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(54) **Title:** FORCE-TO-TORQUE CONVERSION DEVICE

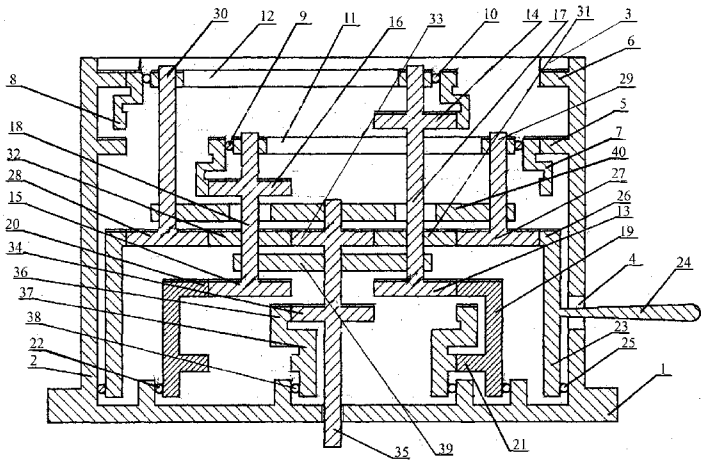

Fig. 1

(57) **Abstract:** The invention relates to mechanical engineering, in particular to radial force-to- torque conversion devices. The device, according to the invention, comprises a cylindrical body (2) with two main wheels (5 and 6), which fixed on a base (1) and closed with a cover (3). On the base (1) are mounted by means of bearings (25) a drum (19) with two main wheels (20 and 21), a hollow carrier (23) with a primary pinion (26) and a satellite (37) with a double gear wheel (36). In the body (2) are placed shafts (17, 18 and 29, 30) with paired satellites (13, 14 and 15, 16) and satellites (11, 12 and 27, 28) and an output shaft (35) with two sun wheels (33 and 34). The hollow carrier (23) is equipped with a handle (24), passing through a transverse through channel (4), made in the body (2). The device further comprises two intermediate gear wheels (31 and 32) and two double gear wheels (7 and 8). The shafts (17, 18 and 29, 30) are fixed, in pairs, on abutment bars (39, 40).

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[Continued on next page]

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, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

— *of inventorship (Rule 4.17(iv))*

Published:

— *with international search report (Art. 21(3))*

FORCE-TO-TORQUE CONVERSION DEVICE

Description

The invention relates to mechanical engineering, in particular to radial force-to-torque conversion devices.

It is known a planetary gear, comprising a main gear wheel, a carrier with satellites and a sun wheel, which due to its construction is capable, within a geometrical axis of rotation, to vary, add and distribute the angular speeds and/or the torque applied [1].

The disadvantage of this planetary gear lies in the fact that the principle of operation is based only on the application of rotational or torque moments.

The technical problem solved by the invention consists in creating a compact device converting radial force, applied and maintained constantly on the handle of the hollow carrier, into a constant torque on the output shaft, as well as increasing the reliability and maintainability.

The radial force-to-torque conversion device, according to the invention, eliminates the above-mentioned disadvantage by the fact that it comprises a cylindrical body, fixed on a base and closed with a cover. On the base is mounted by means of a bearing a hollow carrier, equipped with a handle, passing through a transverse through channel, made in the body. In the carrier is fixed a primary pinion, which is engaged with two satellites, mounted on one end of some shafts, and on the opposite end thereof is mounted a satellite. The satellites are engaged with an intermediate gear wheel, which in turn is engaged with a first sun wheel, mounted on an output shaft, on which is mounted a second sun wheel, engaged with a double gear wheel, placed on the end of a satellite, the opposite end of which is mounted by means of a base bearing, the satellite being engaged with a main wheel, fixed in a drum, one end of which is mounted by means of a base bearing, and at the opposite end is fixed a main wheel, which is connected to paired satellites, mounted, in pairs, on a shaft, on the free ends of which are mounted satellites. The paired satellites are engaged with a double gear wheel, each being mounted by means of bearings on satellites, the wheels being engaged with a main wheel, fixed in the body. The shafts are fixed, in pairs, on an abutment bar.

