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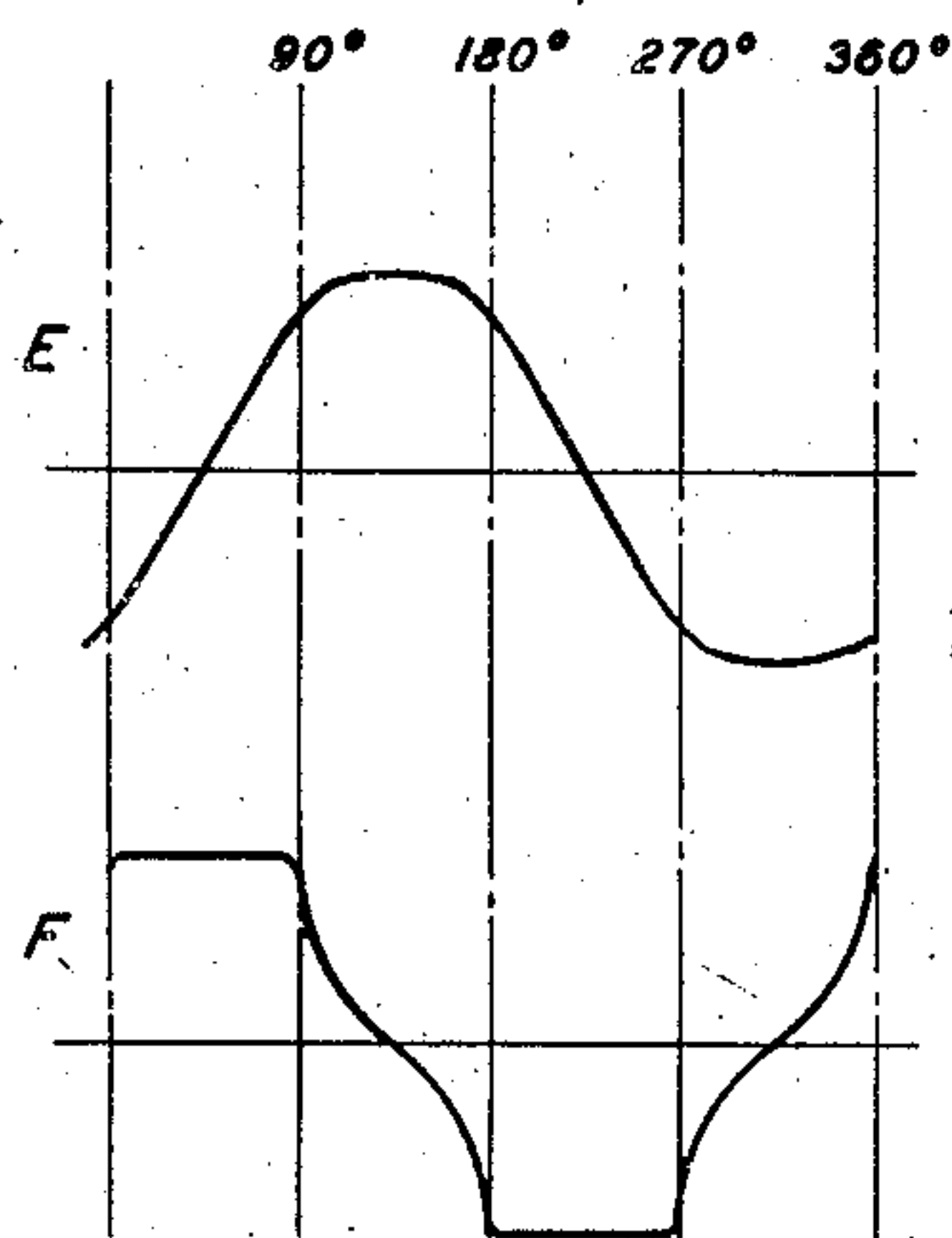
