NOTE: DOD-STD-2146 has been redesignated as a Design Criteria Standard. The cover page has been changed for Administrative reasons. There are no other changes to this Document.

METRIC

DOD-STD-2146 (SH)
1 JUNE 1983

DEPARTMENT OF DEFENSE
DESIGN CRITERIA

DIRECT CURRENT GENERATORS AND MOTORS, LOW STRAY MAGNETIC FIELD, DESIGN OF (METRIC)

AMSC N/A

FSC 6115

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DEPARTMENT OF THE NAVY
NAVAL SEA SYSTEMS COMMAND

Washington, DC 20362

Direct Current Generators and Motors, Low Stray Magnetic Field, Design of (Metric).

DOD-STD-2146(SH)

1. This Military Standard is approved for use by the Naval Sea Systems Command, Department of the Navy, and is available for use by all Departments and Agencies of the Department of Defense.

2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, Naval Sea Systems Command, SEA 55Z3, Department of the Navy, Washington, DC 20362, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

FOREWORD

1. This standard provides the designers of direct current (d.c.) generators and motors with techniques for reducing to a minimum the stray magnetic field produced by these motors and generators.

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FIGURES

1. SCOPE

1.1 Scope. This standard covers the requirements for the design of d.c generators and motors (machines) that will minimize the stray magnetic field emanated by the generators and motors.

1.1.1 Application. This standard applies specifically to the design of magnetic minesweeping generators since they generate large output currents and are used in minesweepers that will pass over magnetic-influence mines. Consequently, they must produce as small a stray magnetic field as possible, in order to minimize the danger of detonating a mine under the minesweeper. The requirements of this standard also apply to the design of any d.c. motor or generator for which a small stray magnetic field is an important consideration.

1.1.2 Limitations. This standard shall be used in conjunction with the requirements of technical specifications and standards for a specific d.c. generator or motor. In the event that any design features of this standard (see 4.2.1 and 4.2.2) conflict with the requirements of other technical specifications and standards for the generator or motor, the design requirements of this standard shall apply.

2. REFERENCED DOCUMENTS

2.1 Issues of documents. The following documents, of the issue in effect on date of invitation for bids or request for proposal, form a part of this standard to the extent specified herein.

STANDARD

MILITARY

DOD-STD-2133 - Cable Arrangement For Minimum Stray Magnetic Field (Metric).

DOD-STD-2141 - Definitions and Systems of Units, Magnetic Silencing (Metric).

(Copies of specifications, standards, drawings, and publications required by contractors in connection with specific acquisition functions should be obtained from the contracting activity as directed by the contracting officer.)

3. DEFINITIONS

3.1 General magnetic silencing terms. The meanings of general magnetic silencing terms used in this standard are in accordance with DOD-STD-2141.

3.1.1 Equalizer connections. Equalizer connections connect lap wound armature winding parallel circuits that, theoretically, are at the same potential. They are not, however, at the same potential due to minor variations in machine adjustment and materials. These voltage differences, if not corrected would cause equalizing currents through the brushes and cables connecting brush studs of the same polarity. These equalizing currents would generate stray magnetic fields.

3.1.2 Commutating poles (interpoles). Commutating poles are used to improve commutation. They are located midway between the main field poles and are frequently referred to as interpoles. Some d.c. machines have commutating poles but no compensating winding; other d.c. machines have commutating poles and a compensating winding as well. Current in the commutating circuit is present in the commutating coils and in the connections to the coils. (The coils themselves produce only a small stray magnetic field; hence, the problem involved in the design of the commutating circuit is to arrange the connections so that they will provide only a small stray magnetic field.)

3.1.3 Compensating (pole-face) windings. Compensating windings are used on large d.c. machines to compensate armature reaction and improve performance. A compensating winding consists of conductors embedded in slots in the faces of the main field poles (hence, the alternative terminology of pole-face winding) and end connectors. The conductors in the faces of the main field poles are parallel to the axis of the machine. The end connectors connect the pole-face conductors together and are perpendicular to the axis of the machine. It is the end connectors that give rise to turns around the shaft and large stray magnetic fields, if they are not properly arranged. A compensating winding, as defined in this standard, is not intended to compensate stray magnetic fields.