The technical result of the invention consists in the creation of a compact device converting the radial force, applied and maintained constantly on the handle of the hollow carrier, into a constant torque on the output shaft, while the direction of the rotational moment on the output shaft depends on the direction of the constantly applied and maintained moment of radial force.

The features of the invention make it possible to convert the force applied and maintained constantly on the handle into a constant torque on the output shaft, due to the use of conjugation of the modules between the gear wheels and the planetary gears, wherein in applying and constantly maintaining a radial force on the handle of the hollow carrier, the occurring moments of force interact in accordance with the lever rule.

The invention is explained by the drawings in FIG. 1 and FIG. 2, which represent:

- FIG. 1, radial force-to-torque conversion device, general view in section;
- FIG. 2, the schematic diagram of the moments of forces of the device, top view.

The radial force-to-torque conversion device, according to the invention, comprises the base 1, on which is fixed the cylindrical body 2, closed with the cover 3 (Fig. 1). In the body 2 is made the transverse through channel 4 and are fixed the main wheels 5 and 6, which are engaged with a double gear wheel 7 and 8, each of which is mounted by means of the bearings 9 and 10 on the satellites 11 and 12. The device further comprises the paired satellites 13, 14 and 15, 16, mounted, in pairs, on a shaft 17 and 18, the drum 19 with the main wheels 20 and 21 and the bearing 22, the hollow carrier 23 with the handle 24, the bearing 25 and the primary pinion 26, the satellites 27 and 28 (Fig. 2), mounted on a shaft 29 and 30, the intermediate gear wheels 31 and 32, the sun wheels 33 and 34, mounted on the output shaft 35, the double gear wheel 36, the satellite 37 with the bearing 38 and the abutment bars 39 and 40 of the shafts 17, 18 and 29, 30.

The radial force-to-torque conversion device operates as follows.

Upon application and constant maintenance of the force F on the handle 24, rigidly fixed on the hollow carrier 23, which can freely displace in the transverse through channel 4, made in the body 2, there takes place an initial angular displacement of the carrier 23, which with one end is mounted by means of the bearing 25 on the base 1, the initial angular displacement of the carrier 23 is transmitted through the teeth of the primary pinion 26, fixed on the other end of the carrier 23, towards the satellites 27 and 28, mounted on one end of the shafts 29 and 30, and at the opposite end thereof is

mounted a satellite 11 and 12. The satellites 27 and 28, through the intermediate gear wheels 31 and 32, transmit the angular displacement to the sun wheel 33, mounted on the output shaft 35 and then to the sun wheel 34, which is also mounted on the shaft 35. Next, from the sun wheel 34, the angular displacement is transmitted through the double gear wheel 36, placed on the end of the satellite 37, the opposite end of which is mounted by means of the bearing 38 on the base 1, to the main wheel 21 of the drum 19, one end of which is mounted by means of the bearing 22 on the base 1, and then to the main wheel 20, which transmits the angular displacement towards the paired satellites 13, and 15, 16, placed on the shafts 17 and 18, on the free ends of which are mounted the satellites 11 and 12. The angular displacement from the satellites 14 and 16 is transmitted to the double gear gears 7 and 8, mounted by means of the bearings 9 and 10 on the satellites 11 and 12, which move on the inner teeth of the main wheels 5 and 6, which are rigidly fixed in body 2. At the same time, the force F, applied and constantly maintained on the handle 24, transmitted to the hollow carrier 23 through the teeth of the primary pinion 26 and the satellite 27 generates a moment of force, which acts on the shaft 29 with a value of $M_1^1 = F \cdot r$, acting on the satellite 11 at the peripheral location of the shaft 29, also, the initial angular displacement of the hollow carrier 23 through the teeth of the primary pinion 26, of the satellite 28 and the intermediate wheel 32 generates a moment of force, which acts on the shaft 18 with a value of $M_2^1 = F \cdot 3 \cdot r$, acting on the satellite 11 at the peripheral location of the shaft 18, in the direction opposite to the moment of force M_1^1. Thus, as a result of action of the moments of force M_1^1 and M_2^1 with a multilateral direction and an unequivocal value of the action, the satellite 11 tends to rotate towards the action of the moment of force M_2^1.

