Oct. 18, 1938. I. W. COX 2,133,686

MAGNETOGENERATOR

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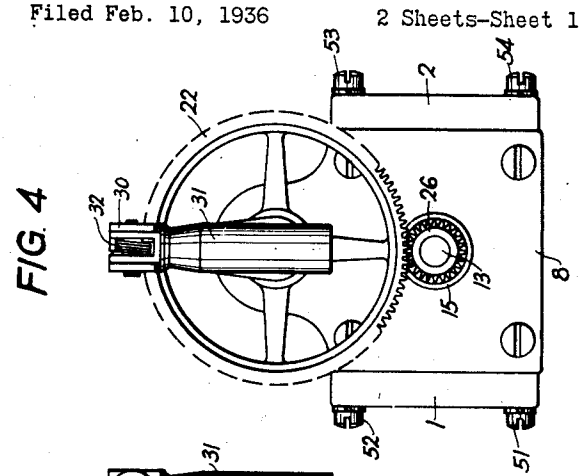


FIG. 4

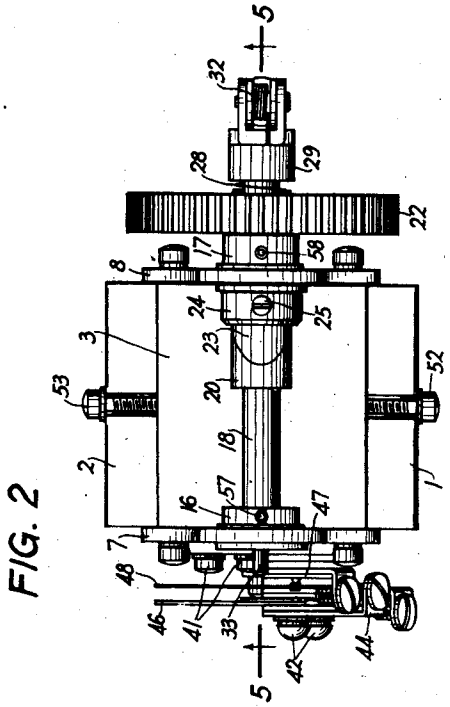


FIG. 2

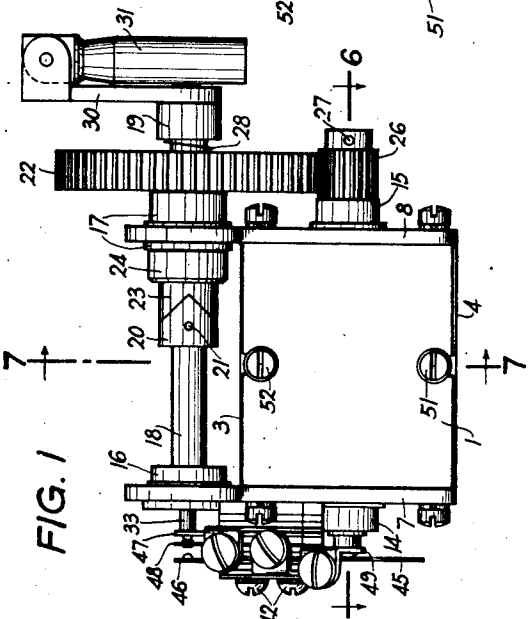


FIG. 1

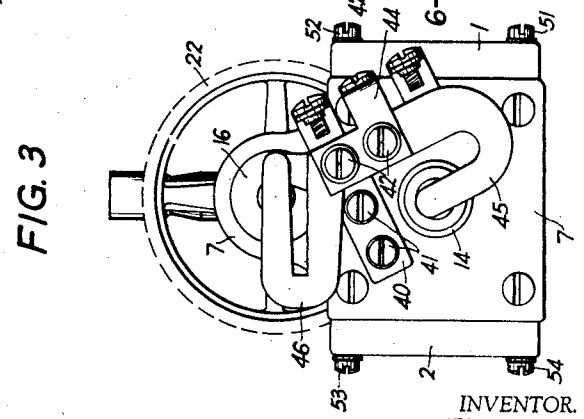


FIG. 3

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FIG. 6

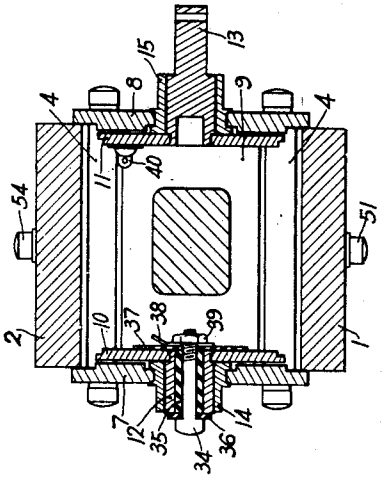


FIG. 5

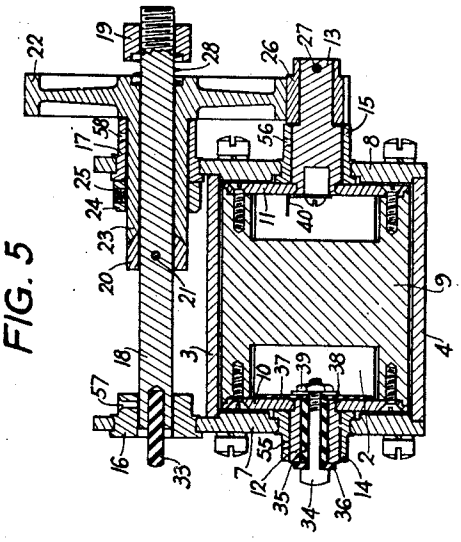


FIG. 8

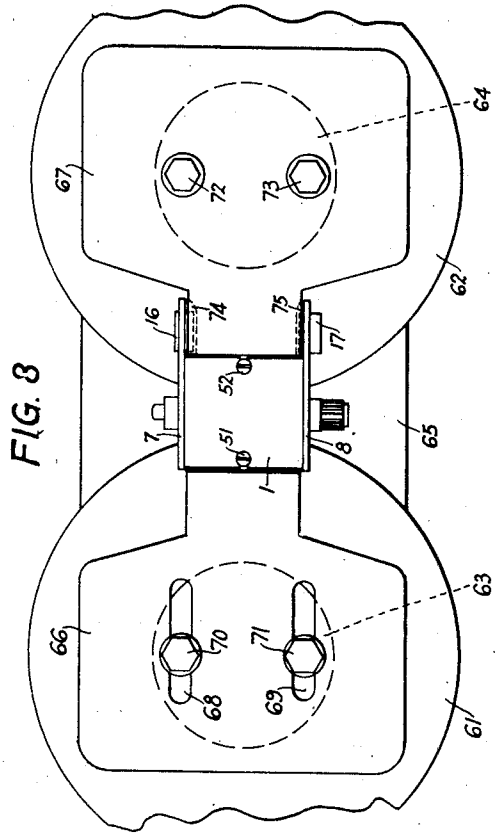
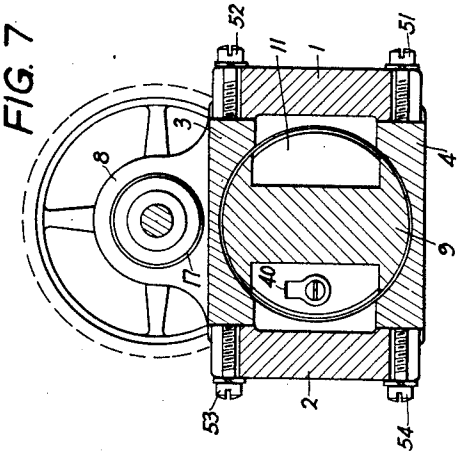


FIG. 7



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MAGNETOGENERATOR

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Application February 10, 1936, Serial No. 63,113

3 Claims. (Cl. 171—209)

The present invention relates to magneto-generators; that is, generators of electric current utilizing permanent-magnet field-excitation. The main object of the invention is the production of a new and improved magneto-generator having a more efficient magnetic circuit and a more efficient mechanical construction, whereby a generator of a given power output may be more economically produced and a greater power output may be obtained from a given weight or cost of material.

Additional objects are to devise a method for preventing undue self coercion of the permanent magnets following magnetization, and a method for reliably performing an artificial ageing operation of the generator before test which brings the performance capacity of the generator down to a value corresponding to that obtained after severe service.