3.1.4 Current loop. A current loop is a closed electric conductor. It may have one or more turns of any size or shape and may be arranged in any way. A simple current loop is a closed conductor making one turn in a single plane, or alternatively, making a number of turns which are in the same plane or in parallel planes and so close together that, to a first approximation, they can be considered to be physically coincident in space. More complicated current loops can be resolved into a combination of simple current loops.

3.1.5 Current take-off points. Current take-off points are the points at which the armature current leaves one brush collector ring and returns to another brush collector ring.

3.1.6 Machine. A machine is a generator or motor.

3.1.7 Magnetic minesweep cable. The magnetic minesweep cable is the interconnecting cable between the magnetic minesweep generators and the minesweep cable terminal box.

3.1.8 Magnetic minesweeping generator. A magnetic minesweeping generator is a generator which produces the current for the magnetic minesweeping tail.

3.1.9 Minimum magnetic moment. A minimum magnetic moment has a magnitude close to zero.

3.1.10 Polar leakage field. Polar leakage field is the stray magnetic field that is emanated by the field coils alone.

4. GENERAL REQUIREMENTS

4.1 Cause of stray magnetic field. Stray magnetic fields in a d.c. machine are caused by current in the field circuit and armature circuit of the machine. In order to reduce a machine's stray magnetic field, the field circuit design shall be in accordance with the requirements of 5.1 and armature circuit design shall be in accordance with the requirements of 5.2.

4.2 Low stray field features in machine design. The low stray field features of 4.2.1 through 4.2.12 shall be incorporated into the design of the machine. These features are described in detail in section 5.

4.2.1 Frame design. Frame design of a machine shall meet the following requirements:

- (a) The frame shall be either of two types, (1) one piece with no joints, or (2) laminated.
- (b) The weld in the frame shall be at a main pole (see 5.1.3.4.2).
- (c) The frame shall be machined inside and outside, to insure uniform cross section throughout (see 5.1.3.4.3).
- (d) The material of the frame shall be magnetically homogeneous throughout (see 5.1.3.4.4).
- (e) The outside of the magnetic material in the frame shall be a smooth surface of revolution with its axis coincident with the axis of the generator. There shall be no magnetic feet or other major projections of magnetic material on the outside of the frame (see 5.1.3.4.5).
- (f) Current-carrying leads shall not be taken through the frame. They shall go through some part of the machine enclosure which is non-magnetic (see 5.1.3.4.6).

4.2.2 Number of field poles. The machine shall have an adequate number of field poles in accordance with 5.1.3.1.

4.2.3 Symmetry and uniformity. The following requirements of symmetry and uniformity shall be applied:

- (a) Air gaps shall be uniform (see 5.1.3.4.7).
- (b) In machines which have commutating poles, there shall be as many commutating poles as main poles (see 5.1.3.4.8).
- (c) Coils of the same type (such as, shunt field coils and commutating pole coils) shall be of the same size and have exactly the same number of turns (see 5.1.3.4.9).

4.2.4 Wiring around the frame. Wiring around the frame of a machine shall meet the following requirements:

- (a) Connections to the shunt field coils shall have no net turns around the shaft and no uncompensated current loops (see 5.1.4).
- (b) End connections to the commutating coils and the compensating winding shall have no net turns around the shaft and no uncompensated current loops (see 5.2.6.2 and 5.2.7.2).

4.2.5 Lap-wound armature. Lap-wound armatures shall have equalizer connections in the form of rings of uniform cross section throughout (see 5.2.1.1).