According to the same principle, the initial angular displacement of the carrier 23 through the teeth of the primary pinion 26 and the satellite 28 generates a moment of force, which acts on the shaft 30 with a value of $M_1^2 = F \cdot r$, acting on the satellite 12 at the peripheral location of the shaft 30, also, the initial angular displacement of the hollow carrier 23 through the teeth of the primary pinion 26, of the satellite 27 and the intermediate wheel 31 generates a moment of force, which acts on the shaft 17 with a value of $M_2^2 = F \cdot 3 \cdot r$, acting on the satellite 12 at the peripheral location of the shaft 17, in the direction opposite to the moment of force M_1^2. Thus, as a result of action of the moments of force M_1^2 and M_2^2 with a multilateral direction and an unequivocal value of the action, the satellite 12 tends to rotate towards the action of the moment of force M_2^2.

Thus, satellites 11 and 12 under the action of the moments of force M_2^1 and M_2^2 rotate on a generator of the main wheels 5 and 6 and transmit the torque moment through the double gear wheels 7 and 8 to the paired satellites 13, 14 and 15, 16, mounted on the shafts 17 and 18 to the main wheel 20 of the drum 19, which from the main wheel 21, through the double gear wheel 36 and the satellite 37, transmits the torque moment to the sun wheel 34, which maintains the torque moment at the shaft 35.

At the same time, the F force applied to the handle 24 is not removed, that is, it is kept constant, the hollow carrier 23 does not rotate, and the satellites 27 and 28 move on the inner teeth of the primary pinion 26.

Upon removal of the F force from the handle 24, the hollow carrier 23 is actuated, and the satellites 27 and 28 cease to move on the teeth of the primary pinion 26, blocking the rotation of the intermediate wheels 31 and 32 as well as the rotation of the sun wheel 33. In this case, the moments of force M_1^1, M_2^1, M_1^2 and M_2^2, acting on the shafts 17, 18 and 29, 30, are equal to zero, therefore the rotations transmitted from the satellites 11 and 12 through the kinematic constraints on the output shaft 35 stop. In order to resume the rotation of the output shaft 35, it is necessary to apply and constantly maintain again the force F on the handle 24, while the direction of the torque on the output shaft 35 depends on the direction of the radial force F applied and maintained constantly.

Information sources:

1. https://ru.wikipedia.org/wiki/planetarnaya peredachia

Claims

Radial force-to-torque conversion device, comprising a cylindrical body (2), fixed on a base (1) and closed with a cover (3); on the base (1) is mounted by means of a bearing (25) a hollow carrier (23), equipped with a handle (24), passing through a transverse through channel (4), made in the body (2); in the carrier(23) is fixed a primary pinion (26), which is engaged with two satellites (27 and 28), mounted on one end of some shafts (29 and 30), and on the opposite end thereof is mounted a satellite (11 and 12); the satellites (27 and 28) are engaged with an intermediate gear wheel (31 and 32), which in turn engages with the first sun wheel (33), mounted on an output shaft (35), on which is mounted a second sun wheel (34), engaged with a double gear wheel (36), placed on the end of a satellite (37), the opposite end of which is mounted be means of a bearing (38) on the base (1), the satellite (37) being engaged with a main wheel (21), fixed in a drum (19), one end of which is mounted by means of a bearing (22) on the base (1), and at the opposite end is fixed a main wheel (20), which is coupled with paired satellites (13, 14 and 15, 16), mounted, in pairs, on a shaft (17 and 18), on the free ends of which are mounted the satellites (12 and 11); the satellites (16 and 14) are engaged with a double gear wheel (7 and 8), each being mounted by means of bearings (9 and 10) on the satellites (11 and 12), at the same time the wheels (7 and 8) are engaged with a main wheel (5 and 6), which are fixed in the body (2); the shafts (17, 18 and 29, 30) are fixed, in pairs, on an abutment bar (39, 40).