General description

Pursuant to a realization of the main object of the invention, a novel structure has been produced, the design of which is based particularly on the efficient use of permanent-magnet material having a very high optimum value of sustained specific magneto-motive force, lying above the maximum specific magneto-motive force of the best known cobalt-steel permanent-magnet material, and capable of sustaining a higher maximum field energy per unit volume of permanent-magnet material than the best known cobalt-steel permanent-magnet material.

The permanent-magnet material used in the improved magneto-generator construction is a ferrous alloy containing in the neighborhood of twenty-five per cent nickel, twelve to fifteen per cent aluminum, two to four per cent cobalt, and the remainder iron. This material is first cast to the desired size and configuration and is then allowed to cool, following which it is reheated in the performance of a process known as precipitation hardening. It is understood that this hardening operation permits particles to crystallize out of solution, whereby the resulting aggregate material becomes magnetically very hard, acquiring a very high coercivity and a relatively low permeability.

Tests of cast and treated samples of this material show a residual flux, following saturation, of seven thousand maxwells per square centimeter of cross section at zero external magneto-motive force, and that a coercing magneto-motive force of 430 gilberts per lineal centimeter is required to reduce this flux to zero. These figures compare with ten thousand maxwells and 250 gilberts for the best obtainable grades (about thirty-six per cent cobalt) of cobalt steel.

Comparative tests show further that the optimum working point of the iron-aluminum-nickel-cobalt material is with a magneto-motive force of about 310 gilberts developed in the external field per linear centimeter of magnet material, which is in excess of the total coercive force (250 gilberts) per centimeter required to reduce the flux through the best cobalt steel to zero. With this developed magneto-motive force (310 gilberts per centimeter), the flux density in the cast material is 4500 maxwells per square centimeter of cross section, while at the optimum value of magneto-motive force (160 gilberts per centimeter) the flux density in the tested cobalt steel is slightly in excess of seven thousand maxwells per square centimeter. Multiplying the maxwells obtaining at the optimum value of developed gilberts, we obtain an optimum field-energy product of $4500 \times 310 = 1,395,000$ gilbert-maxwells per cubic centimeter of the cast material. This is substantially in excess of the corresponding field-energy product (1,152,000 gilbert-maxwells per cubic centimeter) of cobalt steel. From these figures, it will be at once apparent that for a given external field structure to be energized, a well-designed cast magnet of the described material, while of a somewhat lesser cubical content than an equivalent magnet of cobalt steel, is much shorter, measured between its pole faces, than the one of cobalt steel. It was the recognition of this fact that enabled the novel design hereinafter disclosed to be evolved.

It will be understood, of course, that a large saving in cost is realized by the use of the cast material, not alone from the fact that less labor is required in casting it into form than in working steel, but also because of the relatively high cost of cobalt, of which the cast material contains only a small amount as compared to about thirty-six per cent for what is known as cobalt steel.

It will be understood further that other alloys than the one described may be used, provided they respond to precipitation hardening or other processes to acquire a high coercivity and a high energy-product value, as above set forth.

Readily distinguishable features of the novel construction disclosed herein may be enumerated as follows:

1. By employing magnetic material of high coercive force, relatively short magnets may be used which may be made of rather large cross-section and still be comparatively small in volume,

whereby relatively small magnets may give the required power in the magnetic field.

2. Two parallel magnetic circuit paths are employed to supply magneto-motive force to the useful field of the structure. The permanent magnets are located on opposite sides of the useful field of the generator, whereby a more symmetrical device is obtained. This arrangement permits a more uniform distribution of magnetic flux in the pole shoes and results in a lower apparent reluctance of the pole shoes than that which would obtain if the permanent-magnet material were all concentrated on one side of the structure, in which latter case a higher-magneto-motive force would need to be employed, which would necessitate increased length and weight of magnet material.

3. With the improved construction, the armature chamber is effectively enclosed on all sides by the essential parts of the structure, whereby no additional protective, enclosing members or sheets are required: the usual bearing end plates enclose the ends of the inter-pole space; the magnets themselves enclose the front and rear sides; and the pole shoes enclose the top and bottom of the armature chamber.

