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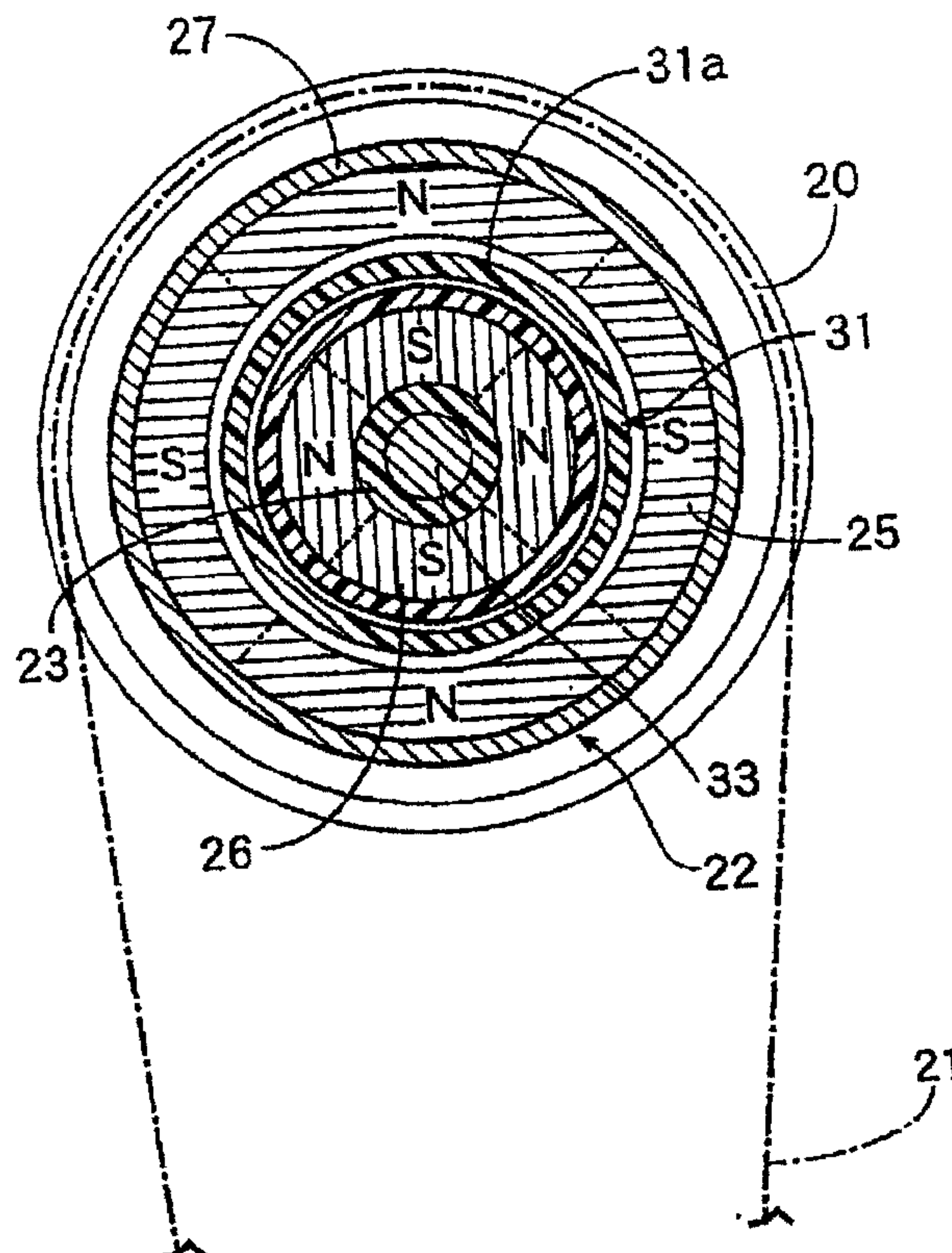
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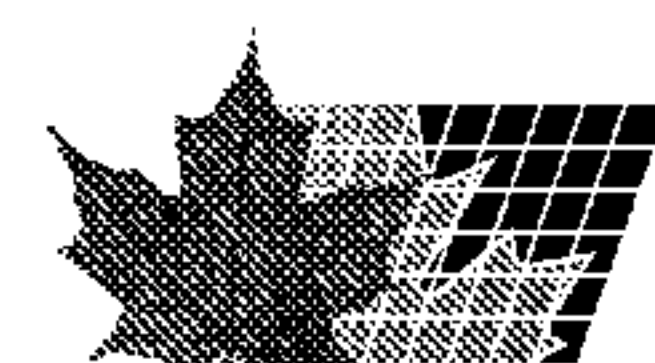
(54) Titre : POMPE A ENTRAINEMENT MAGNETIQUE POUR MOTEUR A COMBUSTION INTERNE DE VEHICULE

