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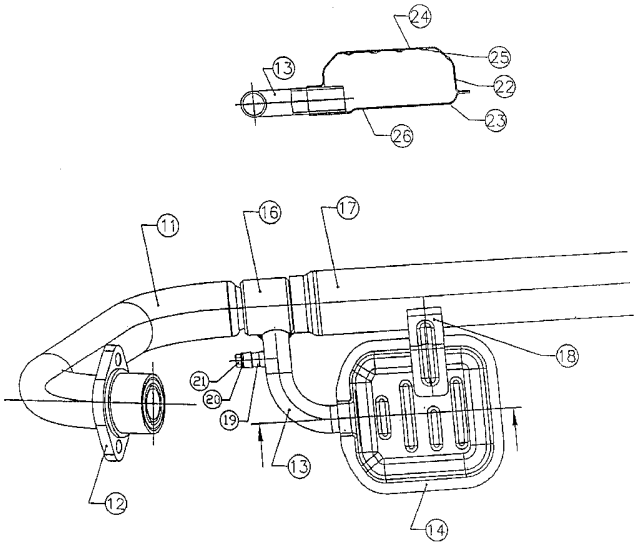
(54) Title: AN IMPROVED EXHAUST SYSTEM OF A SINGLE CYLINDER FOUR STROKE SPARK IGNITION ENGINE



(57) Abstract: An exhaust system for improving the torque characteristics of a single cylinder for stroke spark ignition engine which exhaust system comprises a header pipe (1), a chamber (14) and a muffler (15); one end with exhaust flange (12) of the said header pipe being adapted for connection to an engine exhaust port and the other end being connected to the said muffler (15); the said chamber (14) being connected between said one end with exhaust flange (12) and said muffler (15) at a point preferably between 40% to 60% of developed length of header pipe from the face of the said exhaust flange (12) along the length of said header pipe.

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AN IMPROVED EXHAUST SYSTEM OF A SINGLE CYLINDER FOUR STROKE SPARK IGNITION ENGINE

The present invention relates to an improved exhaust system of a single cylinder four stroke spark ignition engine.

The invention relates to improvement in exhaust system of single cylinder four stroke spark ignition engine used in vehicles, which results in enhanced performance.

More particularly the invention enables an improvement in the torque production of the engine at lower engine speeds. For example, the applicant has designed engines utilizing the invention in which torque improvements have been made at engine speeds ranging from 3000 to 5000 RPM, which is typically a normal vehicle driving zone, while still achieving high power outputs at higher engine speeds. This invention is especially useful to engines used as prime movers for two and three wheeled vehicles. For simplicity of explanation, a reference to "vehicles" in this specification should be taken to be a reference to vehicles using single cylinder, four stroke, spark ignition engines and a reference to 'engines' in this specification is meant for single cylinder, four stroke, spark ignition engines.

Vehicles are generally equipped with an exhaust system in order to achieve desired performance characteristics of the engine, reduce noise of combustion from of the engine and to allow products of combustion of air-fuel mixture to escape to the atmosphere in a defined direction. For example, a simple motorcycle exhaust system consists of header pipe, a muffler and if necessary, a guard or heat

shield. The header pipe may be of single diameter or with one or more steps of different diameters. One end of the exhaust system is attached to the exhaust port of the engine and other end is at the rear of vehicle. The exhaust system is neatly packaged within the space available in the motorcycle.

One of the difficulties experienced with conventional exhaust systems for the above mentioned engines is that when the exhaust system is designed to achieve desired performance levels, adequate compromise between available torque at lower speeds and performance at higher speeds is difficult. Hence, to achieve better performance, particularly maximum net power at higher engine speeds, it is often necessary to sacrifice the better torque availability at lower engine speeds.

Yet another difficulty is that the improvement in performance, usually, is associated with increase in noise level which is undesirable and may also exceed statutory limits.

In order to overcome at least some of the above problems, the applicants have invented an exhaust system wherein higher torque is produced at lower engine speeds whilst still retaining the desired engine performance and torque at higher engine speeds and also maintaining desirable noise levels. This is achieved by connecting a chamber of predetermined volume, externally to the header pipe (stepped or otherwise) of the exhaust system at a point preferably between 40% to 60% of developed length of the header pipe from the face of exhaust flange along the length of said header pipe either directly or through a connecting tube. Conveniently, the location of

the chamber is selected to accommodate it within available space in motorcycle and without sacrificing the ground clearance.

Usually, if a typical known engine is tuned to have a maximum net power at 8000 RPM, then a good engine can achieve a peak torque at 6000 RPM. In this case, the torque at 3500 RPM would be approximately 15% lower than the peak torque. This leads to poor driveability of vehicle at low engine speeds, while giving good performance at higher engine speeds. On the contrary, if the engines were to be tuned to achieve peak torque at lower speeds, for instance 5000 RPM, the peak power would occur at approximately 7000 RPM but would normally be of lesser value. Based on a comparison using the same vehicle gear ratios, this would mean that the vehicles with such engines would have
better low speed drivability but poorer high-speed performance.

In order to achieve better performance of this engine, the applicants' improved exhaust system according to this invention enables at least two torque peaks to be produced in the torque vs. engine speed relationship.

In a certain embodiment of the invention, one of the torque peaks occurs at approximately 4500 engine RPM and second at approximately 6000 engine RPM. In such an application, it was found that the exhaust system enables availability of torque at 3500 RPM to be within 5% of the peak torque at 6000 RPM.

The improved exhaust system according to the present invention works on the principles of pulse tuning of the exhaust system. The

chamber of a pre-determined volume is connected directly or by a tube of pre-determined diameter and length to header pipe at a developed distance preferably ranging from 40% to 60% of the total developed length of header pipe from the face of the exhaust flange. The two torque peaks are produced by the combination of reflection of pressure waves at the end of header pipe and that at the mouth of chamber.