4. The magnets are cast to the desired size and shape, requiring only that the pole faces of the magnets which contact the pole shoes of the generator be ground smooth to insure a good metal-to-metal contact, while additionally the magnets are cast with open slots through which the magnet-mounting screws may pass, as the extreme hardness of the material practically precludes drilling.

5. By virtue of the short-magnet construction, utilizing magnets which do not extend beyond the surface of the pole pieces of the generator, the magnets may be readily magnetized to saturation after the magnetic structure has been completely assembled, and the magnetization may be performed in such a way as to produce the poles of the permanent magnets at the desired points (adjacent the pole shoes of the structure), for the pole shoes of the generator are left uncovered by the magnets themselves, making it easy to apply the pole pieces of a magnetizer to the pole shoes of the generator for the purpose of magnetizing the permanent magnets in place in the assembled structure.

6. The efficiency of the magnetic path through the armature has been increased by recessing or grooving the armature end plates so as to permit of a greater effective length of armature pole within a given length of armature chamber.

7. In addition to the foregoing, incidental benefits resulting from the improved construction have to do with such features as permitting more ready access to the crank shaft and the set screw which holds it in place, whereby the crank-shaft assembly may be more readily removed for repair or replacement, and it permits also of a more advantageous location of an oil hole for the oiling of the distant bearing of the crank shaft.

Detailed description

Referring now to the accompanying drawings, comprising Figures 1 to 8, Figures 1 to 7 show the construction in sufficient detail of a magneto-generator embodying the features of the invention to enable the invention to be readily understood, and Figure 8 illustrates the preferred method of magnetizing the permanent magnets after they have been secured in place in the magnetic structure of the generator.

The structure

Referring now particularly to Figures 1 to 7: Figure 1 is a front view of the new magneto-generator; Figure 2 is a view as seen from the top; Figure 3 is an end view as seen from the left; Figure 4 is an end view of the generator as seen from the right; Figure 5 is a front sectional view taken along the line 5—5, Figure 2; Figure 6 is a top sectional view taken along the line 6—6, Figure 1; and Figure 7 is a left section taken along the line 7—7, Figure 1.

The magnets 1 and 2, whose cross-section may be seen best in Figure 7, are substantially U-shaped in cross-section. In the model illustrated, the magnets have relatively short horizontal limbs, but the length of limb may be greater when additional magneto-motive force is required. Each of these magnets is pre-cast to the desired size and shape and is machine ground only on its pole faces where it contacts with the pole pieces 3 and 4, which latter are preferably made of cold-rolled steel. Mounting screws 51 to 54, best seen in Figure 7, pass thru open slots which are formed in the molding or casting operation, as the alloy is too hard for machining or drilling.

In addition to the magnets 1 and 2 and the pole shoes 3 and 4, the main structure of the generator includes the end plates 7 and 8, which fit over the ends of the magnets 1 and 2 and over the end of the pole pieces 3 and 4, as may be seen best in Figures 5 and 6. The end plates are machined so as to leave an integral disc on the inside surface thereof concentric with the armature shaft, which serves to fix the distance between the poles, while upward extensions of the end plates hold the bearings for the crank shaft.

The armature 9, as is shown in Figures 5, 6, and 7, is of the usual shuttle type of construction, giving ample space for the armature winding. The armature is provided with end plates 10 and 11 into which the armature shaft-members 12 and 13 are placed and are secured by an operation known as "staking". It is to be noted that the allowable effective length of armature pole is increased by machining away part of each end plate around the rim, thereby decreasing the armature reluctance. The shaft bearings 14 and 15 are staked into the end plates 7 and 8, and they are proportioned so as to space the armature assembly accurately within the armature chamber and hold it against substantial endwise movement.

