

"FORM 1 THE PATENTS ACT 1970 (39 of 1970) and THE PATENTS RULES, 2003 APPLICATION FOR GRANT OF PATENT (See section 7, 54 and 135 and sub-rule (1) of rule 20)				(FOR OFFICE USE ONLY)	
				Application No.	
				Filing date:	
				Amount of Fee paid:	
				CBR No:	
				Signature:	
1. APPLICANT'S REFERENCE / IDENTIFICATION NO. (AS ALLOTTED BY OFFICE)					
2. TYPE OF APPLICATION [Please tick (✓) at the appropriate category]					
Ordinary (✓)		Convention ()		PCT-NP ()	
Divisional ()	Patent of Addition ()	Divisional ()	Patent of Addition ()	Divisional ()	Patent of Addition ()
3A. APPLICANT(S)					
Name in Full		Nationality	Country of Residence	Address of the Applicant	
BAJAJ AUTO LIMITED		India	India	House No.	-
				Street	Akurdi,
				City	Pune,
				State	Maharashtra.
				Country	India.
				Pin code	411035.
3B. CATEGORY OF APPLICANT [Please tick (✓) at the appropriate category]					
Natural Person ()		Other than Natural Person			
		Small Entity ()		Startup ()	Others (✓)
4. INVENTOR(S) [Please tick (✓) at the appropriate category]					
Are all the inventor(s) same as the applicant(s) named above?				Yes ()	No (✓)
If "No", furnish the details of the inventor(s)					
Name in Full		Nationality	Country of Residence	Address of the Applicant	
1. JOSEPH ABRAHAM		Indian	India	House No.	BAJAJ AUTO LIMITED
				Street	Akurdi,
				City	Pune,
				State	Maharashtra.
				Country	India.
				Pin code	411035.

2. JOSHI ASHISH MOHANIRAJ	Indian	India	House No.	BAJAJ AUTO LIMITED	
			Street	Akurdi,	
			City	Pune,	
			State	Maharashtra.	
			Country	India.	
			Pin code	411035.	
3. GUPTA AVIJIT GHANSHYAM DAS	Indian	India	House No.	BAJAJ AUTO LIMITED	
			Street	Akurdi,	
			City	Pune,	
			State	Maharashtra.	
			Country	India.	
			Pin code	411035.	
5. TITLE OF THE INVENTION					
"A TRANSMISSION SYSTEM"					
6. AUTHORISED REGISTERED PATENT AGENT(S)	IN/PA No.	INPA269			
	Name	Ms. BRINDA MOHAN			
	Mobile No.	-			
7. ADDRESS FOR SERVICE OF APPLICANT IN INDIA	Name	M/s. MOHAN ASSOCIATES,			
	Postal Address	Advocates, Patent & Trade Mark Attorneys, Ceebros Building, D-4, 11th Floor, New No.32(Old No.11), Cenotaph Road, Teynampet, Chennai - 600 018, India.			
	Telephone No.	24339983/84/85			
	Mobile No.	-			
	Fax No.	24339982			
	E-mail ID	brinda@iprightsindia.com, aamohan@iprightsindia.com			
	8. IN CASE OF APPLICATION CLAIMING PRIORITY OF APPLICATION FILED IN CONVENTION COUNTRY, PARTICULARS OF CONVENTION APPLICATION				
Country	Application Number	Filing date	Name of the applicant	Title of the invention	IPC (as classified in the convention country)
N/A	N/A	N/A	N/A	N/A	N/A
9. IN CASE OF PCT NATIONAL PHASE APPLICATION, PARTICULARS OF INTERNATIONAL APPLICATION FILED UNDER PATENT CO-OPERATION TREATY (PCT)					
International application number			International filing date		
N/A			N/A		
10. IN CASE OF DIVISIONAL APPLICATION FILED UNDER SECTION 16, PARTICULARS OF ORIGINAL (FIRST) APPLICATION					
Original (first) application No.			Date of filing of original (first) application		
N/A			N/A		

11. IN CASE OF PATENT OF ADDITION FILED UNDER SECTION 54, PARTICULARS OF MAIN APPLICATION OR PATENT

Main application/patent No.	Date of filing of main application
N/A	N/A

12. DECLARATIONS:

(i) Declaration by the inventor(s)

(In case the applicant is an assignee: the inventor(s) may sign herein below or the applicant may upload the assignment or enclose the assignment with this application for patent or send the assignment by post/electronic transmission duly authenticated within the prescribed period).

We, the above named inventor(s) is/are the true & first inventor(s) for this Invention and declare that the applicant(s) herein is/are my/our assignee or legal representative.

i)

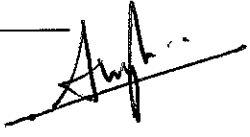
(a) Date _____

(b) Signature 

(c) Name: JOSEPH ABRAHAM

ii)

(a) Date _____

(b) Signature 

(c) Name: JOSHI ASHISH MOHANIRAJ

iii)

(a) Date _____

(b) Signature 

(c) Name: GUPTA AVIJIT GHANSHYAM DAS

(ii) Declaration by the applicant(s) in the convention country

(In case the applicant in India is different than the applicant in the convention country: the applicant in the convention country may sign herein below or applicant in India may upload the assignment from the applicant in the convention country or enclose the said assignment with this application for patent or send the assignment by post/electronic transmission duly authenticated within the prescribed period)

I/We, the applicant(s) in the convention country declare that the applicant(s) herein is/are my/our assignee or legal representative. N/A

(a) Date

(b) Signature(s)

(c) Name(s) of the signatory

(iii) Declaration by the applicant(s) :

We the applicant(s) hereby declare(s) that: -

- ☒ We are in possession of the above-mentioned invention.
- ☐ The provisional/complete specification relating to the invention is filed with this application.
- ☐ The invention as disclosed in the specification uses the biological material from India and the necessary permission from the competent authority shall be submitted by us before the grant of patent to us.
- ☒ There is no lawful ground of objection(s) to the grant of the Patent to us.
- ☐ we are the true & first inventor(s).
- ☒ we are the assignee or legal representative of true & first inventor(s).
- ☐ The application or each of the applications, particulars of which are given in Paragraph-8, was the first application in convention country/countries in respect of our invention(s).
- ☐ We claim the priority from the above mentioned application(s) filed in convention country/countries and state that no application for protection in respect of the invention had been made in a convention country before that date by us or by any person from which We derive the title.
- ☐ Our application in India is based on international application under Patent Cooperation Treaty (PCT) as mentioned in Paragraph-9.
- ☐ The application is divided out of our application particulars of which is given in Paragraph-10 and pray that this application may be treated as deemed to have been filed on DD/MM/YYYY under section 16 of the Act.
- ☐ The said invention is an improvement in or modification of the invention particulars of which are given in Paragraph-11.

13. FOLLOWING ARE THE ATTACHMENTS WITH THE APPLICATION

(a) Form 2

Item	Details	Fee	Remarks
Complete/ provisional specification)#	No. of pages: 18	3200	Addition of pages (4) Addition of claims (6)
No. of Claim(s)	No. of claims: 16 and No. of pages: 3	9600	
Abstract	No. of pages: 1		
No. of Drawing(s)	No. of drawings: 12 and No. of pages: 12		

In case of a complete specification, if the applicant desires to adopt the drawings filed with his provisional specification as the drawings or part of the drawings for the complete specification under rule 13(4), the number of such pages filed with the provisional specification are required to be mentioned here.

(b) Complete specification (in conformation with the international application)/as amended before the International Preliminary Examination Authority (IPEA), as applicable (2 copies). -
N/A

(c) Sequence listing in electronic form – **N/A**

(d) Drawings (in conformation with the international application)/as amended before the International Preliminary Examination Authority (IPEA), as applicable (2 copies). – **N/A**

(e) Priority document(s) or a request to retrieve the priority document(s) from DAS (Digital Access Service) if the applicant had already requested the office of first filing to make the priority document(s) available to DAS. – **N/A**

(f) Translation of priority document/Specification/International Search Report/International Preliminary Report on Patentability. – **N/A**

(g) Statement and Undertaking on Form 3

(h) Declaration of Inventorship on Form 5

(i) Power of Authority

(j).....

Total fee Rs..... in Cash/ Banker's Cheque /Bank Draft bearing No.....

Date.....on Bank.

We hereby declare that to the best of my/our knowledge, information and belief the fact and matters slated herein are correct and I/We request that a patent may be granted to me/us for the said invention.