(54) Title: MAGNETIC DRIVING PUMP OF VEHICLE INTERNAL COMBUSTION ENGINE



(57) Abrégé/Abstract:

To reliably prevent the occurrence of pull out phenomenon in a magnetic driving pump of vehicle internal combustion engine where permanent magnets, magnetized to have alternate N poles and S poles around an axial line of a drive shaft and a driven shaft, are respectively fixed to the drive shaft interlocked with a crankshaft and the driven shaft coaxially provided with the drive shaft. Permanent magnets 25 and 26, magnetized to have alternate N poles and S poles 90 degrees or 180 degrees in phase in a peripheral direction, are respectively fixed to the drive shaft and the driven shaft 23.



ABSTRACT OF THE DISCLOSURE

To reliably prevent the occurrence of pull out phenomenon in a magnetic driving pump of vehicle internal combustion engine where permanent magnets, magnetized to have alternate N poles and S poles around an axial line of a drive shaft and a driven shaft, are respectively fixed to the drive shaft interlocked with a crankshaft and the driven shaft coaxially provided with the drive shaft. Permanent magnets 25 and 26, magnetized to have alternate N poles and S poles 90 degrees or 180 degrees in phase in a peripheral direction, are respectively fixed to the drive shaft and the driven shaft 23.

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TITLE: Magnetic Driving Pump Of Vehicle Internal
Combustion Engine

FIELD OF THE INVENTION

5 The present invention relates to a magnetic
driving pump of vehicle internal combustion engine in
which permanent magnets, magnetized to have alternate N
poles and S poles around an axial line of a drive shaft
and a driven shaft, are respectively fixed to the drive
10 shaft interlocked with a crankshaft and the driven shaft
coaxially provided with the drive shaft.

BACKGROUND OF THE INVENTION

15 Conventionally, a magnetic driving pump, in
which mutually magnetizing permanent magnets are
respectively fixed to a drive shaft driven by an electric
motor and a driven shaft coaxially provided with the
drive shaft, is known in, e.g., Japanese Published
Unexamined Patent Application No. Sho 64-66490.

20 However, in this magnetic driving pump, a phase
difference between magnetic poles of the permanent magnet
on the drive shaft side and the permanent magnet on the
driven shaft side increases by a resonance phenomenon due
to variations in revolution on the drive shaft side and
25 variations in revolution on the driven shaft side to
which power is transmitted from the drive shaft side by
the magnetic force. The phase difference may exceed a
relative angle range of magnetic poles for power
transmission between the drive shaft and the driven
30 shaft, and a power-transmittable torque between the drive
shaft and the driven shaft is degraded by degradation of
relative magnetic force. Then a step out (pull out)
phenomenon in which the driven shaft side cannot rotate
in correspondence with the drive shaft side may occur.

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Accordingly, in the magnetic driving pump disclosed in the above Japanese Published Unexamined Patent Application No. Sho 64-66490, an inertial moment of the drive shaft side is set to a value 4 or more times greater than that on the driven shaft side, thereby variations in revolution on the drive shaft side is suppressed, to attain mild acceleration and prevent the occurrence of the pull out phenomenon on the driven shaft side.

10 However, in a magnetic driving pump where a drive shaft is interlocked with a crankshaft of internal combustion engine having a wide revolution area, especially internal combustion engine mounted on a vehicle, the occurrence of the pull out phenomenon on the driven shaft side cannot be completely prevented only by change in inertial mass as described above.

20 The present invention has been made in view of the above situation, and has its object to provide a magnetic driving pump of vehicle internal combustion engine to reliably prevent the occurrence of the pull out phenomenon.

SUMMARY OF THE INVENTION

To attain the foregoing object, the invention is characterized in that in a magnetic driving pump of vehicle internal combustion engine, in which permanent magnets, magnetized to have alternate N poles and S poles around an axial line of a drive shaft and a driven shaft, are respectively fixed to the drive shaft interlocked with a crankshaft and the driven shaft coaxially provided with the drive shaft, the permanent magnets, magnetized to have alternate N poles and S poles 90 degrees or 180 degrees in phase in a peripheral direction, are respectively fixed to the drive shaft and the driven shaft.