4.2.6 Brush collector rings. Brush collector rings shall meet the following requirements:

(a) The brush collector rings shall be complete rings, concentric with the axis of the machine, and of uniform cross section throughout the entire circumference (see 5.2.4).
(b) There shall be either: (1) three brush collector rings equally spaced in the direction parallel to the axis of the machine, with the center ring carrying full positive (or negative) current and each of the two outer rings carrying one-half of the negative (or positive) current; or (2) two concentric rings, one larger than the other, mounted in the same plane perpendicular to the axis of the machine (see 5.2.4.1).
(c) The current take-off points for the brush collector rings shall be either: (1) in-line with the axis of the machine for machines with three brush collector rings; or (2) in a plane passing through the axis of the machine for machines with two concentric brush rings in the same plane (see 5.2.4.2).

4.2.7 Connections from brush collector rings. Connections from brush collector rings of a machine and the associated circuit shall be arranged with a central conductor carrying full current and two symmetrically placed flanking conductors, each carrying half current, all so arranged as to avoid unbalanced current loops (see 5.2.5).

4.2.8 Double-armature machines. Machines with two armatures on the same shaft shall be designed in accordance with the principle of mutual compensation; the two armatures shall be as nearly alike as possible and have their connections so arranged that the magnetic field of one is in opposition to the other.

4.2.9 Angular position of take-off points. The current take-off point from one brush collector ring shall be at the same point where one set of brushes is connected to the ring (see 5.2.4.4).

4.2.10 Number of commutator bars. The number of commutator bars shall be equal to an integral multiple of the number of field poles (see 5.2.2).

4.2.11 Brush rigging. Brush rigging shall be designed in a manner to force a well-defined current path between a set of brushes and the brush collector ring. This current path shall be in a plane which passes through the axis of the machine (see 5.2.3).

4.2.12 Position of brush collector rings. The axial distance from the brush collector rings to the commutator risers shall be selected in a manner to minimize the effect of unequal current division between different sets of brushes (see 5.2.4.3).

5. DETAILED REQUIREMENTS

5.1 Field circuit design.

5.1.1 Applicability. Since minesweeping generators are separately excited generators, the requirements of 5.1.3.1 through 5.1.4 apply specifically to the field circuit of a separately excited generator. Similar requirements can be applied to the design of field circuits for self-excited, d.c. shunt motors and generators.

5.1.2 Sources of stray magnetic field. The field circuit consists of field coils and connections to the field coils. Design requirements to minimize the stray magnetic field produced by the field coils shall be as described in 5.1.3.1 through 5.1.3.4.10. Design requirements to minimize the stray magnetic field produced by the connections to the field coils shall be as described in 5.1.4.

5.1.3 Minimization of stray magnetic field produced by the field poles (polar leakage field).

5.1.3.1 Number of field poles. The number of field poles used in the design of a machine shall be as large as possible, in order to minimize the stray magnetic field. Eight field poles shall be the minimum number of field poles for minesweeping generators. For all other d.c. machines, two field poles shall never be used; four or six poles shall be the minimum. Rotary amplifier exciters, such as amplidynes, which have only two magnetic poles, shall not be used even though they may have more physical poles.

5.1.3.2 Orientation of field poles. For minimization of the vertical component of the stray magnetic field, one pair of main field poles shall be vertically oriented or oriented so that the vertical equally divides the angle between adjacent main field poles. Figure 1 illustrates this orientation for a six-pole machine.

5.1.3.3 Distance of the field coils from the center of the machine. The distance from the centers of the field coils to the center of the machine shall be kept as small as possible, as is consistent with conventional machine design. This requirement is relative; abnormally long and small diameter machine designs are usually unnecessary, and abnormally short and large diameter designs shall be avoided, since they tend to increase the stray magnetic field.

5.1.3.4 Uniformity and symmetry. The frame and associated field poles shall be made as uniform and symmetrical as possible, by incorporating the requirements of 5.1.3.4.1 through 5.1.3.4.10 into the design of the machine.

5.1.3.4.1 Frame construction. The frame of the machine shall consist of two parts: the magnetic frame and the nonmagnetic frame support. The magnetic frame shall be either of one piece construction or a radially laminated construction such that the flux density in the outer 25 percent of the frame thickness will remain in the linear portion of the d.c. B-H curve of the magnetic material used throughout the operating range of the machine.