Dated on this the 22nd day of Dec 2016

For **BAJAJ AUTO LIMITED,**

Authorised signatory :



Name in full : **SRINIVASAN RAVIKUMAR**

Designation : **PRESIDENT (BD&A)**

Seal :

Authorised signatory :



Name in full : **R. NARASIMHAN**

Designation : **VICE PRESIDENT (R&D)**

Seal :

To,
The Controller of Patent,
The Patent Office,
at Mumbai.

FORM 3

THE PATENT ACT, 1970
(39 of 1970)
&
The Patents Rules, 2003
STATEMENT AND UNDERTAKING UNDER SECTION 8
(See section 8, rule 12)

We, **BAJAJ AUTO LIMITED**, an Indian Company, incorporated under the Indian Companies Act, 1956, having its registered office at Akurdi, Pune – 411035, State of Maharashtra, India, do hereby declare that that we have made this invention **"A TRANSMISSION SYSTEM"** under application no. 4942/MUM/2015 dated 30 / 12 / 2015, made for the substantially same invention application for patent in the other countries, the particulars of which are given below:

Name of the Country	Date of application	Application No.	Status of the application	Date of Publication	Date of grant
N/A	N/A	N/A	N/A	N/A	N/A

that the rights in the application have been assigned to **N/A**.

The applicant has not filed equivalent application outside India.

- (i) that We would keep him informed in writing the details regarding corresponding applications for patents filed outside India within six months from the date of filing of such application.

Dated this on the 28th day of December, 2016.

For **BAJAJ AUTO LIMITED**,

Authorized Signatory :



Name in Full : **SRINIVASAN RAVIKUMAR**

Designation : **PRESIDENT (BD&A)**

Seal :

To
The Controller of Patents,
The Patent Office,
Mumbai.

FORM 5
THE PATENT ACT, 1970
(39 of 1970)
&
The Patents Rules, 2003
DECLARATION AS TO INVENTORSHIP
[See section 10(6) and rule 13(6)]

1. NAME OF APPLICANTS

Name	Nationality	Address
BAJAJ AUTO LIMITED	Indian	Akurdi, Pune – 411035, State of Maharashtra, India.

hereby declare that the true and first inventor(s) of the invention disclosed in the provisional specification filed in pursuance of our application

No. : 4942 /MUM/2015

Title : " **A TRANSMISSION SYSTEM**"

Dated : 30 / 12 /2015

Are

2. INVENTORS

NAME	Nationality	Address
1. JOSEPH ABRAHAM	Indian	BAJAJ AUTO LIMITED Akurdi, Pune – 411035, State of Maharashtra, India.
2. JOSHI ASHISH MOHANIRAJ	Indian	BAJAJ AUTO LIMITED Akurdi, Pune – 411035, State of Maharashtra, India.
3. GUPTA AVIJIT GHANSHYAM DAS	Indian	BAJAJ AUTO LIMITED Akurdi, Pune – 411035, State of Maharashtra, India.

Dated this on the 22nd day of December, 2016.

Signature :

Name: **JOSEPH ABRAHAM**

Signature :

Name: **JOSHI ASHISH MOHANIRAJ**

Signature :

Name: **GUPTA AVIJIT GHANSHYAM DAS**

3. DECLARATION TO BE GIVEN WHEN THE APPLICATION IN INDIA IS FILED BY THE APPLICANT(S) IN THE CONVENTION COUNTRY:- NOT APPLICABLE

We the applicant(s) in the convention country hereby declare that our right to apply for a patent in India is by way of assignment from the true and first inventor(s)

Dated this on the 22nd day of Dec December 2016

Signature

Name of the signatory

4. STATEMENT (to be signed by the additional inventors not mentioned in the application form)

We assent to the invention referred to in the above declaration, being included in the complete specification filed in pursuance of the stated application.

Dated this on the 22nd day of December, 2016.

Signature :

Name: **JOSEPH ABRAHAM**

Signature :

Name: **JOSHI ASHISH MOHANIRAJ**

Signature :

Name: **GUPTA AVIJIT GHANSHYAM DAS**

To
The Controller of Patents,
The Patent Office,
Mumbai.

भारतीय गैर न्यायिक

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ONE
HUNDRED RUPEES

भारत INDIA
INDIA NON JUDICIAL

तमिलनाडु TAMILNADU

BRINDA MOHAN
ADVOCATE
CHENNAI - 600 018

BD 863672

28 857
03 DEC 2016

V. THAMARAICHELVI
S.M.L. No: 4379/D/2013/3.03
Nungambakkam,
Chennai - 600 004.

FORM - 26

THE PATENTS ACT, 1970

Section 39 of 1970 and The Patent Rules, 2003

FORM OF AUTHORISATION OF A PATENT AGENT IN A MATTER
OR PROCEEDING UNDER THE ACT.

We, **BAJAJ AUTO LIMITED**, an Indian Company incorporated under the Laws of Companies Act 1956, having its registered office at Akurdi, Pune - 411035, State of Maharashtra, India do hereby authorize **Mrs. BRINDA MOHAN**, Registered Trade Mark and Patent Agent of **M/s. MOHAN ASSOCIATES**, Advocates, Patent and Trade Mark Attorneys, Ceebros Building, D-4, III Floor, No. 32, Cenetoph Road, Teynampet, Chennai - 600 018.

FORM - 26

THE PATENTS ACT, 1970

Section 39 of 1970

**FORM OF AUTHORISATION OF A PATENT AGENT IN A MATTER
OR PROCEEDING UNDER THE ACT.**

(Section 127/132; rule 135)

We, **BAJAJ AUTO LIMITED**, a Company incorporated under the laws of Company's Act 1956, having its registered office at Akurdi, Pune – 411035, State of Maharashtra, India, do hereby authorize Mrs. **BRINDA MOHAN**, Registered Trade Mark and Patent Agent of M/s. **MOHAN ASSOCIATES**, Advocates, Patent and Trade Mark Attorneys, Ceebros Building, D-4, III Floor, New No. 32, (Old No. 11), Cenotaph Road, Teynampet, Chennai - 600 018, to act on our behalf in connection with registration of Patent for the invention "**A TRANSMISSION SYSTEM**" under application No. 4942 /MUM/2015 dated 30 / 12 /2015 and request that all notices, requisitions and communications relating thereto may be sent to such agent at the above address.

We hereby revoke all previous authorizations, if any made, in respect of the same matter or proceeding.

Dated this on the 28th day of December, 2015.

For **BAJAJ AUTO LIMITED**,

Authorized Signatory :



Name in Full

: **SRINIVASAN RAVIKUMAR**

Designation

: **PRESIDENT (BD&A)**

Seal

:

To,
The Controller of Patents,
The Patent Office,
Mumbai.

FORM - 2

THE PATENTS ACT, 1970

(39 of 1970)

&

The Patents Rules, 2003

COMPLETE SPECIFICATION

(SECTION 10 AND RULE 13)

TITLE

"A TRANSMISSION SYSTEM"

A P P L I C A N T

We, BAJAJ AUTO LIMITED, an Indian Company, having its registered office at Akurdi, Pune - 411035, State of Maharashtra, India.

The following specification describes the nature of this invention:-

FIELD OF INVENTION

This invention relates to a transmission system for use in automotive vehicles such as compact two/three/four wheeled vehicles. The invention relates, more particularly, though not exclusively, to sequential automated manual transmission systems.

BACKGROUND OF THE INVENTION

Transmission systems employing drum shift between gears are known in the automotive industry. For example, US Patent No. 4754662 assigned to Honda discloses a typical example of conventional transmissions for motorcycles comprising a drum shift, or drum shifter, which can be considered as a rotary cam for converting its rotation into translation (along the drum shifter axis) of the gears in order to engage/disengage different gears. A shift drum has cam grooves formed in an outer peripheral surface thereof which have specific characteristics which can be defined in terms of index, ramp and dwell angles.

Shift forks are mounted on a shaft for sliding movement there along and received at one ends respectively in the cam grooves. The other ends of the shift forks are engaged with shifters or shift collars mounted on an input shaft and an output shaft, and input and output gears are mounted on the input shaft and the output shaft, respectively. In operation, a gear shift is manually operated to rotate the shift drum, so that the shifters are moved by the co-acting shift forks to drivingly connect the input and output shafts together through the meshed input and output gears, thereby transmitting the rotation of a crankshaft of an engine of the motorcycle to the output shaft at a selected gear or transmission ratio. To that end, the shift drum is provided with a specific index angle for each gear ratio which can be selected only in a rising or descending sequence. To select a desired gear ratio (1st gear, 2nd gear, 3rd gear and so on), the shift drum is rotated by the predefined index angle during the gear shift process through a manually operated actuator (gear shift pedal) or by an automatically operated gear shift actuator.