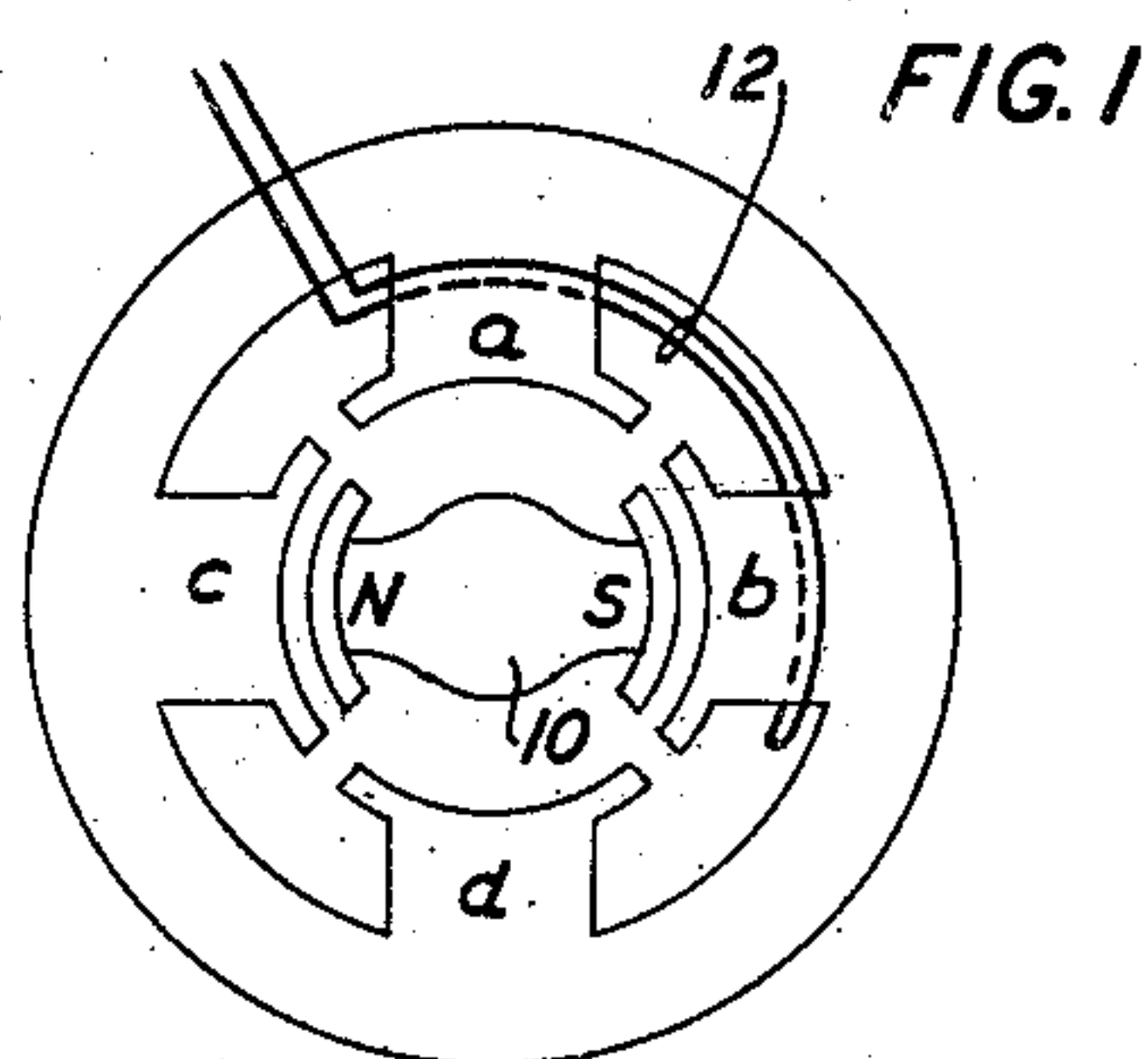
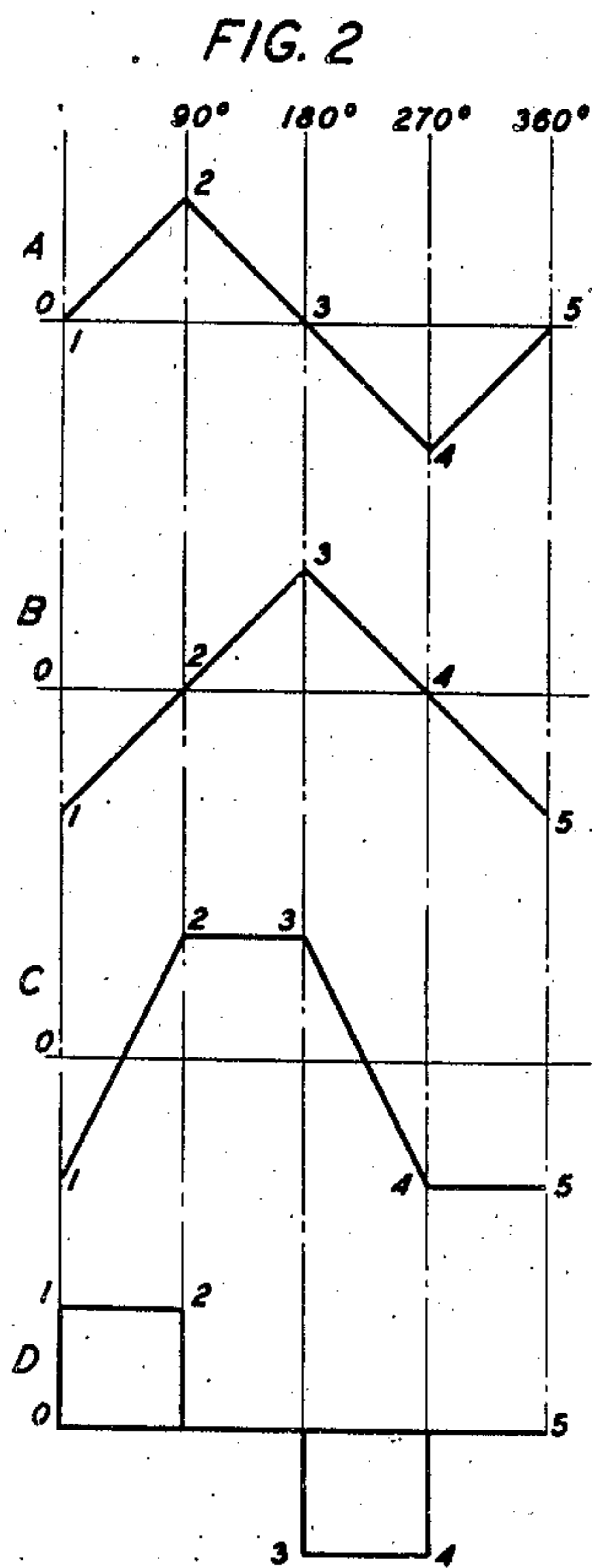
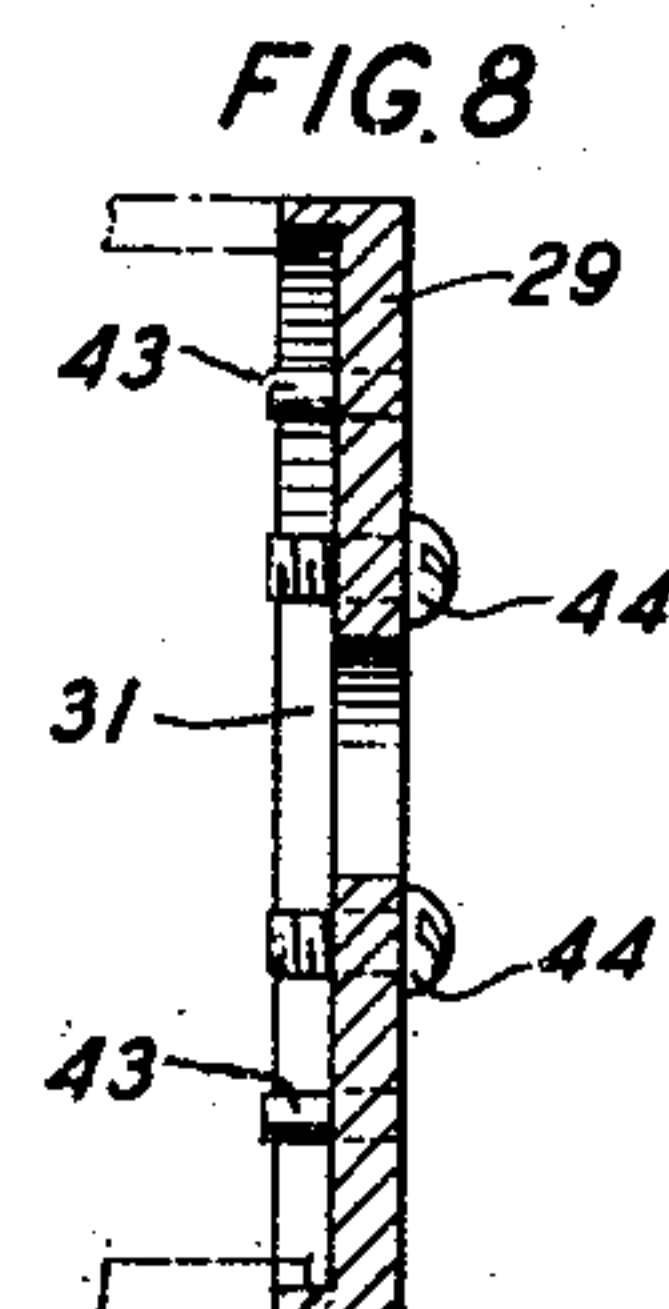
