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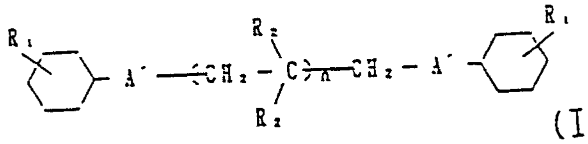
(54) TRACTION FLUID.

(57) A traction fluid which is prepared by compounding 0.1 to 70 wt % of branched poly-α-olefin in a diester compound represented by general formula (I)



(I)

(wherein A′ represents an ester bond of –COO– or –OOC–, n is 1 to 6, R_1 represents one or two members selected from among a hydrogen atom and C_{1-8} alkyl groups, and R_2 represents one or two members selected from among C_{1-3} alkyl groups) is disclosed. This traction fluid is used with a power transmission, particularly a traction drive unit.

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SPECIFICATION

Traction Fluid

FIELD OF THE INVENTION

This invention relates to a traction fluid. More particularly, the present invention is concerned with a traction fluid obtained by compounding a diester or its derivative having two cyclohexyl rings with a branched poly-α-olefin as the base oil.

BACKGROUND OF THE INVENTION

In the field of automobiles and industrial machinery, traction drive power transmissions, which transmit power to a driven part through a traction drive mechanism, have recently attracted attention, and research and development has recently been proceeding. A traction drive mechanism is a power transmitting mechanism using a rolling friction. Unlike conventional drive mechanisms it does not use any gears. This results in reduced vibrations and noise, as well as a very smooth speed change in high-speed rotation. An important goal in the automobile industry is improvement in the fuel consumption of automobiles. It has been suggested that if the traction drive were to be applied to the automobile transmission to convert the transmission to the continuous variable-speed transmission, fuel consumption could be reduced by at least 20% over conventional transmission systems, since the drive can always be in the optimum speed ratio. Recent studies have resulted in the development of materials having high fatigue resistance as well as resulted in a theoretical analysis of traction mechanisms. As regards the traction fluid, the correlation of traction coefficients is gradually being understood at the molecular structure level of the components. The term "traction coefficient" as used herein is defined as the ratio of the tractional force which is caused by slipping, at the contact points, between rotators that contact each other in the power transmission of the rolling friction type to the normal load.

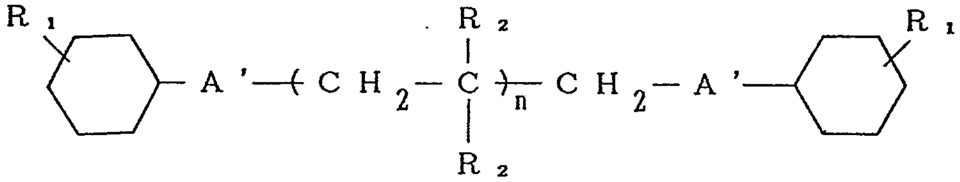
The traction fluid should be a lubricating oil having a high traction coefficient. It has been confirmed in this connection that a traction fluid possessing a molecular structure having a naphthene ring exhibits high performance. "Santotrack®," manufactured by the Monsanto Chemical Company, is widely known as a commercially available traction fluid. Japanese Patent Publication No. 47-35763 discloses di(cyclohexyl)alkane and dicyclohexane as traction fluids having a naphthene ring. This patent publication discloses that a fluid obtained by incorporating the above-mentioned alkane compound in a perhydrogenated (α-methyl)styrene polymer, hydrindane compound, or the like, has a high traction coefficient. Further, Japanese Patent Laid-Open No. 59-191797 discloses a traction fluid containing an ester compound having a naphthene ring. It discloses that an ester obtained by the hydrogenation of the aromatic nucleus of dicyclohexyl cyclohexyldicarboxylate or dicyclohexyl phthalate is preferred as the traction fluid.

