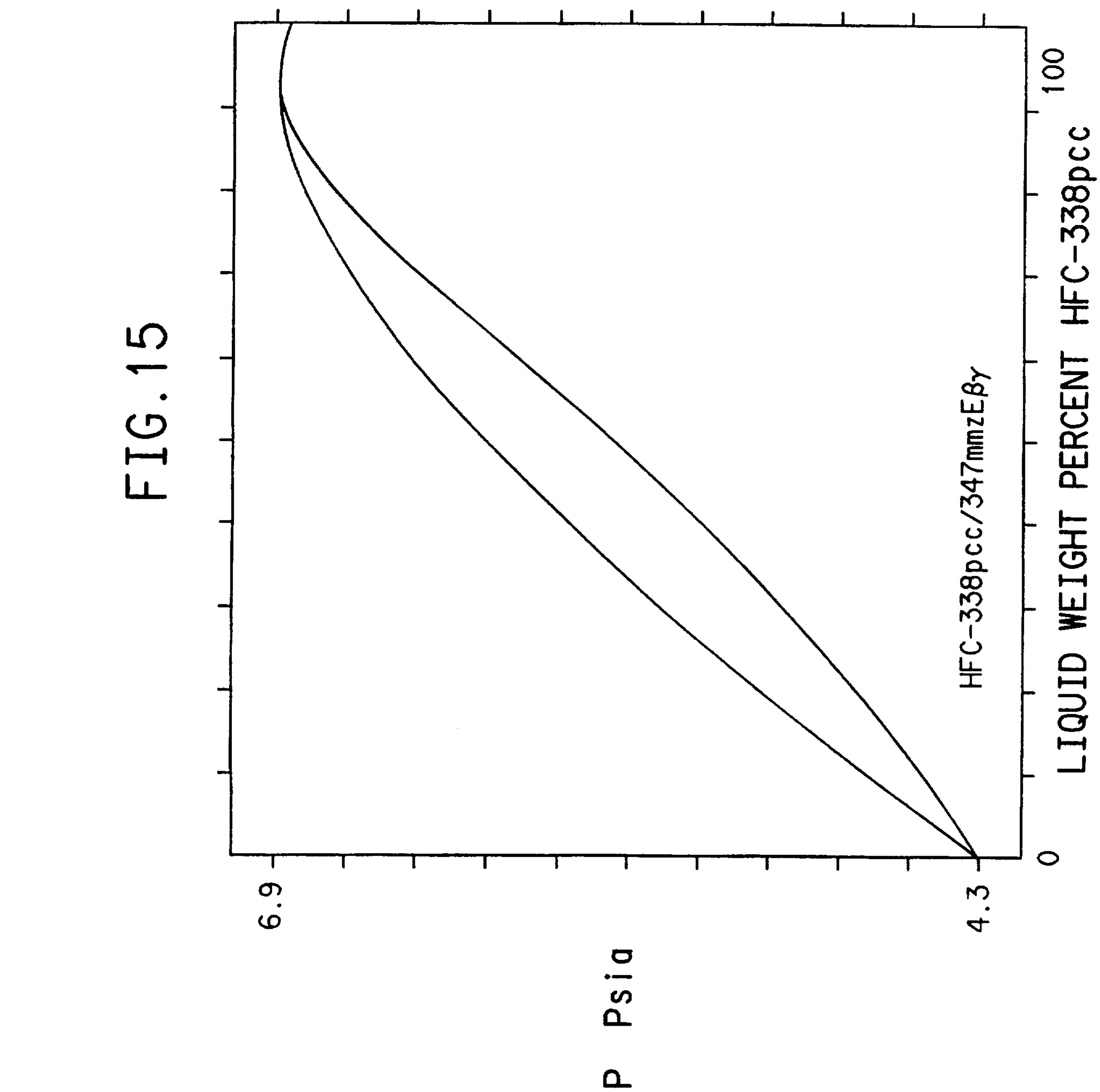

P Psia
6.9
4.3
0
100
LIQUID WEIGHT PERCENT HFC-338pcc
HFC-338pcc/347mmzEβγ

FIG.16

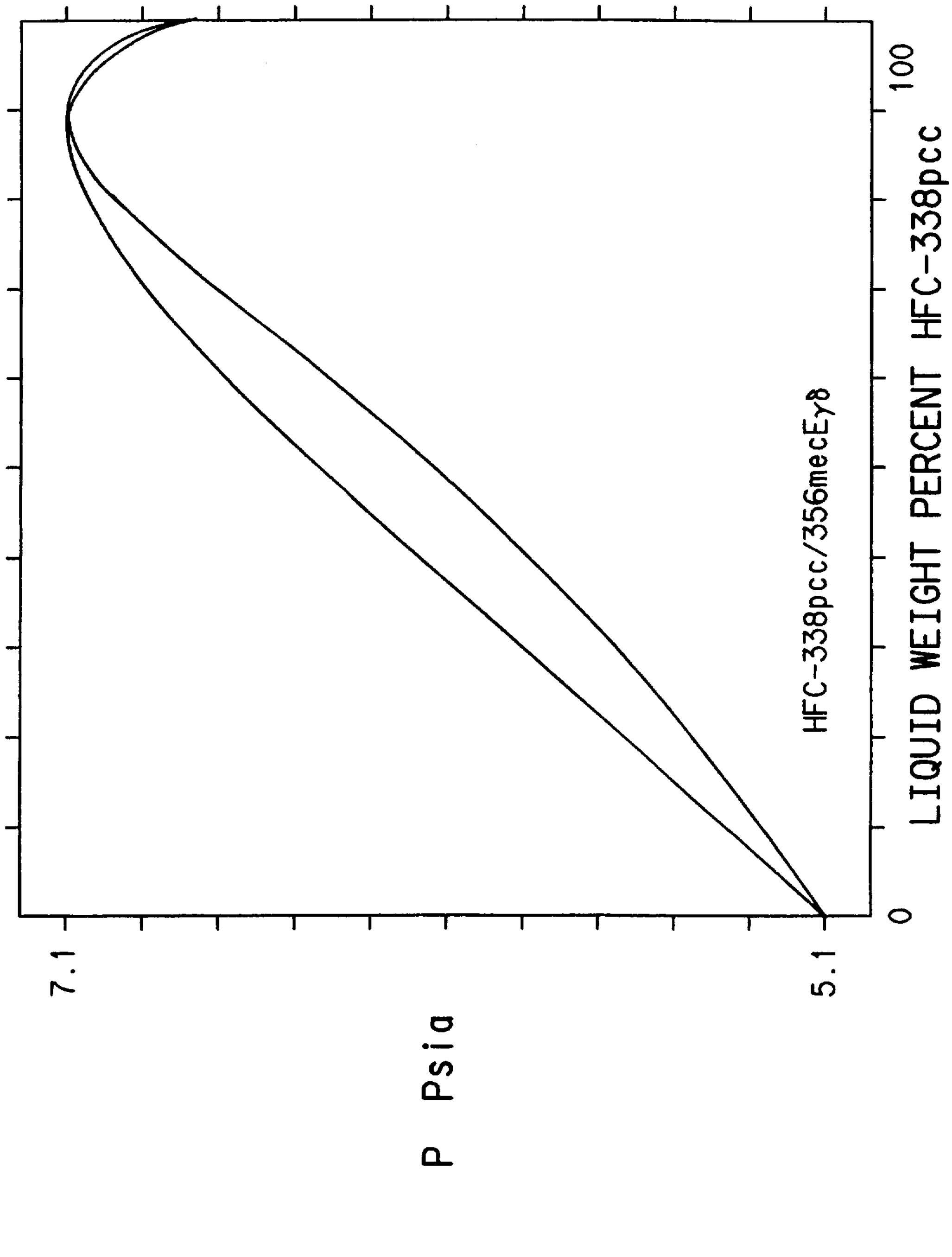

HFC-338pcc/356mecEγδ
7.1
5.1
P Psia
0
100
LIQUID WEIGHT PERCENT HFC-338pcc

