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(71) **Applicant** *(for all designated States except US)*: **PARKER-HANNIFIN CORPORATION** [US/US]; 6035 Parkland Boulevard, Cleveland, OH 44124 (US).

(72) **Inventors; and**
(75) **Inventors/Applicants** *(for US only)*: **LARKIN, Bruce** [US/US]; 237 Deer Run, Plainwell, Michigan 49080-9123 (US). **HARTTER, Larry** [US/US]; 501 Apple Hill Lane, Rochester Hills, Michigan 48306 (US). **KORENKIEWICZ, Paul** [US/US]; 55741 Lorraine Drive, Shelby Township, Michigan 48316 (US).

(74) **Agent**: **JACOBS, Christopher B.**; Renner, Otto, Boisselle & Sklar, LLP, 1621 Euclid Ave., 19th Floor, Cleveland, OH 44115 (US).

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[Continued on next page]

(54) **Title**: VARIABLE DISPLACEMENT HYDRAULIC PUMP/MOTOR WITH HYDROSTATIC VALVE PLATE

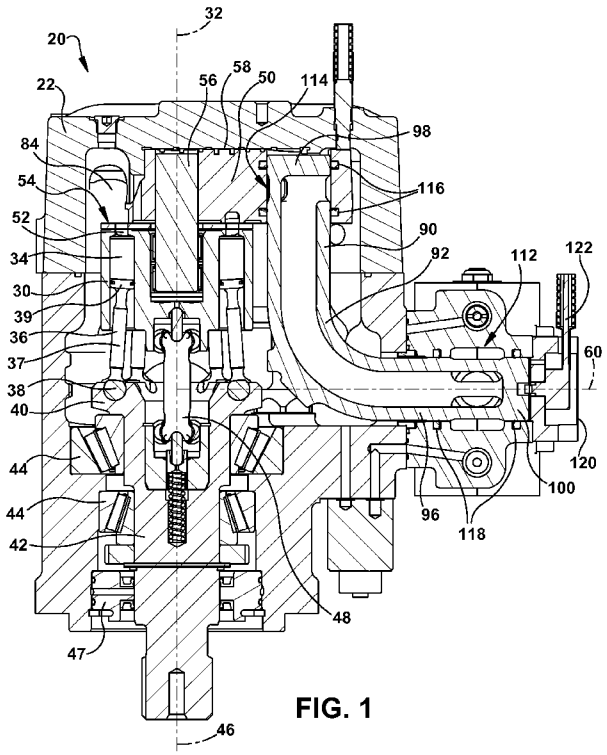

FIG. 1

(57) **Abstract**: A variable displacement hydraulic axial piston machine includes (a) a housing having an outlet opening; (b) a barrel mounted in the housing for rotation about a rotation axis; (c) a plurality of pistons movable in respective bores in the barrel; (d) a valve plate coupled to the barrel and having a fluid passage therein that ends at an outlet opening; and (e) a flow tube connecting the outlet opening in the valve plate to the outlet opening in the housing. The barrel and the valve plate are pivotally movable together about a pivot axis transverse the rotation axis for varying the displacement of the pistons in the bores. An end of the flow tube connects to the valve plate while allowing for axial movement of the flow tube relative to the valve plate in a direction parallel to the rotational axis of the barrel.

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TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

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(88) Date of publication of the international search report:
22 March 2012

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2011/046123

A. CLASSIFICATION OF SUBJECT MATTER
INV. F03C1/06 F04B1/20 F04B1/32
ADD.

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)
F04B F03C F16H

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)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X,P	WO 2010/091305 A2 (US GOV ENV PROTECTION AGENCY [US]; GRAY CHARLES L JR [US] US GOVERNMEN) 12 August 2010 (2010-08-12) page 11, line 18 - page 12, line 27; claims 1,3,8; figures 1-5 page 14, line 18 - page 21, line 3	1-15
Y	US 2005/193888 A1 (GRAY CHARLES L JR [US] GRAY JR CHARLES L [US]) 8 September 2005 (2005-09-08) paragraphs [0004] - [0063]; figures 2,5a-6	1-15
Y	US 4 129 063 A (IFIELD RICHARD J) 12 December 1978 (1978-12-12) column 1, line 4 - column 3, line 37; figures 1-3	1-15

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

[X] See patent family annex.

* Special categories of cited documents :

"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

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"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 when the document is taken alone

"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

Date of the actual completion of the international search	Date of mailing of the international search report
12 October 2011	03/02/2012

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Jurado Orenes, A

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2011/046123

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

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

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
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, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

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

see additional sheet

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

2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

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

4. ☒ 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 claims Nos.:

see additional sheet(s)

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2011/046123

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 6 604 446 B1 (SKIRDE ECKHARD [DE] ET AL) 12 August 2003 (2003-08-12) column 3, line 27 - column 4, line 33; figures 1,2	1-15
A	US 4 991 492 A (BRATT STIG [SE] ET AL) 12 February 1991 (1991-02-12) cited in the application the whole document	1-15

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2011/046123

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2010091305 A2	12-08-2010	CN 102308089 A	04-01-2012
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		US 4991492 A	12-02-1991

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-15

A variable displacement hydraulic axial piston machine, comprising:
a housing having an outlet opening;
a rotatable member rotatably-mounted in the housing for rotation about an axis;
a valve plate having a fluid passage therein that ends at an outlet opening,
a barrel mounted between the valve plate and the rotatable member, the barrel being coupled to the valve plate for rotation relative to the valve plate and the barrel being pivotally coupled to the rotatable member for rotation about a rotation axis, the barrel including a plurality of piston bores;
a plurality of pistons movable in respective bores in the barrel and coupled to the rotatable member for rotation with the rotatable member, the barrel and the valve plate being pivotally movable together about a pivot axis transverse the rotation axis for varying the displacement of the pistons in the bores;
a flow tube connecting the outlet opening of the valve plate to the outlet opening in the housing, the flow tube having a first connector at a first end that connects the flow tube to the valve plate while allowing for axial movement of the flow tube relative to the valve plate in a direction parallel to the rotational axis of the barrel, and a second end opposite the first end, the flow tube having a second connector at the second end that connects the flow tube to the outlet opening in the housing while allowing for angular movement of the flow tube about the pivot axis.

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2. claims: 16-18

A variable displacement hydraulic axial piston machine, comprising:
a housing;
a rotatable member rotatably-mounted in the housing for rotation about a rotation axis;
a barrel coupled to the rotatable member, the barrel including a plurality of piston bores;
a plurality of pistons movable in respective bores and coupled to the rotatable member for rotation with the rotatable member;
a valve plate coupled to the barrel and constrained in the housing for rotation with the barrel, the barrel and the valve plate being pivotally movable together about a pivot axis transverse the rotation axis for varying the displacement of the pistons in the bores;
a working fluid within the housing;
wherein the housing, the working fluid, and the valve plate

cooperate to define a hydrostatic pad between the valve plate and the housing to decrease friction and wear from the relative movement between the housing and the valve plate.

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3. claims: 19, 20

A variable displacement hydraulic axial piston machine, comprising:
a housing;
a rotatable member rotatably-mounted in the housing for rotation about a rotation axis;
a barrel coupled to the rotatable member, the barrel including a plurality of piston bores;
a plurality of pistons movable in respective bores and coupled to the rotatable member for rotation with the rotatable member;
a valve plate coupled to the barrel and constrained in the housing for rotation with the barrel, the barrel and the valve plate being pivotally movable together about a pivot axis transverse the rotation axis for varying the displacement of the pistons in the bores;
wherein valve plate includes a planar running surface facing a corresponding surface of the barrel.