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According to this construction, 4-pole or 2-pole permanent magnets where magnetic poles adjacent in a peripheral direction are different are respectively fixed to the drive shaft and the driven shaft. The driving force can be transmitted between the 4-pole or 2-pole permanent magnets within a range of 90 degrees or 180 degrees of mutual phase difference. As it is apparent from experimental results as described below, the phase difference between the driven shaft and the drive shaft in use of 4-pole permanent magnets is 60 degrees at the maximum in an anteroposterior direction on one side, and there is an allowable phase difference of 30 degrees (=90-60) before the occurrence of pull out phenomenon. As the allowable phase difference is sufficient in consideration of changes in magnetic force due to temperature changes, a relative dimensional error between the permanent magnets upon assembly of pump, variation in inertial mass on the driven shaft side, and the width of variations in revolution on the internal combustion engine side, the occurrence of the pull out phenomenon can be reliably prevented. Further, in use of 2-pole permanent magnets, the pull out phenomenon does not occur before the phase difference on the driving shaft side with respect to the driven shaft side becomes 180 degrees on one side. As there is a sufficient allowable phase difference, the occurrence of the pull out phenomenon can be reliably prevented as in the case of 4-pole permanent magnets. On the other hand, in use of 6 or more pole permanent magnets, according to the experimental results shown, there is merely an allowable phase difference of 15 degrees or less on one side before the occurrence of the pull out phenomenon. The allowable phase difference cannot be sufficient to prevent the occurrence of the pull out phenomenon.

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Further, in addition to the construction of the above-described invention, one of the permanent magnets having a ring shape is provided in the inner perimeter of a cup-shaped rotary member fixed to the drive shaft, and
5 the other one of the permanent magnets having a ring shape is fixed to the driven shaft in the portion coaxially covered with the rotary member. According to this construction, in comparison with the case where a pair of permanent magnets are provided at an interval in
10 an axial direction, an area in which the respective magnetic poles of one permanent magnet face the other permanent magnet side can be increased, to increase transmission torque by the magnetic force. Further, an impeller or the like provided on the driven shaft side
15 can be provided more closely to the rotary member on the drive shaft side in the axial direction, thereby the inertial mass on the driven shaft side can be set to a small value, to increase the response of the driven shaft side and more reliably prevent the occurrence of the pull
20 out phenomenon.

Further, in addition to the construction of the above-described invention, the drive shaft is a camshaft interlocked and connected with the crankshaft at a deceleration ratio of $1/2$. According to this
25 construction, as the number of revolutions of the camshaft is $1/2$ of that of the crankshaft, variations in revolution of the drive shaft can be suppressed as much as possible, and the occurrence of the pull out phenomenon can be reduced.

30

BRIEF DESCRIPTION OF THE DRAWINGS

Preferred embodiments of the invention are shown in the drawings, wherein:

Fig. 1 is a vertical cross-sectional view showing a part of the internal combustion engine.

Fig. 2 is a cross-sectional view along the line 2-2 in Fig. 1.

Fig. 3 is a diagram showing the experimental results of measurement of variations in revolution on the driving side with respect to the number of engine revolutions while changing the number of poles.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Hereinbelow, an working example of the present invention will be described in accordance with an embodiment of the present invention as shown in the attached drawings.

Fig. 1 is a vertical cross-sectional view showing a part of an internal combustion engine; Fig. 2, a cross-sectional view along a line 2-2 in Fig. 1; and Fig. 3, a diagram showing experimental results of measurement of variations in revolution on the driving side with respect to the number of engine revolutions while changing the number of poles.

First, in Fig. 1, an engine main body 5 of a water-cooled internal combustion engine E mounted on e.g. a motorcycle has a cylinder block 6 with a cylinder bore 9 slidably engaged with a piston 8, a cylinder head 7 connected to the cylinder block 6, forming a combustion chamber 10 between a top of the piston 8 and the cylinder head, and a crank case (not shown) connected to the cylinder block 6, rotatably supporting the crankshaft 12 connected to the piston 8 via a connecting rod 11. Further, the cylinder block 6 and the cylinder head 7 are provided with a water jacket 13 to circulate cooling

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water. An ignition plug 14, facing the combustion chamber 10, is attached to the cylinder head 7.

5 A valve chamber 16 is formed between the cylinder head 7 and a head cover 15 connected to the cylinder head 7. The valve chamber 16 includes an intake valve (not shown) to control supply of air-fuel mixture to the combustion chamber 10 and a valve mechanism 17 to drive an exhaust valve (not shown) to control exhaustion of burned gas from the combustion chamber 10. A camshaft 10 18 forming a part of the valve mechanism 17 is rotatably supported on the cylinder head 7 on an axial line parallel to the crankshaft 12.