In the past, various inventions were carried out in the field of exhaust systems. However, their teachings are very different to the present invention, for an example:

1) US4779415: Illustrates use of a Helmholtz resonator attached to the exhaust manifold of a **multicylinder engine** for the purposes of noise suppression. Multicylinder engines are subject to very different exhaust gas dynamics as compared to single cylinder engines. The overlapping exhaust pulsations of a multicylinder engine create opportunities for exhaust tuning effects, which are not available to single cylinder engines.

2) JP11-062547: Illustrates the use of Helmholtz resonators in an engine exhaust system which teaches to create specific frequency of waves by resonator effect by means of Helmholtz resonator, which silences the system resonance. As for the above case, the teachings are also illustrated with reference to multi-cylinder engine applications.

Therefore, there are no teachings in these patents directed to torque enhancement and the special requirements for single cylinder engines, in clear contradiction to the applicants' teachings.

The invention will now be further elaborated with reference to following figures enclosed with this specification: -

Fig 1 – Illustrates a typical exhaust system of engines according to the prior art.

Fig 1A - Illustrates top view of location of typical exhaust system in motorcycle according to prior art

Fig 1B - Illustrates side view of the location of typical exhaust system in motorcycle according to prior art

Fig 2 – Illustrates torque curve of a typical engine according to the prior art.

Fig 3 – Illustrates an exhaust system incorporating a chamber according to the present invention.

Fig 3A: - Illustrates top view of location of typical exhaust system in motorcycle according to the present invention.

Fig 3B: - Illustrates side view of location of typical exhaust system in motorcycle according to the present invention

Fig 4 – Illustrates details of joining the chamber to header pipe of exhaust system of engine according to the present invention.

Fig 5 – Illustrates typical torque curve of engine fitted with improved exhaust system according to the present invention.

In one embodiment, an improved exhaust system according to the invention comprises of a header pipe small (11), an exhaust flange (12), a connecting tube (13), a chamber (14), a tube (16), a header pipe large (17), a nipple (19), a washer (20), a bolt (21) and bracket (18).

Fig.1, 1A and 1B illustrate a typical exhaust system and its location according to the prior art. It consists of header pipe (1) one end of which is assembled with flange (2). The flange (2) is connected to cylinder head (not shown) of the engine with suitable bolts or studs and nuts. The other end of the header pipe is either welded or assembled to the muffler (3). Exhaust gases from the cylinder head are led to the said header pipe and then to the muffler and then released to the atmosphere. The heat shield (4) provided on the muffler guards the rider and pillion from the heat of the exhaust system. This exhaust system is well known and does not need any detailed explanation.

Fig 2 illustrates typical wide open throttle torque curve of a typical engine fitted with the exhaust system according to prior art. It is observed from the curve that the peak torque is occurring at around 6500 engine RPM.

Figs 3, 3A, 3B and 4, illustrate an improved exhaust system according to the invention having a chamber (14), a connecting pipe (13) connecting said chamber to tube (16), said tube (16) being positioned between a front header pipe (11) and rear header pipe

(17), the header pipe (11) being provided with an exhaust flange (12) and said rear header pipe (17) is connected to the said muffler (15).

As an alternative to using the tube (16) as an intermediate connector between the front header pipe (11) and rear header pipe (17) the connecting pipe (13) could be welded directly to header pipe (1) as shown in fig (1).

As an alternative to connecting the said connecting tune (13) and said chamber (14) to the header pipe (1), the said chamber (14) could be welded directly to header pipe (1) as shown in fig (1).

As shown in Figs 3, 3A, 3B and 4 the header pipe (1) is split as a front header pipe (11) and a rear header pipe (17). The ends of said front and rear header pipes connecting to the engine exhaust and the said muffler are identical to the header pipe (1). The developed length of said front header pipe (11) is decided considering the parameters like engine power, torque requirement at various engine revolutions, diameter of the pipe etc. In order to strengthen the fitment of chamber (14), a tube (16) is welded joining the rear header pipe (17) and the said chamber (14). The muffler (15) is connected to rear header pipe (17). The said connecting tube (13) is provided at a point, preferably 40% to 60% of developed length of header pipe (that is the combined length of the front and rear header pipes and connecting tube) from the face of said exhaust flange (12) along the length of the said header pipe. The connecting tube (13) or tube (16) is provided with a nipple (19). The other end of nipple is threaded which is closed by means of a washer (20) and a bolt (21). The said washer and bolt can be removed to

allow for the convenient measurement of exhaust gas emission values by a suitable instrument. Bracket (18) is provided between the chamber (14) and rear header pipe from strength considerations.

The chamber (14) is of a pre-determined volume and is made of two sheet metal halves welded together. Conveniently, reinforcing dimples (25) are added to the top surface (24) of the chamber (14) to provide rigidity and reduce noise caused by the vibration of this surface. An additional convenient feature of the present embodiment is the location of the bottom surface (26) of the chamber (14) to be slightly higher and sloped downwards towards the connecting pipe 13. This allows for any accumulated moisture to drain from the chamber (14) back into the exhaust system.

The length of connecting pipe (13) is so chosen that the desired result of improvement in torque characteristics is achieved and the said chamber is well located beneath the motorcycle in available space without sacrificing ground clearance. This is a very simple matter of design and in some cases can be readily determined with non-inventive trial and error.

Fig 3A and 3B illustrates a typical such location. The shape of the chamber and construction can vary with location on motorcycle.

Fig 5 illustrates typical wide open throttle torque performance curves of the engine fitted with the exhaust system according to depicted embodiment of the invention with respect to the engine speed in RPM. It can be observed that the torque of the engine between the speed range of 3000 to 5000 RPM which is the normal vehicle driving zone for a typical motorcycle has substantially improved, while

maintaining substantially the original toque at engine speeds beyond 7000 RPM which is important for the performance of the engine. The applicants have carried out substantial testing and concluded that improvement in torque of a typical engine in the speed range between 3000 to 5000 RPM is of the order of 5 to 7%. Also, the vehicles do meet statutory requirements of noise level.

An improved exhaust system for vehicles as described herein and as illustrated in the drawings accompanying herewith and having variations and modifications well within the knowledge of a person skilled in the art without deviating from scope of the invention are within the scope of the present invention and its embodiments.