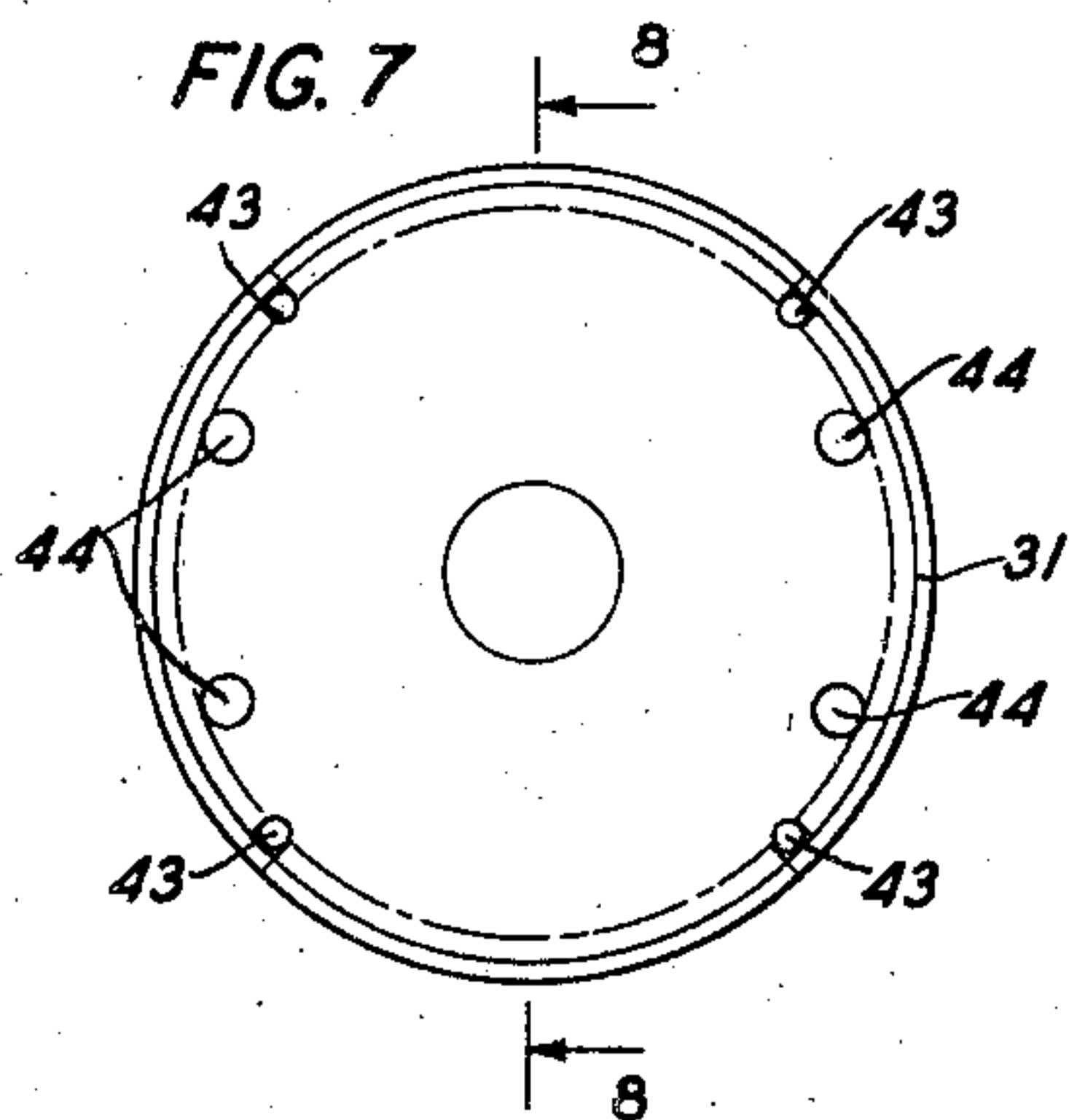
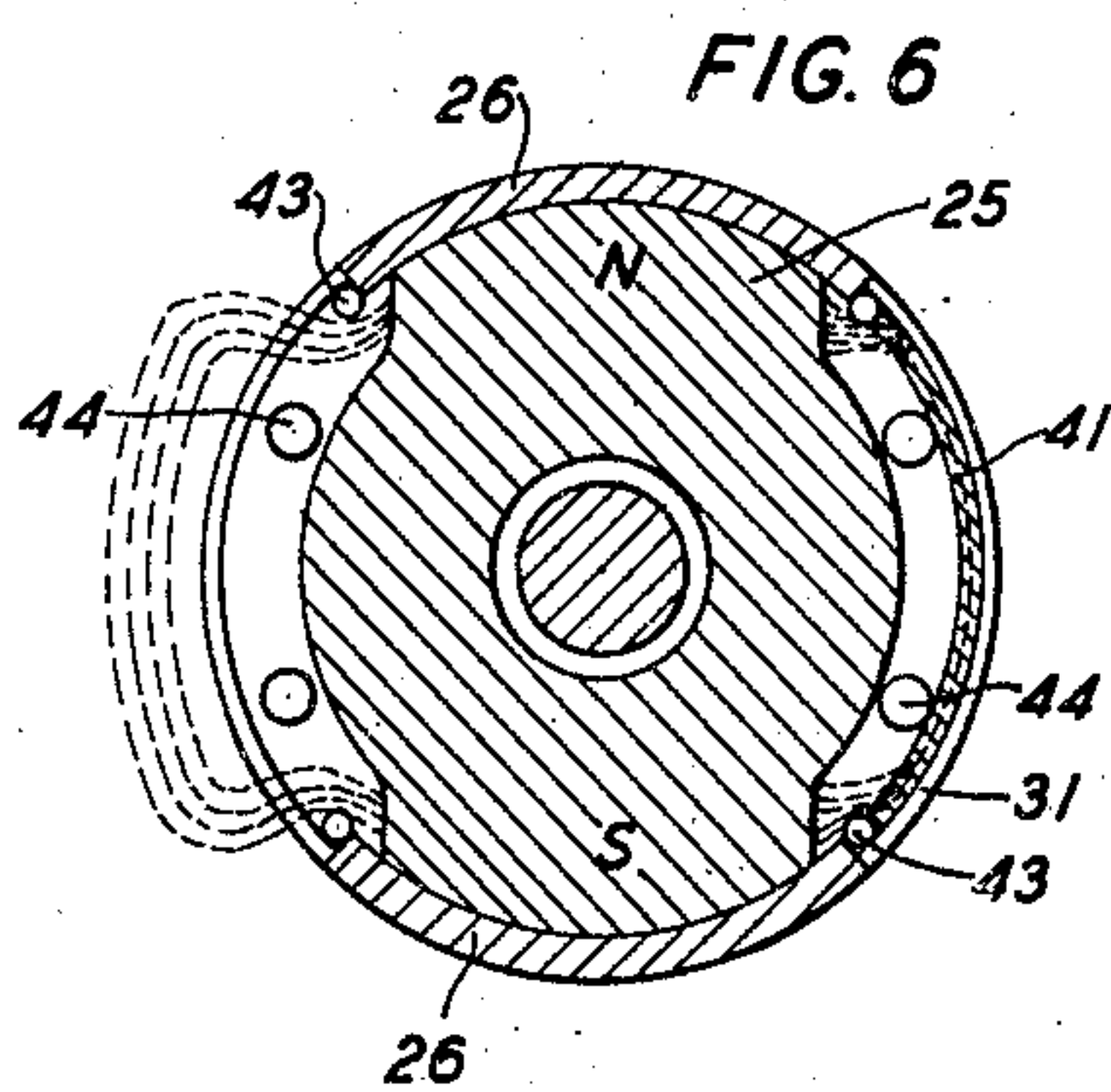
E. R. MORTON