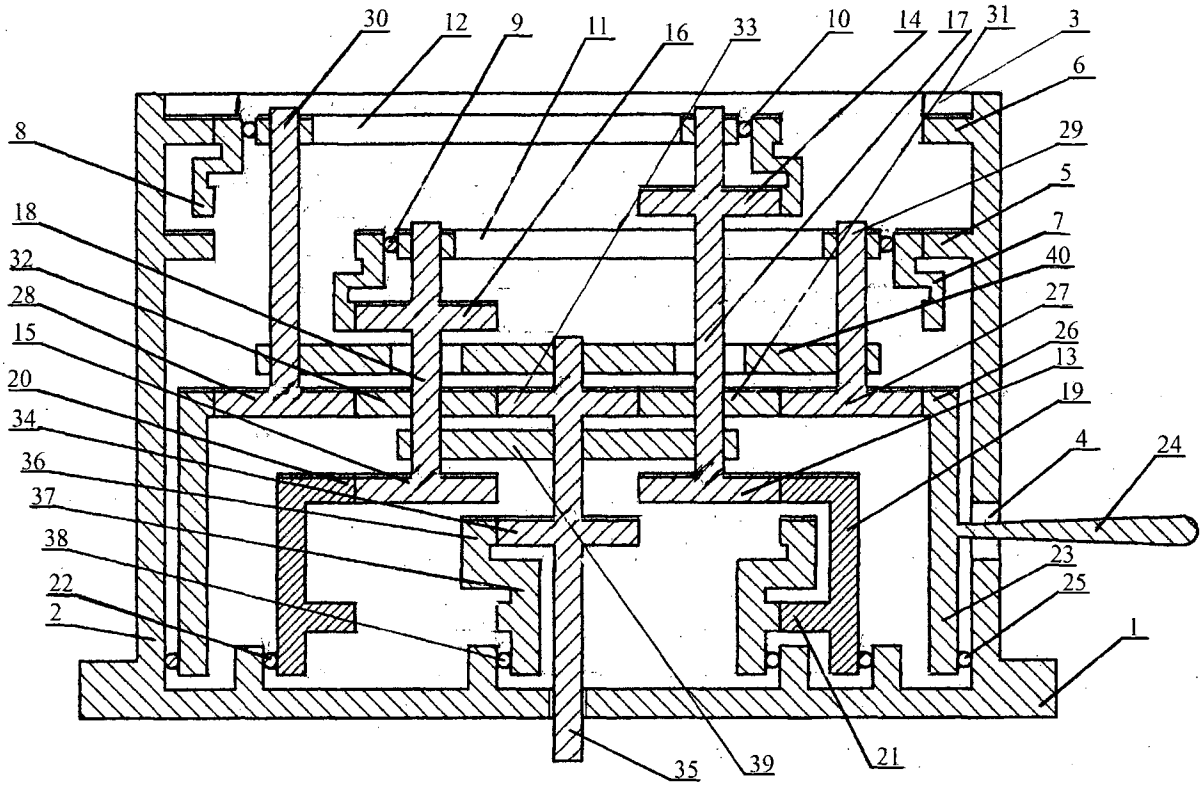
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Fig. 1