5.1.3.4.2 Location of weld. The magnetic frame of the machine is usually made by rolling a steel slab into a ring and welding the ends of the slab together. The weld shall be located at the centerline of the top main field pole for vertically oriented poles, and at the center of one of the two highest main field poles for machines with the vertical equally dividing the angle between these two highest field poles. The main flux splits at the centerline of the main pole. Any lack of magnetic homogeneity at the weld will have a minimum effect by locating the weld on the centerline of a main field pole.

5.1.3.4.3 Machining. After the frame of the machine has been welded into a ring and seasoned, it shall be machined inside and outside and on the ends to ensure uniform cross section throughout. If the ring is machined only on the inside, there will inevitably be differences in the thickness of the frame, at different points, and loss of symmetry.

5.1.3.4.4 Material. The material of which the frame is made shall be magnetically homogeneous, to avoid lack of symmetry.

5.1.3.4.5 Outside of frame. The outside of the frame shall be as magnetically smooth and symmetrical as possible. Feet and other major projections shall be welded to the frame support in such a manner as not to affect the symmetry of the magnetic frame. Pole bolt heads shall be recessed, and, preferably, shall be slotted round heads which almost completely fill the holes in the frame to recess the heads.

5.1.3.4.6 No leads through frame. No current-carrying leads shall pass through the magnetic frame or other magnetic parts of the machine. These penetrations inevitably introduce a lack of symmetry. The effects of this lack of symmetry will be less if the leads go through nonmagnetic parts of the enclosure.

5.1.3.4.7 Air gaps. Air gaps shall be as nearly equal as possible.

5.1.3.4.8 Number of commutating poles. Machines shall have as many commutating poles as main poles.

5.1.3.4.9 Coils. All coils of the same kind (such as shunt field coils, series field coils, and commutating field coils) shall be of the same size and shape and shall have the same number of turns.

5.1.3.4.10 Equalizer connections. Equalizer connections shall be used on the armature of lap-wound machines, in accordance with 5.2.1.1, to compensate for nonuniformities such as those found in air gaps and field coils which are not of exactly equal magnetic moment because of manufacturing tolerances.

5.1.4 Minimization of stray magnetic field produced by the connections to the field coils. The preferred and non-preferred methods of making connections to the field coils are illustrated on figure 2. The preferred method of making connections shall be used (see figure 2A). The shunt field connections shall all be at the same end of the machine and shall be as close together as possible.

5.2 Armature circuit design. Design requirements to minimize the stray magnetic field produced by the armature circuit of the machine shall be considered for the following parts of the armature circuit:

(a) The armature windings (see 5.2.1).
(b) The commutator bars (see 5.2.2).
(c) The brush rigging (see 5.2.3).
(d) The brush collector rings (see 5.2.4).
(e) The connections from the brush collector rings to the commutating winding, the compensating winding and the machine's terminals to an external circuit (see 5.2.5).
(f) The commutating winding (see 5.2.6).
(g) The compensating winding (see 5.2.7).

5.2.1 Armature windings. Armature windings shall be lap-wound with equalizer connections or wave-wound.

5.2.1.1 Lap-wound armature. Lap-wound armatures shall have equalizer connections (armature cross connections) in the form of complete rings of uniform cross section, which are concentric with the shaft of the machine and are connected to all points on the armature winding, to compensate for field poles of unequal strength and unequal brush resistance, connected to all points of equal potential on the armature winding. Minimizing the stray magnetic field produced by the field circuit shall not depend primarily upon the design of the equalizer connections; the uniformity and symmetry requirements of 5.1.3.4 shall be adhered to in the design of the field circuit.

5.2.2 Number of commutator bars. The number of commutator bars shall be equal to an integral multiple of the number of field poles.