Such transmission systems need to be compact as there is little space to accommodate them. Accordingly, much effort has been expended in devising transmission systems which are more compact. One example is described in Honda Motor Co Ltd US 2010/0218634 which provides a multi-speed sequential transmission with a shift drum having an outer peripheral surface formed with shift guide grooves of spiral configuration. The shift guide grooves are operable to move the gear shift actuator to enable gear ratio changes. The turning of the shift drum is restricted at a turning angle corresponding to each gear speed by turning restrictive means having a restrictive member pressed against a cam surface of a turning restrictive cam mounted to the shift drum so as to be turnable as one body with the shift drum; commonly the restrictive means or restrictive member is known as a detent mechanism.

Another transmission system is described in Honda Motor Co Ltd US 2008/00821725. This transmission system includes a shift drum center with a plurality of gear train establishment notches disposed equally spaced apart from each other, on the outer periphery of the shift drum center. The gear train establishment notches establish a specific gear train selected from among a plurality of gear trains by selectively engaging a drum stopper arm therein. The shift drum center further includes half neutral notches to be engaged with the drum stopper arm. The half neutral notches are also disposed on the outer periphery of the shift drum center and at a central portion between each pair of the gear train establishment notches, respectively. The transmission system is intended to suppress an engagement noise during changing of a gear position through a sliding motion of a shifter.

For transmission systems, such as automated manual transmission (AMT) systems, packaging of actuators and sensors is difficult for two wheelers due to smaller transmission system size. The Applicant has observed further difficulty where the entire transmission is packaged on the rear wheel axis,

with limited space available for such packaging, particularly of the shifting arrangement, considering the rear wheel rim and rear suspension mounting details.

An AMT also creates additional challenges for the rider who is not able to manually de-clutch or select a gearbox neutral, which may be required or desirable in certain situations of malfunction, for example a flat battery.

OBJECTS OF THE INVENTION:

It is a first object of the present invention to provide a transmission system which is more compact, easier to package and less costly than prior art transmission systems, for example, those described above.

It is a second object of the present invention to provide a transmission system which enables effective gear shift operation with less bulky and less complex gear actuating components reducing power, and motor rating, required to operate the system. It would also be advantageous to use a lower cost, simpler control system than typically employed in transmission systems of the prior art. Whilst complexity may be aimed at precision in gear shifting, such precision comes at a cost desirable to minimise.

SUMMARY OF INVENTION

With such objects in view, the present invention provides a transmission system comprising:

- a gear shift drive system including:

- a shift drum for controlled angular movement about an axis thereof, said shift drum having an outer peripheral surface formed with a plurality of actuator grooves engageable with respective shifters to establish at least a selected gear ratio dependent on said angular movement of said shift drum; and

- a gear shift actuator for turning said shift drum, on demand, through a selected angular movement to a selected shift drum position

wherein said shift actuator for turning said shift drum holds said shift drum in said position until a further shift drum position is selected without use of a detent or stopper mechanism. The shift actuator allows the detent or stopper mechanisms used in prior art transmission systems, such as those described above, to be avoided. This assists in making the transmission system more compact as is one of the objects of the present invention. Further this makes the transmission system and the control system simple and cost effective.

The selected shift drum position advantageously corresponds to a selected gear ratio or a desired neutral position. The selected shift drum position may correspond with any other position in between dependent on shift drum control strategy.

Whilst the transmission system could be a manual transmission system, it is more conveniently an automated manual transmission or a fully automated transmission. Such transmissions offer operator convenience and comfort, for example in the case of a small vehicle, such as a motorcycle or scooter, through automating the gear shift process. Such automated transmission systems typically include a control unit for controlling operation of the transmission system. In that case, the control unit may, in accordance with a pre-determined strategy control the operation of the shift actuator so that it holds the shift drum in the required position, unacceptable error between selected shift actuator position and actual shift actuator position being reduced by initiating angular movement of the shift drum towards the selected position. A more continuous control is achievable in the absence of a detent mechanism.

Advantageously, the shift actuator includes an electric actuation motor or other comparable device including, where necessary, a reduction gearbox, for turning the shift drum through the demanded angular movement under supervision of the control unit operating in accordance with the pre-determined control strategy. The reduction gearbox may employ any of a

number of suitable gear train configurations. The reduction gear train advantageously directly engages with the shift drum without requirement for any other linkages, so saving packaging space. Such actuation motor only needs to overcome torque generated directly from shifting of the forks (typically used as shifters) and drum inertia. As no detent mechanism is employed, such actuation motor does not have to overcome any additional biasing forces as would be provided by a detent mechanism.

The shift drum actuator grooves have properties which include index, ramp and dwell angles which may be defined as follows. The index angle of a drum may be defined as the angle between subsequent gear positions, and - where neutral gears are positioned between gear positions as described below - the angle between gear and neutral positions. Index angle is the angle by which the shift drum requires to be rotated in order to reach the next position which may be a gear position or a neutral gear in the embodiment as described below.

The ramp angle of an actuator groove can broadly be defined as the slope of an actuator groove, at a particular selected position, and it determines the effort required for rotating the shift drum when shifting gear. It is the angle between the inclined portions of an actuator groove proximate the selected position and a line subtending the outer peripheral surface of the shift drum.

The dwell angle of an actuator groove is an angular measure of the, typically flat, portion (i.e parallel to the shift drum peripheral surface) at the gear or neutral positions. Within this zone, the shift fork lug does not change its axial position and thus maintains the selected position, such as the gear or neutral position, despite the rotation of the shift drum. Dwell angle assists in maintaining the required selected position despite inevitable manufacturing/stacking variations. The dwell angle also helps in positioning the gear in automated shifting as a wider drum angle is the target for the gear shift actuator rather than a precise single value which would complicate

control over the gear shift actuator. A dwell angle range can allow for a larger target drum angle and thus easier and quicker control. For example, a dwell angle range of $\pm 8^\circ$ means that for a selected gear position, the drum can be stopped anywhere in a 16° range.

The gear shift drive system allows optimisation of the shift drum, enabling more efficient use of a larger portion of its outer peripheral surface and circumference for a given duty (and drum size) than prior transmission systems. Over 300° , desirably over 330° , of the shift drum circumference can be deployed with actuator grooves extending over this sector. This enables the use of increased index angles and dwell angles, as defined above, for a given drum size. Such angular extent is significantly higher than for manual transmission systems which have ergonomic and packaging limitations on index angles and a requirement for detent mechanisms to hold the shift drum in correct position. The higher index angles in manual transmission would require higher rotation angles of the shift mechanism/linkage, hence space is to be made in the engine layout to accommodate this higher angle. On the other hand, the benefits are achieved without requiring actuation groove lengths in excess of the circumference of the drum as in some prior automated manual transmission systems. For example some prior art patents disclose excessive actuation groove length. But this has some disadvantages. One disadvantage is for sensing of the gears. Basically two or more gears would have same angular position on the drum. The control system needs to be able to differentiate between the two gears. This is particularly difficult, when the system is started after some time as there is no prior data available. Some additional logic/mechanism is required for this sensing. Another disadvantage is that the shift travel must be high enough to allow the groove overlap above 360 degrees to run side by side and still leave enough drum wall thickness between them. Shift travel of most two wheeler vehicles is not enough for this. This can be overcome by having a special gear arrangement in which the overlapping portion has both the gears travelling away from each other to create the wall thickness.

Ramp angles may also be selected, below about 40°, at relatively low values which allow selection of a smaller electrical motor for a given duty than typical for prior automatic manual transmissions as less effort is required to rotate the shift drum. A typical AMT could have the low motor size while having low ramp angles by increasing the drum diameter. The absence of a detent mechanism is also most advantageous in this respect.

A neutral position is conveniently provided between two gear positions along an actuator groove. Desirably, and advantageously for safety reasons, a plurality of neutral positions are provided for the transmission system to enable the shift drum to be brought to the nearest neutral position as quickly as possible, with minimum time lag, in case of urgency and to avoid clash. The actuator grooves of the shift drum are configured accordingly. Still more advantageously, neutral positions and gear positions are arranged alternately so that – most desirably – an intermediate neutral position is provided between each gear position along an actuator groove. Such intermediate neutral positions are actual “working” neutrals that can be held in position, so being contrasted from prior art technically neutral positions that are only effective during a gear change transition, being essentially present to ensure one gear is released before the next is engaged. Such a technical neutral position is not suitable for the Applicant’s purposes, being unstable – because of the detent and because of the bias of such a shifting drum to rotate to a gear engagement position rather than hold at the neutral position.