Bearings 16 and 17 for the crank shaft 18 and the sleeve 23, formed integrally with the driving gear 22, are staked in the end plates 7 and 8. The crank-shaft stop-collar 19, threaded on the inside, is screwed onto the end of the crank shaft 18 to limit the endwise movement of crank shaft 18 imparted by the interaction between the cam collar 20 (see Figures 1 and 2) and the cam cut in the sleeve 23 forming an extension of driving wheel 22. Cam collar 20 is held in position by pin 21, Figures 1 and 5. This endwise movement of crank shaft 18, it will be understood, takes place when the crank 30 is turned by the handle 31, in order to shift the spring combination by the means of the thrust action of buffer 33, composed of insulating material and fitted snugly in a hole in the end of the crank shaft 18. The coiled spring 28 restores the crank shaft 18 endwise to the position shown in the drawings when the crank is released. The assembly composed of the crank shaft and the

driving wheel is held in position by the collar 24, secured to sleeve 23 by the headless set screw 25, Figures 2 and 5.

Bearings 16 and 17 may be oiled through oil holes 57 and 58, and bearings 14 and 15 may be oiled through holes 55 and 56. It is to be noted particularly that oil hole 57 is conveniently located on the extended inside portion of bearing 16. It is accessible for oiling in this position in the illustrated construction because the magnet structure has been changed from the usual horseshoe form; in the usual generator construction, an oil hole placed on the inside portion of this bearing is inaccessible because it is covered by the horseshoe permanent magnets.

Armature pinion 26, seen best in Figures 1, 4, and 5, is fitted over the end of shaft member 13 and is secured in place by pin 27.

In order to fit the generator better for use in a portable container, the crank handle 31 is of the folding construction illustrated, coiled spring 32, Figure 2, being provided to restore the crank handle 31 to the position shown after it has been extended in use, perpendicular to crank 30.

Although the armature 11 has been shown unwound for the sake of simplicity, it will be understood that in practice the armature is wound with the desired size of wire until the winding space is filled to such an extent that a cross-section of the wound armature is substantially circular.

One end of the armature winding is soldered to lug 40, secured to the front armature-end-plate 11, as may be seen in Figures 5, 6, and 7. The other end of the armature winding is secured to lug 38, which is held beneath the nut 39 which holds the contact stud 34 in place. The contact-stud assembly is insulated from the metallic frame structure of the armature by bushing 35 (Figures 5 and 6), washer 36, and plate 37, all composed of insulating material.

As seen in Figures 1 to 3, a spring assembly, mounted on bracket 40, is secured to the rear end plate 7 by screws 41, Figures 2 and 3. Of the members in the spring assembly mounted on bracket 40, by means of screws 42, and suitably insulated from each other, the terminal plate 44 is in contact with the spring washers held under the heads of screws 42, and through the screws 42 with the frame structure of the generator, whereby plate 44 may conveniently serve as one terminal point to which an output conductor may be secured by means of the illustrated binding post, or terminal screw. Contact with the other terminal of the armature winding is maintained by contact spring 45, which presses against contact stud 34, Figures 5 and 6, as may be seen best in Figures 1 and 3. Contact spring 45 is assembled in contact with spring 46, against which buffer 33 propels the movable spring 48 when endwise movement of the crank 18 occurs upon the turning of the crank. Plate 49 is assembled in contact with the movable spring 48, and is provided with the illustrated terminal screw, to which the other output lead of the generator may be connected. The remaining terminal plate in the spring assembly is connected to the contact spring 47, normally engaged by the traveling spring 48 for whatever switching function may be necessary in the use of the generator.

Magnetizing the assembled generator

Referring now particularly to Figure 8, the generator of Figures 1 to 7 is shown in association with a magnetizer before the crank assembly has been placed in the generator, but after the generator is otherwise structurally complete. Bracket 40 and associated spring asembly may be mounted either before or after the magnetization of the permanent magnets has been accomplished.

The magnetizer consists essentially of spool-type electromagnets 61 and 62, provided with circular cores 63 and 64 and a return yoke 65, connecting the lower ends of the cores together, forming a horseshoe electro-magnet. Pole pieces 66 and 67 are provided. Pole piece 67 is secured in position by bolts 72 and 73 threaded into tapped holes in the end of core 64, while pole-piece 66 is slidably secured to core 63 of spool 61 by bolts 70 and 71.