A drive sprocket 19 is fixed to the crankshaft 12. On the other hand, a driven sprocket 20 is fixed to 15 the camshaft 18. An endless chain 21 is put around the driven sprocket 20 and the drive sprocket 19. By this arrangement, the revolution power of the crankshaft 12 is reduced at a deceleration ratio of 1/2 and transmitted to the camshaft 18.

20 The camshaft 18 also functions as a drive shaft of a water pump 22 as a magnetic driving pump according to the present invention. In the water pump 22, permanent magnets 25 and 26, magnetized to have alternate N poles and S poles around an axial line of the camshaft 25 18 and a driven shaft 23, are respectively fixed to the camshaft 18 as the drive shaft and the driven shaft 23 coaxially provided with the camshaft 18 and is provided with an impeller 24.

Also referring to Fig. 2, a cup-shaped rotary 30 member 27 pressed from e.g. a thin stainless steel plate is coaxially fastened, with the driven sprocket 20, to the camshaft 18 by plural bolts 28, 28, and the ring-shaped permanent magnet 25 is fixed to an inner perimeter of the rotary member 27.

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The impeller 24 is accommodated in an eddy chamber 30 formed in a pump housing 29. The pump housing 29 has a housing main body 31 with an open end opposite to the camshaft 18, and a pump cover 32 which closes the open end of the housing main body 31 by forming the eddy chamber 30 between the cover and the housing main body 31. The pump housing is fastened to the cylinder head 7 with a part of the housing main body 31 inserted into the cylinder head 7.

10 The housing main body 31 of non-magnetic material has a bottomed cylindrical part 31a with a closed camshaft 18 side. The bottomed cylindrical part 31a is coaxially inserted into the permanent magnet 25 fixed to the inner perimeter of the rotary member 27
15 which rotates with the camshaft 18.

Both ends of support shaft 33 coaxial with the camshaft 18 are fixed to the closed end of the bottomed cylindrical part 31a and the pump cover 32 in the housing main body 31. A cylindrical-shaped driven shaft 23 of
20 e.g. synthetic resin, coaxially surrounding the support shaft 33, is rotatably supported by the support shaft 33. Further, the ring-shaped permanent magnet 26 is fixed to an outer perimeter of the driven shaft 23.

The permanent magnet 26 is covered with a
25 coating 34 of synthetic resin, and the impeller 24 is integrally formed with the coating 34. That is, the impeller 24 is fixed to the driven shaft 23 via the coating 34 and the permanent magnet 26, and in a portion coaxially covered with the rotary member 27 where the
30 ring-shaped permanent magnet 25 is fixed to the inner perimeter, the ring-shaped permanent magnet 26 is fixed to the driven shaft 23, with the bottomed cylindrical part 31a and the coating 34 positioned between the magnet 26 and the permanent magnet 25.

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An intake port 35 communicated with a central portion of the eddy chamber 30 is provided in a central portion of the pump cover 32, and cooling water taken from the intake port 35 into the eddy chamber 30 is
5 pressed by rotation of the impeller 24. Then the cooling water discharged from the water pump 22 is supplied to the water jacket 13 of the engine main body 5 shown in Fig. 1, and the water jacket 13 is connected to a radiator (not shown).

10 Further, the pump cover 32 includes a thermostat 36. The thermostat 36 operates to select connection or disconnection of the intake port 35 with an exit of the radiator in correspondence with the temperature of the cooling water. That is, in a state
15 where the cooling water temperature is low i.e. in a state where the internal combustion engine E is cooled, the cooling water from the water jacket 13 is restored to the water jacket 13 via the thermostat 36 and the water pump 22, while in a state where the cooling water
20 temperature is high i.e. in a state where the internal combustion engine E has been warmed up, the cooling water is restored to the water jacket 13 via the radiator, the thermostat 36 and the water pump 22, thus the cooling water is cooled by radiation in the radiator.

25 In the water pump 22 of this magnetic driving type, resonance may occur between variations in revolution of the camshaft 18 due to variations in revolution of the engine E and variations in revolution on the driven shaft 23 side to which the driving force is
30 transmitted by the magnetic force from the camshaft 18. That is, as the driving side permanent magnet 25 rotates around the axial line, a force to restore the phase difference between the magnetic poles of the both permanent magnets 25 and 26 to "0" acts between the
35 permanent magnets 25 and 26 on the driving side and the

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driven side, and the restoration force changes to a nonlinear force in correspondence with the phase difference. If the restoration force is replaced by a spring force, a spring constant is reduced in accordance with increment of amplitude, and a natural oscillation is moved to a lower value. The movement of the natural oscillation causes resonance with the driving side on the driven side. This resonance may increase the phase difference between the driving side and the driven side even with a statically sufficient transmission torque, to cause the pull out phenomenon.

