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(71) Applicant *(for all designated States except US)*: BORAL JOHNS PERRY INDUSTRIES PTY. LTD. [AU/AU]; A.C.N. 004 745 260, 45 Wangara Road, Cheltenham, VIC 3192 (AU).

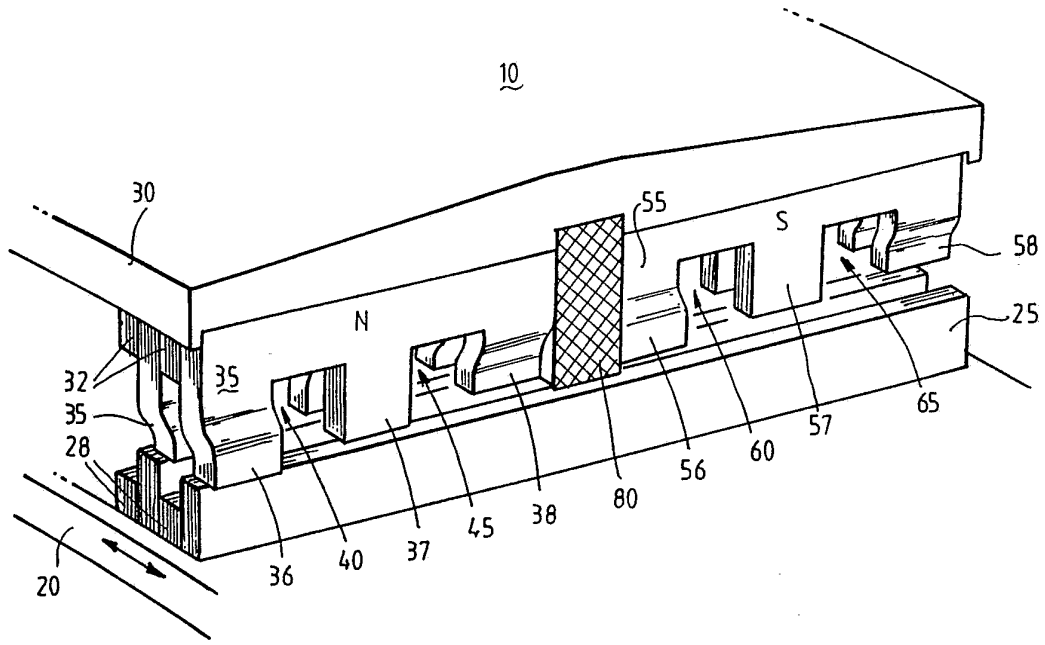
(72) Inventor; and
(75) Inventor/Applicant *(for US only)* : ECKERSLEY, Gregory, Peter [AU/AU]; 5 Reeves Court, Kew, VIC 3101 (AU).

(74) Agent: WILSON, Stephen, Henry; Griffith Hack & Co., 509 St. Kilda Road, Melbourne, VIC 3004 (AU).

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(54) Title: AC MACHINE



(57) Abstract

An AC machine such an an AC motor is disclosed which has particular application for raising and lowering lift cars in a lift well. The motor has a stator (30) and a rotor (20). The stator (30) has stator pole pairs (35, 55) and a coil (80) is interposed between the pairs (35 and 55). Each stator pole has slots (40, 45, 60, 65) which extend circumferentially about the motor. The slots (40, 45, 60, 65) receive stator windings such as conductors (41, 42, 43, 44, 61, 62, 63, 64). The stator poles are formed from laminations and the rotor has rotor poles formed from laminations which are arranged at right angles to the migration axis or direction of movement of the motor. The rotor laminations extend the entire width of the stator so that they come under the influence of the full length of the stator poles (35, 55). The stator pole pairs have limbs (36, 37, 38, 56, 57, 58) which define the slots (40, 45, 60, 65) and the limbs are offset relative to one another.

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AC MACHINE

This invention relates to an AC machine, and particularly to an AC motor for raising and lowering lift cars in a lift well.

The use of AC motors in lifting operations places stringent design criteria on the low speed performance of the motor to provide precisely controlled levelling, thus ensuring a smooth ride for passengers in a lift car. The speed regulation performance sought can usually only be produced with large numbers of stator poles, and typically hundreds in number.

The incorporation of such large numbers of stator poles in a motor creates difficult mechanical design problems, especially given that space must be left to wind two or more stator windings around each stator pole. The high number of stator poles in turn results in large amounts of copper being needed for the windings, adding to the cost of the motor. A flow on design effect relates to cooling requirements in consequence of joule heating losses of the conductors, i.e. the motor becomes larger, heavier and even more expensive.

There are further disadvantages in traditional slow speed AC machine designs, and particularly eddy current heating losses due to compromises made in the configuration of the magnetic circuit.

The present invention is directed to an AC machine which has improved low speed performance, and due to its mechanical configuration provides savings in the amount of materials needed for its construction.

The invention may be said to reside, in part, in an AC machine comprising:

a stator having a plurality of laterally extending stator pole pairs spaced along its length, each pole pair having a north pole and a south pole with like poles in each stator pole pair being adjacent throughout the length of the stator, and a field extending continuously the length of the stator;

a rotor having a plurality of rotor poles extending laterally and spaced along the rotor, the rotor poles being in constant spaced relation with the stator pole pairs across an air gap, the rotor poles spanning at least the whole length of each stator pole pair;

and wherein each pole of a stator pole pair comprises two or more limbs, with adjacent ones of the limbs forming a slot therebetween, and each slot carries one or more conductors, each conductor extending longitudinally over the length of the stator.

Preferably there are no more than two conductors per slot, and each conductor relates to one electrical phase of the stator.

Preferably for a three phase AC machine each stator pole is "E" shaped thereby providing three limbs and two slots.

Preferably for a single or two phase AC machine each stator pole is "C" shaped thereby providing two limbs and one slot.

Preferably the spacing of adjacent stator pairs and between adjacent rotor pairs is the same.

Preferably the stator poles and rotor poles are formed of laminations stacked lengthwise across the stator and rotor respectively, which stacking arrangement is advantageous as the magnetic flux linking the laminations across the air gap is incident upon a minimised cross sectional area being the thickness of each lamination, thereby reducing eddy current losses in the machine.

Preferably the field is interposed between the north pole and south pole of each stator pole pair.

Alternatively, the field extends the width of the stator and is placed above the stator poles on the side of the stator poles opposite the air gap.

Preferably the stator and rotor are cylindrical, with their respective lengths forming their respective circumferences.

The invention may further be said to reside in an AC machine comprising:

a stator having a plurality of laterally extending stator pole pairs spaced along its length, each pole pair having a north pole and a south pole with like poles in each stator pole pair being adjacent throughout the length of the stator, and a field extending continuously the length of the stator;

a rotor having a plurality of rotor poles extending laterally and spaced along the rotor, the rotor poles being in constant spaced relation with the stator pole pairs across an air gap, the rotor poles spanning at least the whole length of each stator pole pair;

and wherein each pole of a stator pole pair comprises two or more limbs with adjacent ones of the limbs forming a slot to carry a stator winding, the limbs being

offset relative to one another so as to, in use of the machine, induce a progressing magnetic flux from a leading limb to a trailing limb which can then couple into the leading limb of an adjacent stator pole thereby to provide for improved resolution of the rotor rotational motion.