As mentioned above, in recent years in the automobile industry there has been progress in the development of continuous variable-speed transmissions. The higher the traction coefficient of the lubricating fluid the larger the permissible transmission force in the same device. This allows a reduction in size of the entire device with a concomitant reduction in those exhaust gases that pollute. Therefore, there is a demand for a fluid having a traction coefficient as high as possible. However, even the use of Santotrack®, which is the traction fluid having the highest performance of all the currently commercially available fluids, in such a traction drive device, provides unsatisfactory performance with respect to the traction coefficient, and it has a problem is that it is also expensive. The traction fluid which has been proposed in Japanese Patent Publication No. 46-35763 contains Santotrack® or its analogue as a component and, therefore, is also unsatisfactory with respect to its performance and cost.

DISCLOSURE OF THE INVENTION

The present inventors have made extensive studies with a view to developing a traction fluid which not only exhibits a high traction coefficient but is also relatively inexpensive. As a result, the inventors have found that the addition of a specific amount of a branched poly-α-olefin to a diester or its derivative having two cyclohexyl rings can provide a high-performance base oil fluid , that is economic, and they have accomplished the present invention.

The present invention relates to a traction fluid characterized by compounding 0.1 to 70% by weight of a branched poly-α-olefin with a diester represented by the following general formula:



wherein A' is an ester linkage of -COO- or -OOC-, n is an integer of 1 to 6, R_1 is one or two members selected from a hydrogen atom and alkyl groups having 1 to 8 carbon atoms, and R_2 is one or two members selected from alkyl groups having 1 to 3 carbon atoms, or its derivative.

A first object of the present invention is to provide a high-performance traction fluid having a high traction coefficient. A second object of the present invention is to provide a traction fluid which is not only economical but is also readily available and easily applicable to devices.

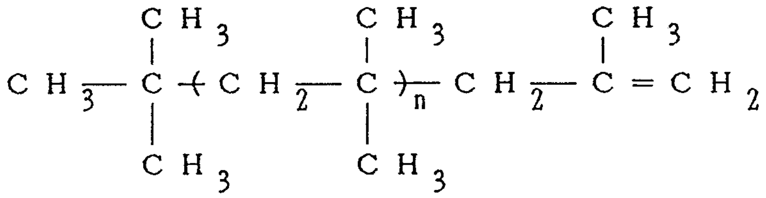
The traction fluid of the present invention comprises a base oil comprised of two components, i.e., it is obtained by compounding a specific amount of a branched poly-α-olefin as component B with a diester or its derivative as component A.

In the present invention component A is a diester or its derivative having two cyclohexyl rings and is represented by the above-mentioned structural formula. A ' of the ester linkage is -COO- or -OOC-, and the number, n, of the repeating units of the gem-dialkyl structure is 1 to 6, preferably 1 to 3. When n is zero the traction coefficient is unfavorably low, while when n is 7 or more the viscosity is unfavorably high. This diester or derivative thereof preferably has a viscosity of 20 to 50 cst, preferably 24 to 30 cst at 40°C, and 4 to 10 cst, preferably 4 to 6 cst at 100°C. Further, the viscosity index is preferably in the range of 40 to 100, particularly preferably in the range of 50 to 80.