Each intermediate neutral position, as proposed by the Applicant, may be achieved by providing a flat land or dwell in an actuator groove of the drum shift between each gear position. This is expected to assist in a number of ways. First, effective drum neutral angle between any two gears is increased, thus making control easier (i.e. the selection of neutral is easier and faster due to wider drum angle). Second, the flat in drum profile should ensure that there is no torque/load acting on the shift drum which would result in an unstable neutral position (particularly compared to the case where the neutral

is achieved by simply stopping at a sloped portion of drum while in transition between the gears). This feature combined by the absence of a detent mechanism enables holding of any neutral position without having to spend a significant amount of energy with benefits in motor cost reduction. Thirdly, and due to the above, any intermediate neutral can be maintained easily in vehicle 'off' state (also flat battery condition) which is likely to be very helpful for moving and servicing the vehicle while in case of a breakdown or any malfunction.

It will be understood that, subject to packaging constraints, the necessity of accommodating each gear and neutral position within a 360 degree angle of rotation of the shift drum and the object of achieving a compact transmission system, each of the neutral and gear positions has a dwell angle selected to optimise control unit costs, ease of neutral and gear position selection, operator comfort otherwise and safety. For purposes of illustration, the Applicant has found that, preferably, the dwell angle for each gear position is at least ± 3 degrees, preferably at least ± 4 degrees and most preferably about ± 8 degrees. Preferably, dwell angle for neutral position is at least ± 3 degrees, more preferably at least ± 4 degrees. The transmission system is a sequential transmission and the angular movement required to rotate the shift drum between each gear position is also called the "index angle". The transmission system may also include any desired number of gear ratios though four, five or six gear ratio or speed systems are preferred in the marketplace. Index angle for automated manual transmission systems or automatic transmissions can exceed those attained or it can have the same index angle as in manual transmission systems (60 degrees maximum for 6 speed transmission and 72 degrees maximum for 5 speed transmission) where rider comfort places limits on index angle range and use of the circumference of the shift drum to implement various gear selection options. Preferably, the index angle for each gear position in a six speed transmission automated manual transmission system as described exceeds 60 degrees. . Preferably, the index angle for each gear position in a four speed transmission

automated manual transmission system may exceed 90 degrees and could extend up to 108 degrees; for a five speed transmission automated manual transmission system as described exceeds 72 degrees, advantageously with a maximum at 80 degrees or more (say for example 81 degree); and for a six speed transmission automated manual transmission system could extend from 60 degrees up to 65 degrees subject to constraints imposed, for example, by gear shift position sensors. The magnitude of these index angles, as well as the dwell angles mentioned above, reduces gear shift actuator complexity and bulk and transmission control system costs in comparison with transmission systems with more constrained index angle and dwell angle ranges. Gear shift performance is also improved.

The transmission system may include any convenient number of shafts, for example input and output shafts (2 shaft system) or input, intermediate and output shaft (3 shaft system). A three shaft system is particularly desirable for use in rear wheel driven motorcycles and scooters, ensuring that input and output shafts rotate in the same direction which is operationally convenient. In a three shaft transmission system, according to the invention, an intermediate shaft or layshaft, is disposed in parallel relation with the input and output shafts described above. Forward input gears are meshable with corresponding gears on the intermediate shaft, such corresponding gears also being meshable with the forward output gears in the selected gear ratio. In this situation, which is particularly convenient where a chain or belt drive is used to transmit engine drive to the driven wheel(s) of a vehicle, the forward input gears and forward output gears are indirectly meshable in the selected gear ratio. In a two shaft transmission system, having input and output shafts according to the invention, the forward input gears and forward output gears are directly meshable in the selected gear ratio.

The transmission system is a non-synchromesh transmission, advantageously operable in constant or sliding or clash mesh, advantageously using the positive drag mechanism as described in the Applicant's co-pending Indian

Patent Application the contents of which are hereby incorporated herein by reference, if necessary. The expense of synchromesh mechanisms can thus be avoided.

The transmission system may include a reverse gear. The shift drum may have a modular construction as described in Indian Patent No 2282/CHE/2007, the contents of which are hereby incorporated herein by reference.

Engines and/or vehicles including transmission systems as described above form another aspect of the present invention. Whilst such transmission systems are applicable to a wide range of vehicles, the transmission system may be used, to particular advantage, in two or three wheeler vehicles, especially motorcycles and scooters.

BRIEF DESCRIPTION OF DRAWINGS

In the drawings:

Figure 1 is a sectional view of a sequential transmission system according to one embodiment of the present invention

Figure 2 is a cross sectional developed view of the sequential transmission system of Figure 1 showing the gear shift actuator system.

Figure 3 is a front view of the gear train of the sequential transmission system as shown in Figure 2.

Figure 4 is a detail side cross-sectional view of the drum shift and drum shift actuator of the sequential transmission system as shown in Figures 1 to 3.

Figure 5 is a rear side view showing the sequential transmission system and its relationship to the rear wheel of a motorcycle employing the sequential transmission system.

Figure 6 is an isometric view of the shift drum of the sequential transmission system as shown in Figures 2 to 5.

Figure 7 is a top view of the shift drum of Figure 6 showing its mounting in the transmission system and

Figure 8A is a developed view of the shift drum for a five speed transmission shown in Figures 6 and 7.

Figure 8B is a developed view of the shift drum for a five speed transmission shown in Figures 6 and 7 showing index and ramp angles for the shift drum.

Figure 9 is a developed view of the shift drum for a five speed transmission according to prior art transmission system.

Figure 10 is a developed view of a shift drum similar to that shown with reference to Figure 9 and applied to a six speed transmission shown as another prior art transmission system.

Figure 11 is a view of a handlebar of a motorcycle including the transmission system illustrated with reference to Figures 1 to 8.

DESCRIPTION OF PREFERRED EMBODIMENTS

Description of preferred but non-limiting embodiments of the transmission system of the present invention will now follow with reference to the above drawings.

Referring now to Figures 1 to 7, there is shown an automated manual transmission system 10 mounted in a scooter type motorcycle for transmitting power from the crankshaft 200 of a single cylinder internal combustion engine 150 to which it is mated to the rear wheel 300 (as conveniently shown in Figure 5) through a drive chain 90 and, through operation of the transmission system 10, at a desired gear ratio.

Cylinder 400 is shown together with its associated con rod 410 connecting its piston to the linkage 415 for providing drive to the crankshaft 200 as a gaseous or liquid fuel is combusted in cylinder 400. Magneto 270 is also shown mounted to crankshaft 200. The crankshaft 200 and linkage 415 are mounted within crankcase 210.

Rotation of the crankshaft 200 causes rotation of drive sprocket 205 and chain 90. A substantial portion of the chain drive 90 is enclosed within chain case 220. Chain drive 90 is lubricated using a lubrication system (not shown). To facilitate operation of transmission system 10, the direction of rotation of the chain drive 90 is made common with the engine (through crankshaft 200) and the rear wheel 300 by including intermediate shaft 23.

Automated manual transmission system 10 includes a powertrain housing 20 which is separated and made distal from, though integral with, engine crankcase 210 by chain case 220. Rotatably mounted within powertrain housing 20 is the rotating output sprocket 95 of drive chain 90. The output sprocket 95 rotates essentially at a speed equal to engine speed divided by reduction ratio, through the transmission system 10 is required for driving rear wheel 300. To that end, the output sprocket 95 is engageable with the primary gear 94 of an input shaft 22 rotatably mounted to the housing 20, through operation of clutch 60 by automatically controlled clutch motor 620, required speed being achieved through establishment of a gear ratio.

Transmission system 10 is a sequential drum shift transmission system having five gear ratios in the illustrated embodiment and includes input, intermediate and output gear trains comprising three gears for each of the input shaft 22 (gears 22a-22c), intermediate shaft 23 (gears 23a-23c) and output shaft 24 (gears 24a-24c).

Movement between the gear ratios, in sequential manner, involves a gear shift drive system 35 including a gear shift drum 40 and a shift drum drive 45

for turning the shift drum 40, on demand, through a selected angular movement to a position corresponding to a selected gear ratio. Arrangement of the components of gear shift drive system 35, including gear shift detector or potentiometer 411 and its protective cover 412, is conveniently shown in Figures 4 and 7. The absence of detent mechanisms may especially be noted.