FIG.17

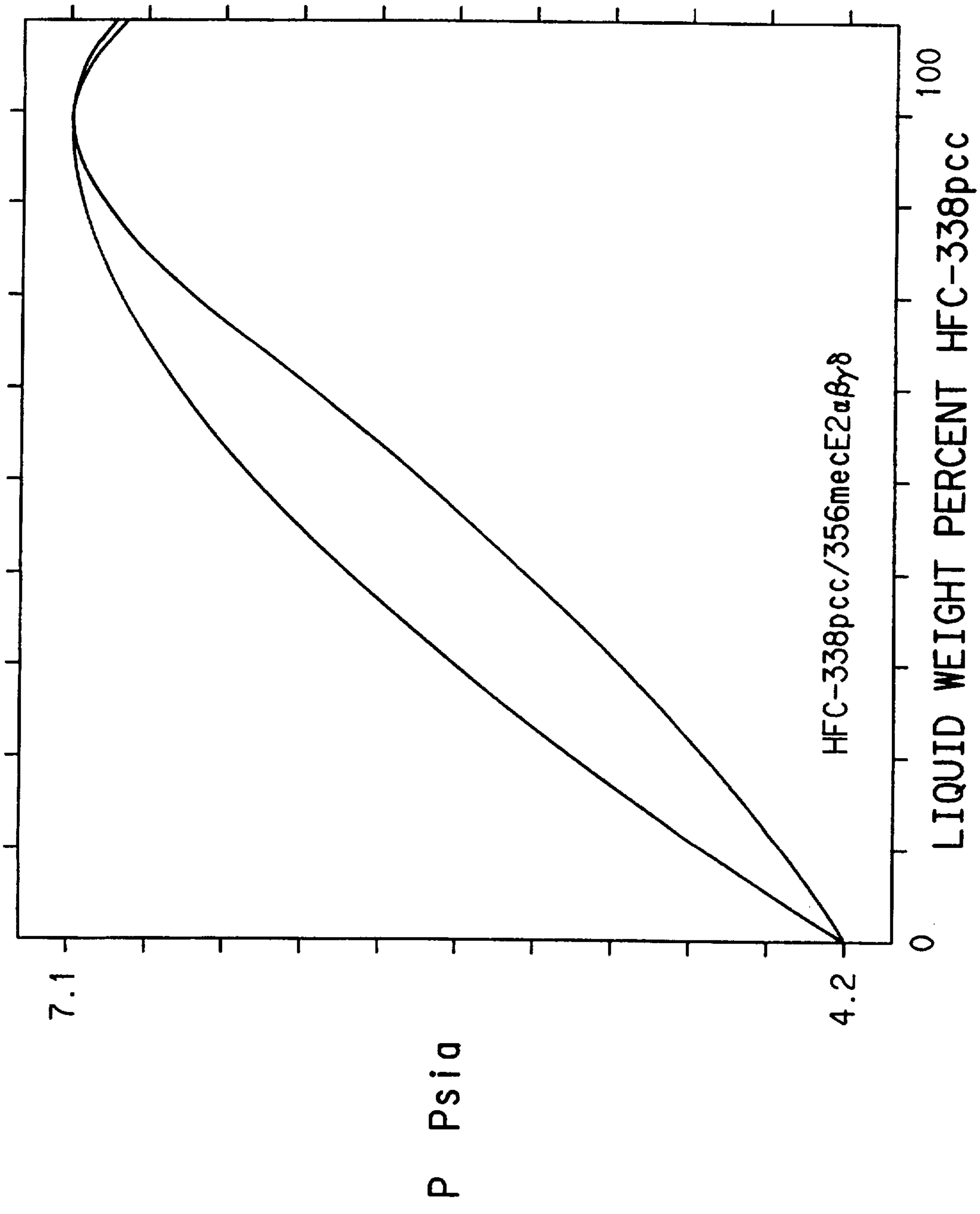

7.1
4.2
P Psia
0
100
HFC-338pcc/356mecE2αβγδ
LIQUID WEIGHT PERCENT HFC-338pcc

FIG.18

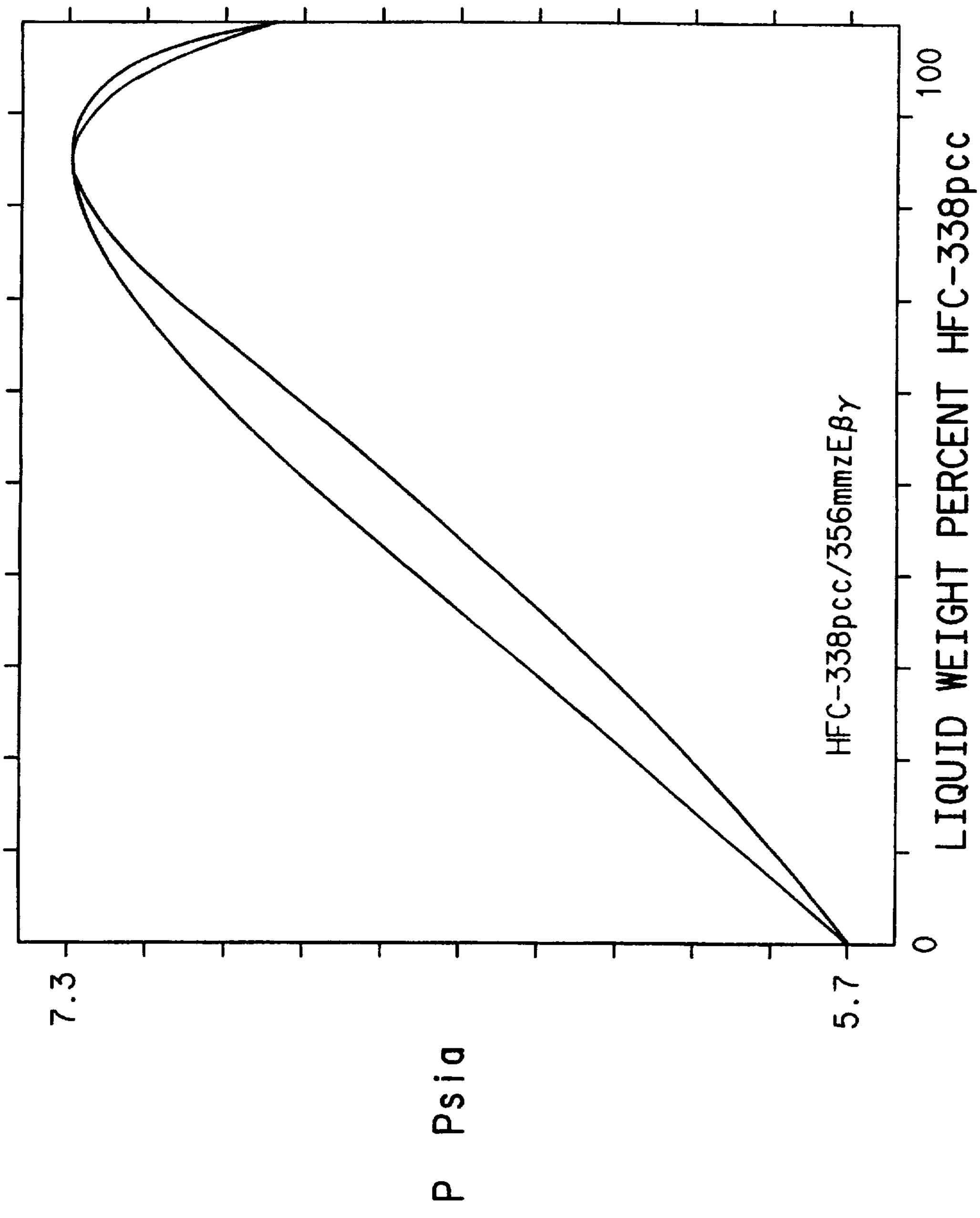

7.3
5.7
P Psia
0
100
LIQUID WEIGHT PERCENT HFC-338pcc