2,432,117

ALTERNATING CURRENT GENERATOR

Filed May 2, 1944

2 Sheets-Sheet 1



INVENTOR  
E. R. MORTON  
BY *A. F. Kane*  
ATTORNEY



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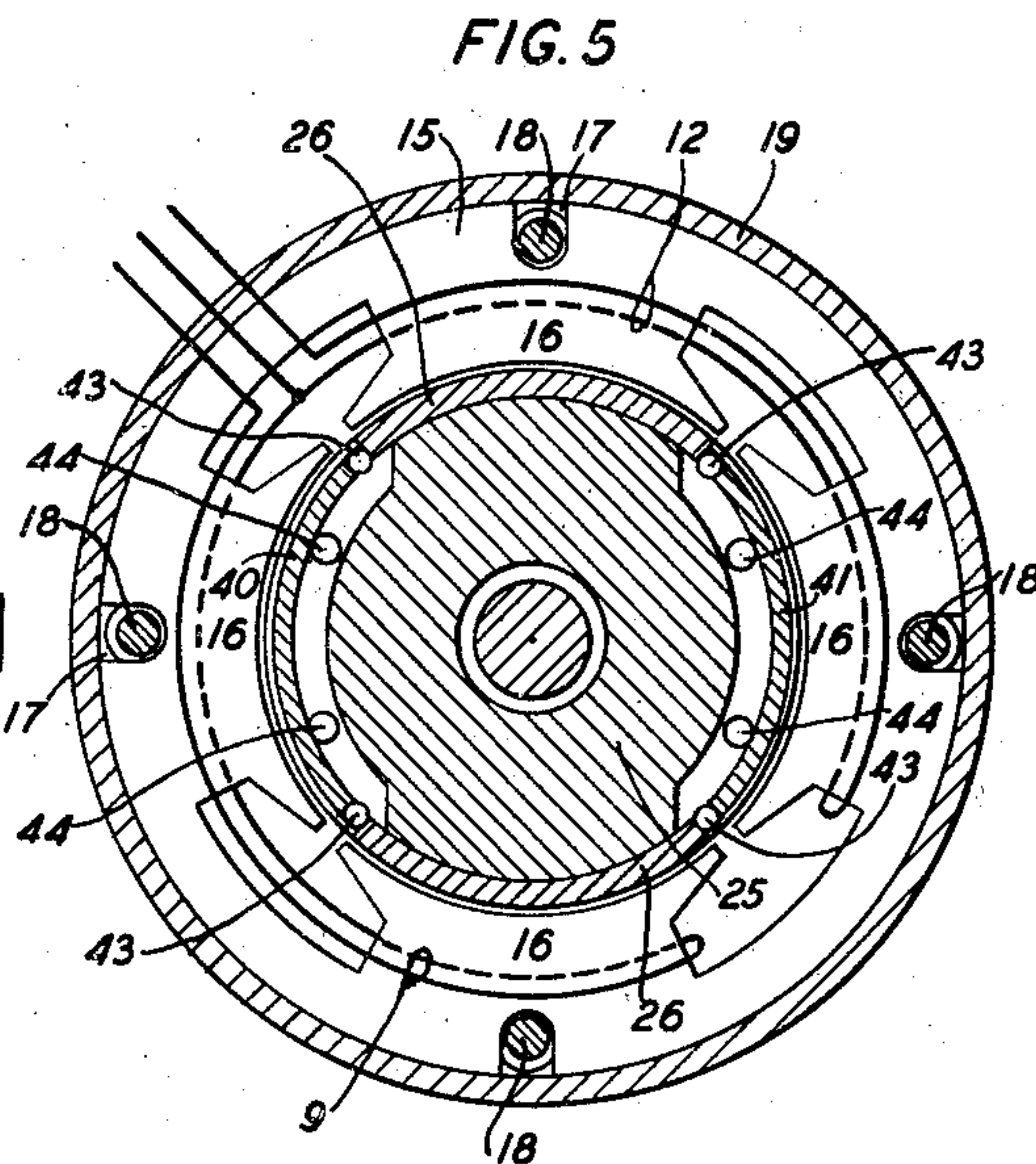
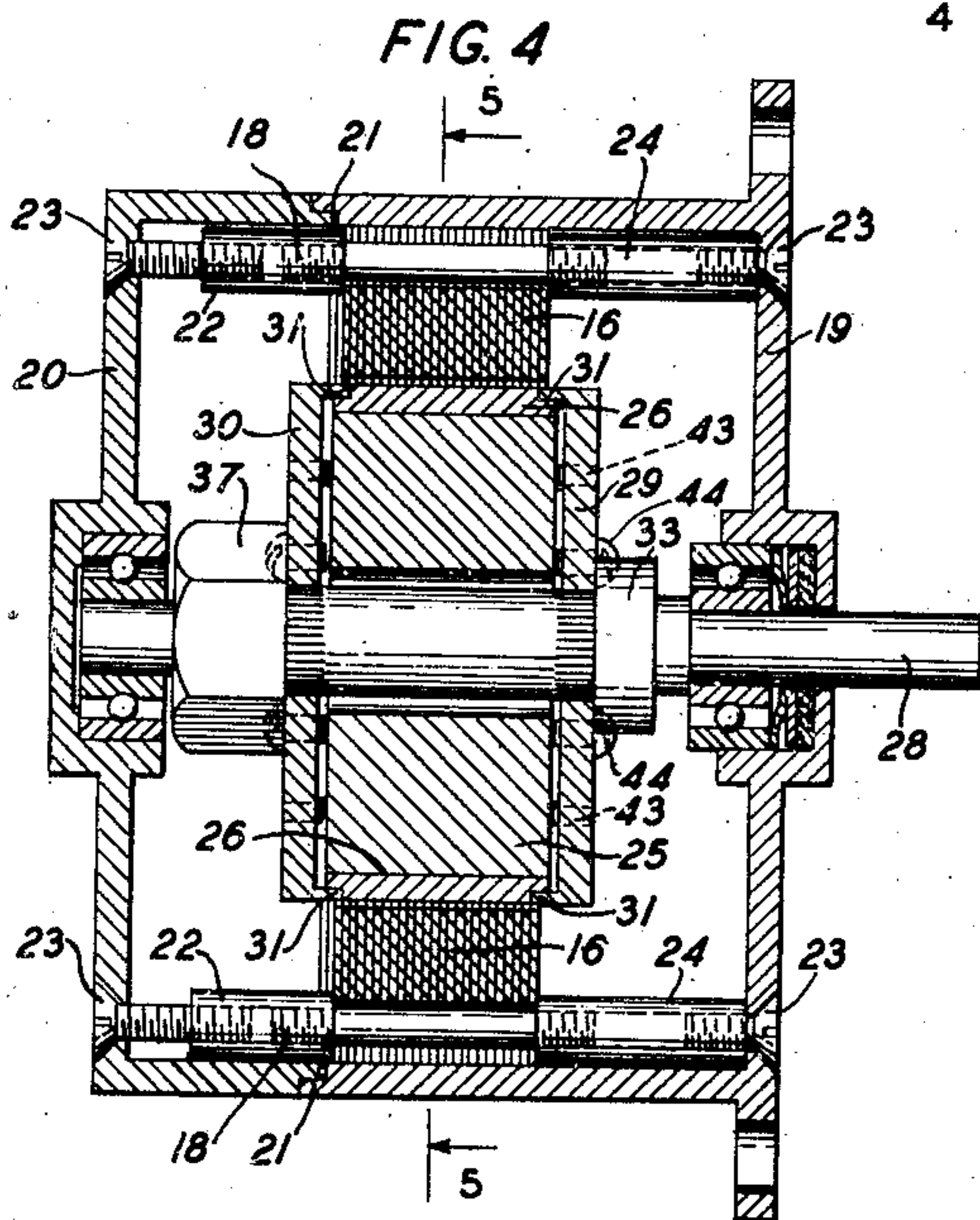
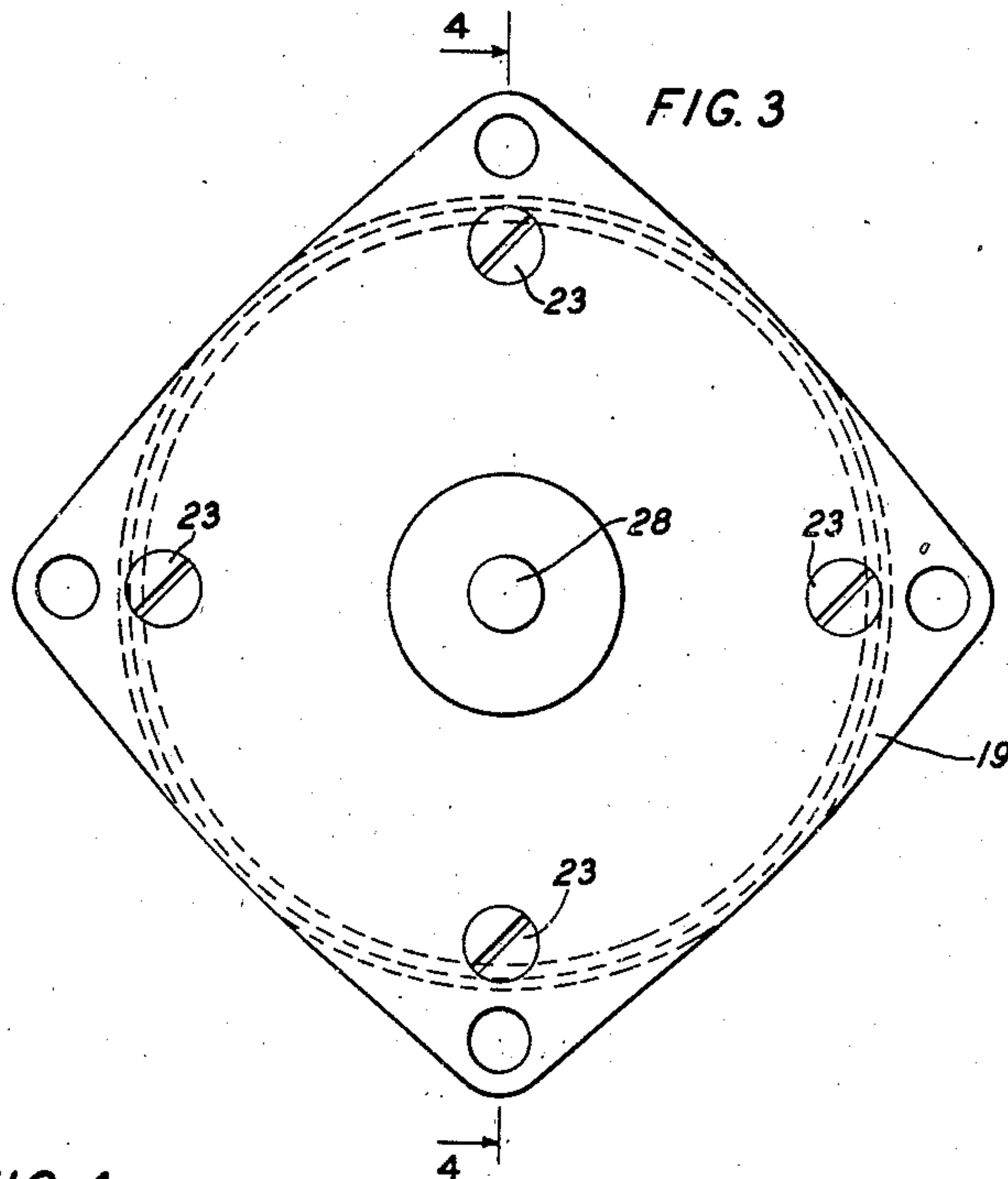
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2 Sheets-Sheet 2



INVENTOR  
E. R. MORTON

BY

*A. J. Kane*

ATTORNEY



## UNITED STATES PATENT OFFICE

2,432,117

## ALTERNATING CURRENT GENERATOR

Edmund R. Morton, Brooklyn, N. Y., assignor to  
Bell Telephone Laboratories, Incorporated, New  
York, N. Y., a corporation of New York

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4 Claims. (Cl. 171—209)

1

This invention relates to dynamo-electric machines and particularly to alternating current generators having a permanent magnet excitation system and capable of developing an alternating current voltage having a substantially square, or rectangular wave form.