Shift drum 40 is provided on its outer peripheral surface 40B with three actuating or cam grooves 40A, each corresponding with the respective input shaft 22, intermediate shaft 23 and output shaft 24, which extend around substantially the whole circumference, approximately 330° , of the shift drum 40. Use of a substantial portion of the circumference of the shift drum 40 enables a higher index angle (I) and higher dwell angle (D) without increasing the ramp angle (R) and without increasing the drum diameter. This assists in achieving the object of transmission system compactness without requiring ramp angle selection which would require a larger electric motor for a given duty. Actuator grooves 40A have a relatively low ramp angle (R), as shown in Fig. 8A, about 36° .

The configuration of actuator grooves 40A, which accommodate and enable sliding movement of shift forks 47a-47c (respectively operating the respective gear trains G_i , G_{in} and G_o to establish the gear ratio required by the transmission control unit) within them through an index angle (I) of rotation of shift drum 40 enabling change in gear ratio under control of the transmission control unit will be described further below.

Shift drum drive 45 comprises an electric gear shift motor 120, a stepper motor, operated on demand by the transmission control unit, mounted using suitable bearings 20B to portion 20A of the housing 20. Shift motor 120 has an output shaft 121 projecting into a reduction gearbox comprising a reduction gear train including a drive gear 122 forming a splined portion of output shaft 121, sector gear 123, driving gear 124 and driven gear 41

connected to an axle 42 of shift drum 40. Axle 42 has an axis also in parallel with input shaft 22, intermediate shaft 23 and output shaft 24. Sector gear 123 is rotatably mounted on shaft 127 and driving gear 124 is formed integral with rotatable shaft 127. Connected to shaft 127 is a clashmesh mechanism 300 to reduce jerk when the drive gear 122 rotates, during operation of shift motor 120, rotating sector gear 123 and shaft 127 and its fixed driving gear. Spring 310 of clashmesh mechanism 300 urges the sector gear 123 into engagement with driving gear 124.

The gear shift actuator 35, as described above, allows the detent or stopper mechanisms used in prior art transmission systems, such as those described above, to be avoided. This assists in making the transmission system more compact as is one of the objects of the present invention. At the same time, sizing of electric stepper motor 120 can be reduced for the given duty since there is no need for stepper motor 120 to provide energy to overcome the biasing forces generated by a detent or stopper mechanism.

Operation of gear shift actuator 35 is controlled by a transmission control unit in accordance with a pre-determined control strategy and with minimal operator, i.e rider, involvement. The control unit therefore causes the shift drum 40 to turn through a required angular movement, or index angle, through use of a shift drive system as described below.

Angular movement of shift drum 40, by controlled movement on operation of electric gear shift motor 120 (for example a stepper motor), by the transmission control unit, causes its associated shifters or forks 47a-47c to controllably slide along cam grooves 40a to move splined gears included in each of the gear trains described above into position to establish the required gear ratio under control of a transmission control unit (not shown). Such operation of a gear shift drive system corresponds with that known in the art.

Angular movement of shift drum 40 when demanded for a gear shift is sensed by potentiometer 411 and input to the transmission control unit which will command corrective action to reduce any error between sensed or actual position of the shift drum 40 and required position to properly establish a gear ratio. Transmission control unit may also implement strategies to reduce torque during a gear shift by various strategies, for example as described in the Applicant's Indian Patent No.3470/CHE/2011.

Shift forks 47a-47c are slidably mounted on guide shafts 471, 472 and 473 and move into position, as they move along actuator grooves 40A to bring required gears in gear trains G_i , G_{in} and G_o into engagement to establish a gear – when commanded by the transmission control unit - by positioning shift forks 47a-47c in particular portions corresponding with each gear within each actuator groove 40A.

The portions corresponding with each gear are shown, in Figures 8A-C marked "1", "2", "3", "4" and "5" for each of actuator grooves 40A. Figure 10, being for a six speed transmission has an additional gear position "6". These positions are separated by an index angle (I) at least 60° as shown for the six speed transmission in Figure 10 and it is possible to reach 81° as shown in Figures 8A and 8B. The alternative five speed transmission of Figure 9 has an index angle (I) of 72° . Such index angle (I) compares with 60° or less in prior art transmission systems. The magnitude of the index angle achievable for transmission system 10 reduces gear shift actuator complexity, cost and ease of operation compared with such prior transmission systems, especially when factors as further described below are accounted for.

The peripheral surface of shift drum 40 is used more efficiently and position of the shift drum 40 corresponding with a selected gear ratio extends over a larger angular interval or "dwell angle" (D) than in shift drums of prior art transmission systems. This facilitates gear selection and also accommodates variability in manufacturing of components, particularly the shift drum 40.

Shift drum 40 provides a dwell angle (D) for each gear of at least ± 4 degrees for every gear position including 1st and 5th gear endstop positions. For 2nd to 4th gear positions, dwell angle (D) is ± 8 degrees. For the shift drum 40 shown in Figures 8A and 8B, 332 degrees of the circumference is efficiently used (i.e. $4 \times 81 \times 4 + 4(1^{\text{st}} \text{ gear}) + 4(5^{\text{th}} \text{ gear})$), this only being limited by the detection range of potentiometer 411 to 334 degrees.

Another benefit of such dwell angle range is that the required transmission control unit does not need to operate so precisely, so saving cost whilst noticeably facilitated.

Gear shift drive bulk and inertia can also be reduced in comparison with prior transmission systems, not least because it is no longer necessary to select electric motor 120 to overcome the biasing forces of a detent mechanism.

Desirably, and advantageously for safety reasons, a plurality of neutral positions, N, in which a forward gear ratio is not selected are provided for the transmission system 10. This means that the rider can move the motorcycle engine quickly to neutral position. To that end, a neutral "N" position is provided alternately between each gear position 1-5 with the actuator grooves 40A of the shift drum 40 being configured accordingly by providing a flat land or dowel in actuator groove 40A between each gear position 1-5 as shown in Figures 8A and 8B. Still more advantageously, neutral positions and gear positions are arranged alternately so that – most desirably – an intermediate neutral position is provided between each gear position at about 40.5 degrees of index angle between each gear position as shown in Figure 8B. Dwell angle for each neutral position in the illustrated shift drum 40 is at least ± 4 degrees. A relatively low or shallow ramp angle, here about 36 degrees, as noted hereinabove is also achievable with shift drum 40 diameter being 42mm. Such working intermediate neutral positions, and the configuration of these positions, has the advantages described above.

The five speed transmission illustrated with reference to Figure 9 and the six speed transmission illustrated with reference to Figure 10 has a single neutral position at 36° and 30° respectively between 1st and 2nd gear position according to prior art.

At least one neutral position N can be actuated by the rider using a manually operable neutral position selector. An operator might select this or any of the neutral positions in the event of urgency, such as a technical problem with the motorcycle. The plural neutral positions also assist in avoiding clash. A switch 502 is provided on handle bar 500 to command, via the transmission control unit, movement of shift drum 40 to bring the gears to nearest neutral position as shown in Figure 11. Once the transmission is in neutral position, the motorcycle with transmission system 10 can typically be more readily moved to a repair location.

Transmission system 10 is a convenient inclusion within motorcycles and scooters with benefits in terms of packaging, motor rating and cost. On motor rating, shift motor 120 as described herein has power of 32W. Approximately 30% more power would be required for a conventional like AMT system considering higher ramp angle and the presence of detents. Even more power might be required dependent on the strength of detents. Such power requirements would add to cost demonstrating the cost advantages of transmission system 10...

Modifications and variations to the transmission system described in this specification may be apparent to skilled readers. The applicant also relies upon the provisional specification and drawings submitted with provisional specification for the purpose of disclosure of this complete specification. Such modifications and variations are deemed within the scope of the present invention.

WE CLAIM :

1. A transmission system comprising:

a gear shift drive system including:

a shift drum for controlled angular movement about an axis thereof, said shift drum having an outer peripheral surface formed with a plurality of actuator grooves engageable with respective shifters to establish at least a selected gear ratio dependent on said angular movement of said shift drum; and

a gear shift actuator for turning said shift drum, on demand, through a selected angular movement to a selected shift drum position

wherein said shift actuator for turning said shift drum holds said shift drum in said position until a further shift drum position is selected without use of a detent or stopper mechanism.

2. The transmission system of claim 1 wherein said selected shift drum position corresponds to a selected gear ratio or a desired neutral position.

3. The transmission system of claim 1 or 2 including a control unit which, in accordance with a pre-determined control strategy, controls the operation of the shift actuator so that it holds the shift drum in the required position, unacceptable error between selected shift drum position and actual shift drum position being reduced by initiating angular movement of the shift drum towards the selected position.