We claim:

1. An exhaust system for improving the torque characteristics of a single cylinder four stroke spark ignition engine comprising a header pipe (1), a chamber (14) and a muffler (15); one end with exhaust flange (12) of the said header pipe being adapted for connection to an engine exhaust port and the other end being connected to the said muffler (15); the said chamber (14) being connected between said one end with exhaust flange (12) and said muffler (15) at a point preferably between 40% to 60% of developed length of header pipe from the face of the said exhaust flange (12) along the length of said header pipe.

2 An exhaust system for improving the torque characteristics of a single cylinder four stroke spark ignition engine as claimed in claim 1 wherein said chamber (14) is connected to the said header pipe (1) with a connecting tube (13).

3. An exhaust system for improving the torque characteristics of a single cylinder four stroke spark ignition engine as claimed in claim 2 wherein said header pipe (1) comprises a front header pipe (11) having its said first end (12) connected to an engine exhaust port and a rear header pipe (17) connected to said muffler (15); said front header pipe (11) and said rear header pipe (17) being interconnected with a joining tube (16) to which said chamber (14) is fitted with a connecting tube (13).

4. An exhaust system for improving the torque characteristics of a single cylinder four stroke spark ignition engine as claimed in any

of the preceding claims wherein said exhaust system is applied to a two or three wheeled vehicle.

5. An exhaust system for improving the torque characteristics of a single cylinder four stroke spark ignition engine as claimed in any of the preceding claims, wherein said chamber (14) is located below the engine.

6. An exhaust system for improving the torque characteristics of a single cylinder four stroke spark ignition engine as claimed in any of the preceding claims wherein said chamber (14) has a flat shape wherein its vertical dimensions are substantially smaller than its horizontal dimensions.

7. An exhaust system for improving the torque characteristics of a single cylinder four stroke spark ignition engine as claimed in claim any of the preceding claims wherein said chamber (14) is having predetermined volume and is made of sheet metal.

8. An exhaust system for improving the torque characteristics of a single cylinder four stroke spark ignition engine as claimed in any of the preceding claims wherein said chamber (14) is rectangular in shape having an upper half and a lower half and said two halves being joined to each other to form a sealed volume.

9. An exhaust system for improving the torque characteristics of a single cylinder four stroke spark ignition engine as claimed in any of preceding claims wherein said chamber (14) is fitted to said connecting tube (13) such that a bottom surface of the said

chamber is at higher level than the connecting tube enabling condensed water to drain from chamber into the connecting tube.

10. An exhaust system for improving the torque characteristics of a single cylinder four stroke spark ignition engine as claimed in any of preceding claims wherein said chamber (14) is horizontally located below the engine maintaining ground clearance and not extending beyond width of vehicle.

11. An exhaust system for improving the torque characteristics of a single cylinder four stroke spark ignition engine as claimed in any of the preceding claims wherein said connecting tube (13) is provided with a nipple (19) for the purpose of allowing sampling of exhaust gases.

12. An exhaust system for improving the torque characteristics of a single cylinder four stroke spark ignition engine as claimed in claim (3) wherein said tube 16 is provided with a nipple 19 for the purpose of allowing sampling of exhaust gases.

13. An exhaust system for improving the torque characteristics of a single cylinder four stroke spark ignition engine as claimed in any of the preceding claims wherein said bracket (18) provided between the said chamber (14) and the said header pipe (17) from strength considerations.