Alternatively the stator poles are planar and the rotor poles are offset in segments along their length so as to induce a progressing magnetic flux relative to the limbs of stator poles and to couple the magnetic flux into an adjacent rotor pole thereby to provide for improved resolution of the rotor rotational motion.

Preferably both the stator and the rotor are cylindrical with their respective lengths forming their respective circumferences.

Preferably the field is interposed between the north pole and south pole of each stator pole pair.

Preferred embodiments of the invention will be described in more detail, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a view of an AC machine embodying the invention;

Figure 2 shows greater detail of a stator pole pair and windings in a three phase machine;

Figure 3 shows detail of a stator pole pair and windings in a single or two phase machine;

Figure 4 is a diagrammatical representation of the relative placement of the rotor and stator coils for a three phase machine;

Figure 5 is a diagram similar to Figure 4 but for a single phase machine;

Figure 6 is a view of a further embodiment of an AC machine constructed in accordance with the invention;

Figure 7 shows one rotor pole lamination for the embodiment of Figure 6;

Figures 8 through 10 show various rotor/stator/sheave configurations for the AC machine; and

Figures 11 through 13 show other field/stator/rotor configurations where a permanent magnet implementation is utilised.

It is convenient to refer to the embodiments as AC motors, however, it is equally the case they could be used as AC generators, hence use of the generic expression "AC machine".

The AC motor 10 of Figure 1 can be characterised as a low speed salient pole synchronous type. The motor 10 shown is a three phase implementation, of cylindrical construction having an inner rotor 20 enveloped by a stator 30. The rotor 20 is the moving part of the motor 10 with a direction of motion, or migration axis, indicated by the arrow. It is equally the case that the motor could be a linear type extending over some length rather than about a circumference.

The stator 30 has radially inward directed and laterally extending complimentary stator pole pairs spaced about the periphery. Each stator pole pair consists of a north pole 35 and a south pole 55. There may be of the order of two hundred stator poles spaced about the periphery.

In this stator arrangement the north poles 35 are adjacent one another about the whole of the stator periphery. The same is the case for the south poles 55. This is in

contrast to prior art machines where the north and south stator poles alternate in adjacent pole pairs. Each stator pole 35,55 is constituted by a stacked arrangement of laminations. In Figure 1 a three phase or "E" lamination stacking arrangement is shown. This provides three limbs 36,37,38 for the north pole and three limbs 56,57,58 for the south pole which define two stator slots 40,45 and 60,65 in each pole respectively. The stator slots extend circumferentially. The space between adjacent stator poles is occupied by spacer laminations 32.

A circumferentially wound DC field coil 80 (shown in section) interposes respective stator pole pairs. Typically the field winding comprises 300 turns wound in stacked formation on a former. The field coil 80 could equally be a permanent magnet. The use of a permanent magnet provides other advantages. First, the AC machine would always behave as a generator when not motoring, and therefore allows for machine braking when the stator windings are near short-circuited or switched to a current limiting resistor. This provides a very useful back-up to the usual mechanical brake. Second, a substantial saving in copper is made since no large field winding is required. This will help decrease the cost of the motor. Third, the design means that relatively less permanent magnetic material need be used than for conventional designs, thereby promoting further savings, given that permanent magnets are usually quite expensive.

As shown in Figure 2, the stator windings within the slots extend circumferentially about the periphery of the motor 10. The conductors of the three phase implementation are shown as single cables, but could be implemented as such as ten conductors wired in parallel and bundled to look like

one conductor. The conductors identified by numerals 44,61 are for phase X, while 43 and 42,62 and 63 are for phase Y and 41,64 are for phase Z.

Figure 3 shows the stator winding for a single or two phase implementation, in which case the stator poles are constructed from "C" laminations. The north pole 75 and south pole 85 are interposed by the field winding 80. In the one slot of each pole is a pair of circumferential windings 71,72 and 81,82 respectively. In the single phase implementation windings 71,72 are the one phase but at 180 degree phase difference. The same is the case for windings 81,82. In a two phase implementation the windings 72,81 are for one phase, while windings 71,82 are for the other phase.

In both the instances of Figures 2 and 3 the stator winding would be terminated at some convenient point about the periphery of the motor.

For both the three phase and single phase implementations the rotor poles 25 of the rotor 20 extend laterally. The rotor poles 25 and spaces 28 between adjacent poles are made of laminations arranged to be at right angles to the migration axis. The rotor poles 25 extend at least over the whole width of the rotor thereby coming under the influence of the full length or extent of both stator poles 35,55. The air gap between the rotor 20 and stator 30 is relatively small, as is usually the case for such AC machines. This therefore requires fine machining tolerance in the preparation and stacking of the laminations.

The specific arrangement of the stator poles shown in Figure 1 is such as that respective limbs of a pole are

offset with respect to the angular position of the rotor. This angular offset provides a space travelling flux path which goes to establishing smooth rotational performance of the rotor.

Figure 4 shows the relative angular positions of the limbs of one "E" lamination stator pole pair. The reference numeral "B" is conveniently limb 36. The stator slots are also clearly identified. The relative 120 degree phase difference between each phase in each half of a pole pair can be noted. The other half of the pole pair is 180 degrees behind the corresponding one of the other pole.

Figure 5 shows a similar diagram where a "C" lamination is used for each pole. This configuration is single phase, in which case there is 180 degrees phase difference in the limbs of the north pole, with a relative 90 degree lag to the corresponding ones of the south pole.

In operation of the machine, current is driven through the stator coils 41-44, 61-64 under the influence of the field 60, generating a magnetic moment and causing movement of the rotor 20. Because of the offsets of the limbs of the stator poles this rotation is easily continued to the next adjacent pole pair providing precise and greatly resolved control over rotational motion of the rotor. The arrangement of circumferentially wound stator windings through adjacent stator poles in akin to the winding regime for a transformer which has phase windings wound around limbs such as those shown.

In the design of the motor 10, as noted previously, both the stator and rotor laminations are at right angles to the migration axis. The cross sectional area of each pole

(stator and rotor) with respect to the flux linkage across the air gap and incident upon the poles is limited to the thickness of each lamination. The advantage gained is that the flux path from the stator poles across the air gap to the rotor poles can change at a rate of hundred times per second without inducing lossy eddy currents, as would occur with a large cross sectional area lying normal to the flux path. This has great advantage in the sizing of both the stator and rotor poles and the overall motor frame size.

Figure 6 is a similar view to Figure 1, showing another embodiment of an AC motor 100. This motor differs from that of the other embodiment in that it is the rotor pole laminations that are shaped segmentally to provide the necessary offset with respect to the stator poles which are now aligned; otherwise the embodiments are the same. This arrangement has the effect of providing the same relative angular displacement of stator poles by phase as the arrangement shown in Figure 4. Figure 6 also details a clamping method for the stator and rotor laminations which promotes ease of construction.

Figure 7 shows one lamination for a rotor pole having offset segments to match a straight or aligned "E" lamination. Figure 6 also details a clamping method for the stator and rotor laminations which promotes ease of construction.

Both embodiments shown have the rotor located within the surrounding stator, however, it is equally possible that other configurations could be adopted and which would take advantage of the beneficial inventive concepts already disclosed.