4. The transmission system of claim 3 wherein said shift actuator includes an electric actuation motor including a reduction gearbox for turning the shift drum through the demanded angular movement under supervision of the control unit operating in accordance with the pre-determined control strategy and wherein the reduction gearbox has a reduction gear train directly engages with the shift drum without requirement for any other linkages.

5. The transmission system of any one of the preceding claims wherein over 300°, preferably over 330°, of the shift drum circumference is deployed with actuator grooves extending over this sector.

6. The transmission system of any one of the preceding claims wherein an index angle being the angular extent between selected positions exceeds 60 degrees for a 6 speed transmission and exceeds 72 degrees for a 5 speed transmission and exceeds 90 degrees for a 4 speed transmission.

7. The transmission system of claim 6 wherein maximum index angle for a 6 speed transmission is 65 degrees and maximum index angle for a 4 speed transmission is 108 degrees.

8. The transmission system of claim 6 wherein said index angle exceeds 80 degrees for a 5 speed transmission.

9. The transmission system of any one of the preceding claims wherein a dwell angle being an angular extent in which a selected position of the shift drum is maintained for a given drum size is at least +/-3 degrees, preferably at least +/-4 degrees and most preferably about +/- 8 degrees.

10. The transmission system of any one of the preceding claims wherein a ramp angle below about 40° is selected for a selected position.

11. The transmission system of any one of the preceding claims wherein a neutral position is provided between two gear positions along an actuator groove.

12. The transmission system of claim 11 wherein a plurality of neutral positions are provided.

13. The transmission system of claim 12 wherein each neutral position is provided between each gear position along said at least one actuator groove.

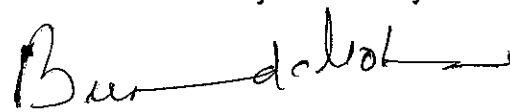
14. The transmission system of any one of the preceding claims being a non-synchromesh transmission,

15. An engine mated with a transmission system as claimed in any one of the preceding claims.

16. A vehicle including the transmission system of any one of claims 1 to 14 and/or the engine of claim 15.

Dated on this the 22nd day of December, 2016.

For **BAJAJ AUTO LIMITED,**
By its attorney


(**BRINDA MOHAN**)
INPA269

Application No. : 4942/MUM/2015

Title : **A TRANSMISSION SYSTEM**

Applicant name: Bajaj Auto Limited

ABSTRACT

A transmission system (10) comprising:

- a powertrain housing (20); and

- a gear shift drive system (35) mounted within said powertrain housing (20) including:

- a shift drum (40) mounted for controlled angular movement about an axis thereof, said shift drum (40) having an outer peripheral surface (40B) formed with a plurality of actuator grooves (40A) engageable with respective shifters (47a-c) to establish at least a selected gear ratio dependent on said angular movement of said shift drum (40); and

- a gear shift actuator (120) for turning said shift drum (40), on demand, through a selected angular movement to a selected shift drum position wherein said shift actuator (120) for turning said shift drum holds said shift drum (40) in said position until a further shift drum position is selected.

Figure 1



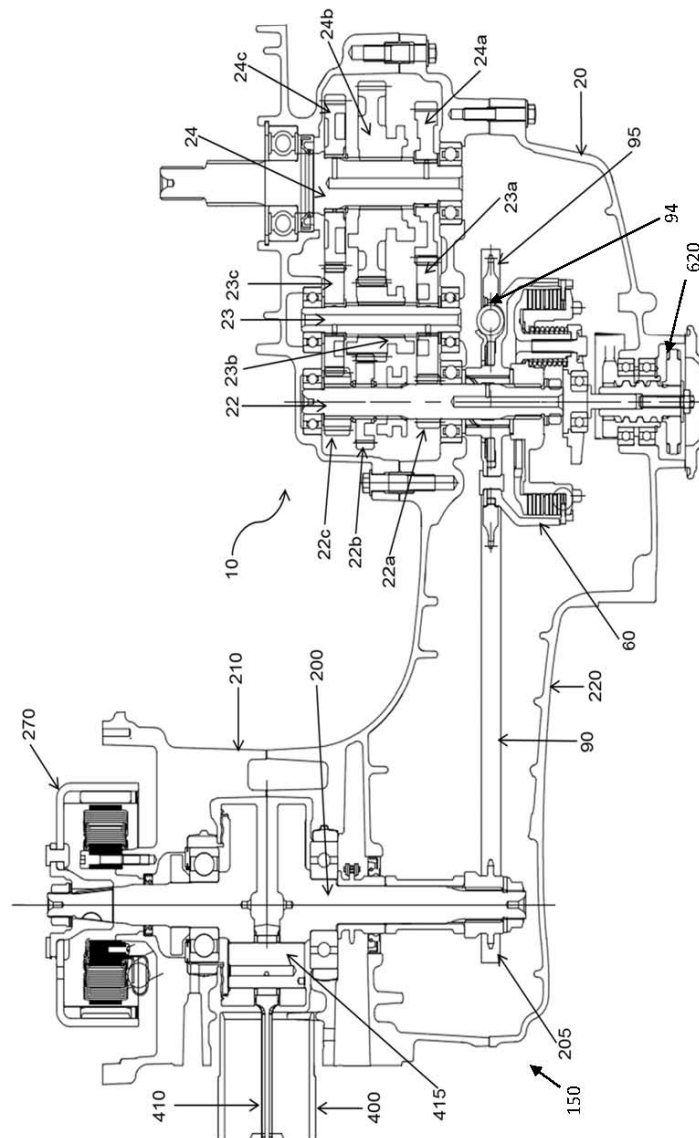


FIGURE 1

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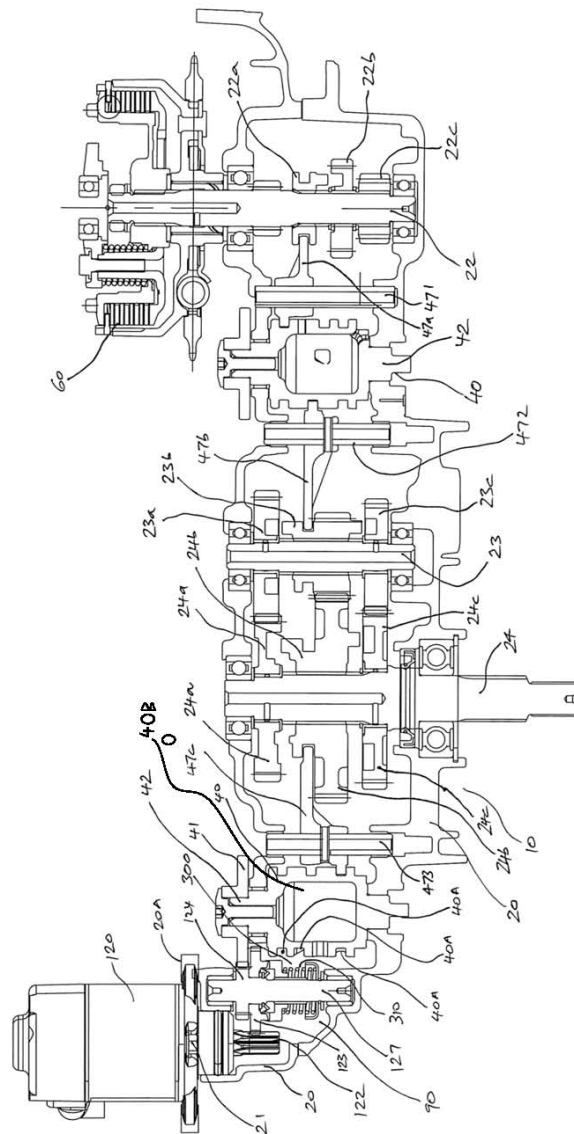