HFC-338pcc/356mmzEβγ

FIG.19

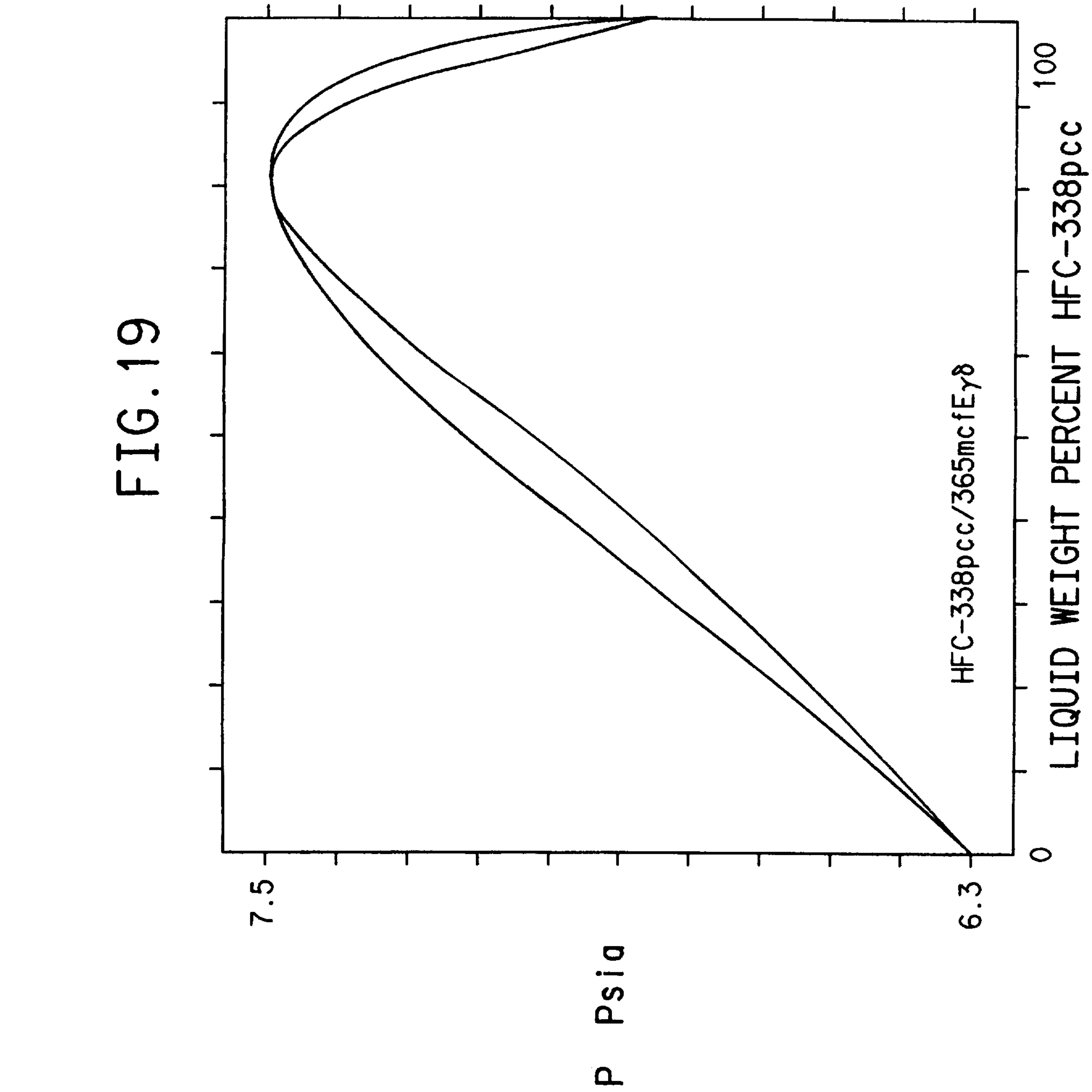

7.5
6.3
P Psia
0
100
LIQUID WEIGHT PERCENT HFC-338pcc
HFC-338pcc/365mcfEγδ

FIG.20

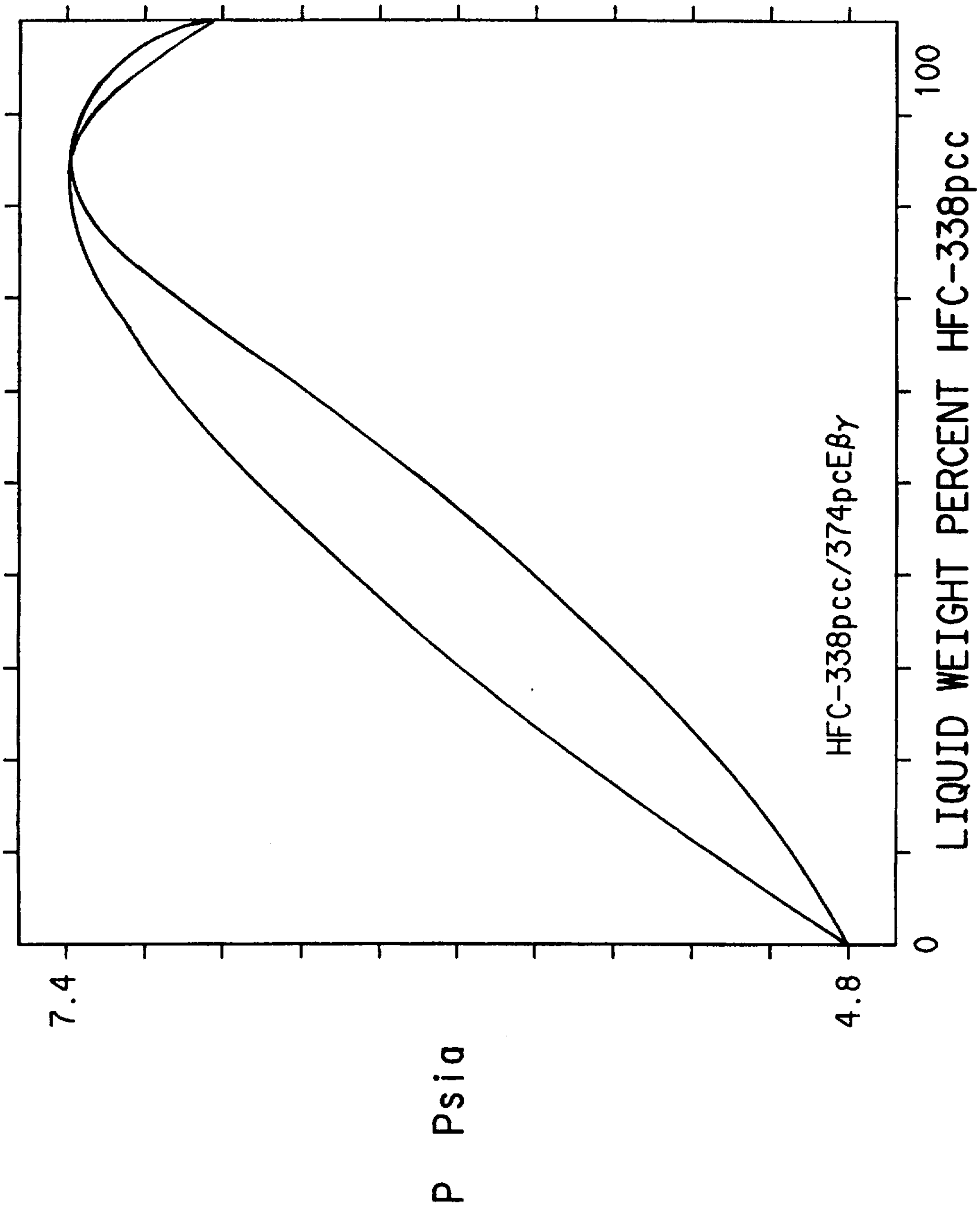

7.4
4.8
P Psia
0
100
LIQUID WEIGHT PERCENT HFC-338pcc