The component A can be prepared by the following method. Specifically, the component A can be obtained by the esterification reaction of a glycol compound with a cyclohexanecarboxylic acid compound. The glycol compound to be used has 1 to 6 gem-dialkyl structural units. A preferred glycol compound is neopentyl glycol. Examples of the cyclohexanecarboxylic acid compound include, besides cyclohexanecarboxylic acid, those having an alkyl group with 1 to 8 carbon atoms, e.g., methylcyclohexanecarboxylic acid, ethylcyclohexanecarboxylic acid, etc. Cyclohexanecarboxylic acid is particularly preferred. The esterification reaction is conducted using substantially stoichiometric amounts of the reactants or in the presence of an excess amount of the acid. The former method requires the use of a catalyst and, further, has a problem in that a monoalcohol is produced as the by-product. Therefore, it is preferred that the esterification reaction be conducted in the presence of an excess amount of the acid. Specifically, 1 mol of the glycol compound is reacted with the acid in 2 to 5-fold by mol excess (particularly preferably in 2.5 to 4-fold by mol excess. The reaction temperature is about 150 to 250°C, preferably 170 to 230°C, and the reaction time is 10 to 40 hrs, preferably 15 to 25 hrs. Although the esterification reaction may be conducted under either elevated or reduced pressures, it is preferred that the reaction be conducted at atmospheric pressure from the standpoint of ease of reaction operation. Under this condition, the excess acid serves as a catalyst. An alkylbenzene such as xylene or toluene can be added in a suitable amount as a solvent. The addition of the solvent enables the reaction and the temperature to be easily controlled. As the reaction proceeds water formed during the reaction evaporates. The reaction is terminated when the amount of water reaches twice by mol that of the alcohol. The excess acid is neutralized with an aqueous alkaline solution and removed by washing with water. When an acid which is difficult to extract with an alkali washing is used the reaction is conducted using the acid in an amount of 2 to 2.5-fold mol excess over the alcohol in the presence of a catalyst. As the catalyst, phosphoric acid, p-toluenesulfonic acid, sulfuric acid, etc., can be used. The most preferred catalyst is phosphoric acid, because it enhances the reaction rate and increases the yield of the ester. The reaction product is finally distilled under reduced pressure to remove water and the solvent, and thereby the diester compound of the present invention is obtained.

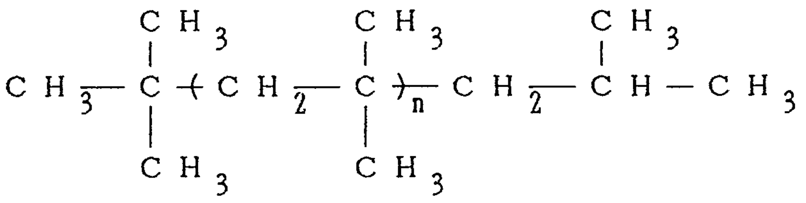
The component A of the present invention can also be prepared by the esterification reaction of a cyclohexanol compound with a dicarboxylic acid having a quaternary carbon atom. In this case, cyclohexanol, methylcyclohexanol, or the like, is used as the cyclohexanol compound, while neopenthyldicarboxylic acid or the like is used as the dicarboxylic acid.

The poly-α-olefin component B has a quaternary carbon atom or a tertiary carbon atom in its main chain and is a polymer of an α-olefin having 3 to 5 carbon atoms or the hydrogenation product thereof. Examples of the poly-α-olefins include polypropylene, polybutene, polyisobutylene, polypentene and the hydrogenation products thereof. Particularly preferred are polybutene and polyisobutylene and the hydrogenation products thereof. The polyisobutylene is represented by the following structural formula:



$$CH_3-\overset{CH_3}{\underset{CH_3}{C}}\left(CH_2-\overset{CH_3}{\underset{CH_3}{C}}\right)_n CH_2-\overset{CH_3}{C}=CH_2$$

The hydrogenation product of the polyisobutylene is represented by the following structural formula:



$$CH_3-\overset{CH_3}{\underset{CH_3}{C}}\left(CH_2-\overset{CH_3}{\underset{CH_3}{C}}\right)_n CH_2-\overset{CH_3}{C}H-CH_3$$

In the above-mentioned formula the degree of polymerization, n, is 6 to 200.

Although the polybutene and polyisobutylene are generally commercially available, they may be produced by conventional polymerization methods. The hydrogenation product thereof is produced by reacting polyisobutylene or the like in the presence of hydrogen. The molecular weight of the poly-α-olefin is preferably in the range of 500 to 10,000, more preferably in the range of 900 to 5,000. The molecular weight can be adjusted by suitable methods such as decomposition of a poly-α-olefin having a high molecular weight and mixing of poly-α-olefins having low molecular weights. Although an α-olefin copolymer (OCP) is a type of a poly-α-olefin, it is unsuited for use as component B in the present invention. This is because OCP is obtained by polymerization of two or more α-olefins and has such a structure wherein these α-olefins are irregularly linked, as opposed to the polybutene, etc. of the present invention, which has a regular gem-dialkyl structure.