FIGURE 2

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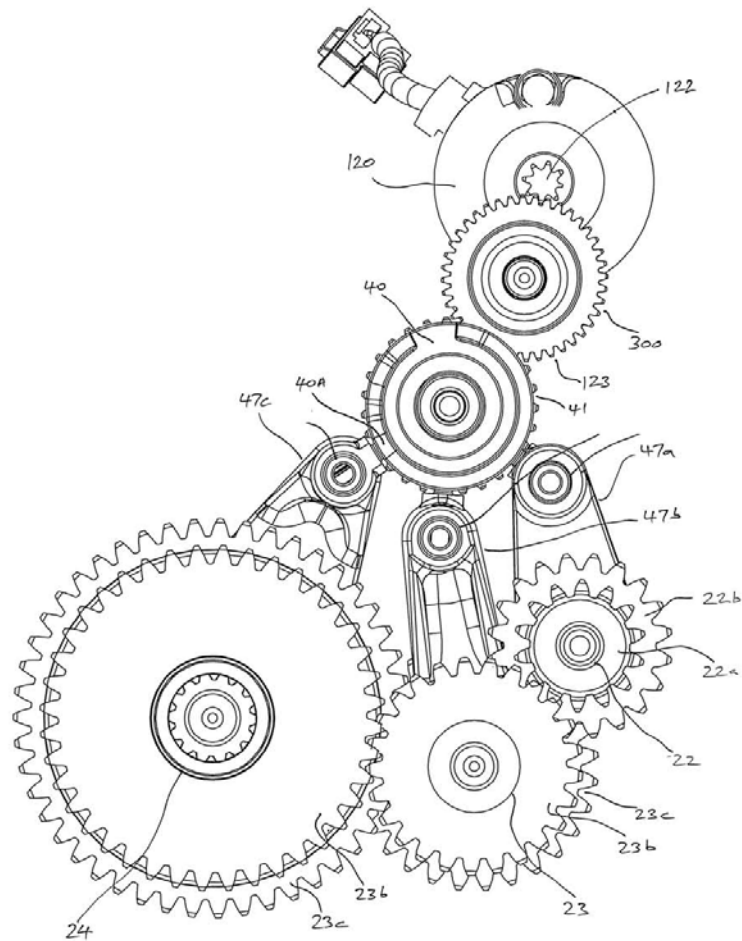


FIGURE 3

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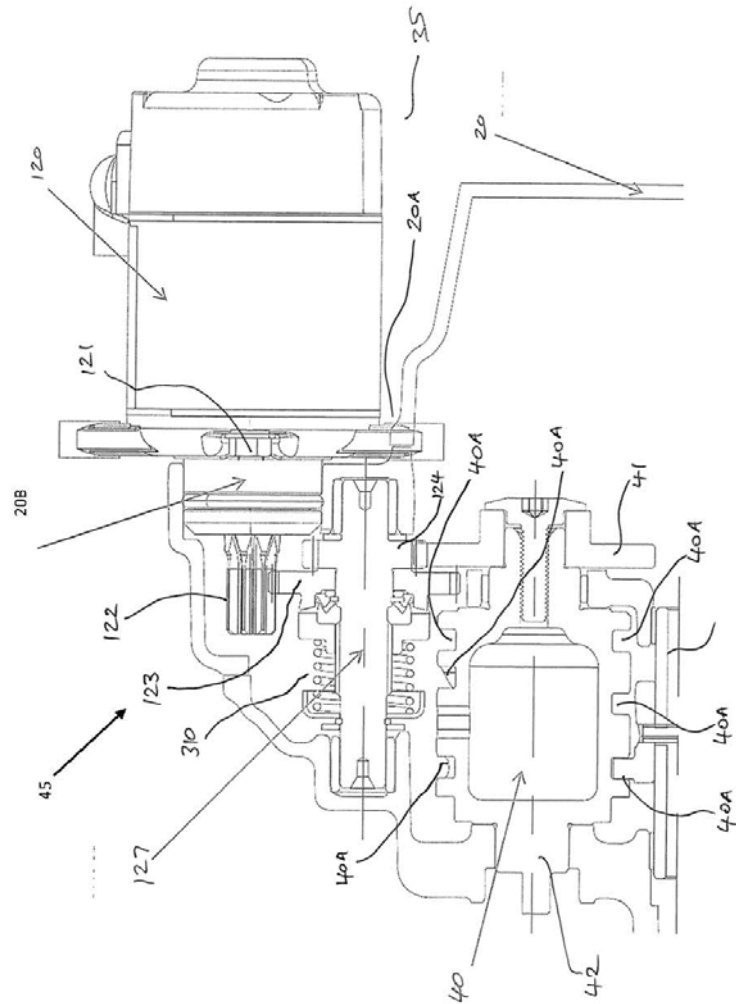


FIGURE 4

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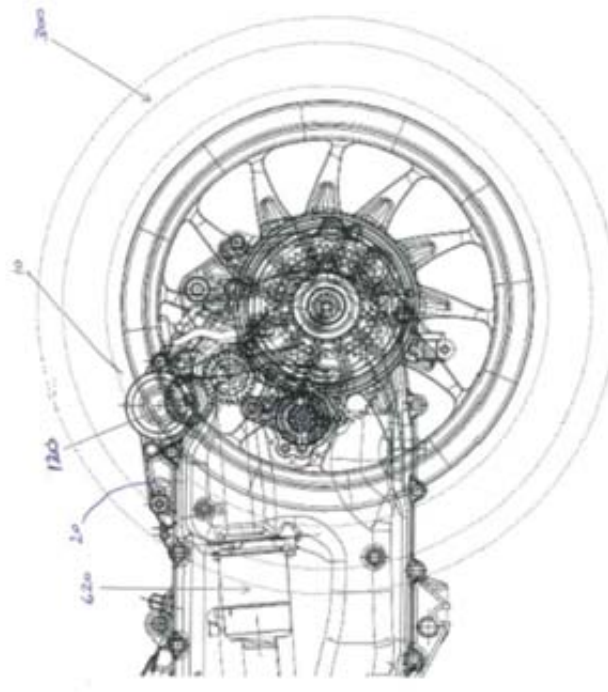


FIGURE 5

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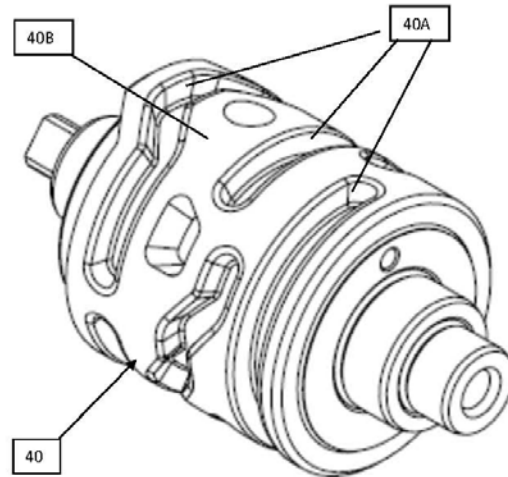


FIGURE 6

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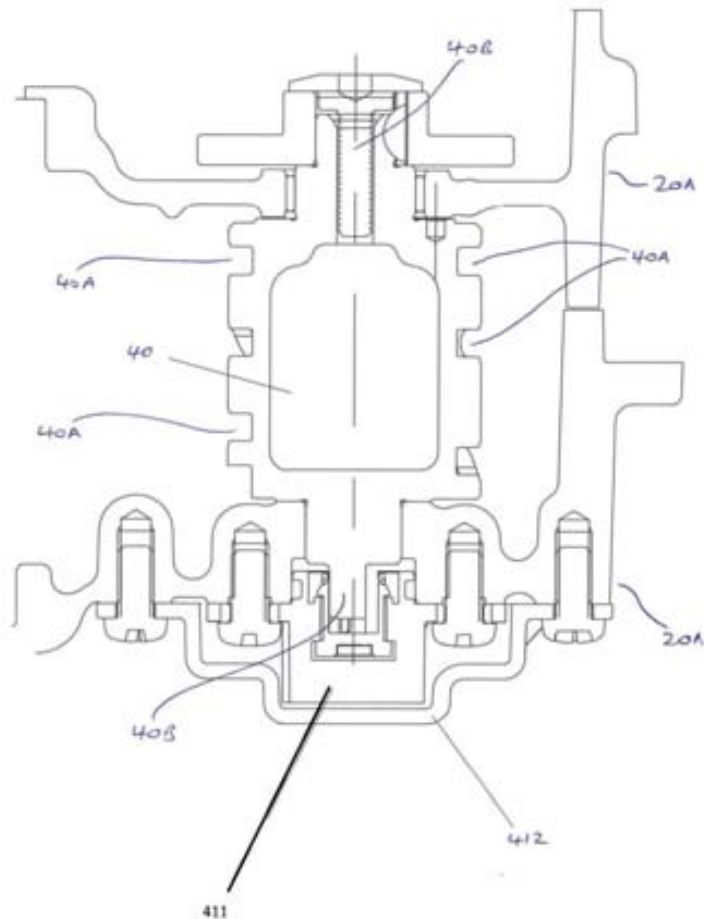