HFC-338pcc/374pcEβγ

FIG.21

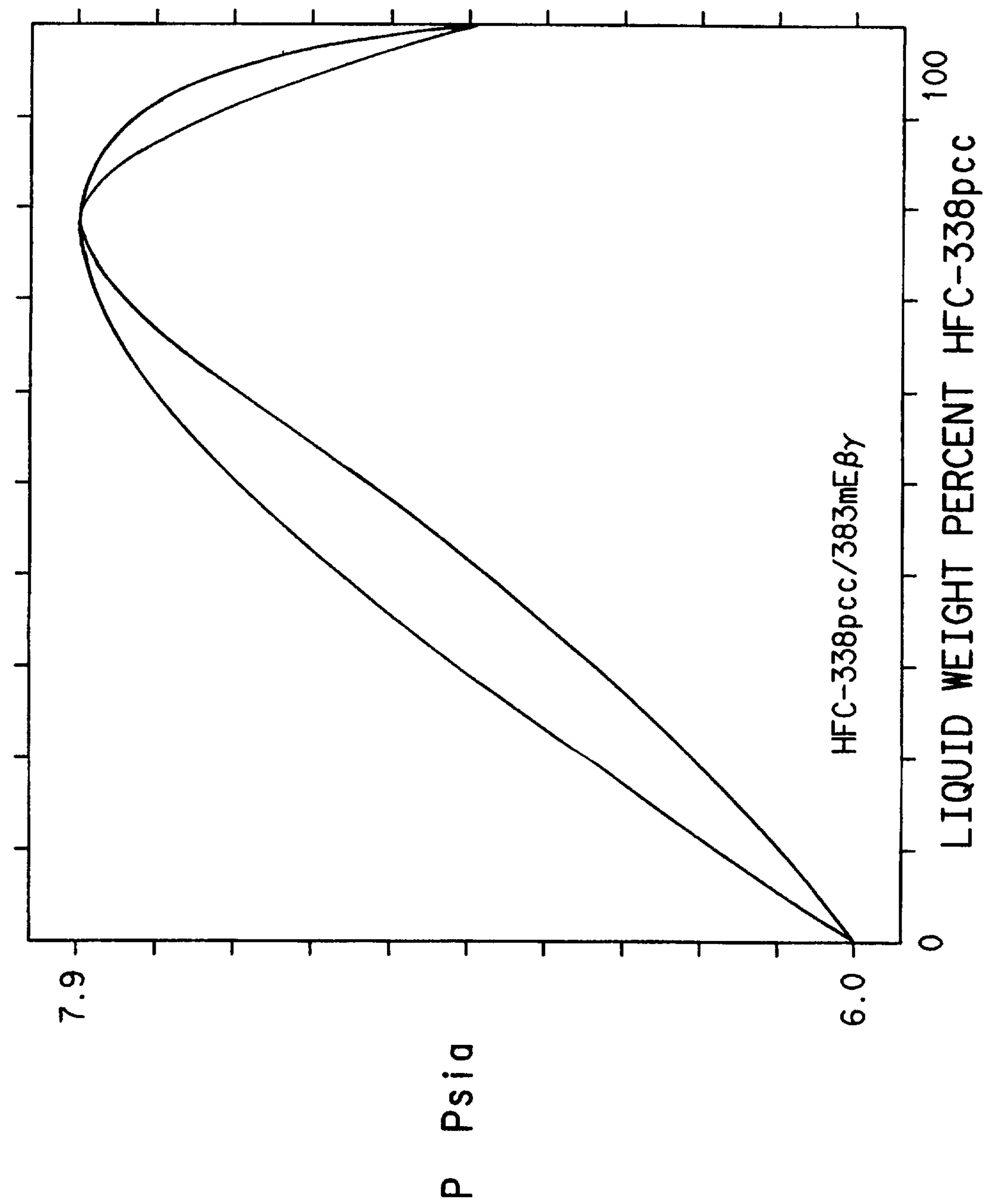

P Psia
7.9
6.0
0
100
LIQUID WEIGHT PERCENT HFC-338pcc
HFC-338pcc/383mEβγ

FIG.22

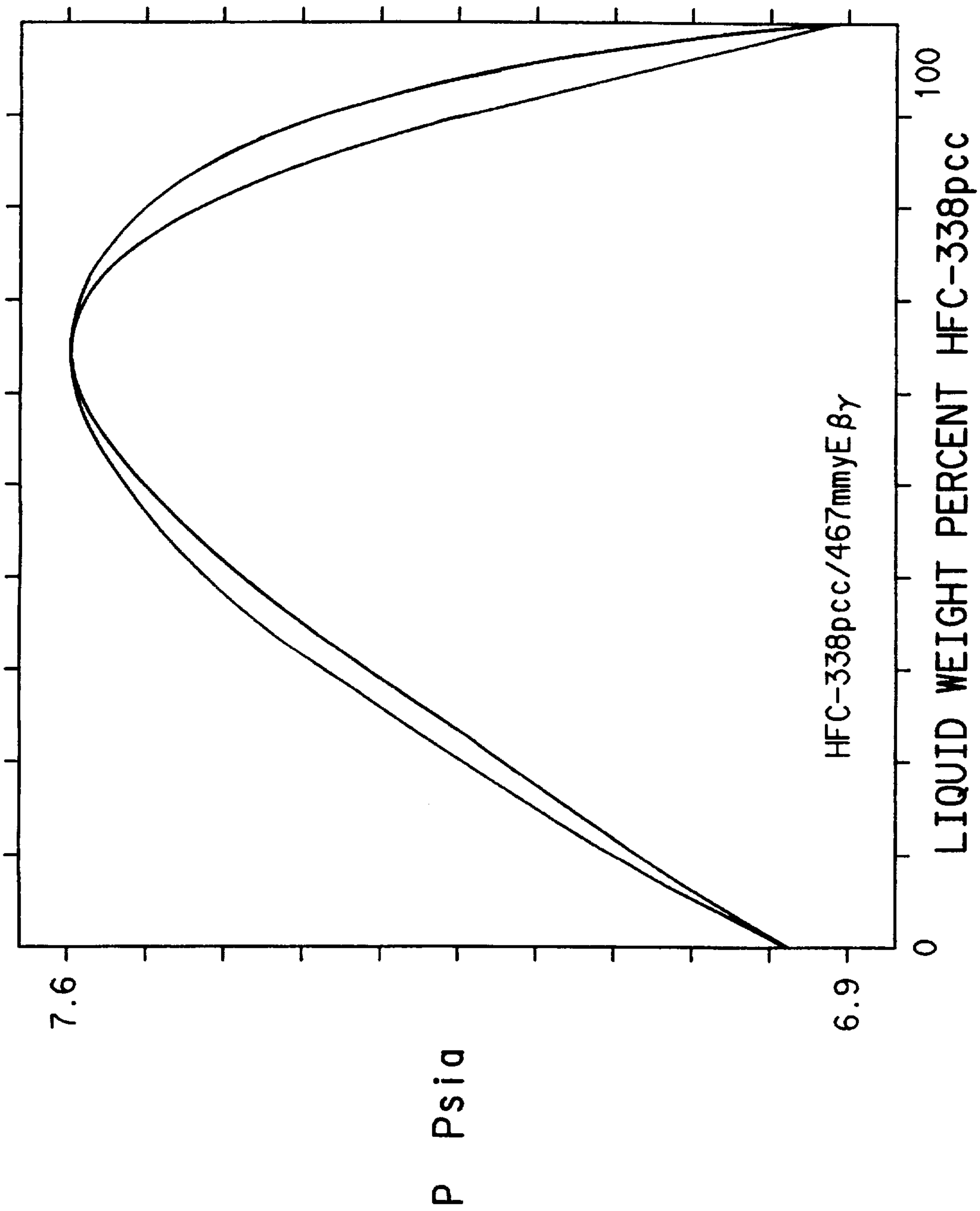
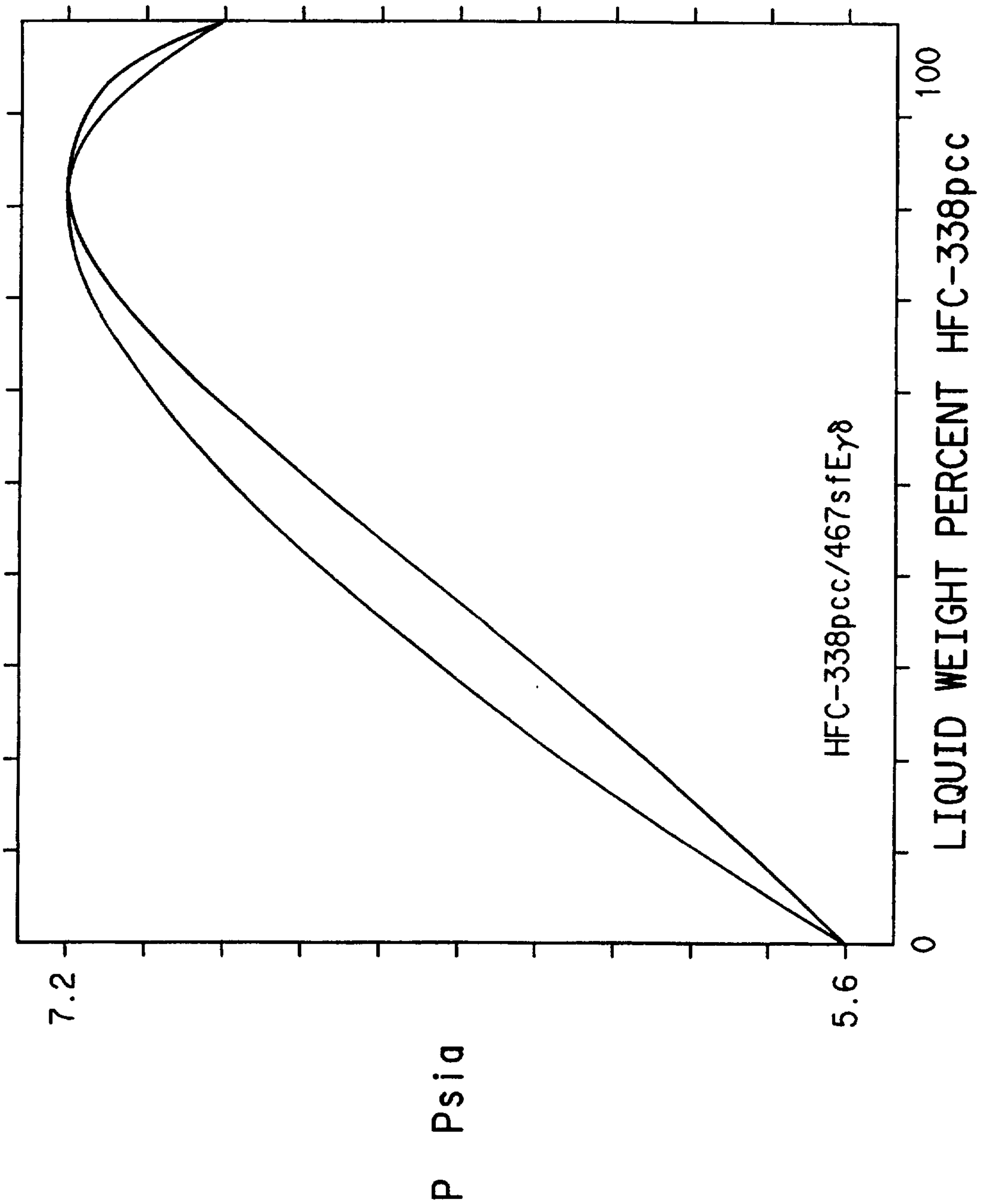