The object of the invention is to provide a simple, compact and inexpensive generator which is capable of developing an alternating current voltage whose wave form, when plotted in rectangular coordinates, comprises sharply defined time spaced alternate positive and negative square, or rectangular loops.

Alternating current generators of the so-called square wave generating type are characterized by the capability of developing an alternating current electromotive force whose wave form consists of alternate positive and negative loops having substantially straight line or flat tops. Due primarily to the presence of leakage flux in such generators it has been difficult to devise a machine capable of developing an electromotive force whose wave form consists of sharply defined square or rectangular loops since the leakage flux produces a distortion in the generated voltage to the extent that the transition from a maximum voltage in one direction to a maximum voltage in the opposite direction, when plotted in rectangular coordinates, is represented by more or less gradually curving line. This is to say, the drop from a maximum voltage in either direction to zero voltage, or the rise from zero voltage to maximum voltage in either direction, is not instantaneous, but is more or less gradual depending upon the extent of the leakage flux. The wave form of such generated voltage therefore is not characterized by a succession of sharply defined alternate positive and negative loops having a square configuration.

In accordance with a feature of the present invention a true square, or rectangular wave form, representative of the generated voltage, is obtained by eliminating the effects of leakage flux and precluding the possibility of such flux linking with the generating coils to produce distortion of the wave in the no voltage interval. More particularly, the generator of this invention embodies a rotating field structure comprising a two-pole permanent magnet rotor equipped with the usual soft iron pole shoes, and a magnetic shield interposed between oppositely polarized poles of consecutive pole shoes. Thus the leakage flux which fringes out from the pole tips of the permanent magnet rotor is diverted from the coil bearing stator and is provided with an auxiliary

2

return path which extends from the tip of one pole of the rotor to the tip of the other pole. By thus diverting the leakage flux and preventing its entry to the stator to link with the generating coils, the generated voltage is produced solely by that flux which traverses the uniform air-gap between the rotor pole shoes and the stator teeth, or poles. In this manner the change from maximum voltage in either direction to zero voltage, and similarly the change from zero voltage to maximum voltage in either direction is substantially instantaneous and when plotted in rectangular coordinates is represented by a vertical line extending in either direction from the zero voltage axis to the beginning or end of the horizontal line which represents the flat top of the wave, or the maximum value of the generated voltage.

An ancillary, or related feature of the invention resides in the particular form of magnetic shield employed and the method of mounting it on the rotor. The shields are substantially arcuate slabs, and each is confined between two disc-like members which function also to support the rotor magnet. Each disc is provided with an inwardly projecting rim and is provided with suitably disposed sets of pins and screws, which serve to space the shields from the rotor pole shoes and from the periphery of the rotor magnets respectively. The pins and screws together with the inner face of the disc rim define a slot or area in each of the discs which receive the shield ends. The shields and the pole shoes, in effect, constitute a substantially complete peripheral enclosure for the rotor magnet interposed between the magnet and the inner periphery of the stator.

A further feature of the invention resides in the distribution of the generating coils over the stator. More particularly, the stator comprises four teeth or poles, each subtending an angle of substantially 90 degrees, and, in the single phase embodiment, is equipped with two coils, each of which spans two adjacent stator teeth, or substantially 180 electrical degrees. Thus, during one-half revolution of the rotor, a coil is under the influence of one rotor pole and during the other half revolution, is under the influence of the other rotor pole. The voltage generated in a coil so distributed, by a two-pole rotating field, when plotted against time in rectangular coordinates, is represented by a series of equi-spaced square, or rectangular loops of alternate polarities, the width of the flat top of the loops being equal to the polar arc of the rotating field. Thus the generator of this invention may be defined as a square wave generator having one coil per



pole covering substantially 180 electrical degrees, and associated field poles having a pole arc substantially equal to the width of the flat top of the generated wave.

These and other features of the invention will be readily understood from the following description when read in connection with the accompanying drawings in which:

Fig. 1 is a schematic illustration of a four-pole, or four-toothed stator in which a single generating coil is shown spanning two consecutive poles or teeth, and a two-pole permanent magnet rotor whose field poles have a pole arc of substantially 90 degrees, or one-half the electrical degree span of a stator coil. It is to be understood that the magnetic shields, which constitute an important feature of the invention have been omitted from the schematic showing of Fig. 1 since they are not essential to the description which is to be directed hereinafter to Fig. 1;

Fig. 2 consists of six curves A, B, C, D, E and F. Curve A is illustrative of the manner in which the flux emanating from the rotor 10, Fig. 1, varies in traversing the stator pole *a* during a complete clockwise revolution of the stator 10 beginning from the position it occupies in Fig. 1. Curve B is similar to curve A except that it illustrates the manner in which the flux, traversing the stator pole *b* during the same period of rotation of the rotor 10 varies. Curve C is the resultant flux curve of curves A and B and illustrates the flux variations to which the single coil 12 is subjected during one revolution of the rotor 10. Curve D is the resulting electromotive force curve illustrating the voltage developed in the coil 12 during one revolution of the rotor 10. Curve E is illustrative of the wave form of the flux to which the coil 12 would be subjected in a generator such as is illustrated in Fig. 1 and which is not provided with the magnetic shields incorporated in applicant's structure to negative the effect of leakage flux. Curve F is illustrative of the wave form of the voltage produced by a flux wave such as shown in curve E;

Fig. 3 is a front plan view of the generator shown in section in Fig. 4;

Fig. 4 is a sectional view of the generator of this invention taken along the line 4—4 of Fig. 1;

Fig. 5 is a section taken along the line 5—5 of Fig. 4 and looking in the direction of the arrows;

Fig. 6 is a sectional view of the generator rotor with one of the magnetic shields omitted and shows schematically, the approximate path of the leakage flux with and without the magnetic shields;

Fig. 7 is an inside plan view of one of the rotor discs, which serves to mount the magnetic shields; and

Fig. 8 is a sectional view taken along the line 8—8 of Fig. 7.

The generator of this invention is completely enclosed in a housing, or casing consisting of two complementary cup-shaped members 19 and 20. The member 19 is provided with a substantially square wall provided at each of its four diagonally disposed corners with apertures suitable for the reception of screws by which the generator may be mounted. The edge of the inwardly projecting annular wall of each member 19 and 20 is flanged as indicated at 21 and when the two members are brought together these flanges mutually overlap. The vertical walls, viewing Fig. 4, consisting of members 19 and 20 are each provided with a circular centrally located compartment which accommodates a bearing of any

suitable design such as the ball bearing type illustrated. These bearings accommodate the two end portions of a shaft 28 which, at predetermined positions, intermediate its ends, is provided with a circular shoulder 33 and a threaded portion which accommodates the nut 37. The shaft 28 constitutes a support for the rotor elements of the generator and is rotatable in the bearings illustrated. The rotor, exclusive of the shaft 28 consists of a permanent magnet 25 with its pole shoes 26, two disc-like elements 29 and 30 and a pair of magnetic shields 40 and 41.