5.2.3 Brush rigging. The brush rigging shall be designed in a manner to force a well-defined current path between a set of brushes and the brush collector ring. The outward current path shall be radially outward through a brush, then along a conductor parallel to the commutator bars until it comes to the plane of a brush collector ring, and then radially outward to the brush collector ring.

5.2.4 Brush collector rings. Each brush collector ring shall be a complete ring, concentric with the axis of the machine, and of uniform cross section throughout the whole circumference so that unequal brush currents will not create non-zero net magnetic moments in the collector ring part of the armature circuit.

5.2.4.1 Arrangement of brush collector rings. In order to create equal and opposite current loops in the circuit of the brush collector rings, one of the two following brush collector ring arrangements shall be used:

(a) Three-brush collector rings, equally spaced in the direction parallel to the axis of the machine, with the center ring carrying the full positive (or negative) current and each of the two outer rings carrying one-half of the full negative (or positive) current. For maximum current loop cancellation, this arrangement requires the currents in the outer brush collector rings to be equal.
(b) Two concentric brush collector rings, one slightly larger than the other, in the same plane perpendicular to the axis of the machine.

5.2.4.2 Arrangement of current take-off points for brush collector rings. For the three-brush collector ring arrangement of 5.2.4.1, current take-off points for the rings shall be in-line with the axis of the machine. For the concentric brush collector ring arrangement of 5.2.4.1, current take-off points for the rings shall be in a plane passing through the axis of the machine.

5.2.4.3 Position of brush collector rings. The axial distance from the brush collector rings to the commutator risers shall be selected in a manner to minimize the effect of unequal current division between different sets of brushes. For the three-brush collector ring arrangement of 5.2.4.1, this distance shall be accomplished by designing the machine so that:

$$T \times (L_1 - L_2) = 2 \times r \times (W + S),$$

where T is the radial distance from the center of the current in the commutator bar to the center in the axial conductor which collects current from the brushes; W is the axial distance between the midpoint of the commutator risers and the midpoint of the brush collector ring closest to the commutator risers; S is the axial distance between the midpoints of two adjacent brush collector rings; r is the radius of the commutator; and L_1 and L_2 are the distances from the two ends of the brush set (or commutator, when the brush set is mounted symmetrically with respect to the commutator) to the center brush collector ring (see figure 3A). For the two concentric brush collector ring arrangement of 5.2.4.1, this distance shall be accomplished by designing the machine so that:

$$T \times (L_1 - L_2) = 2 \times r \times W$$

where all variables are defined as above, except that L_1 and L_2 are the distances from the two ends of the brush set (or commutator, when the brush set is mounted symmetrically with respect to the commutator) to the two concentric collector rings (see figure 3B).

5.2.4.4 Angular position of current take-off points. One current take-off point shall be at the same point where a brush set is connected to a brush collector ring (or rings). This point shall put the other current take-off point midway between the points of connection of two adjacent brush sets to the other brush collector ring (or rings). The current take-off points shall be as high up on the brush collector rings as possible.

5.2.5 Connections from the brush collector rings. Connections from the brush collector rings to the commutating winding, the compensating winding (if used), and the machine's terminals to an external circuit shall be made in accordance with 5.2.5.1 through 5.2.5.3.

5.2.5.1 Conductor arrangement. Three conductors shall be used for connection to the brush collector rings. A central conductor shall carry total armature current in one direction and the two outer conductors, which shall be symmetrically arranged on opposite sides of the central conductor, shall each carry one-half of the total current in the other direction. The conductors shall be kept as close together as possible, while taking into consideration the requirement for insulation between them. This will keep all current loops small and minimize the disturbance caused by departures from exact equality of current division between outer conductors. For each particular machine, details such as the physical arrangement of the different parts and the space available shall be considered for detailed conductor arrangement. Typical arrangements for machines with three-brush collector rings and two concentric brush collector rings, respectively are described in 5.2.5.1.1 and 5.2.5.1.2.

5.2.5.1.1 Typical conductor arrangement for machines with three-brush collector rings. Figure 4 illustrates typical connections for a three-brush collector ring machine. The corresponding current loops are also shown. For every current loop, there is in the same plane a closely adjacent loop of the same magnetic moment but opposite polarity; consequently, the total stray magnetic field will be small.