Three motor configurations are shown in Figures 8, 9 and 10. The configuration of Figure 8 has an external stator mounted to a fixed shaft in accordance with the arrangements shown in Figures 1 and 6. The rotor is internal of the stator, but rather than driving a shaft itself is connected to a bearing mounted sheave onto which a lift car would be roped. The advantages of this configuration are that it is easier to guard the rotational parts of the motor since the stator itself guards much of the rotor. Also, it is relatively easy to arrange a brake to react against the underside of the rotor.

Figure 9 shows two variants in which the stator is internal of the rotor. In both instances it is substantially easier to wind coils into the stator and field slots, and for Figure 9B, the rotor is removable from the shaft and sheave, hence is serviceable without removing the sheave or ropes.

Figure 10 represents a pancake design, where the power output of the motor can be increased by adding or stacking further stator/rotor units. The motor is self guarding and there is improved access for winding the stator and field coils.

Previous reference has been made to the use of a permanent magnet for the field 80. Figures 11-13 show three other field/stator configurations, including the magnetic circuit flux paths. In Figure 11 the field 80 interposes the north pole 35 and south pole 55. The magnetic path is completed by the pieces of iron 90,95. In Figure 12 the field 80 is in two parts above the respective stator poles, and again the magnetic circuit is completed by an iron piece 90 extending the width of the stator. In Figure 13 the field

80 is located under the rotor pole 25.

There are many other possible field configurations where a permanent magnet is used.

5

It will be apparent to those skilled in the art that numerous modifications and alterations can be made without departing from the spirit of the invention, examples of which can be ascertained from the foregoing description.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. An AC machine comprising:

a stator having a plurality of laterally extending stator pole pairs spaced along its length, each pole pair having a north pole and a south pole with like poles in each stator pole pair being adjacent throughout the length of the stator, and a field extending continuously the length of the stator;

a rotor having a plurality of rotor poles extending laterally and spaced along the rotor, the rotor poles being in constant spaced relation with the stator pole pairs across an air gap, the rotor poles spanning at least the whole length of each stator pole pair;

and wherein each pole of a stator pole pair comprises two or more limbs, with adjacent ones of the limbs forming a slot therebetween, and each slot carries one or more conductors, each conductor extending longitudinally over the length of the stator.

2. The machine of claim 1 wherein there are no more than two conductors per slot, and each conductor relates to one electrical phase of the stator.

3. The machine of claim 1 wherein for a three phase AC machine each stator pole is "E" shaped thereby providing three limbs and two slots.

4. The machine of claim 1 wherein for a single or two phase AC machine each stator pole is "C" shaped thereby providing two limbs and one slot.

5. The machine of claim 1 wherein the spacing of adjacent stator pairs and between adjacent rotor pairs is

the same.

6. The machine of claim 1 wherein the stator poles and rotor poles are formed of laminations stacked lengthwise across the stator and rotor respectively, which stacking arrangement is advantageous as the magnetic flux linking the laminations across the air gap is incident upon a minimised cross sectional area being the thickness of each lamination, thereby reducing eddy current losses in the machine.

7. The machine of claim 1 wherein the field is interposed between the north pole and south pole of each stator pole pair.

8. The machine of claim 1 wherein the field extends the width of the stator and is placed above the stator poles on the side of the stator poles opposite the air gap.

9. The machine of claim 1 wherein the stator and rotor are cylindrical, with their respective lengths forming their respective circumferences.

10. An AC machine comprising:

a stator having a plurality of laterally extending stator pole pairs spaced along its length, each pole pair having a north pole and a south pole with like poles in each stator pole pair being adjacent throughout the length of the stator, and a field extending continuously the length of the stator;

a rotor having a plurality of rotor poles extending laterally and spaced along the rotor, the rotor poles being in constant spaced relation with the stator pole pairs across an air gap, the rotor poles spanning at

least the whole length of each stator pole pair;

and wherein each pole of a stator pole pair comprises two or more limbs with adjacent ones of the limbs forming a slot to carry a stator winding, the limbs being offset relative to one another so as to, in use of the machine, induce a progressing magnetic flux from a leading limb to a trailing limb which can then couple into the leading limb of an adjacent stator pole thereby to provide for improved resolution of the rotor rotational motion.

11. An AC machine comprising:

a stator having a plurality of laterally extending stator pole pairs spaced along its length, each pole pair having a north pole and a south pole with like poles in each stator pole pair being adjacent throughout the length of the stator, and a field extending continuously the length of the stator;

a rotor having a plurality of rotor poles extending laterally and spaced along the rotor, the rotor poles being in constant spaced relation with the stator pole pairs across an air gap, the rotor poles spanning at least the whole length of each stator pole pair;

and wherein the stator poles are planar and the rotor poles are offset in segments along their length so as to induce a progressing magnetic flux relative to the limbs of stator poles and to couple the magnetic flux into an adjacent rotor pole thereby to provide for improved resolution of the rotor rotational motion.

12. The machine of claim 10 wherein both the stator and the rotor are cylindrical with their respective lengths forming their respective circumferences.

13. The machine of claim 11 wherein both the stator

and the rotor are cylindrical with their respective lengths forming their respective circumferences.

14. The invention of claim 10 wherein the field is interposed between the north pole and south pole of each stator pole pair.

15. The invention of claim 11 wherein the field is interposed between the north pole and south pole of each stator pole pair.