The disc-like members 29 and 30 are substantial duplicates and each is provided with an inwardly projecting rim 31, a pair of inwardly projecting pins 43 and two screws 44. The pins 43 and screws 44 are located on the discs 29 and 30 so as to permit the magnetic shields 40 and 41 to be removably confined therebetween and against the inner face of the disc rims 31 as clearly shown in Figs. 5, 6 and 7. The magnetic shields may be aptly described as arcuate slabs of soft iron of such lengths as to subtend an angle of substantially 90 degrees when assembled on the rotor. The two discs 29 and 30 are press-fitted onto the shaft 28 so that the former abuts the inner face of the shoulder 33 and the latter is spaced therefrom by a distance slightly greater than the length of the permanent magnet 25. The two discs 29 and 30 thus define an area within which the permanent magnet is located in a manner to be described presently.

The permanent magnet 25 is substantially cylindrical in shape and is provided with an axial bore of a diameter slightly in excess of the diameter of the central portion of shaft 28. It is provided with two diagonally disposed salient poles of opposite polarities and each pole has affixed thereto, in any suitable manner, a soft iron pole shoe 26 of arcuate form. Each pole shoe subtends an angle of substantially 90 degrees and is provided on each of two opposite edges with a flange, which flanges serve to accommodate the inner edges of the rims 31 of the discs 29 and 30. Thus, when the two discs 29 and 30 and the magnet 25 are assembled on the shaft, the extending rim portions 31 of the former overlap the flanges of the pole shoes 26 as clearly illustrated in Fig. 4. A portion of the shaft 23 to the left of the central portion confined between the discs 29 and 30 is threaded to accommodate the nut 37. After the discs with their magnetic shields 40 and 41 and the armature 25 are positioned on the shaft, the nut 37 is screwed up tight, thereby firmly seating the disc rims 31 on the pole shoe flanges and rigidly locating the rotor unit on the shaft.

The stator is made up of a plurality of stacked silicon steel laminations 15 which are annular in shape and provided with four inwardly projecting teeth, or poles 16. Each tooth presents a concave arcuate edge to the rotor periphery of substantially the same length as that of the pole shoes 26. Each lamination is provided at four diagonally disposed points with a slot 17, which slots, when the laminations are stacked in mutual alignment, form four elongated slots into each of which a screw rod 18 is adapted to be inserted and to project therefrom at each end. The projecting ends of each of the screw rods 18 accommodate two internally threaded sleeves 22 and 24, the former being of shorter length than the latter. The sleeves 24 are of such a length that, when interposed between the right face of the stacked laminations and the inner face of the



housing member 19, the stator is accurately positioned midway of the two housing members 19 and 20. Through suitable holes in the housing members the screws 23 pass within the housing so as to screw into the outer ends of the sleeves 22 and 24. When the screws 23 are made up tight they function to compress the laminations into a compact stack and also to draw the two housing members 19 and 20 together.

It will be observed that the pins 43 which are set in the discs 29 and 30 serve to angularly space the magnetic shields 40 and 41 from the pole shoes 26 and that the area defined by a pair of pins 43, a pair of screws 44, acting as removable additional pins and the inner face of a disc rim 31, is such as to snugly accommodate the edge of a magnetic shield 40 or 41. This arrangement precludes the necessity for permanently fixing the shields to the two discs 29 and 30 and simplifies the assembly of the rotor elements. The screws 44, while serving to hold the shields 40 and 41 against the rims 31 of the discs 29 and 30 also act to space the shields from the periphery of the permanent magnet 25.

It will be observed that the thickness of the shields 40 and 41 is less than that of the pole shoes 26. The function of the pole shoe is to distribute evenly possible irregularities of the flux distribution of the field magnet and therefore may require substantial section depending upon the magnitude of the irregularities, whereas the magnetic shield carries only the leakage flux supplied over a relatively large air-gap. The quantity of this flux is therefore small so the section of the magnetic shield may also be small. The shields have relatively large air-gaps to stator to avoid interference with the stator.

Referring now particularly to Fig. 6 which shows the rotor in section and in which the magnetic shield 40 has been omitted for descriptive purpose only, it will be observed that more or less magnetic flux fringes out from the tips of the magnet poles and pole shoes, as indicated by the flux lines illustrated. This flux is characterized as the leakage flux and traverses a path, other than the uniform air-gap between the pole shoes and the stator, the reluctance of which is different than that of the uniform air-gap. This flux enters the stator and threads the generating coil together with the air-gap flux and produces distortion in the wave form of the generated voltage. The magnetic shields, as illustrated on the right of Fig. 6 collect this leakage flux and diverts it from the stator thereby precluding the possibility of it linking with the generator coils and distorting the wave form of the generated voltage. The leakage flux fringing out from the north pole tips enters the magnetic shields, traverses the same to reenter the magnet at the south pole tips. The shields being positioned on the rotor and rotatable therewith function, in every position of the rotor, to collect the leakage flux and divert it from the stator. The voltage generated by the machine of this invention results, therefore, only from the flux which enters the stator by way of the uniform air-gap.

The generating coils 12 and 9 are shown schematically in Fig. 3 in order to simplify the drawing. It will be understood that each coil may include a great number of windings which may be form-wound and placed in position on the stator teeth in any well-known manner. It will be understood also that while Fig. 3 is illustrative of a single phase generator the features of the present invention are not limited in use to such a device.

Obviously, the addition of two more coils on the stator and located so as to precede those illustrated by 90 degrees would result in a two-phase generator.

It will now be described how the particular wave form of the voltage developed by the square wave generator of this invention is obtained and for this purpose particular reference is made to Fig. 1 and to the curves A, B, C, and D of Fig. 2. In the schematic showing of Fig. 1 the permanent magnet rotor is identified by the numeral 10 and the stator teeth or poles by the letters *a*, *b*, *c*, and *d*. In this showing a single coil 12, spanning 180 electrical degrees is illustrated and the magnetic shields have been omitted. To simplify the description the coil 12 is treated as two separate windings, one carried by the stator pole *a* and the other by the stator pole *b* and the rotor will be assumed to make one complete revolution in a clockwise direction starting from the horizontal position illustrated.