5.2.5.1.2 Typical conductor arrangement for machines with two concentric brush collector rings. Figure 5 illustrates typical connections for a two concentric brush collector ring machine. This arrangement can be readily adapted for use on a machine with three-brush collector rings.

5.2.5.2 Terminals to an external circuit. A machine shall have one of the following arrangements for its terminal (input for generator; output for motor) to an external circuit:

(a) Four terminals arranged at the corners of a square with plus terminals at the ends of one diagonal and minus terminals at the ends of the other diagonal.
(b) Three terminals equally spaced along a line with a plus (or minus) terminal at the center and two minus (or plus) terminals on the outside.

5.2.5.2.1 External cable connections to the machine terminals. With the four-terminal arrangement of 5.2.5.2, each cable in a quadded cable run shall be connected to one of the four terminals in accordance with DOD-STD-2133. With a three-terminal arrangement, two diagonally opposite cables in a quadded cable run shall be connected to the center terminal and the other two cables shall be connected to the outside terminals in accordance with DOD-STD-2133.

5.2.5.3 Criteria for conductor arrangement design. The conductor arrangement design shall satisfy the following criteria:

(a) Current loops are individually as small as they can be made, while taking into account the physical dimensions of the conductors and the necessity of spacing to provide room for insulation.
(b) For each current loop, there is in the same plane an immediately adjacent loop, as close as possible, of the same magnetic moment but opposite polarity.
(c) Parallel circuits are and will remain of equal resistance, to ensure equal division of current between the circuits.

5.2.6 Commutating winding.

5.2.6.1 Number of commutating poles (interpoles). When the machine design requires commutating poles, there shall be as many commutating poles as main poles. This is the usual construction for large machines. When this requirement is satisfied, the commutating poles will produce a stray magnetic field of essentially the same pattern and magnitude, but with opposite polarity as the main field poles. The net result is a small stray magnetic field.

5.2.6.2 Arrangement of connections for commutating poles. Connections to commutating poles shall be made as illustrated on figure 6. Connections shall be made at the same end of the machine and as close together as possible. With the connection arranged in this manner, current loops are formed in pairs. The two current loops in a pair have a magnetic field of the same magnitude but opposite polarity; the net magnetic moment for the loops will be near zero.