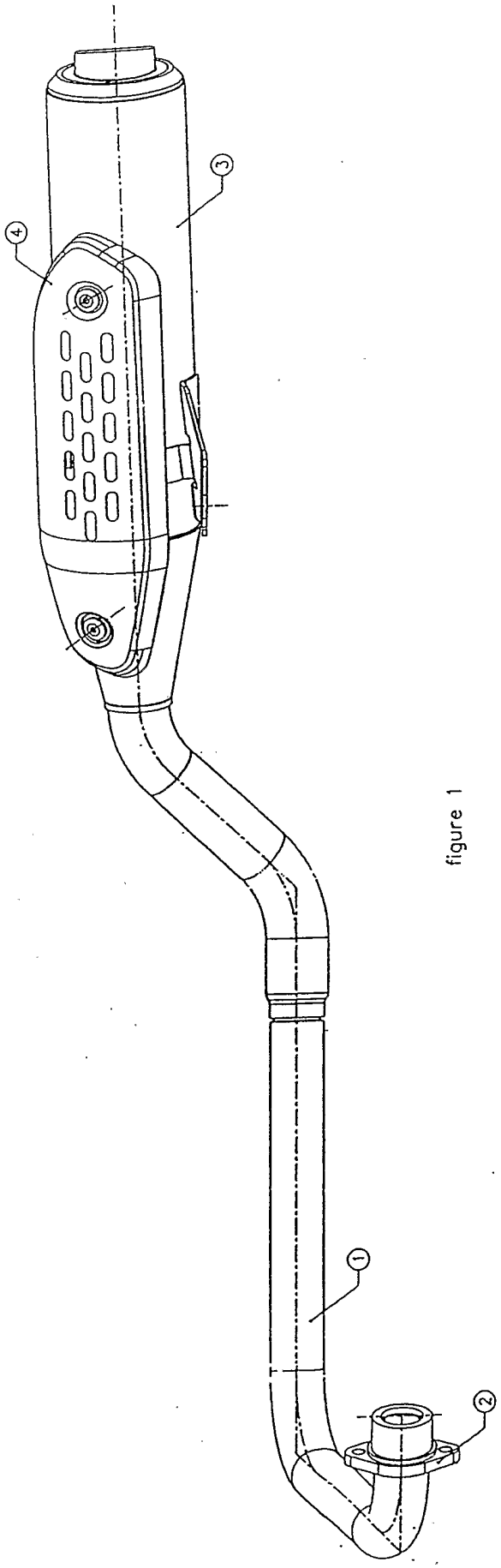

figure 1

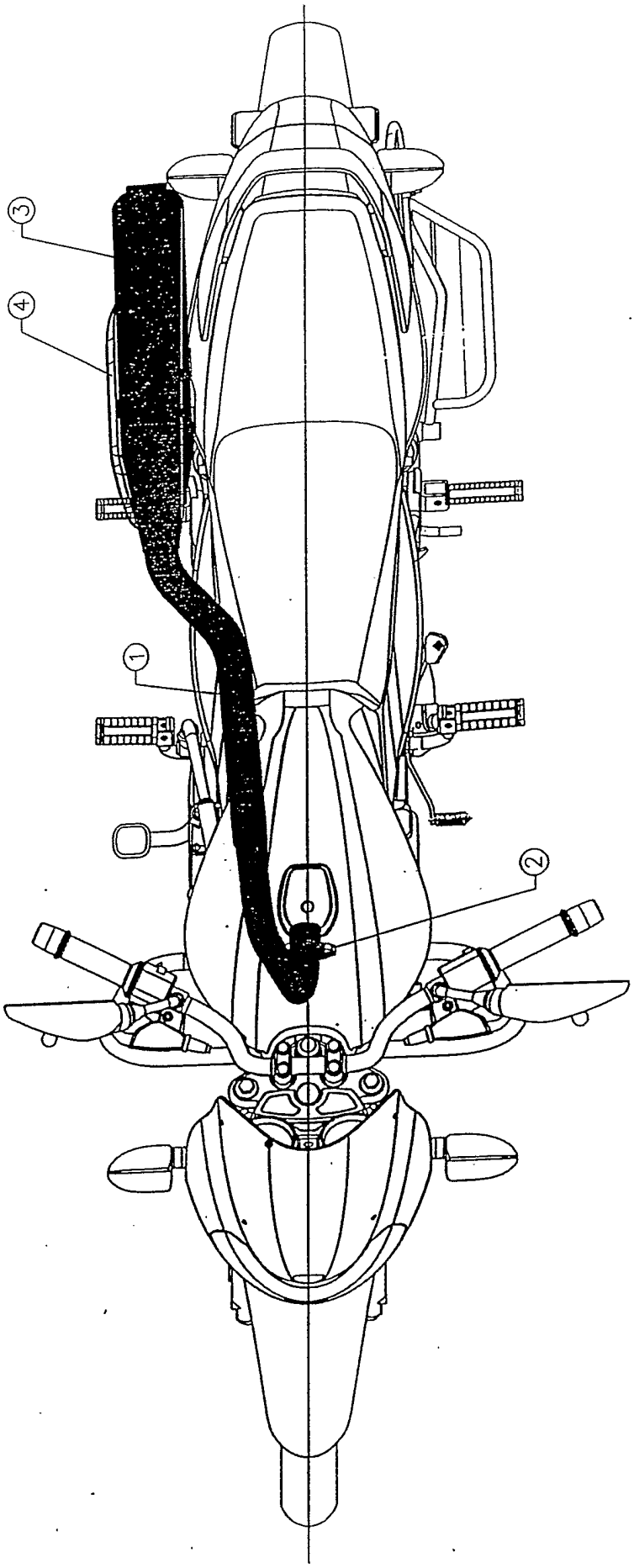

Fig : 1A

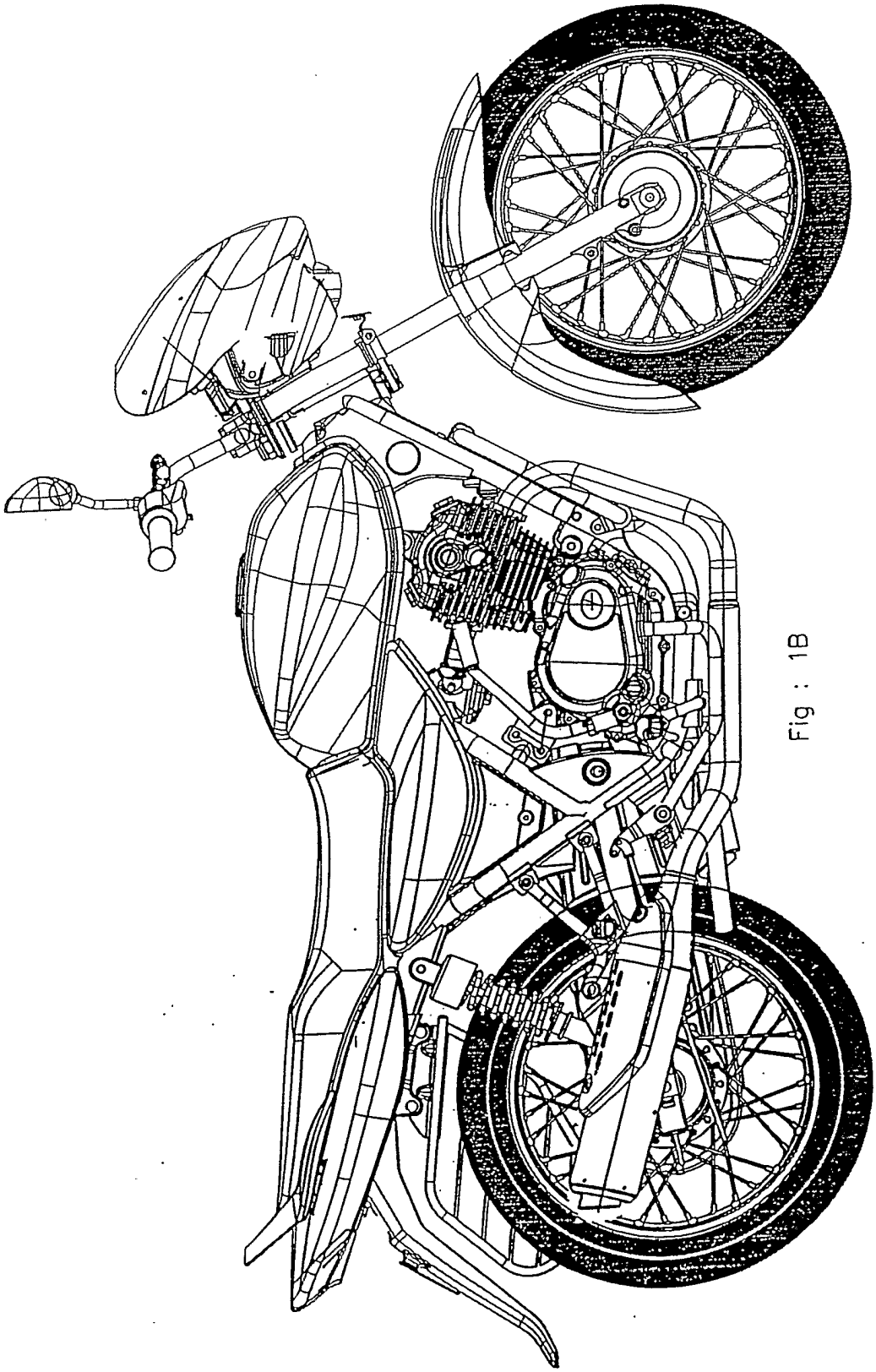

Fig : 1B