P Psia
7.6
6.9
0
100
LIQUID WEIGHT PERCENT HFC-338pcc
HFC-338pcc/467mmyEβγ

FIG.23


P Psia
7.2
5.6
0
100
LIQUID WEIGHT PERCENT HFC-338pcc
HFC-338pcc/467sfEγδ

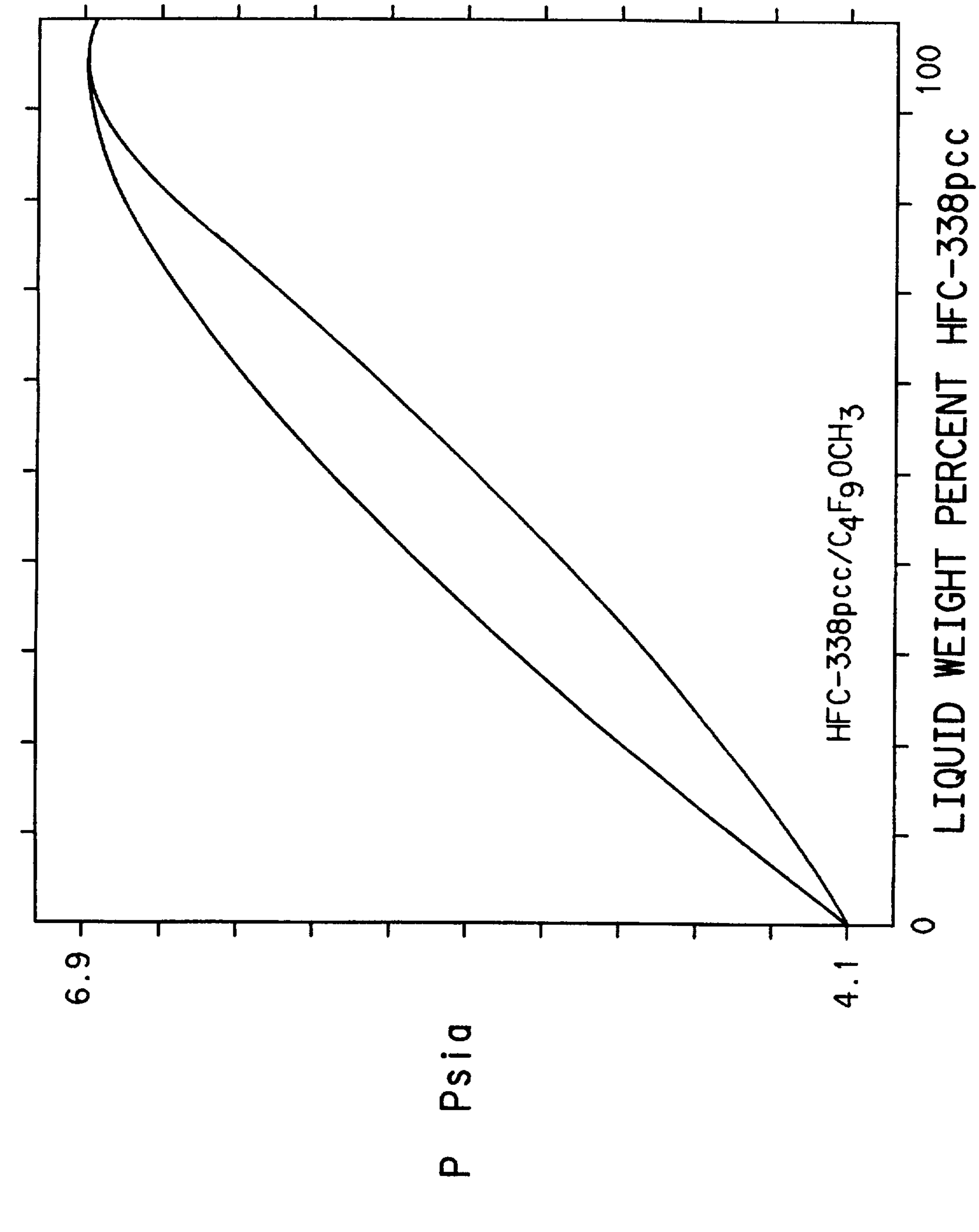

6.9
4.1
P Psia
0
100
LIQUID WEIGHT PERCENT HFC-338pcc
HFC-338pcc/C4F9OCH3

FIG.24

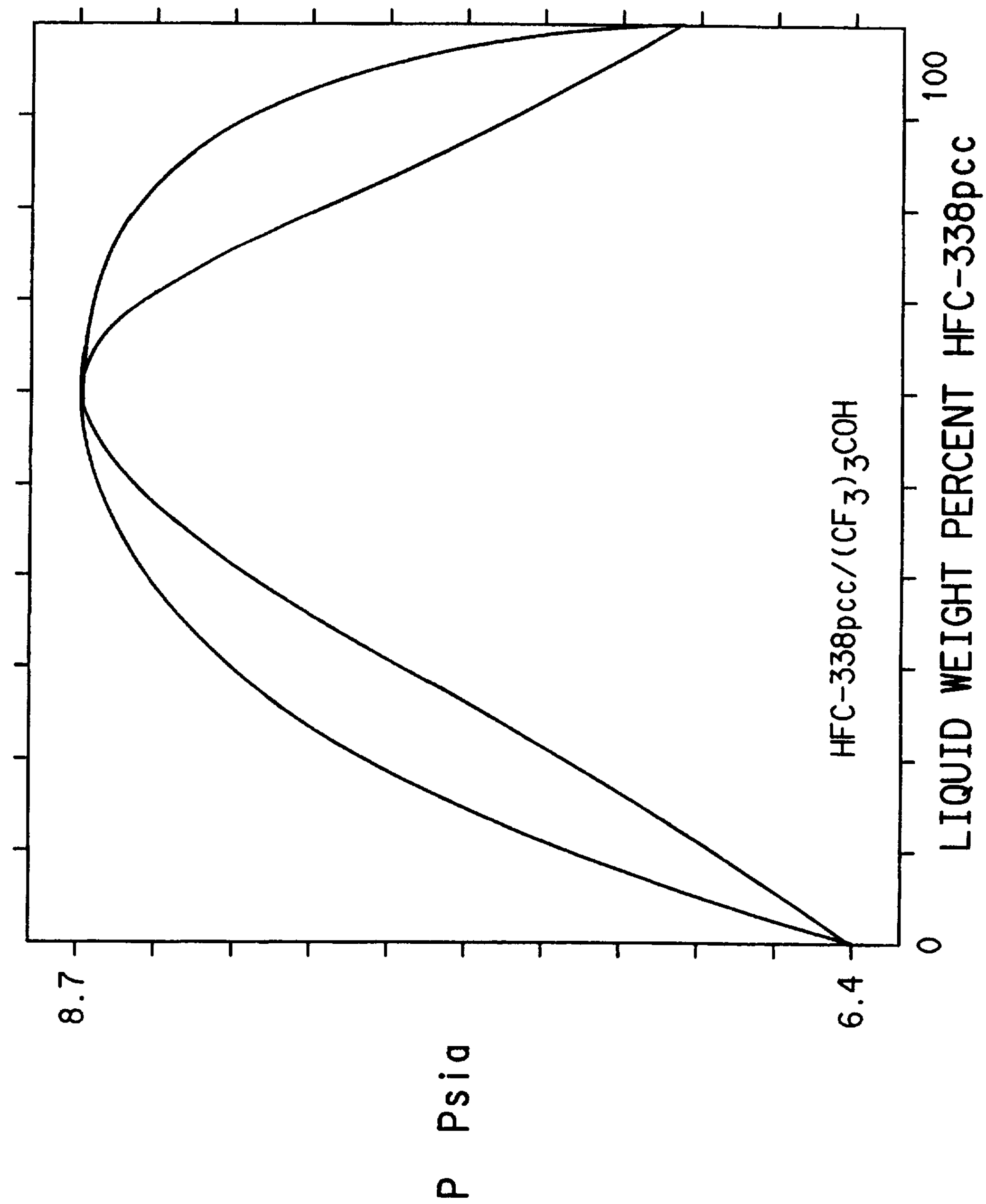

8.7
6.4
P Psia
0
100
LIQUID WEIGHT PERCENT HFC-338pcc
HFC-338pcc/$(CF_3)_3COH$

FIG.25

FIG.26

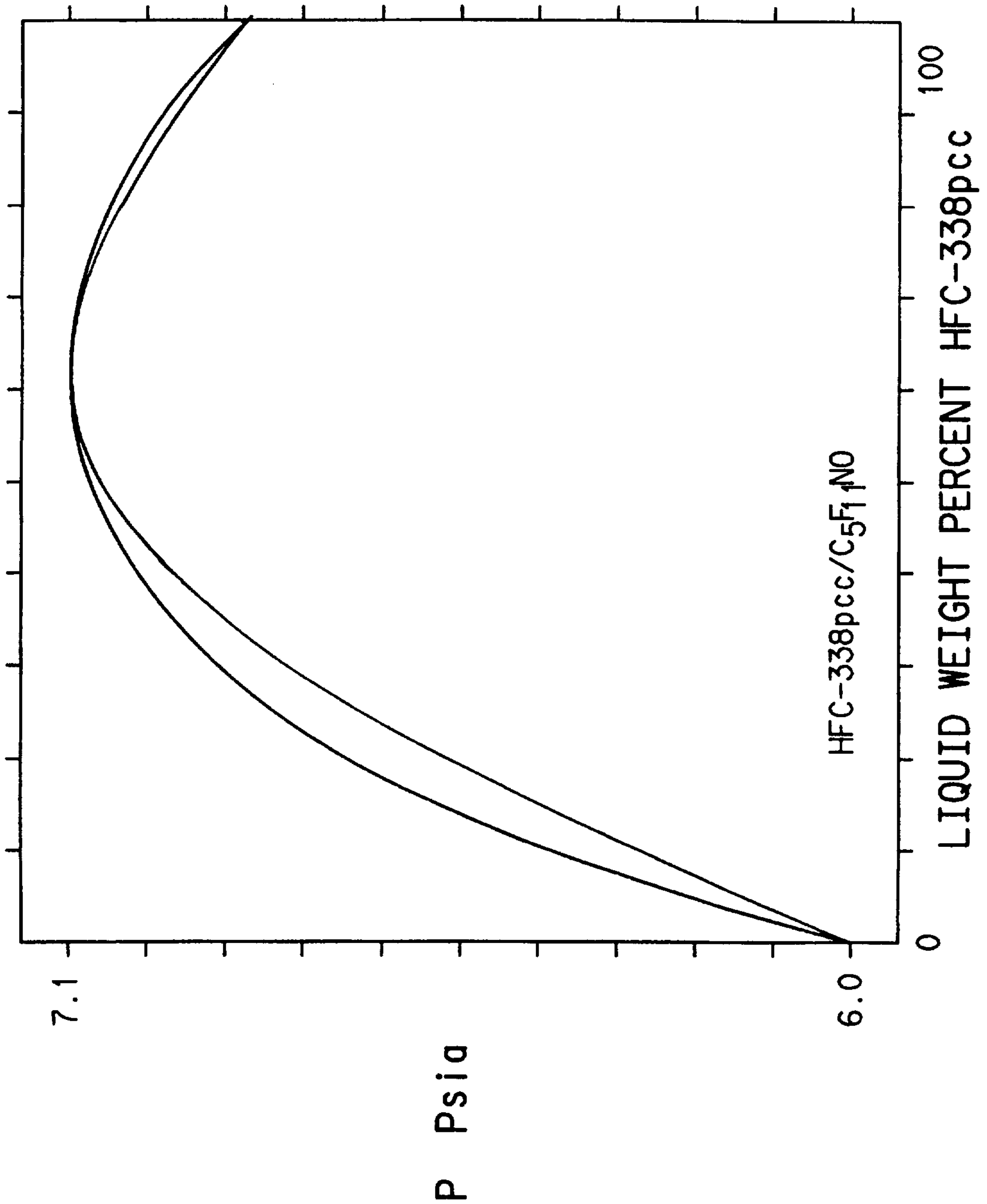

7.1
6.0
P Psia
0
100
LIQUID WEIGHT PERCENT HFC-338pcc
HFC-338pcc/C5F11NO

FIG.27

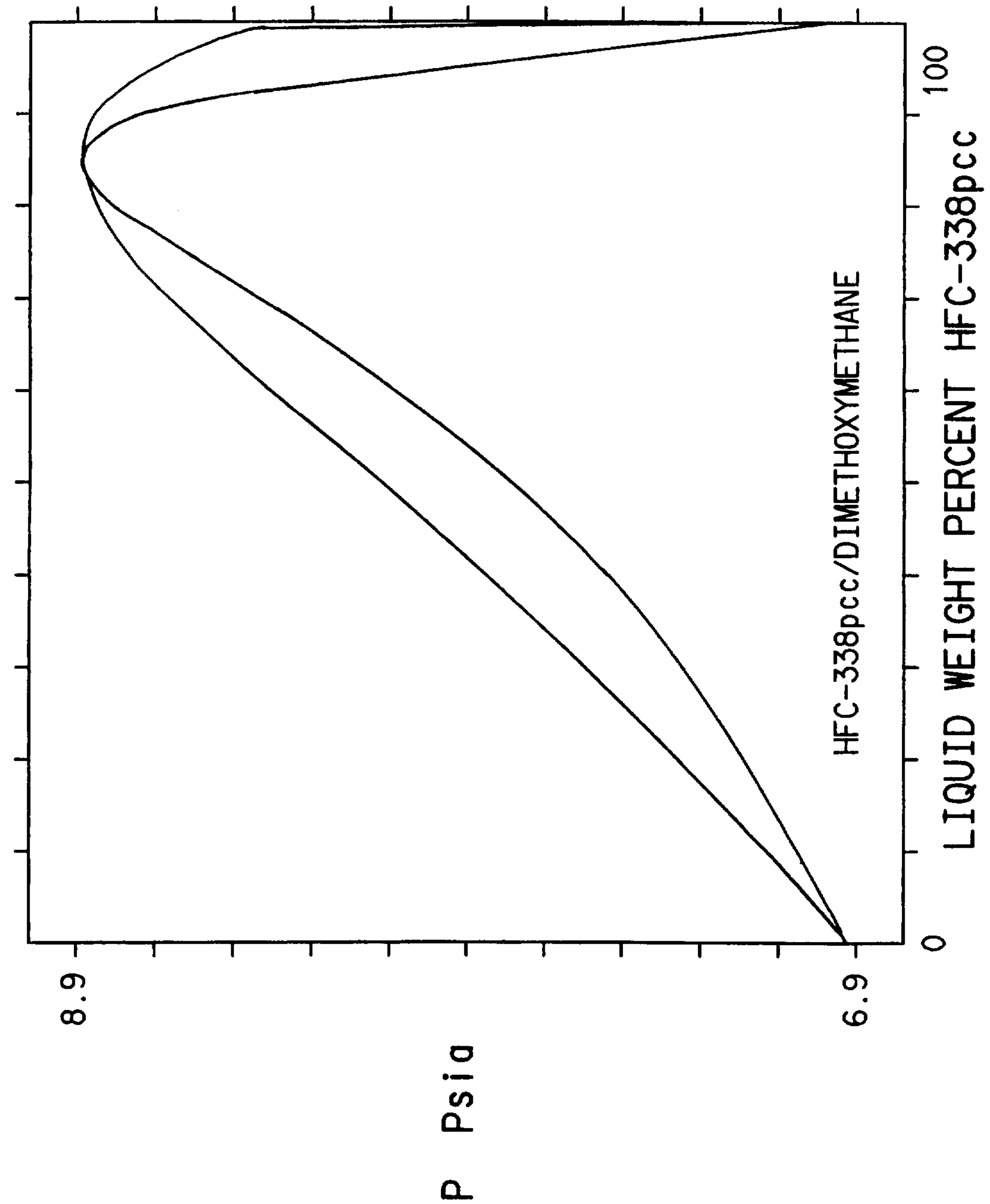

HFC-338pcc/DIMETHOXYMETHANE
8.9