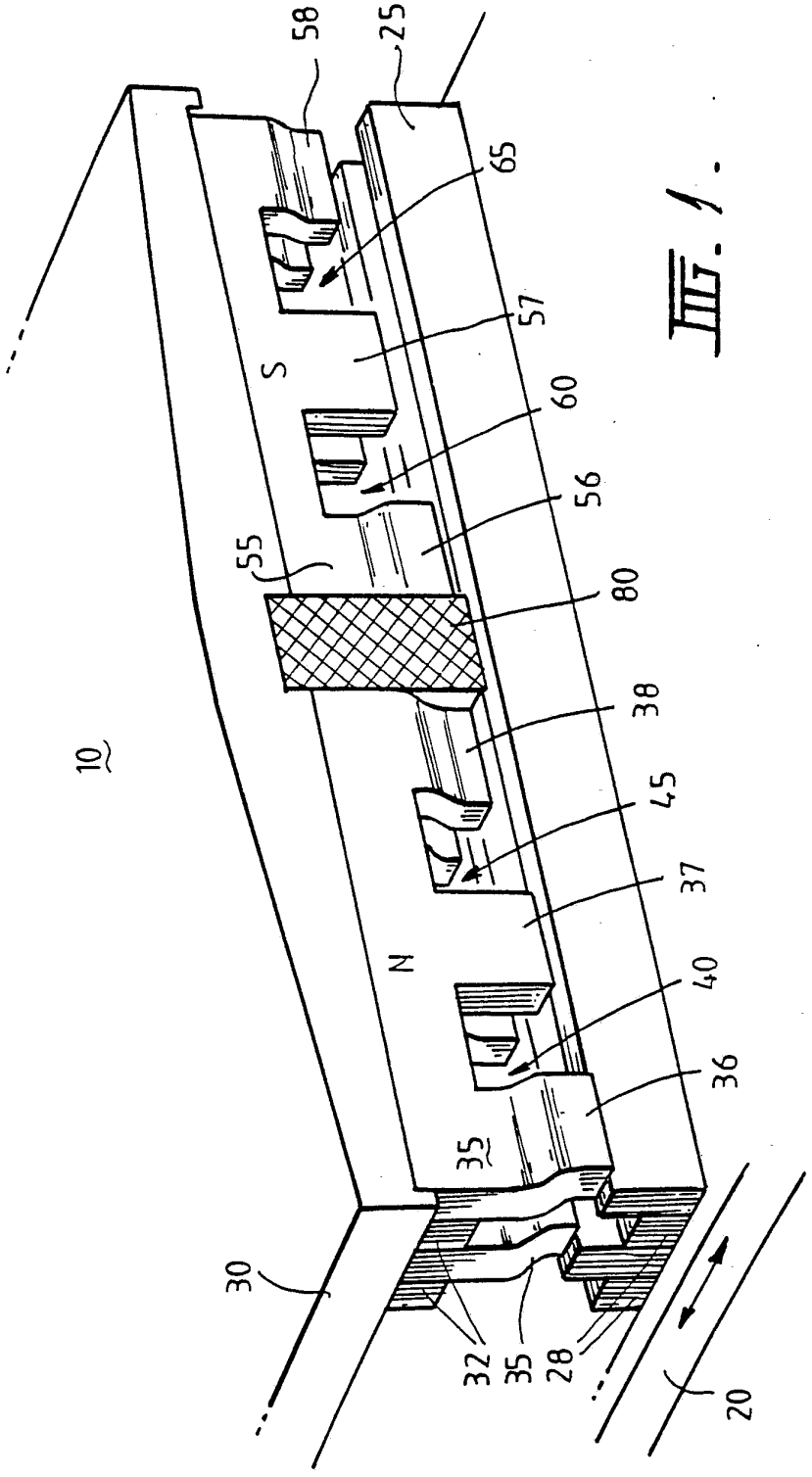


Fig. 1.

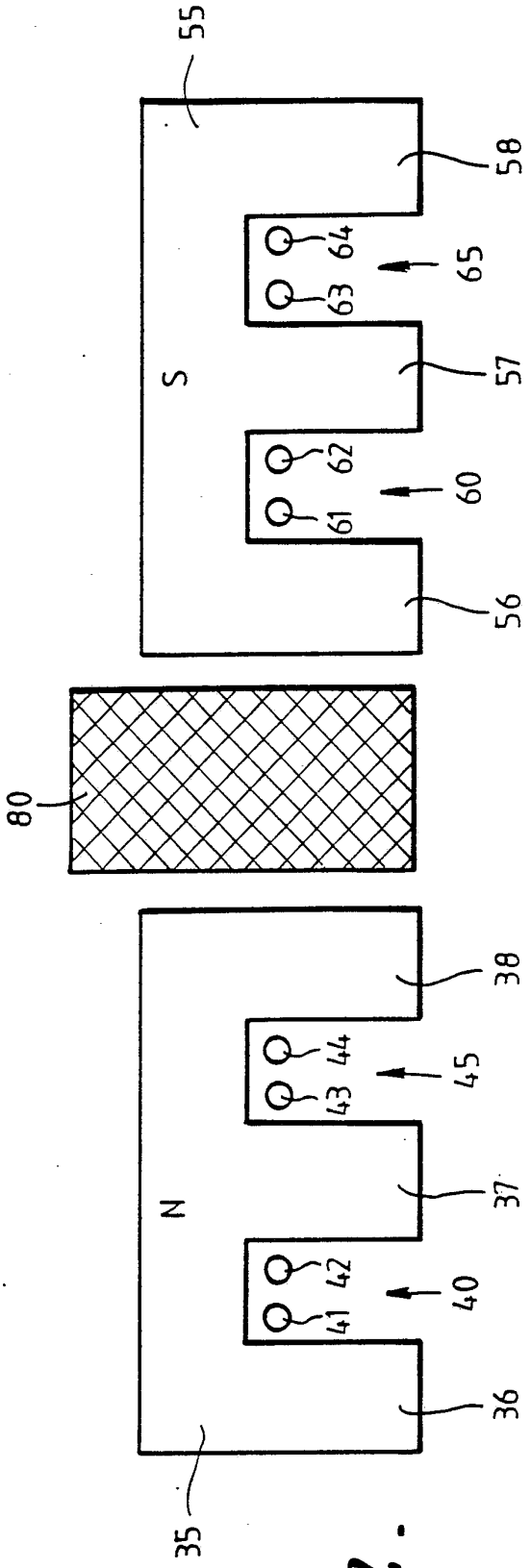

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FIG. 2.

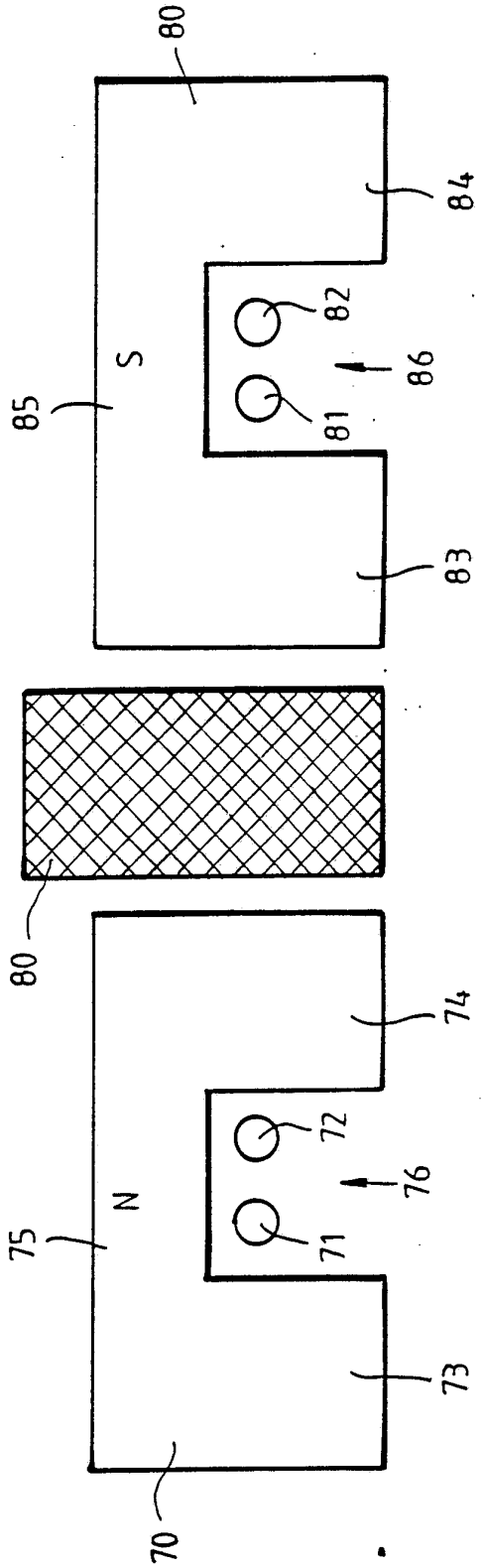

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FIG. 3.