The pole pieces 66 and 67 are formed so that the ends thereof are of substantially the same width as the pole shoes 3 and 4 of the generator, and are moreover preferably of the same thickness as the spacing between the assembled permanent magnets, whereby contact between pole pieces 66 and 67 of the magnetizer and pole shoes 4 and 3 of the generator is made substantially over the entire exposed surface of the pole shoes of the generator. In preparation for the magnetizing operation, the pole piece 66 may be slid to the left in order to permit the generator to be placed in the illustrated relationship to pole piece 67, with the inner parts of the bearing inserts 16 and 17 lying within slots 74 and 75, milled in the edges of the pole piece 67. The pole piece 66 may then be brought up tightly into engagement with pole piece 4 of the generator, following which bolts 70 and 71 may be tightened, if desired, to hold the generator in place until magnetization is effected. It will be understood, of course, that current is preferably applied to the windings of the magnetizer only after the generator has been placed into position to avoid unnecessary waste of energy and accompanying heating of the coils of the magnetizer, as well as to facilitate the handling of the parts, which can be accomplished much better when the magnetizer is not energized.

After the current has been permitted to flow a desired length of time through the magnetizer, whereby a saturated condition is produced in the magnets 1 and 2, the current may be turned off, and the generator removed from the magnetizer.

A great advantage lies in magnetizing the permanent magnets in place, for then the magnets are at no time after being magnetized subjected to the high reluctance of an all-air flux path as they would be, of necessity, if they were mounted after having been magnetized. It has been observed that the magnets are deteriorated as much as twenty per cent if removed from the structure and replaced, resulting from what may be termed self-coercion.

In the event that the reluctance of the pole-shoe-armature magnetic path (in shunt of the magnets during magnetization) draws sufficient flux to render it difficult to impress the desired magneto-motive force with a given magnetizer, the reluctance of this shunt path during magnetization may be reduced by turning the armature ninety degrees.

Artificial ageing and testing

After a generator has been completed, it must be tested to insure that its performance in service will be at least equal to a predetermined standard. It has been found that a generator of the disclosed construction falls off somewhat

in performance after it has aged for some time, and that about the most severe demagnetizing condition imposed upon it in service is cranking it when it is connected to a load circuit of negligible resistance. The heavy current then flowing causes the revolving armature to present an abnormally high inter-pole-shoe reluctance during part of each half-cycle, causing the magnets to undergo self-coercion. Therefore, since any generator is likely at some time to be operated under short-circuit conditions, each generator, before the output test of it is made, is operated long enough (say ten seconds) at short-circuit load to ensure that its deterioration (about ten per cent of initial performance) has substantially reached its maximum. The generator is thereby artificially aged, and no further substantial reduction in its output capacity may be expected to result either from the mere lapse of a reasonable period of time or from operation under severe load conditions. After the described pre-deterioration and consequent ageing operation has been accomplished, a test of the output capacity of the generator may be relied upon to indicate the expected performance of the generator in actual service over a long period of time.

Additional information

Although, for the sake of simplicity, a bottom view of the generator has not been shown, it may be pointed out that mounting holes (four of them) are drilled and tapped in the lower pole shoe 4 of the generator.

Additionally, the density of the cast magnet material is only about nine tenths that of a magnet material, such as cobalt steel. Therefore, since the magnets are smaller than equivalent cobalt-steel magnets, as previously explained, a substantial reduction in weight accrues from using the disclosed magnets.

What is claimed is:

1. The method of producing a magneto generator which has an armature, a pair of pole shoes, and a permanent magnet for energizing the pole shoes, which consists in first assembling the parts enumerated into their permanent locations, and in then applying sufficient magneto-motive force directly across the pole-shoe-armature path to substantially saturate the permanent magnet in a circuit path parallel to the pole-shoe-armature path.

2. The method of producing a magneto generator the characteristics of which do not deteriorate appreciably responsive either to the passage of a substantial period of time or responsive to severe service operation, which consists in applying a sufficient magneto-motive force to the field structure after assembly to produce permanent-magnet saturation, and in then operating the generator for an appreciable time under short-circuit conditions.

3. The method of magnetizing the permanent magnets of a generator comprising a shuttle armature enclosed by a field structure comprising two pole pieces joined at their ends by two permanent magnets, which consists in inserting the assembled field structure and armature between the poles of an electromagnet with the two generator pole pieces in engagement with the two poles of the magnet, respectively, and in causing the electromagnet to drive a saturating flux through a magnetic circuit which includes the two permanent magnets and the armature in parallel.

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