6.9
P Psia
0
100
LIQUID WEIGHT PERCENT HFC-338pcc

FIG.28

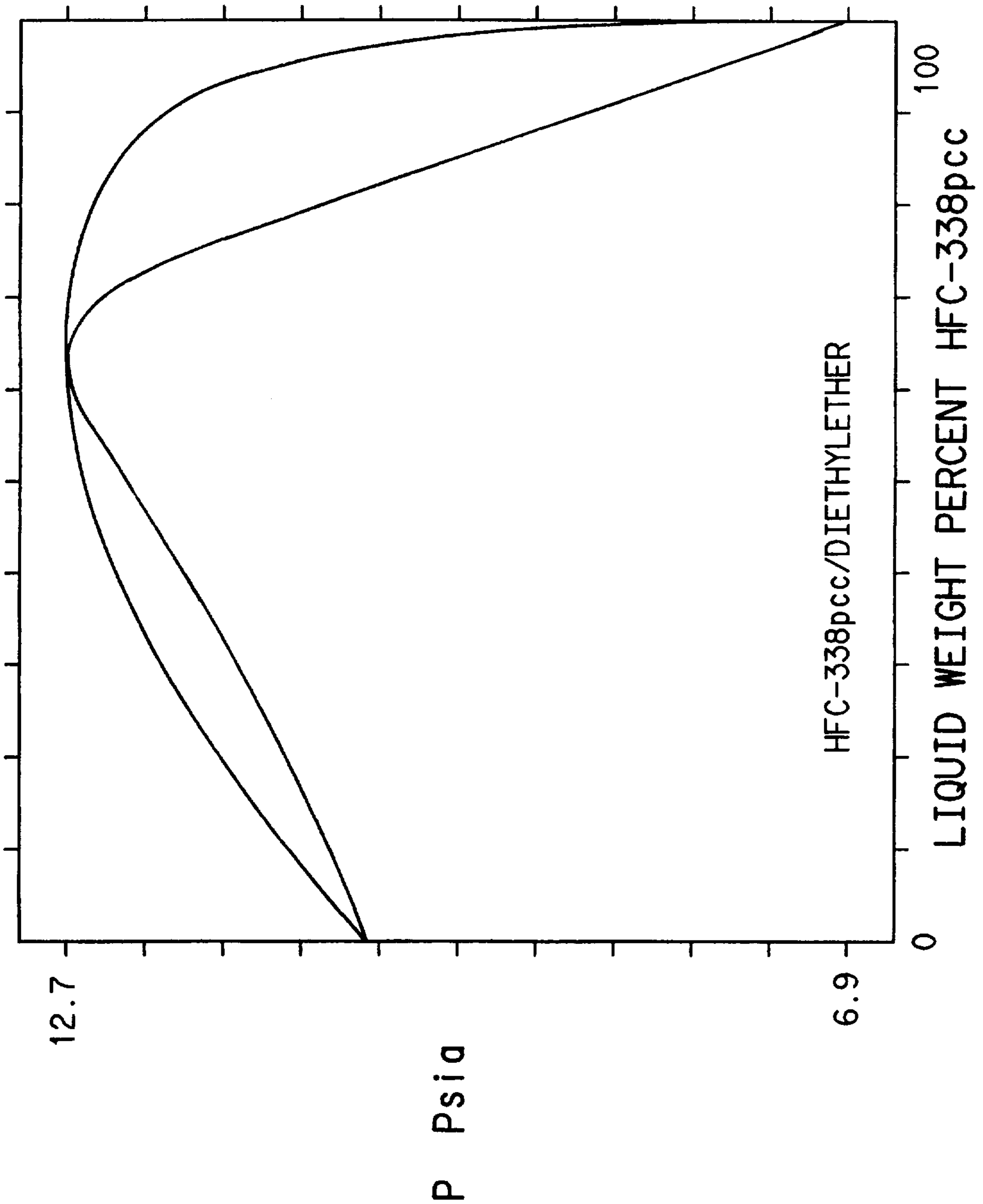

HFC-338pcc/DIETHYLETHER
LIQUID WEIGHT PERCENT HFC-338pcc
0
100
P Psia
12.7
6.9

FIG.29

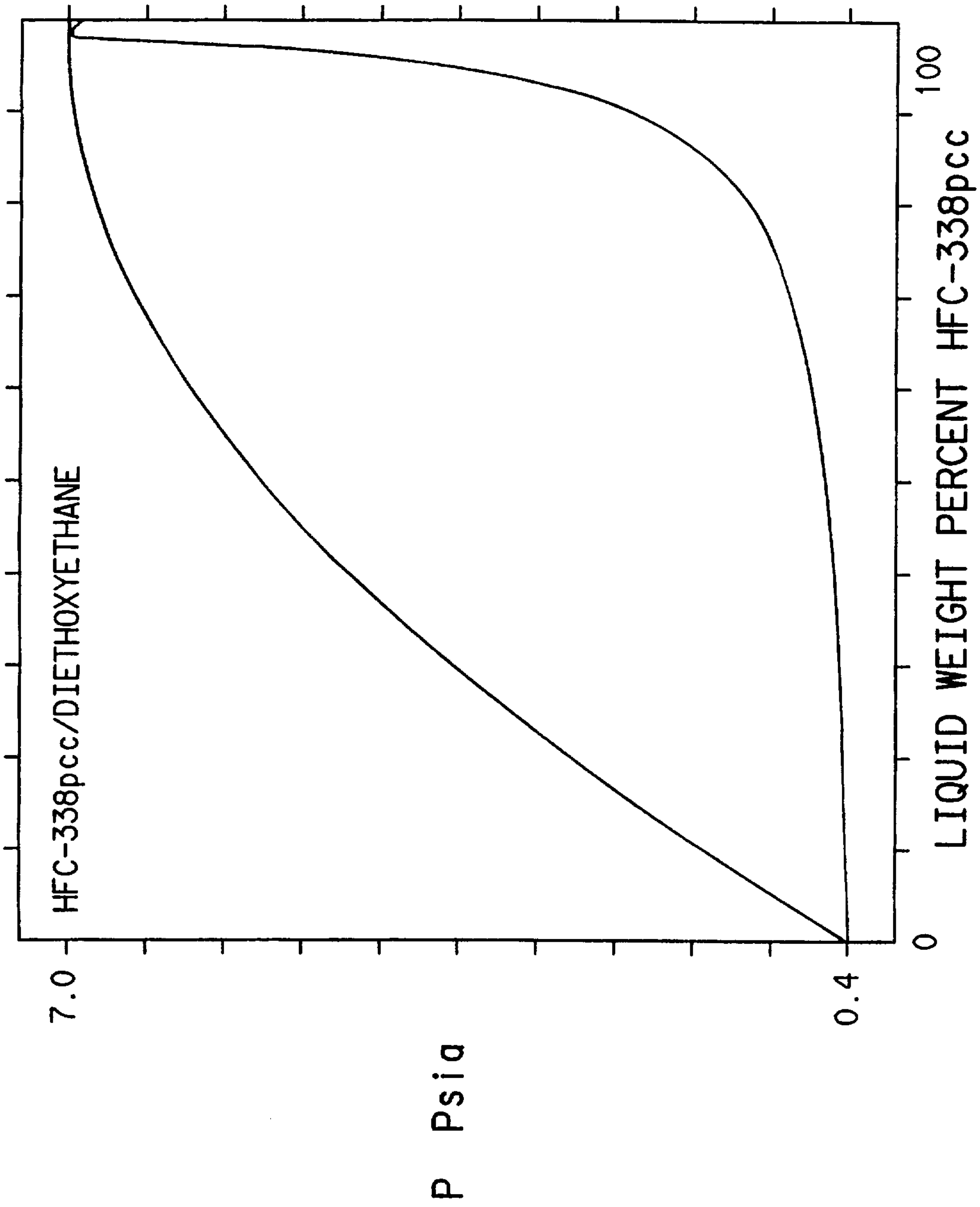
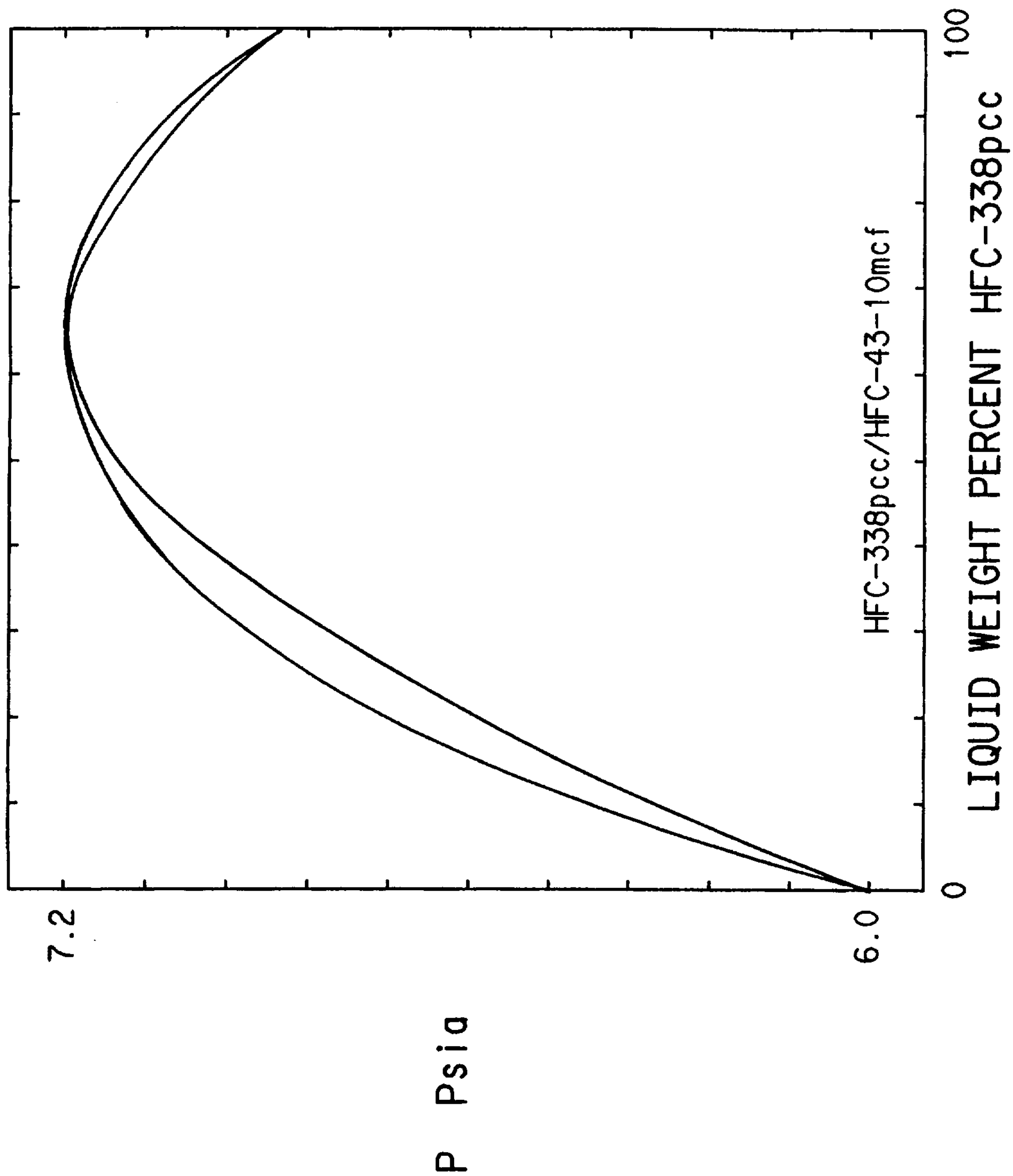

HFC-338pcc/DIETHOXYETHANE
7.0
0.4
P Psia
0
100
LIQUID WEIGHT PERCENT HFC-338pcc

FIG.30


7.2
6.0
P Psia
0
100
HFC-338pcc/HFC-43-10mcf
LIQUID WEIGHT PERCENT HFC-338pcc

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 97/06322

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 C09K5/04 C09K3/30 C08J9/14 C23G5/028 C11D7/50

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 C09K C08J C23G C11D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 96 10062 A (DU PONT) 4 April 1996 see page 1, line 11 - line 16 see page 10, line 24 see page 13, line 21 - line 25 see page 17, line 5 - line 7 see page 19, line 7 - page 20, line 23 see claims 3,6,9-13 ---	1,3,6-20
X	WO 96 10061 A (DU PONT) 4 April 1996 see page 2, line 26 - line 37 see page 4, line 8 - line 23 see page 10, line 17 see page 10, line 22 see page 11, line 41 - page 12, line 10 see page 12, line 36 - line 42 see page 16, line 10 - line 17 see page 16, line 31 - line 33 see claims --- -/--	1,6-20

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
19 August 1997	25.08.97

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 97/06322

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 96 10060 A (DU PONT) 4 April 1996 see page 2, line 28 - line 36 see page 4, line 12 - line 37 see claims; examples	1,3,6-20
X	US 5 169 873 A (BEHME KLAUS-JUERGEN ET AL) 8 December 1992 see column 2, line 22 - line 65 see example 4	3,12-14
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INTERNATIONAL SEARCH REPORT

Information on patent family members

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