Accordingly, the present inventor performed an experiment by using actual startup of the internal combustion engine E mounted on a motorcycle, to check variations in revolution on the driven side with respect to the driving side when the number of magnetic poles are changed to 4 poles, 6 poles and 8 poles, in the permanent magnet 25 fixed to the inner perimeter of the rotary member 27 as the driving side and the permanent magnet 26 fixed to the outer perimeter of the driven shaft 23 as the driven side. Then experimental results were obtained as shown in Fig. 3.

In Fig. 3, the vertical axis indicates the phase difference on one side of the driven side with respect to the driving side. The phase difference is represented by amplitude on the driven side with respect to the driving side in a full load state when the throttle of the internal combustion engine E is full-opened.

Since the water pump 22 substantially functions when the number of revolutions of the internal combustion engine E is equal to or greater than the number of idle revolutions NI (e.g. 1200 rpm), the amplitude may be determined by the number of engine revolutions equal to or greater than the idle revolutions NI. Further, in the

case of motorcycle having an centrifugal clutch between the internal combustion engine E and the driving wheel to establish power transmission upon startup, the amplitude may be determined by the number of engine revolutions equal to or greater than the number of clutch-connected revolutions NC (e.g. 2000 rpm) where the clutch is in connected state.

If the phase difference is examined between the driving side and the driven side by using the permanent magnets 25 and 26 by changing the number of poles on these conditions, in the case of the permanent magnets 25 and 26 magnetized to have 8 poles i.e. respectively-4 alternate N poles and S poles 45 degrees in phase, a maximum phase difference of about 30 degrees occurs on one side when the number of engine revolutions is equal to or greater than the number of idle revolutions NI, about 4000 rpm, and the allowable phase difference $\square 8$ with respect to the phase difference 45 degrees to cause the pull out phenomenon is about 15 degrees.

Further, in the case of the permanent magnets 25 and 26 magnetized to have 6 poles i.e. respectively-3 alternate N poles and S poles 60 degrees in phase, a phase difference of about 45 degrees occurs on one side when the number of engine revolutions is equal to or greater than the number of clutch-connected revolutions NC, about 3000 rpm, and the allowable phase difference $\square 6$ with respect to the phase difference 60 degrees to cause the pull out phenomenon is about 15 degrees. Further, a maximum phase difference of about 42.5 degrees occurs on one side when the number of engine revolutions is equal to or greater than the number of idle revolutions NI, about 1500 rpm, and the allowable phase difference $\square 6'$ with respect to the phase difference 45 degrees to cause the pull out phenomenon is about 2.5 degrees.

Further, in the case of the permanent magnets 25 and 26 magnetized to have 4 poles i.e. respectively-2 alternate N poles and S poles 90 degrees in phase, a phase difference of about 60 degrees occurs on one side
5 when the number of engine revolutions is equal to or greater than the number of idle revolutions NI, about 2500 rpm, and the allowable phase difference 4 with respect to the phase difference 90 degrees to cause the pull out phenomenon is about 60 degrees.

10 According to these experimental results, in the water pump 22 using the 4-pole permanent magnets 25 and 26, the maximum phase difference is 60 degrees on one side on the driving side to the driven shaft 23 i.e. the rotary member 27 and the camshaft 18, and the allowable
15 phase difference 4 is 30 degrees ($=90-60$) before the occurrence of the pull out phenomenon. As the allowable phase difference 4 is sufficient even in consideration of variations in magnetic force due to temperature changes, the relative dimensional error between the both permanent
20 magnets 25 and 26 upon assembly of the water pump 22, the variations in the inertial mass on the driven shaft 23 side, and the amplitude of variations in revolution on the internal combustion engine E side, the occurrence of the pull out phenomenon can be reliably prevented.

25 Further, in the water pump 22 using the 2-pole permanent magnets 25 and 26, the pull out phenomenon does not occur before the phase difference on the driving side with respect to the driven side becomes 180 degrees. As the allowable phase difference is sufficient, the
30 occurrence of the pull out phenomenon can be reliably prevented as in the case of the use of 4-pole permanent magnets.