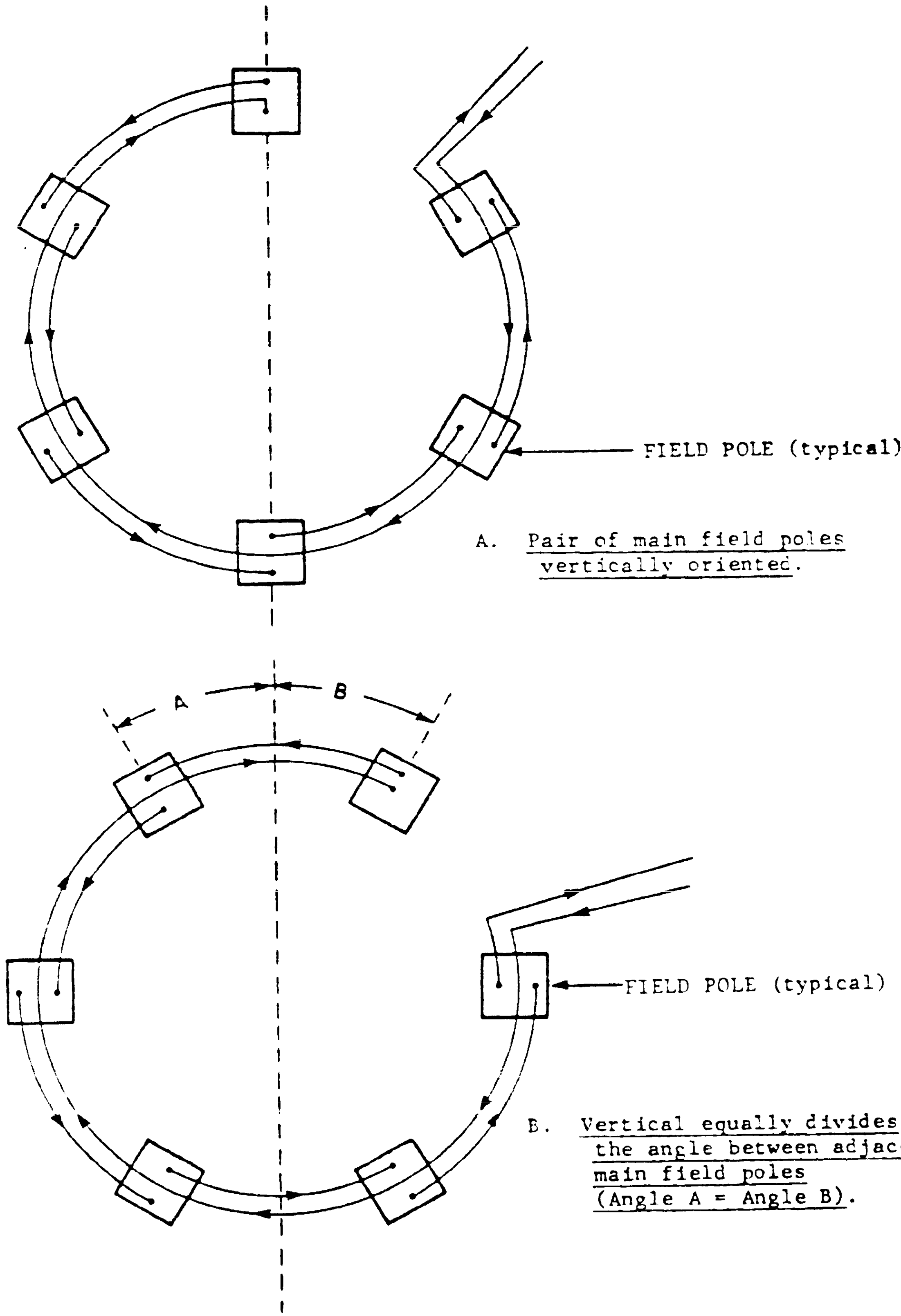
5.2.7 Compensating (pole-face) winding.

5.2.7.1 Arrangement of compensating winding. The design of the arrangement for compensating windings shall be accomplished as follows:

(a) The preferred arrangement shall have the compensating windings in an even number of slots per pole-face. A single series compensating winding which carries full armature current can be used in this case. Figure 7 illustrates a compensating winding for a six-pole machine with four slots per pole-face.
(b) If an odd number of slots must be used, this can be done provided the number of poles is an integral multiple of four. Two parallel windings are used in this case, each carrying one-half of the total armature current. Figure 8 illustrates a parallel circuit compensating winding for an eight-pole machine with three slots per pole-face.
(c) The combination of an odd number of slots per pole-face and a number of poles which is not an integral multiple of four shall not be used in d.c. machines.

5.2.7.2 Arrangement of end connections to compensating windings. End connections to compensating windings shall be arranged so that the current loops in the planes of the end connectors at the two ends of the machine will sum up to zero net magnetic moment at each end.

Preparing activity:
Navy - SH
(Project 6115-N468)