As the rotor 10 rotates in a clockwise direction the flux emanating from the pole N and linking with that portion of coil 12 carried by the stator tooth *a* increases at a uniform rate from zero value to a maximum value, the latter attained when the pole N reaches a position directly under the stator pole *a*, that is, when the rotor has advanced through an arc of 90 degrees. This uniform rate of change of flux is represented by the line 1—2 of curve A, Fig. 2. During the next 90 degrees rotation of the rotor the flux linking that portion of coil 12 carried by the stator pole *a* decreases from a maximum value to zero value, the latter attained when the rotor pole N assumes a position directly opposite the stator pole *b*. This uniform rate of change of flux is represented by the line 2—3 of curve A, Fig. 2. During the third 90 degrees rotation of the rotor, the pole S comes directly under the stator pole *a* so that during this period the flux linking that portion of coil 12 carried by stator pole *a* reverses direction and increases from zero value to maximum value. This uniform rate of change of flux is represented by the line 3—4 of curve A, Fig. 2. As the rotor completes its cycle of rotation the pole S moves from under the stator pole and assumes the position illustrated in Fig. 1. During this period the flux linking with that portion of coil 12 carried by the stator pole *a* changes at a uniform rate from a maximum value to zero value. This flux change is indicated by the line 4—5 of curve A, Fig. 2.

Considering now the flux linking that portion of the coil 12 carried by stator pole *b* during the same cycle of rotation of the rotor 10, the pole S of the rotor starts from the position at which the flux linking that portion of coil 12 is a maximum value in a negative direction and the flux, during the first 90 degrees rotation of the rotor decreases at a uniform rate from the maximum value to zero. This rate of change is illustrated by the line 1—2 of curve B, Fig. 2. During the second 90 degrees rotation the stator pole *b* comes under the influence of the pole N of the rotor so that the flux linking that portion of coil 12 carried by the stator pole *b* reverses direction and increases from zero value to a maximum value. This rate of change is represented by the line 2—3 of curve B, Fig. 2. As the pole N of the rotor moves from under the stator pole *b* the flux linking that portion of coil 12 carried by pole *b* decreases at a uniform rate from a maximum value to zero value. This change of flux is represented by the line 3—4 of curve B, Fig. 2. During the fourth 90 degrees rotation of the rotor



the stator pole *b* again comes under the influence of the pole *S*, so that the flux linking that portion of coil 12 carried by the stator tooth *b* reverses direction, increasing from zero value to a maximum value which latter is attained when the rotor arrives at the position illustrated in Fig. 1. This change of flux is represented by the line 4—5 of curve B, Fig. 2.

By adding the curves A and B, algebraically, the curve C is obtained which illustrates the wave form of the flux to which the coil 12 is subjected during one complete revolution of the rotor. It will be observed that during the first and third 90 degrees rotation of the rotor the flux changes at a uniform rate from a maximum value in one direction to a maximum value in the other direction. During the second and fourth 90 degrees rotation of the rotor there is no rate of change of the flux. Obviously, therefore, there is no voltage generated in coil 12 during the second and fourth periods of rotation of the rotor 10 whereas during the first and third periods the generated voltage is a maximum but of alternate polarities. The curve D represents the wave form of the voltage generated in the coil 12.

It will be noted that the flat top of the voltage wave is 90 degrees in width which corresponds to pole arc of the rotor field poles.

It is to be understood that a second coil 9 (Fig. 5) is employed in a single phase machine and would span the stator poles *c* and *d*, or 180 electrical degree. While the description has been confined to a single phase machine it will be understood that the features of the invention are not limited in use to such a machine. In the case of a two phase machine two more coils would be added, one spanning the stator poles *b* and *d*, and the other spanning the stator poles *c* and *a*.

Curve E of Fig. 2 illustrates the wave form of a single phase machine in which the magnetic shields of this invention are not employed. It will be observed that during the so-called no-voltage period the flux curve is arcuate rather than a straight line as in curve C. This distortion of the flux wave results from the leakage flux emanating from the rotor pole tips and entering the stator by way of a path other than the uniform air-gap existing between the rotor pole shoes and the stator teeth. This distortion of the flux curve is reflected in the voltage developed by such a generator as indicated by curve F. It will be observed that the change in voltage from a maximum in either direction to zero voltage, or from zero voltage to a maximum voltage in either direction does not follow a true vertical line as is the case in curve D but follows a line which is indicative of a more or less gradual change. By the inclusion of the magnetic shields of this invention this wave distortion in the so-called no-voltage interval is eliminated and a true square, or rectangular wave results.

What is claimed is:

1. A rotor for an electric generator comprising a shaft, a cylindrical permanent magnet having an axial bore of greater diameter than the diameter of said shaft through which said shaft extends, pole shoes carried by said permanent magnet, magnetic shields, and means for mounting said permanent magnet, its pole shoes and said magnetic shields as a unit on said shaft comprising a pair of retaining discs slidable on said shaft and provided with means for engaging opposite edges of said pole shoes and with means for supporting said magnetic shields in spaced relation to said pole shoes and to said permanent

magnet, and means for clamping said discs against the edges of said pole shoes whereby said permanent magnet is held in concentric spaced relation to said shaft and is driven by said shaft through said discs.

2. A rotor assembly for an electric generator comprising a shaft, a substantially cylindrical permanent magnet having an axial bore of greater diameter than the diameter of said shaft, a pair of diametrically disposed pole shoes fixed to said permanent magnet, a collar integrally formed on said shaft, a pair of retaining discs slidable on said shaft, and one located thereon so as to abut said collar, each of said discs including an inwardly projecting rim for overlapping oppositely disposed projecting edges of said pole shoes, means for forcing said other disc onto said shaft in the direction of said collar whereby said pole shoes are rigidly clamped between the rims of said discs and said permanent magnet is held in concentric spaced relation to said shaft, a pair of magnetic shields, and means for mounting said shields in spaced relation to said pole shoes and to said permanent magnet comprising a series of pins projecting inwardly from said discs between which and the rims of said discs the said shields are removably confined.

3. In combination with a permanent magnet having a central bore and diametrically disposed polar areas capped by peripheral pole shoes, a shaft of lesser diameter than that of the said bore, a pair of magnetic shields, and means for mechanically associating said permanent magnet with said shaft and for mounting said magnetic shields in peripherally spaced relation to said permanent magnet and in radial spaced relation to said pole shoes comprising a pair of retaining discs positioned on said shaft at opposite ends of said permanent magnet and provided each with an inwardly projecting rim for overlapping engagement with opposite edges of said pole shoes, means comprising a pair of pins inwardly projecting from each of said discs for spacing said shields radially from said pole shoes and a pair of screws inwardly projecting from each of said discs for peripherally spacing said shields from said permanent magnet, each of said pairs of pins and screws defining an area with the rims of their respective discs for accommodating opposite edges of said shields, and means for clamping said discs against the edges of said pole shoes whereby said permanent magnet is held in concentric spaced relation to said shaft and, with said pole shoes and said shields, is driven by said shaft through said discs.

4. A square wave generator comprising a stator each set of two adjacent teeth of which spans substantially 180 electrical degrees, a single coil spanning each set of two adjacent stator teeth, and a two-pole field rotor having a pole arc of substantially 90 degrees and rotatable within said stator.

EDMUND R. MORTON.

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