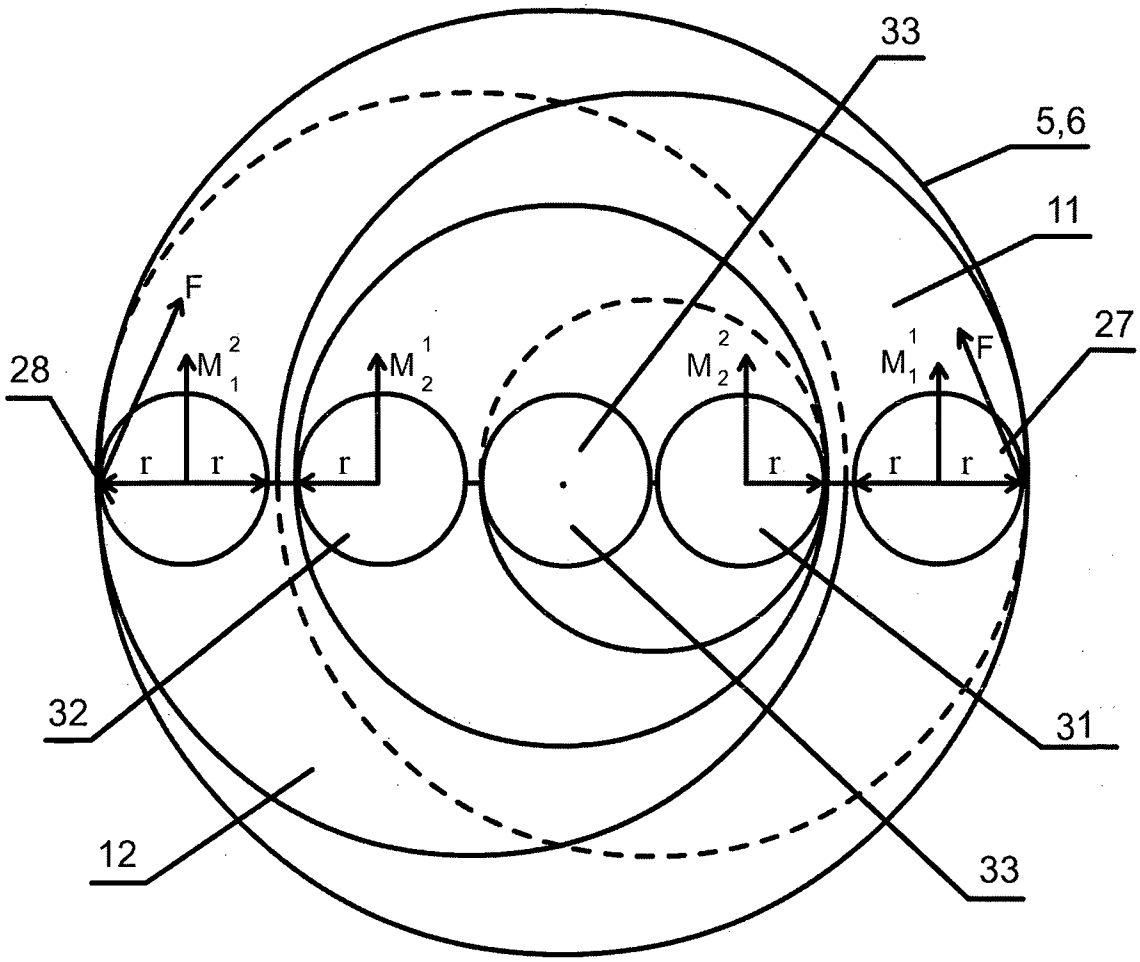

Fig. 2

INTERNATIONAL SEARCH REPORT

International application No
PCT/MD2018/000004

A. CLASSIFICATION OF SUBJECT MATTER
INV. F03G7/10
ADD. F16H1/46 F16H19/00 F16H1/32

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)
F03G 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 practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
L	EP 2 613 067 A1 (JTEKT CORP [JP]) 10 July 2013 (2013-07-10) the whole document	1
L	CN 204 805 443 U (LIN JINGU) 25 November 2015 (2015-11-25) the whole document	1
L	DE 10 2013 101864 A1 (MAUL HANS-ERICH [DE]) 28 August 2014 (2014-08-28) the whole document	1

☐ Further documents are listed in the continuation of Box C.

☒ 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 application or patent 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 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
10 October 2018	24/10/2018

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	Ehrsam, Adrian

INTERNATIONAL SEARCH REPORT

International application No.
PCT/MD2018/000004

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.: 1
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:

see FURTHER INFORMATION sheet PCT/ISA/210

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:

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.:

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.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

Continuation of Box II.2

Claims Nos.: 1

see written opinion

The applicant's attention is drawn to the fact that claims relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure. If the application proceeds into the regional phase before the EPO, the applicant is reminded that a search may be carried out during examination before the EPO (see EPO Guidelines C-IV, 7.2), should the problems which led to the Article 17(2) declaration be overcome.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/MD2018/000004

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 2613067 A1	10-07-2013	CN 103080601 A	01-05-2013
		EP 2613067 A1	10-07-2013
		JP WO2012029756 A1	28-10-2013
		US 2013157795 A1	20-06-2013
		WO 2012029756 A1	08-03-2012
CN 204805443 U	25-11-2015	NONE	
DE 102013101864 A1	28-08-2014	NONE	