FIGURE 7

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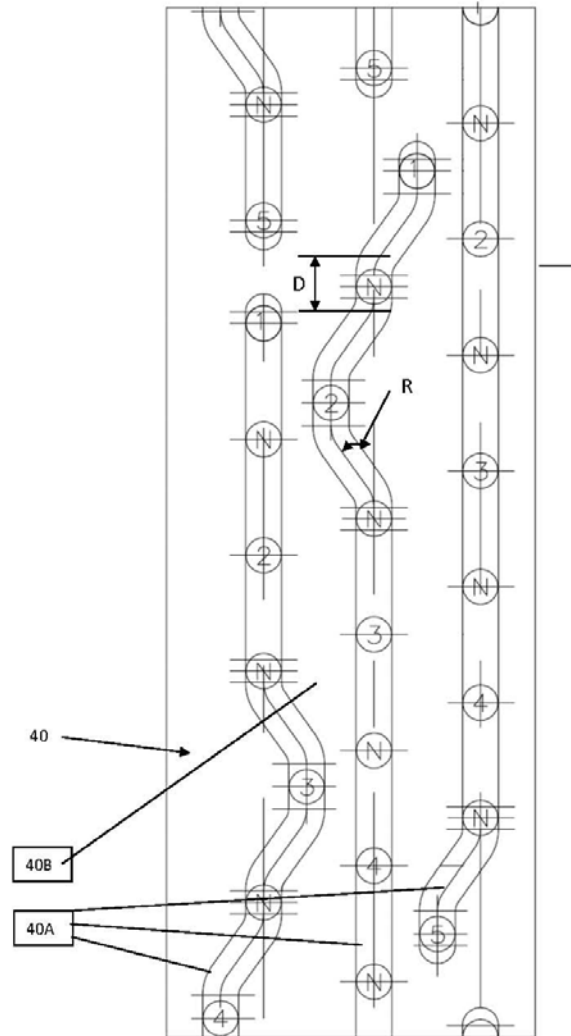


FIGURE 8A

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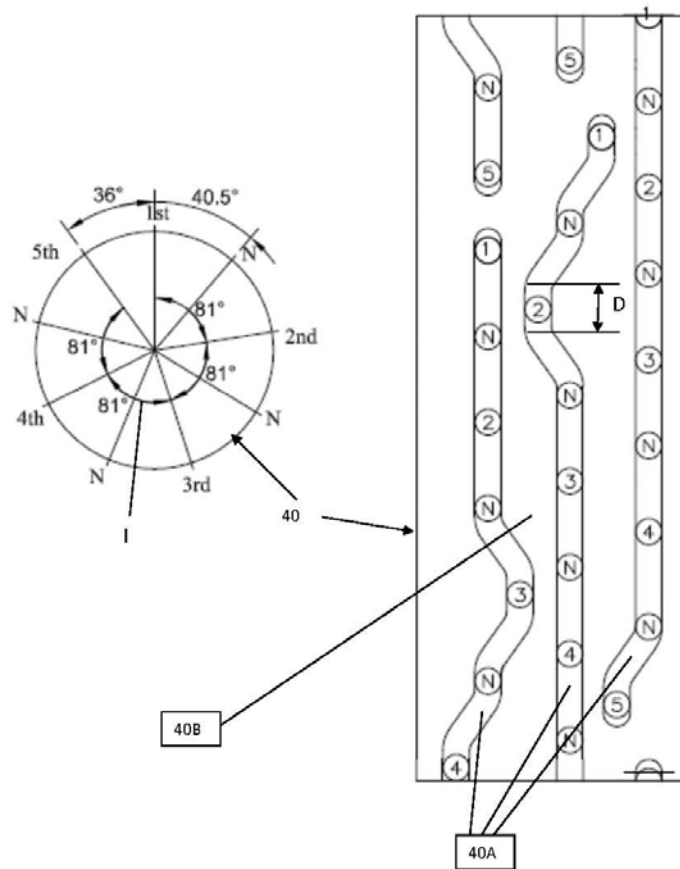


FIGURE 8B

Dated on this the 22nd day of December, 2016.

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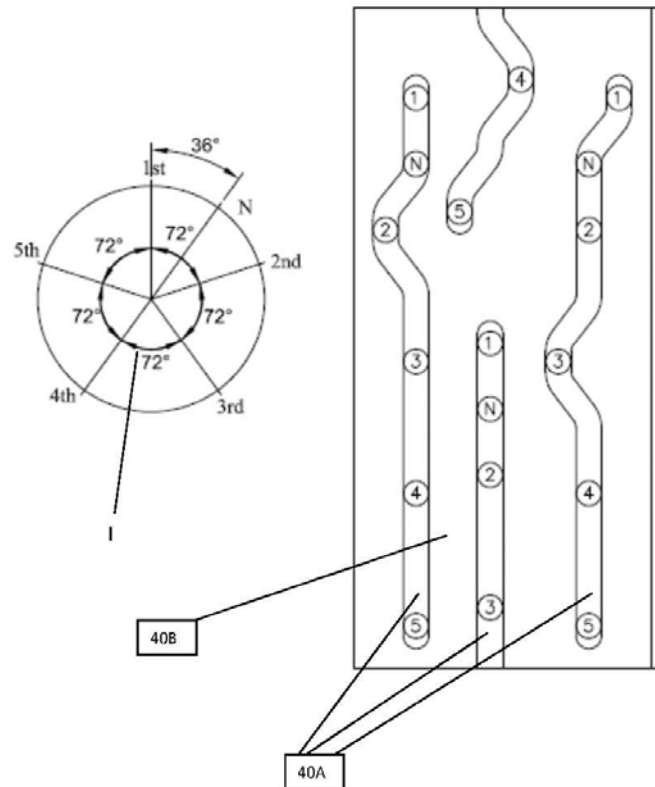


FIGURE 9

Dated on this the 22nd day of December, 2016.

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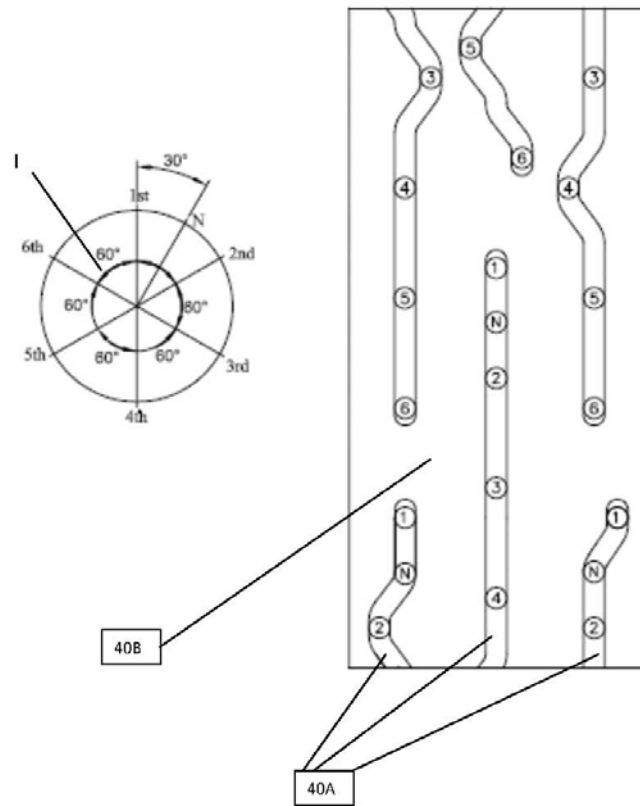


FIGURE 10

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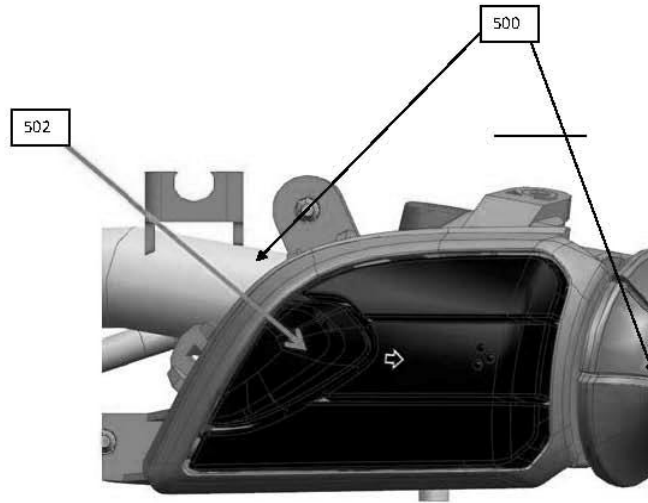


FIGURE 11

Dated on this the 22nd day of December, 2016.

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