Component A of the present invention, e.g., neopentyl glycol cyclohexanecarboxylic acid diester, exhibits a traction coefficient of 0.100 to 0.104, while component B, e.g., polybutene, exhibits a traction coefficient of 0.075 to 0.085.

Since component A of the present invention exhibits a high traction coefficient, its use alone in a traction drive device results in a high performance. However, a more improved traction fluid can be obtained by blending component A with 0.1 to 70% by weight of poly-α-olefin of component B. Specifically, although component B has a lower traction coefficient than component A, the gem-dimethyl group in component B cooperates with the cyclohexyl ring in component A to exhibit a synergistic effect to show an improvement in the traction coefficient. Further, since component B is inexpensive and exhibits excellent viscosity characteristics, a traction fluid can be economically obtained by blending component A with 0.1 to 70% by weight of component B, without lowering the traction coefficient.

Various additives may also be added to the traction fluid of the present invention depending upon their applications. Specifically, when the traction device undergoes a high temperature and a large load at least one additive selected from among an antioxidant, a wear inhibitor, and a corrosion inhibitor, may be added in an amount of 0.01 to 5% by weight. Similarly, when a high viscosity index is required a known viscosity index improver is added in an amount of 1 to 10% by weight. However, since the use of polymethacrylate and olefin copolymer unfavorably lowers the traction coefficient, it is preferred that, if they are present, they be used in an amount of 4% by weight or less.

The term "traction fluid" as used in the present invention is intended to mean a fluid for use in devices which transmit a rotational torque through point contact or line contact, or for use in transmissions having a similar structure. The traction fluid of the present invention exhibits a traction coefficient higher than those of conventionally known fluids, i.e., exhibits a traction coefficient 1 to 5% higher than those of the conventional fluids, although the value varies depending on its properties such as the viscosity. Therefore, the traction fluid of the present invention can be preferably used for large power traction drive devices such as industrial machines, etc., as well as relatively low power drive transmissions including internal combustion engines of small passenger cars, spinning machines, and food-producing machines.

The traction fluid of the present invention exhibits remarkably superior traction coefficient relative to conventional fluids. The reason why the traction fluid of the present invention exhibits a high traction coefficient is not yet fully understood. However, the reason is believed to basically reside in the unique molecular structure of the traction fluid of the present invention.

The traction fluid of the present invention comprises a diester. The diester has two cyclohexyl rings in its molecule, and they are bonded to each other through two ester linkages. The two ester linkages bring about an interdipolar force between the molecules. It is believed that the interdipolar force serves to bring the fluid into a stable glassy state under high load conditions, thereby increasing the shearing force. Further, the traction fluid of the present invention has a quaternary carbon atom of the gem-dialkyl type which is bonded to the two cyclohexyl rings through a methoxycarbonyl linkage. This suppresses internal rotation. Therefore, when the traction device is under high load conditions the cyclohexyl rings are firmly engaged, like gears, with the gem-dialkyl portion of the quaternary carbon atom, while when the device is released from the load this engagement is quickly detached, thereby causing fluidization.

BEST MODES TO EMPLOY THE INVENTION

EXAMPLES 1-11

The diester of neopentyl glycol cyclohexane carboxylic acid compound of the present invention was synthesized by the following method:

First, 1 mol of neopentyl glycol is mixed with 3-fold mols of cyclohexane carboxylic acid and reacted for 20 hours at a reaction temperature of 200°C under atmospheric pressure. Since the acid is in excess in the mixture during the reaction, no catalyst is used and xylene is added as a solvent. The reaction is terminated when the water which has vaporized as the reaction proceeds has reached 2-fold mols of alcohol. The reaction product is washed with an alkaline solution (caustic soda) to remove the excess acid, and is further washed with water until it becomes neutral, followed by vacuum distillation so as to remove water and xylene, thereby isolating the diester of the present invention.

The diester thus produced was blended with polybutene having an average molecular weight of 420 to 2,350, followed by measurement of the traction coefficient. The conditions of measurement of the traction coefficient were as follows: .

measuring equipment:	Soda-type four-roller traction testing machine
test conditions:	a fluid temperature of 20°C; a roller temperature of 30°C; a mean Hertzian pressure of 1.2 GPa; a rolling velocity of 3.6 m/s; and a slipping ratio of 3.0%.