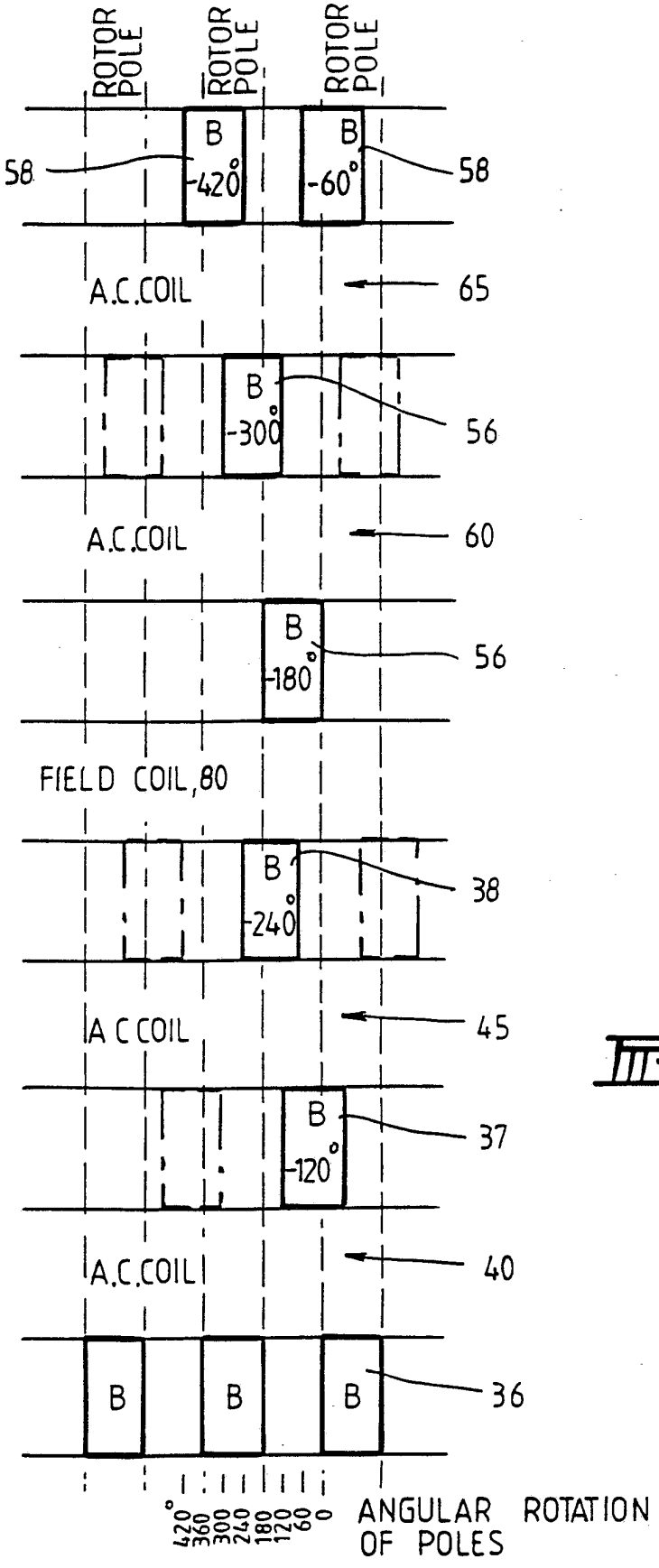


FIG. 4.

RELATIVE POLE POSITIONS OF STATOR AND ROTOR "E" COIL CONFIGURATION.

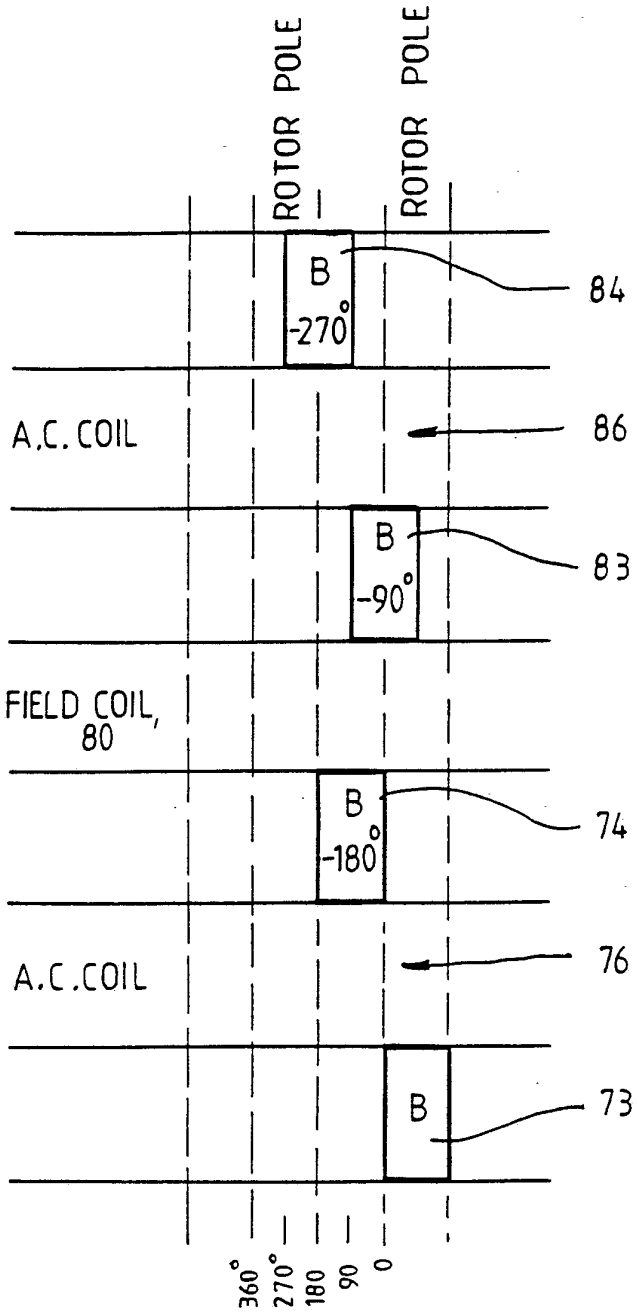


FIG. 5.