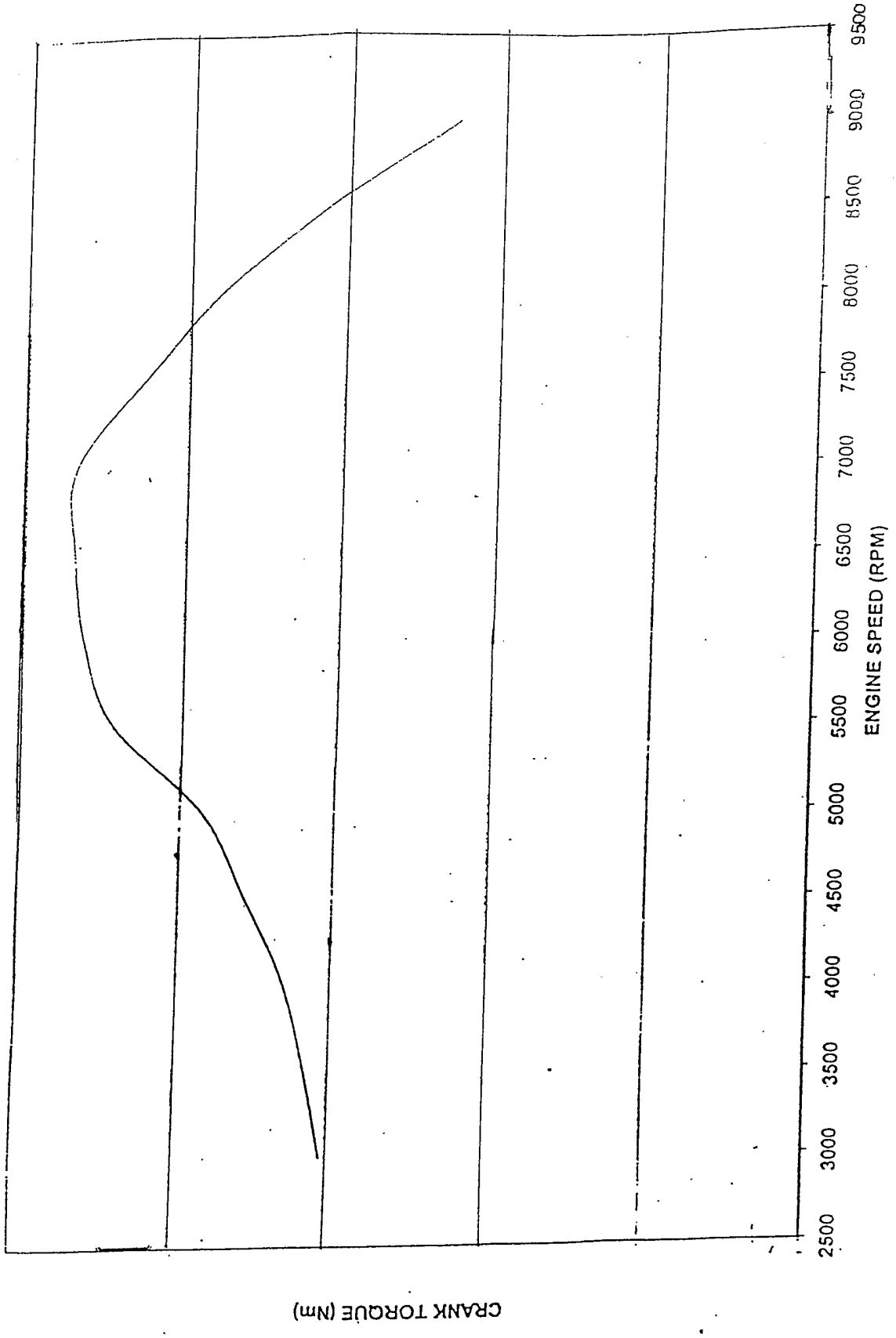
CRANK TORQUE (Nm)
ENGINE SPEED (RPM)
2500
3000
3500
4000
4500
5000
5500
6000
6500
7000
7500
8000
8500
9000
9500