The traction fluid of the present invention was found to be remarkably superior in traction performance to conventional traction fluids, as is shown in Table 1.

COMPARATIVE EXAMPLES 1-7

The traction coefficients were measured under the same conditions as those used in the above examples with respect to a traction fluid consisting of 100% by weight of component B, a traction fluid obtained by blending 90% by weight of B component, a traction fluid obtained by blending component A with OCP or PMA, and a commercially available traction fluid.

The results are shown in Table 1. As can be seen from the data in Table 1, all the comparative samples exhibited traction coefficients 1 to 5% smaller than those of the diester compound of the present invention. It should be noted in this connection that an olefin copolymer, i.e., copolymer (having an average molecular weight of 150,000 to 300,000) of ethylene with propylene, was used as OCP, while polymethacrylate having an average molecular weight of 50,000 to 300,000 was used as PMA.

TABLE I

	A	B		Viscosity (cst)		Viscosity index	Traction coefficient
	Compound amount	Molecular weight	Compound amount	40℃	100℃		
Reference	100	——	0	25.73	4.33	53	0.101
Example 1	90	420	10	26.96	4.47	64	0.100
2	90	900	10	43.26	5.86	66	0.103
3	80	〃	20	72.25	8.25	77	0.104
4	70	〃	30	123.7	11.72	79	0.102
5	60	〃	40	204.3	19.79	111	0.100
6	90	1,260	10	45.76	6.71	99	0.102
7	70	〃	30	166.1	17.24	112	0.104
8	90	2,350	10	60.31	8.64	116	0.104
9	70	〃	30	407.8	34.36	124	0.104
Comp. Ex. 1	0	900	100	11,600	240	108	0.081
2	10	〃	90	2,882	154	155	0.089
Comp. Ex. 3	96	OCP	5	36.80	9.70	264	0.097
4	90	〃	10	108.9	26.41	277	0.097
5	90	PMA	10	35.51	9.25	259	0.097
6	70	〃	30	151.5	34.73	273	0.095
Comp. Ex. 7	"Santotrack®"			13.84	2.99	46	0.087

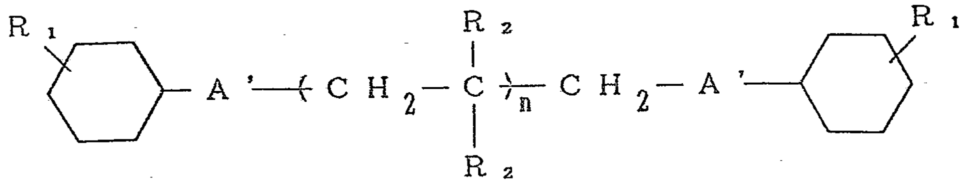
AVAILABILITY OF INDUSTRIAL USAGES

The traction fluid of the present invention, prepared by compounding component A of a diester, etc. having two cyclohexyl rings with a specific amount of component B of a branched poly-α-olefin, not only exhibits an extremely high traction coefficient, but is also inexpensive and exhibits excellent viscosity characteristics.

Therefore, the use of the traction fluid of the present invention in a power transmission, particularly for a traction drive device, results in a remarkable increase in shearing force under a high load. This enables a reduction in size of the device, which leads to a lower cost for the device.

WHAT IS CLAIMED IS:

1. A traction fluid characterized by compounding a diester represented by the formula:



wherein A' is an ester linkage of -COO- or -OOC-, n is an integer of 1 to 6, R_1 is one or two members selected from hydrogen and alkyl groups having from 1 to 8 carbon atoms, and R_2 is one or two members selected from alkyl groups having from 1 to 3 carbon atoms, or its derivative with 0.1 to 70 wt. % of branched poly-α-olefin.

2. The traction fluid of claim 1 wherein said poly-α-olefin is polybutene.

3. The traction fluid of claim 1 wherein the compounding amount of poly-α-olefin is 10 to 50% by weight.

4. The traction fluid of claim 1 wherein R_1 of the diester compound is one or two members selected from hydrogen and alkyl groups having from 1 to 4 carbon atoms.