RELATIVE POLE POSITIONS OF STATOR AND ROTOR
"C" COIL CONFIGURATION

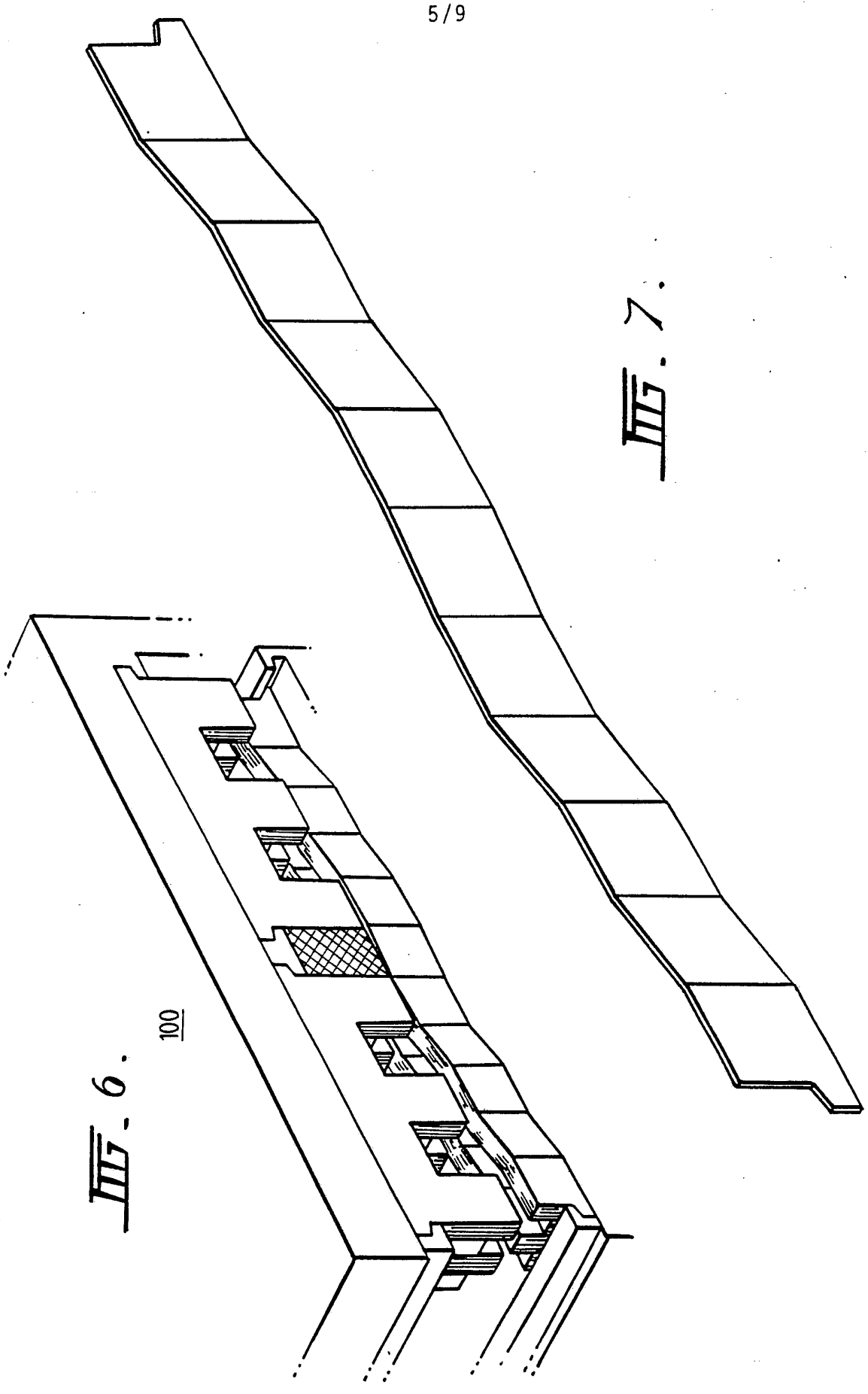
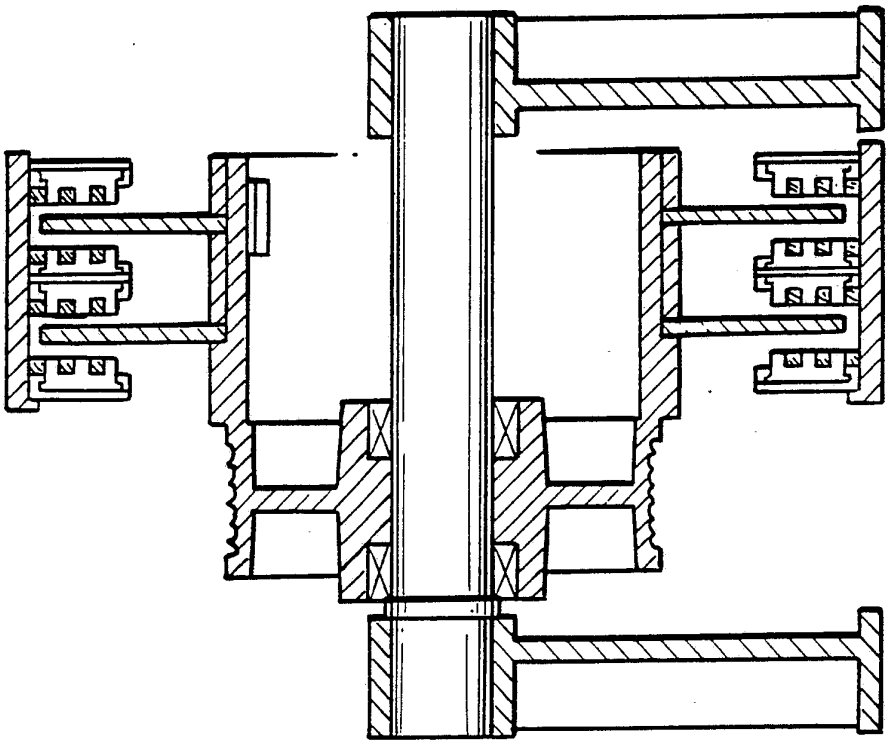
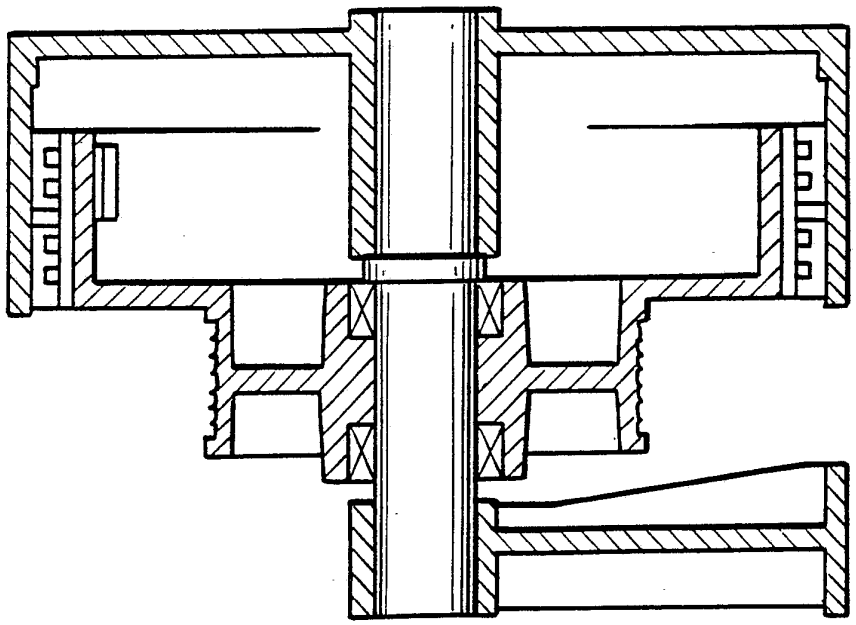


Fig. 6.

Fig. 7.



Фиг. 10.



Фиг. 8.