On the other hand, in the case using the 6 or more pole permanent magnets 25 and 26, the allowable
35 phase difference before the occurrence of the pull out

phenomenon is merely 6, 8, and 8 of 15 degrees or less on one side, which cannot be a sufficient phase difference to prevent the occurrence of the pull out phenomenon.

In this manner, the water pump 22, which
5 enables sufficient torque transmission between the driving and driven sides and reliably prevents the occurrence of the pull out phenomenon, can be obtained by using the 4-pole or 2-pole permanent magnets 25 and 26. The ring-shaped permanent magnet 25 is fixed to the inner
10 perimeter of the cup-shaped rotary member 27 fixed to the camshaft 18 and the other ring-shaped permanent magnet 26 is fixed to the driven shaft 23 in a portion coaxially covered with the rotary member 27, accordingly, in comparison with the arrangement where the pair of
15 permanent magnets are provided in an axial direction at an interval, the transmission torque by the magnetic force can be increased by increasing the area where one of the permanent magnets 25 and 26 faces the other. Further, the impeller 24 on the driven shaft 23 side is
20 provided more closely to the rotary member 27 in the axial direction, and the inertial mass on the driven shaft 23 side is set to a small value, thereby the response of the driven shaft 23 side can be increased, and the occurrence of the pull out phenomenon can be
25 reliably prevented.

Further, as the one permanent magnet 25 rotates with the camshaft 18 interlocked and connected with the crankshaft 12 at a deceleration ratio of 1/2, and the number of revolutions of the camshaft 18 is 1/2 of that
30 of the crankshaft 12, variations in revolution of the camshaft 18 can be suppressed as much as possible, and the occurrence of the pull out phenomenon can be reduced.

The embodiment of the present invention has been described as above, however, the present invention
35 is not limited to the above embodiment but various design

changes can be made without departing from the present invention described in the claims.

As described above, according to the invention, the occurrence of the pull out phenomenon can be reliably
5 prevented.

Further, according to the invention, the transmission torque by the magnetic force can be increased and the response of the driven shaft side can be increased by setting the inertial mass on the driven
10 shaft side to a small value, thus the occurrence of the pull out phenomenon can be more reliably prevented.

Further, according to the invention, the variations in revolution of the driving shaft can be suppressed as much as possible, thereby reduce the
15 occurrence of the pull out phenomenon.

Although various preferred embodiments of the present invention have been described herein in detail, it will be appreciated by those skilled in the art, that variations may be made thereto without departing from the
20 spirit of the invention or the scope of the appended claims.

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**THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE
PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:**

1. A magnetic driving pump for a vehicle internal
5 combustion engine, comprising:

a driving shaft;

a driven shaft mounted coaxially with said driving shaft;
10 and

a pair of permanent magnets, said pair of permanent
magnets being one of 4-pole and 2-pole permanent magnets
where magnetic poles adjacent in a peripheral direction
15 are different and are respectively fixed to said driving
shaft and said driven shaft, respectively, and being
magnetized to have alternate N poles and S poles 90
degrees or 180 degrees in phase in a peripheral direction
around an axis of said driving shaft;

20

wherein each of said pair of permanent magnets is ring
shaped, one of said permanent magnets being provided
within an inner perimeter of a cup-shaped rotary member
fixed to said driving shaft, and the other one of said
25 permanent magnets is fixed to said driven shaft with at
least a portion coaxially covered by said rotary member.

2. The magnetic driving pump according to claim 1,
wherein said driving shaft is interlocked with a
30 crankshaft of the engine, said driving shaft being a
camshaft interlocked and connected with said crankshaft
at a deceleration ratio of 1/2.

3. The magnetic driving pump according to claim 1,
35 further comprising a pump housing, said driven shaft
being mounted for rotation within said pump housing.

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4. The magnetic driving pump according to claim 3,
wherein said driven shaft includes an impeller mounted
for rotation therewith.

5

5. The magnetic driving pump according to claim 1,
wherein each of said pair of permanent magnets is a 2-
pole permanent magnet.

10 6. The magnetic driving pump according to claim 1,
wherein each of said pair of permanent magnets is a 4-
pole permanent magnet.

15 7. A vehicle internal combustion engine, comprising:

an engine main body including a cylinder block and
cylinder head;

20 a magnetic driving pump mounted on said cylinder head,
said magnetic driving pump comprising:

a driving shaft;

25 a driven shaft mounted coaxially with said driving shaft;
and

30 a pair of permanent magnets, said pair of permanent
magnets being one of 4-pole and 2-pole permanent magnets
where magnetic poles adjacent in a peripheral direction
are different and are respectively fixed to said driving
shaft and said driven shaft, respectively, and being
magnetized to have alternate N poles and S poles 90
degrees or 180 degrees in phase in a peripheral direction
around an axis of said driving shaft;

35

wherein each of said pair of permanent magnets is ring

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shaped, one of said permanent magnets being provided within an inner perimeter of a cup-shaped rotary member fixed to said driving shaft, and the other one of said permanent magnets is fixed to said driven shaft with at
5 least a portion coaxially covered by said rotary member.