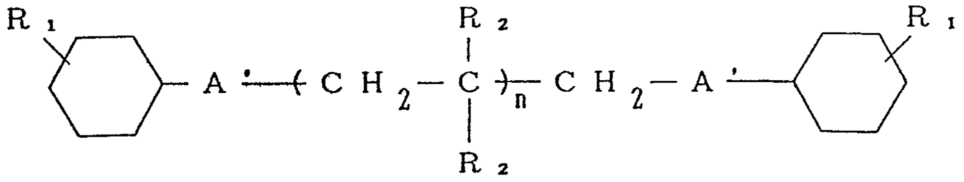
5. The traction fluid of claim 1 wherein said poly-α-olefin has an average molecular weight of 500 to 10,000.

6. The traction fluid of claim 1 wherein n of the diester compound is an integer of from 1 to 3.

7. The traction fluid of claim 1 wherein R_2 of the diester is a methyl group.

ABSTRACT

A traction fluid characterized by compounding 0.1 to 70 wt. % of branched poly-α-olefin in a diester compound represented by the general formula:



(wherein A' represents an ester bond of -COO- or -OOC-, n is an integer of 1 to 6, R_1 represents one or two members selected from among a hydrogen atom and C_{1-8} alkyl groups, and R_2 represents one or two members selected from among C_{1-3} alkyl groups), or its derivative. This traction fluid is used with a power transmission, particularly a traction drive unit.

INTERNATIONAL SEARCH REPORT

0344307

International Application No PCT/JP87/00435

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^4 C10M111/04, C10N40:04

II. FIELDS SEARCHED

Minimum Documentation Searched[4]

Classification System	Classification Symbols
IPC	C10M111/04, 105/38, 107/02-107/10 C10N40:04

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]
Y	JP, A, 59-191797 (Nippon Petrochemicals Co., Ltd.) 30 October 1984 (30. 10. 84) Column 1, lines 5 to 11, column 8, line 4 to column 9, line 11, table 1 (Family: none)	1-7
Y	JP, A, 59-68397 (Maruzen Oil Co., Ltd.) 18 April 1984 (18. 04. 84) Column 1, lines 5 to 11, column 4, line 16 to column 6, line 11 (Family: none)	1-7
Y	JP, A, 61-19697 (Nippon Steel Chemical Co., Ltd.) 28 January 1986 (28. 01. 86) Column 1, line 5 to column 2, line 3, column 8, line 1 to column 9, line 4 (Family: none)	1-7
Y	JP, A, 54-96667 (Bayer A.G) 31 July 1979 (31. 07. 79)	1-7

* Special categories of cited documents:[15]

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed
- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step
- "Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search[2]	Date of Mailing of this International Search Report[2]
September 10, 1987 (10. 09. 87)	September 21, 1987 (21. 09. 87)
International Searching Authority[1]	**Signature of Authorized Officer[20]**
Japanese Patent Office	

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

	Column 1, line 6 to column 2, line 1, column 4, line 12 to column 6, line 3, column 18, line 1 to column 19, line 14 & DE, A1, 2758780 & EP, A1, 3032 & US, A, 4212816 & EP, B1, 3032	
Y	JP, A, 53-127970 (Nippon Oil and Fats Co., Ltd.) 8 November 1978 (08. 11. 78) Column 1, lines 5 to 17, column 5, line 8 to column 6, line 20 (Family: none)	1-7

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:

4.☐ As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

Remark on Protest

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

☐ No protest accompanied the payment of additional search fees.

International Application No. PCT/JP87/00435

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

Y	JP, A, 47-2229 (Sun Oil Company) 3 February 1972 (03. 02. 72) Column 9, line 14 to column 12, line 10 (Family: none)	1-7
Y	JP, A, 61-9497 (Nippon Oil Co., Ltd.) 17 January 1986 (17. 01. 86) Column 1, lines 5 to 16, column 7, lines 5 to 19 (Family: none)	1-7

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

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☐ No protest accompanied the payment of additional search fees.