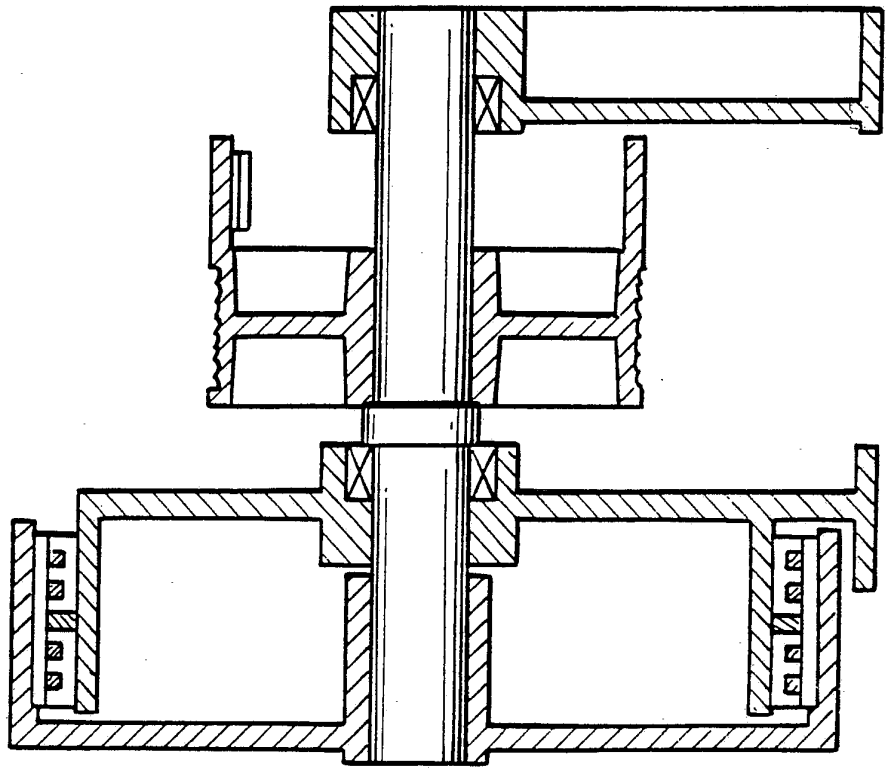


FIG. 9B.

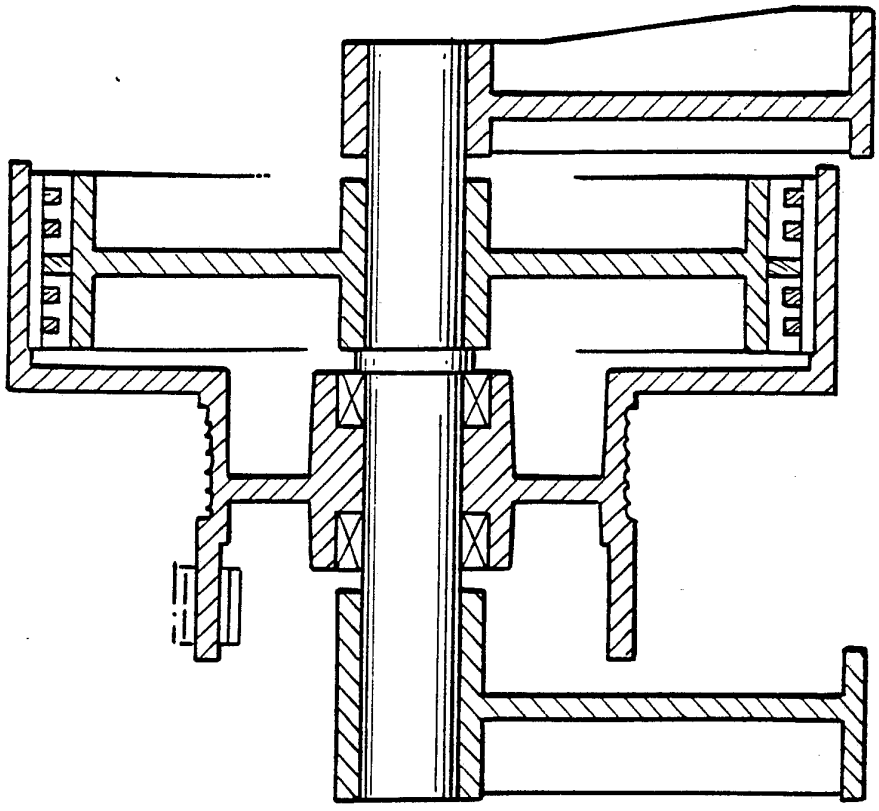


FIG. 9A.

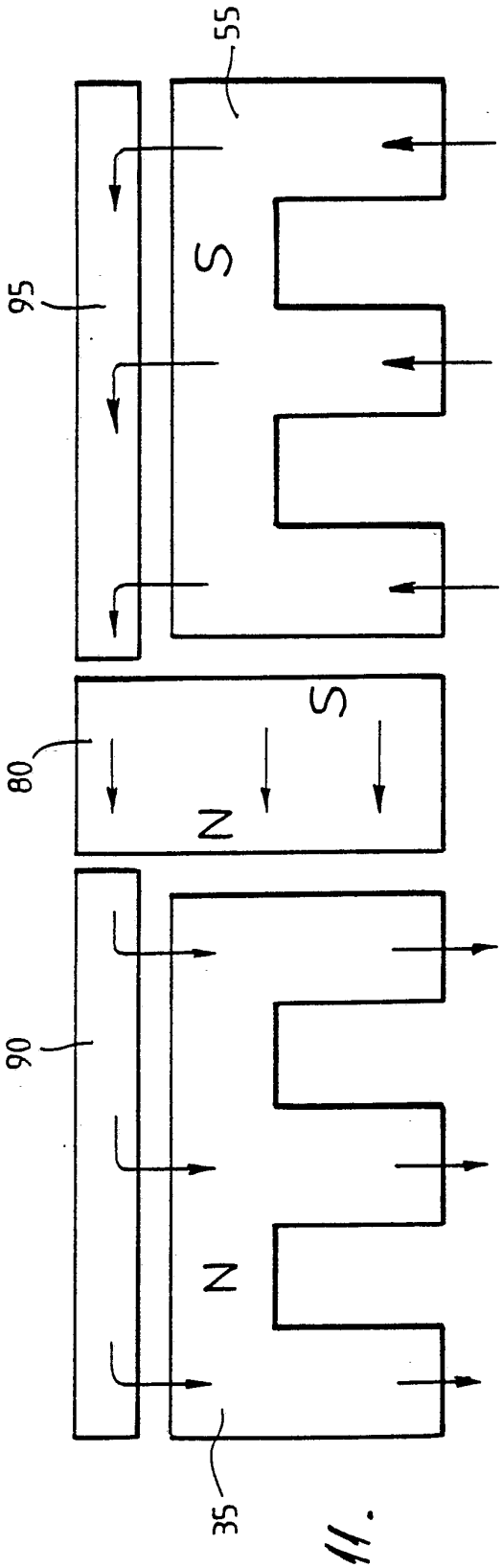


Fig. 11.