Figure 2

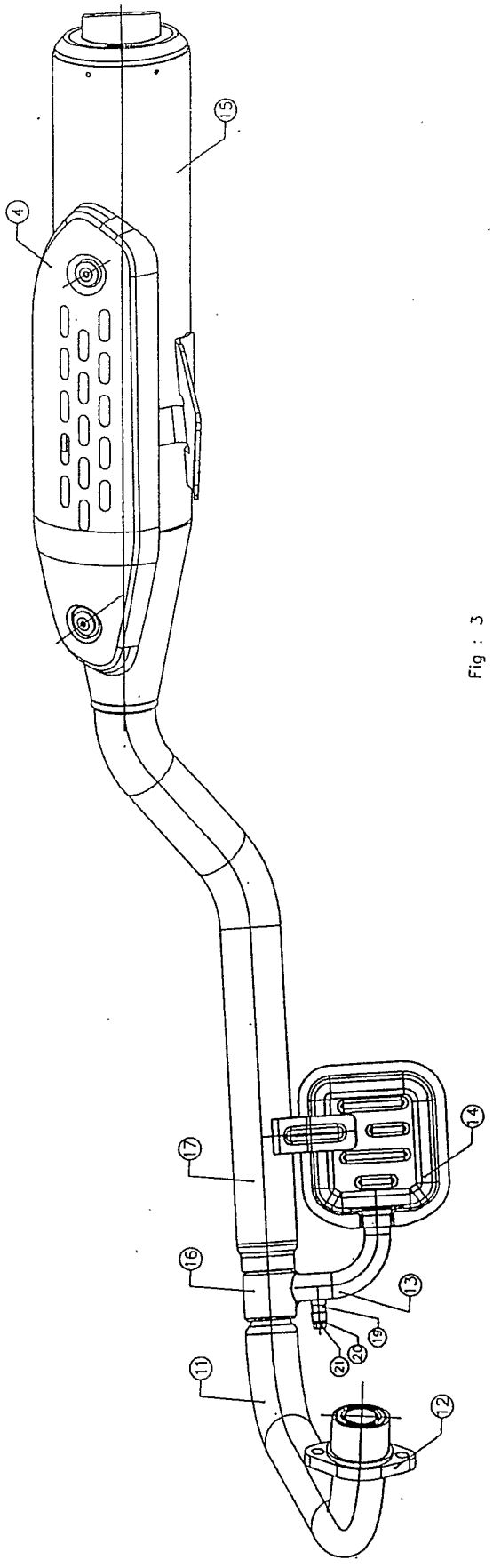

Fig : 3

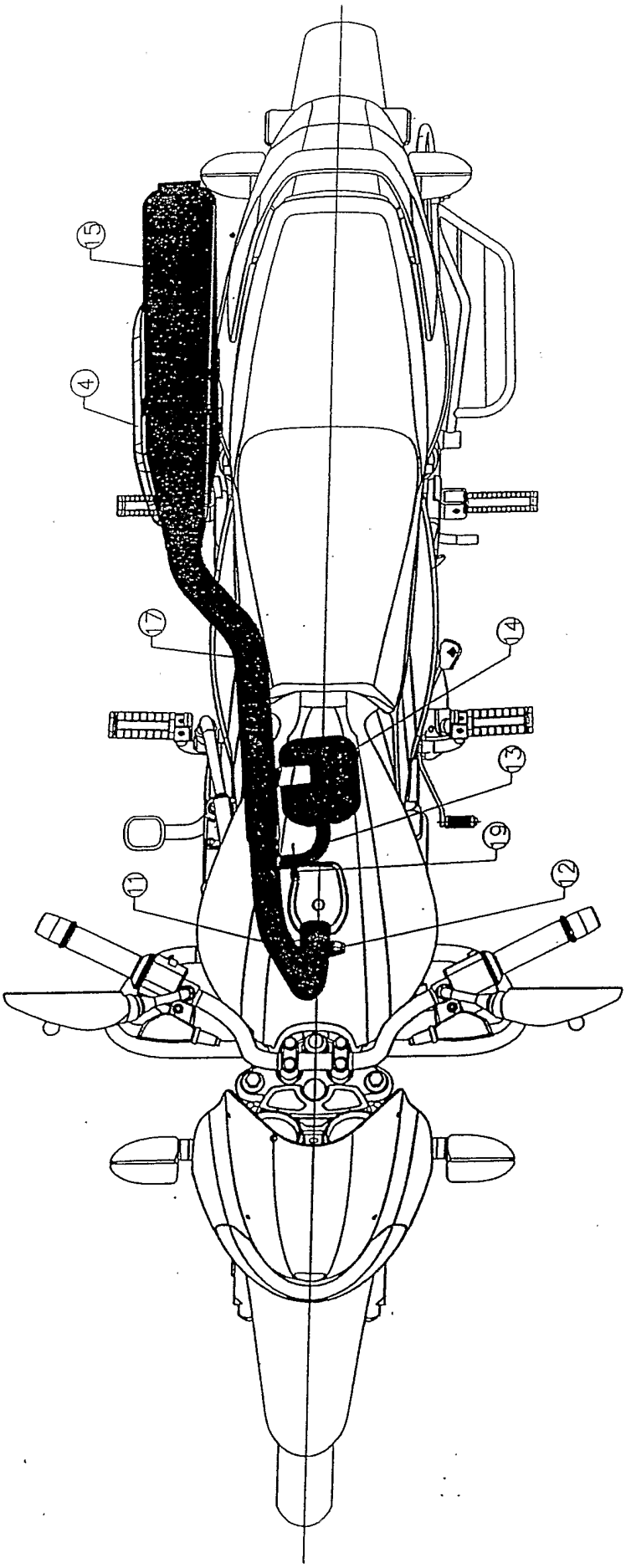

Fig : 3A

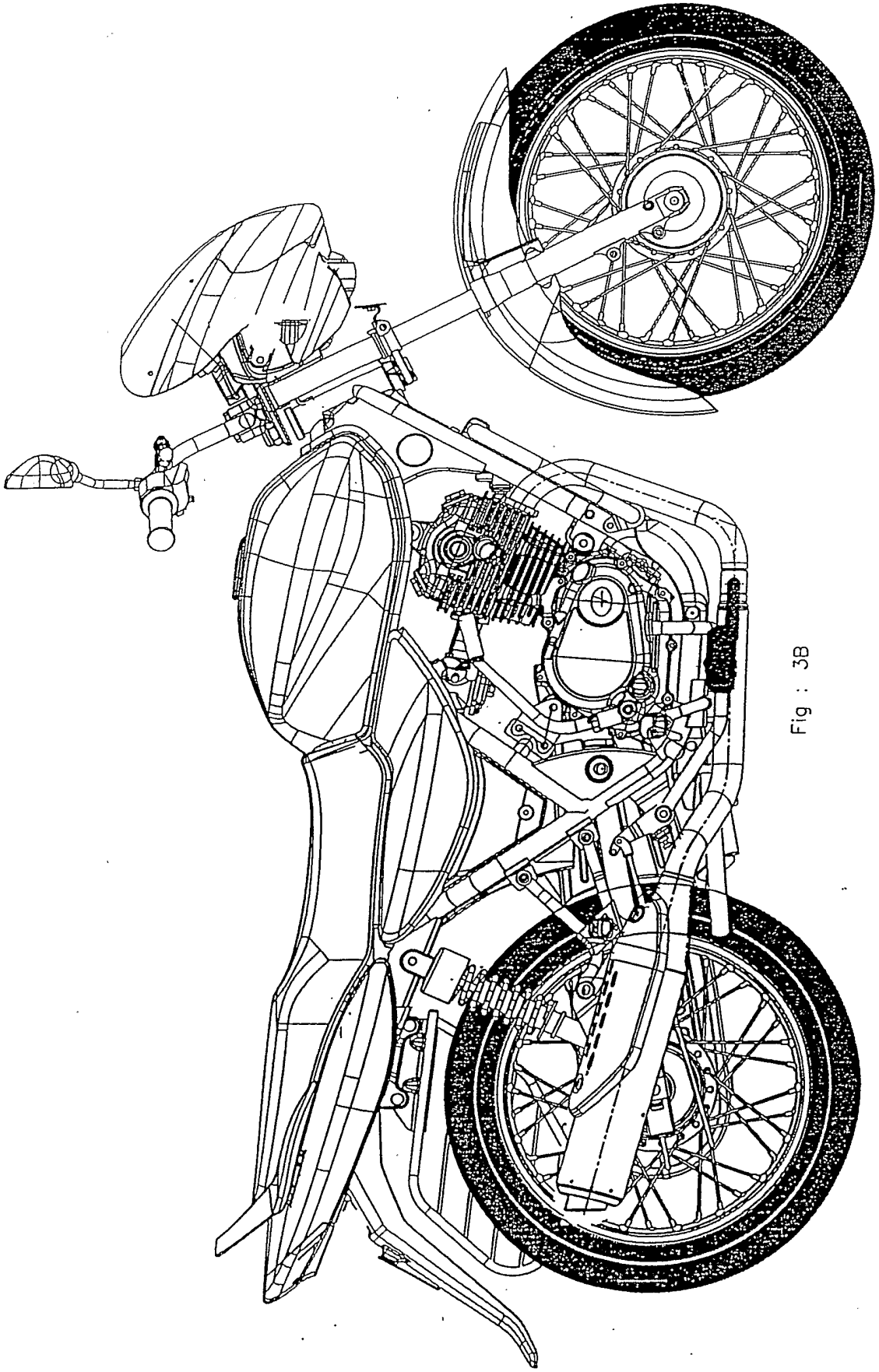

Fig : 3B

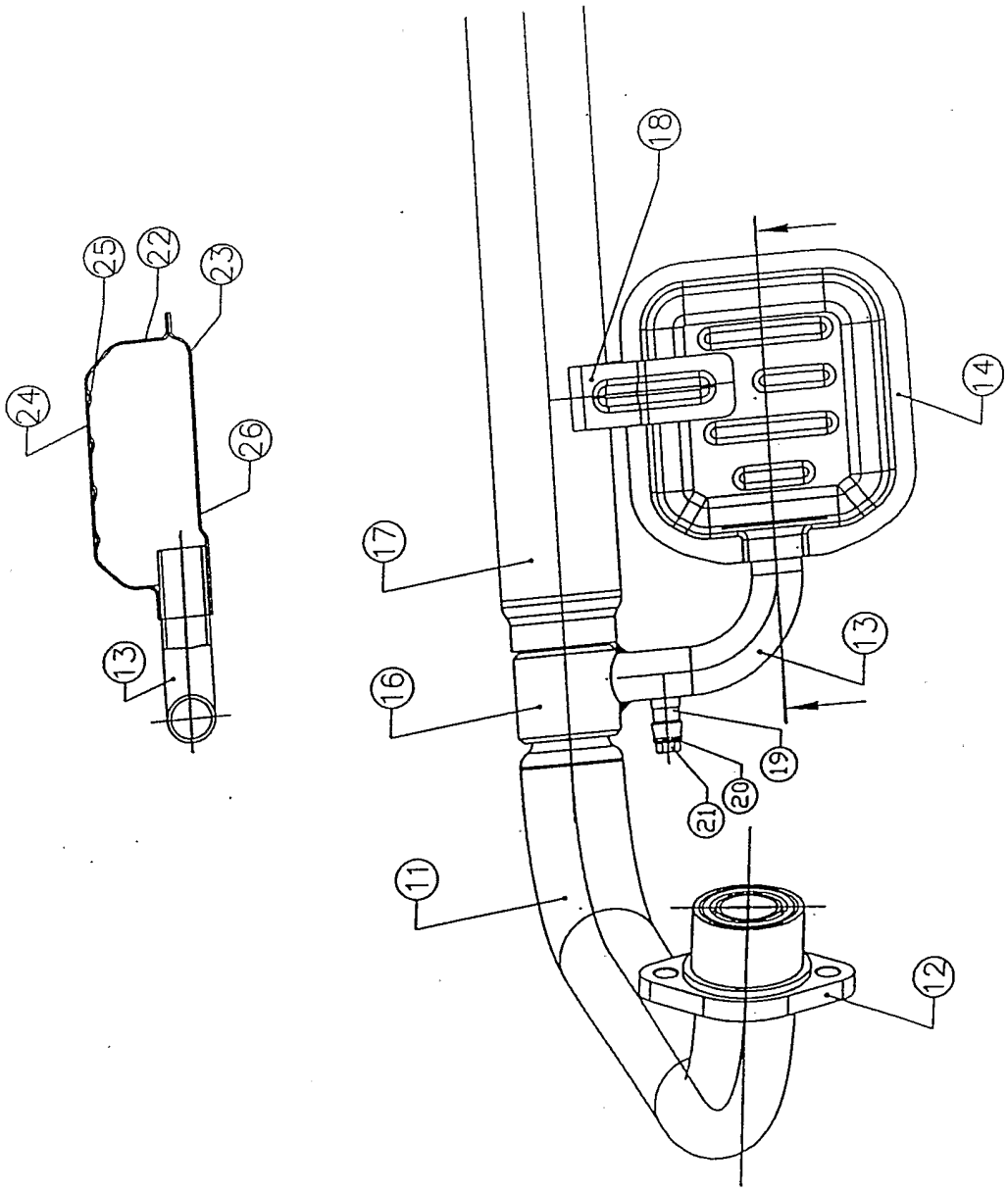

Fig. 4

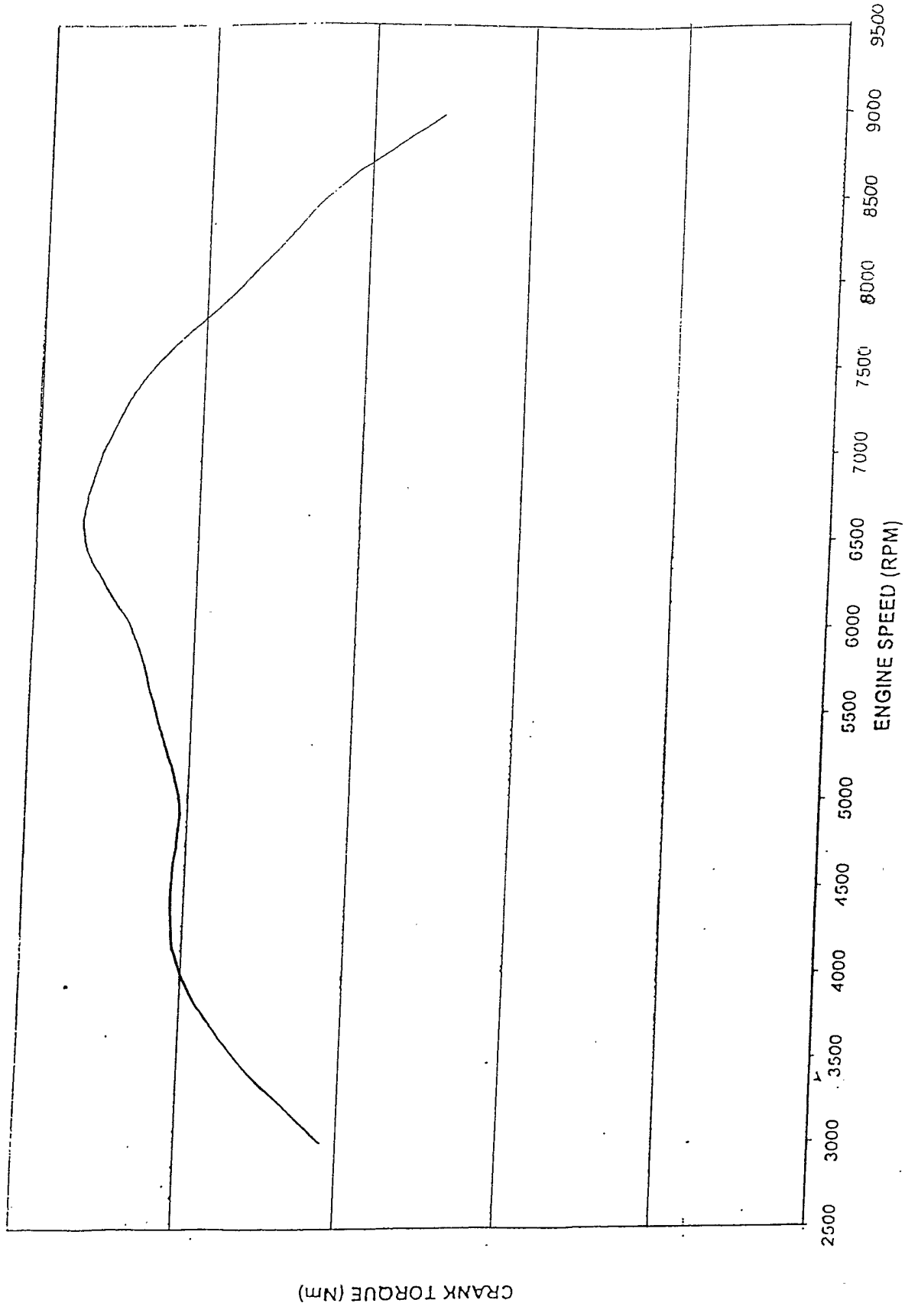
CRANK TORQUE (Nm)
2500
3000
3500
4000
4500
5000
5500
6000
6500
7000
7500
8000
8500
9000
9500
ENGINE SPEED (RPM)

Figure- 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/IN2005/000254

A. CLASSIFICATION OF SUBJECT MATTER
F01N1/02 F01N7/02 F01N1/00

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)
F01N

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, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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X	DE 20 22 851 A1 (CASSEL,THOMAS RICHARD; CASSEL, THOMAS RICHARD, BIRMINGHAM, MICH.) 25 November 1971 (1971-11-25) claim 1; figure 1	1,2
X	AT 395 562 B (M T A MOTECH AUSTRIA S. SCHATZER P. KLAPPER) 25 January 1993 (1993-01-25) the whole document	1,4,5

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

[X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
1 February 2006	15/02/2006

Name and mailing address of the ISA/	Authorized officer
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Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No
PCT/IN2005/000254

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DE 43 30 129 A1 (BAYERISCHE MOTOREN WERKE AG, 80809 MUENCHEN, DE; FRIEDRICH BOYSEN GMBH) 9 March 1995 (1995-03-09) claim 1; figure 1	1
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E,L	WO 2005/072474 A (EMLER, DON, R) 11 August 2005 (2005-08-11) page 32, paragraph 2 - page 37, paragraph 2; figures 28-35 page 38, paragraph 3 - page 38, last paragraph; figure 36	1,4

2

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IN2005/000254

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