8. The vehicle internal combustion engine according to claim 7, wherein said driving shaft is interlocked with a crankshaft mounted for rotation on said cylinder block,
10 said driving shaft being a camshaft interlocked and connected with said crankshaft at a deceleration ratio of 1/2.

9. The vehicle internal combustion engine according to
15 claim 7, said magnetic driving pump further comprising a pump housing, said driven shaft being mounted for rotation within said pump housing.

10. The vehicle internal combustion engine according to
20 claim 9, wherein said driven shaft includes an impeller mounted for rotation therewith.

11. The vehicle internal combustion engine according to claim 7, wherein each of said pair of permanent magnets
25 is a 2-pole permanent magnet.

12. The vehicle internal combustion engine according to claim 7, wherein each of said pair of permanent magnets is 4-pole permanent magnet.

FIG. 1

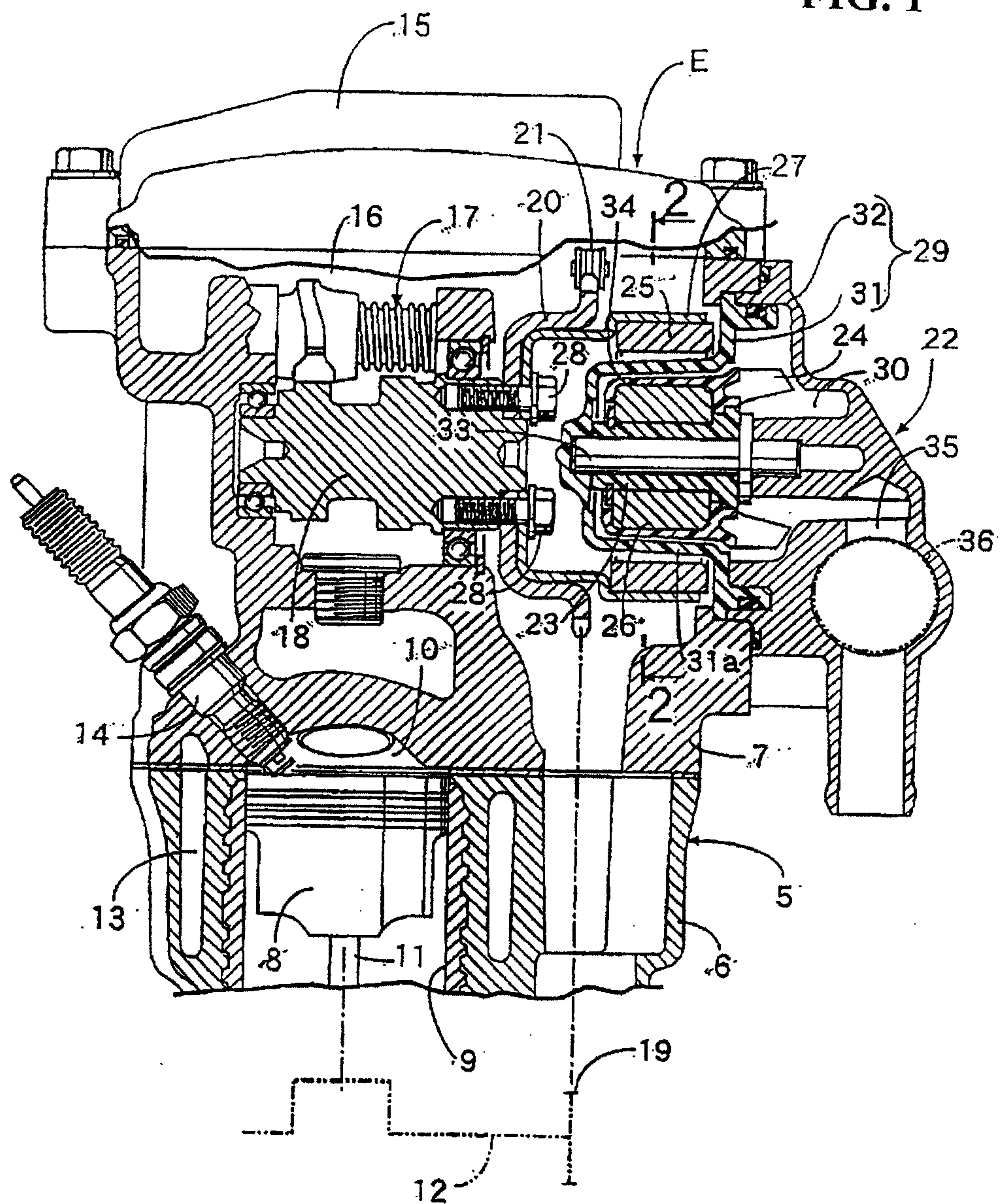


FIG. 2

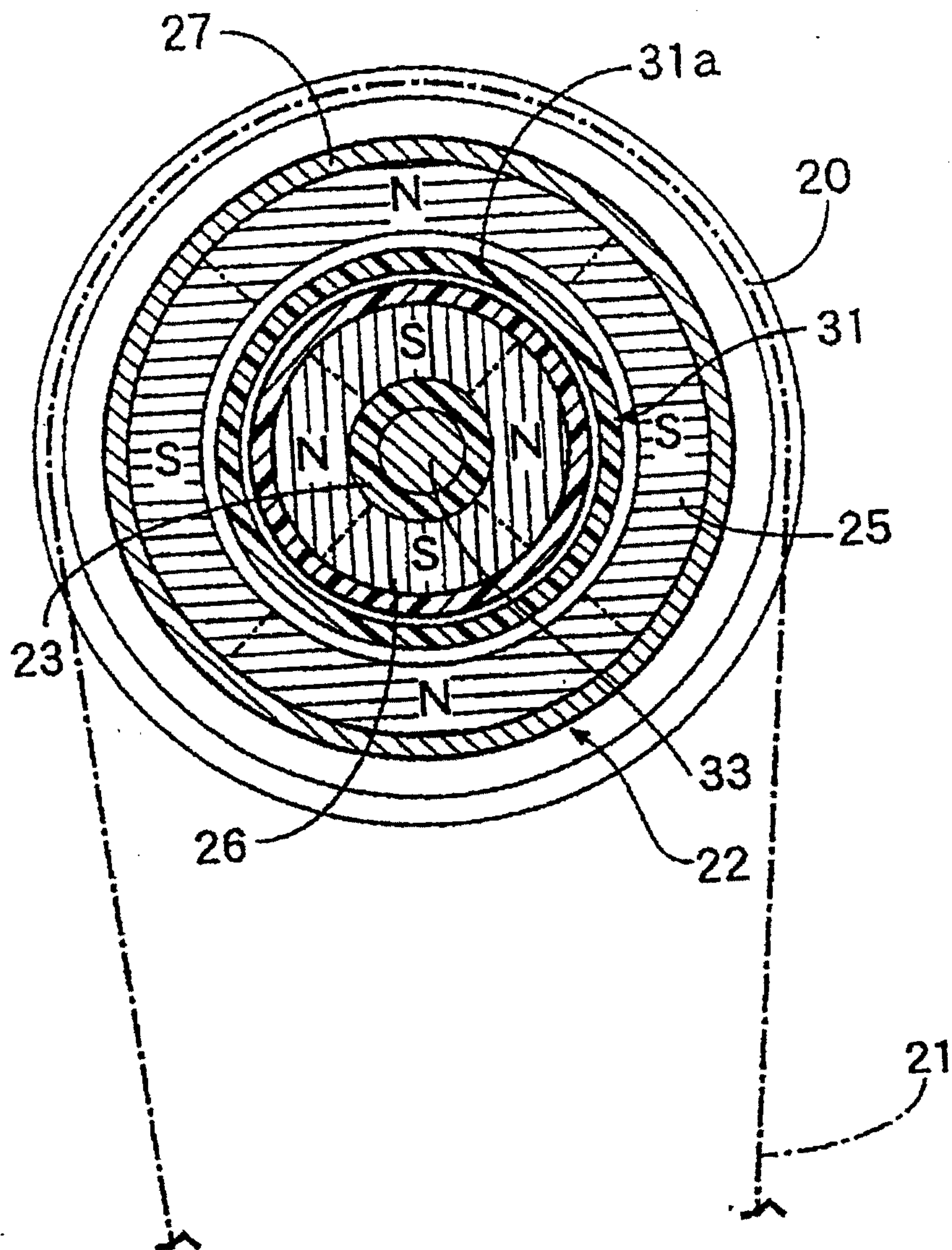


FIG. 3