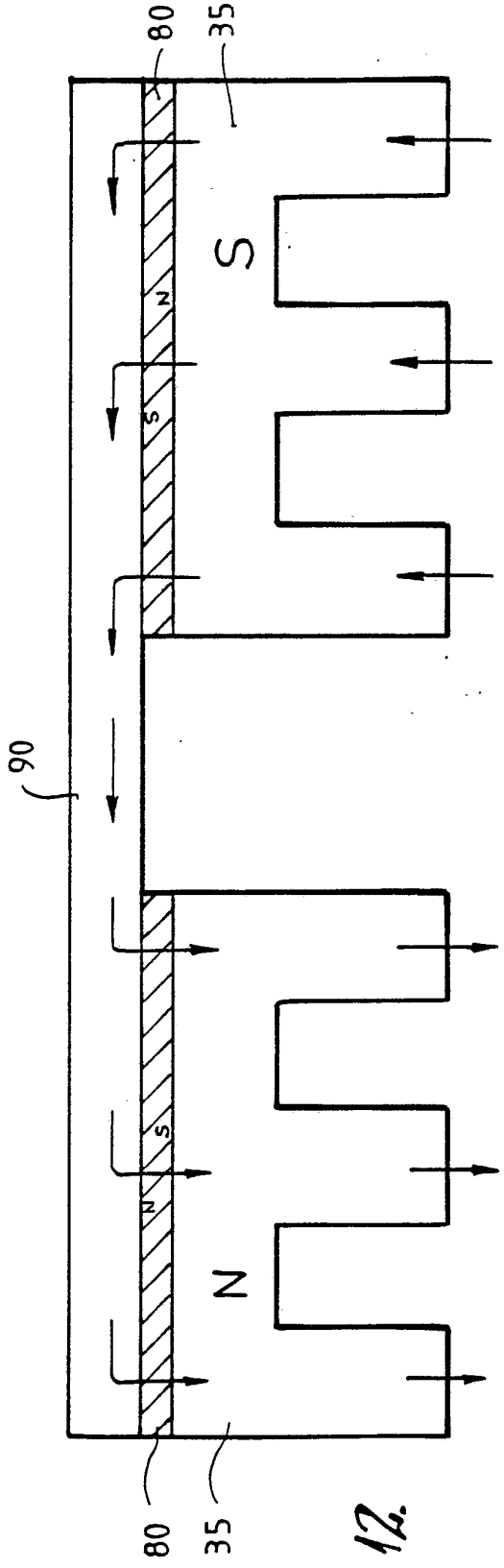


Fig. 12.

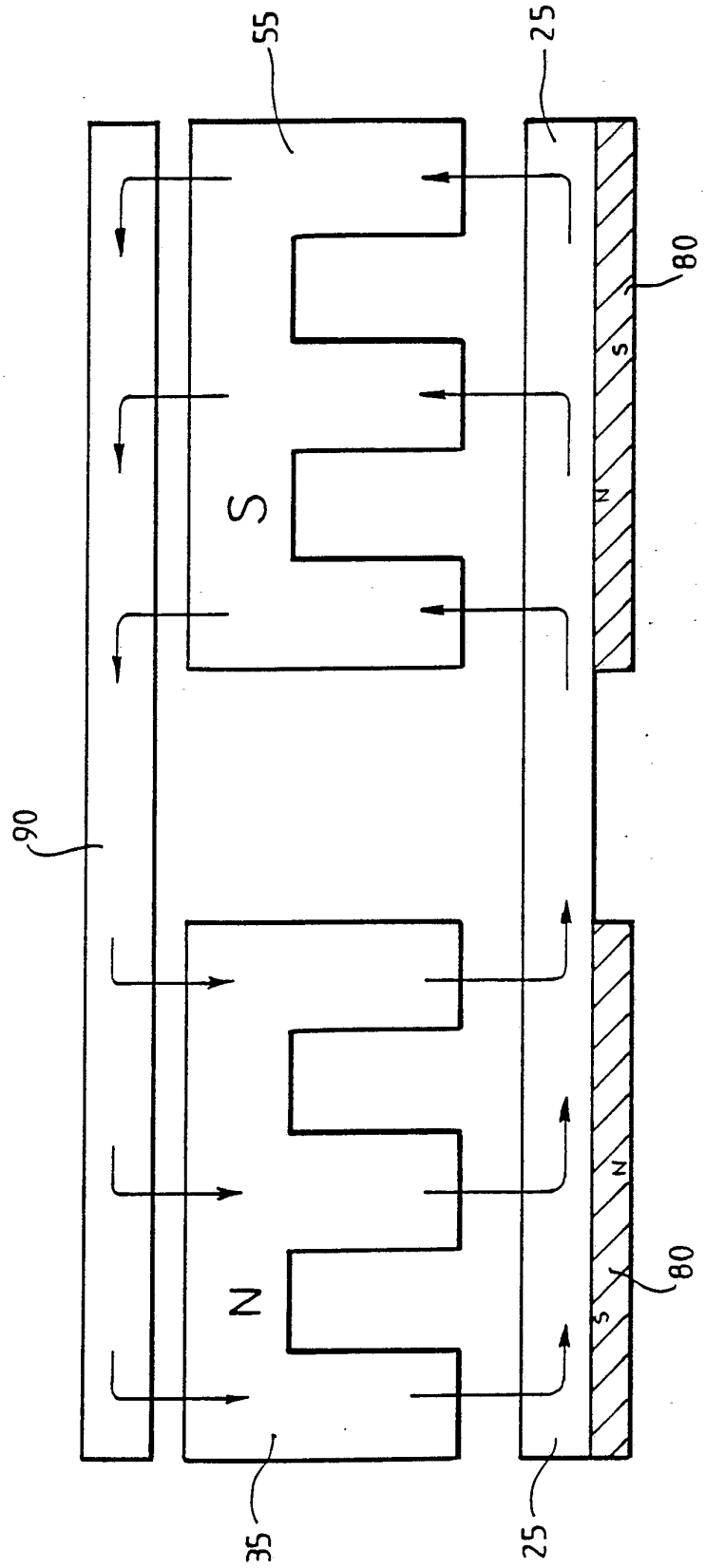


Fig. 13.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU93/00022

A. CLASSIFICATION OF SUBJECT MATTER
Int. Cl.[5] H02K 1/06, 41/03

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)
IPC H02K 1/06, 41/03

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
AU : IPC as above, H02K 1/16, 1/17, 19/00, 19/06, 37/08, 37/18, 41/02

Electronic data base consulted during the international search (name of data base, and where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to Claim No.
X Y	US,A, 4206374 (GODDIJN) 3 June 1980 (03.06.80) entire document	1,4-10,12,14 11,13,15
X Y	GB,A, 2115231 (ROLLS-ROYCE AND ASSOCIATES LIMITED) 1 September 1983 (01.09.83) page 1 line 101 - page 2 line 44, figures 1-3	1,4,5,7-10,12,14 11,13,15

(continued)

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

[X] See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
6 May 1993 (06.05.93)	7 MAY 1993
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200 WODEN ACT 2606 AUSTRALIA Facsimile No. 06 2853929	Authorized officer EDGAR PERRIS Telephone No. (06) 2832167

INTERNATIONAL SEARCH REPORT

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate of the relevant passages	Relevant to Claim No.
X	EP,A, 173389 (N.V. PHILLIPS' GLOEILAMPENFABRIEKEN) 5 March 1986 (05.03.86) page 4 line 13 to page 7 line 23, figures 1-4	1,4,5,8-10,12,14
Y	US,A, 4228372 (POPOV et al) 14 October 1980 (14.10.80) abstract and figure 1	11,13,15
Y	EP,A, 352189 (SHINKO ELECTRIC CO LTD) 24 January 1990 (24.01.90) abstract, figure 3	11
A	US,A, 4255680 (POPOV et al) 10 March 1981 (10.03.81) abstract, figures 1,2	1-15
A	US,A, 4355249 (KENWELL) 19 October 1982 (19.10.82) abstract, figures 1,3,5	1-15

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report	Patent Family Member					
EP 173389	DE	8523360	ES	546207	NL	8402542
	US	4920294				
US 4206374	AT	4788/77	BE	856441	CA	1081756
	CH	625366	DE	2727450	FR	2358046
	GB	1586513	IT	1076074	JP	53005714
	NL	7607381	SE	7707643	ES	460352
	NL	7701510				
US 4228372	DE	2852845	FR	2420869	JP	54125420
EP 352189	JP	2032750	US	5010262	JP	2131350
	JP	2131351	JP	2133060		
						END OF ANNEX