A. Pair of main field poles vertically oriented.

B. Vertical equally divides the angle between adjacent main field poles (Angle A = Angle B).

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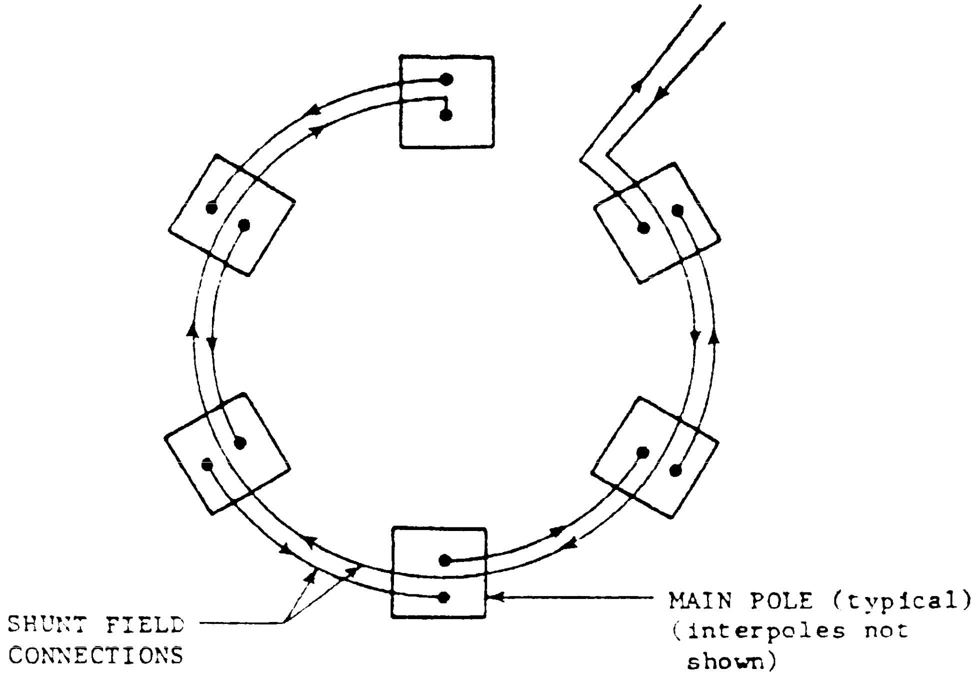
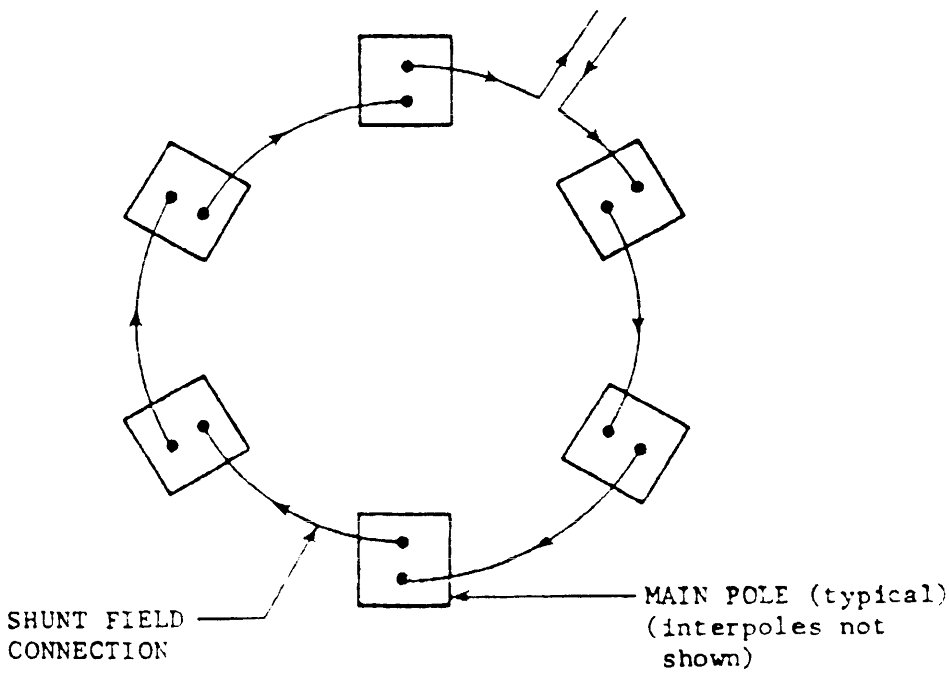
FIGURE 1. Orientations of main field poles for minimization of the vertical component of the stray magnetic field.



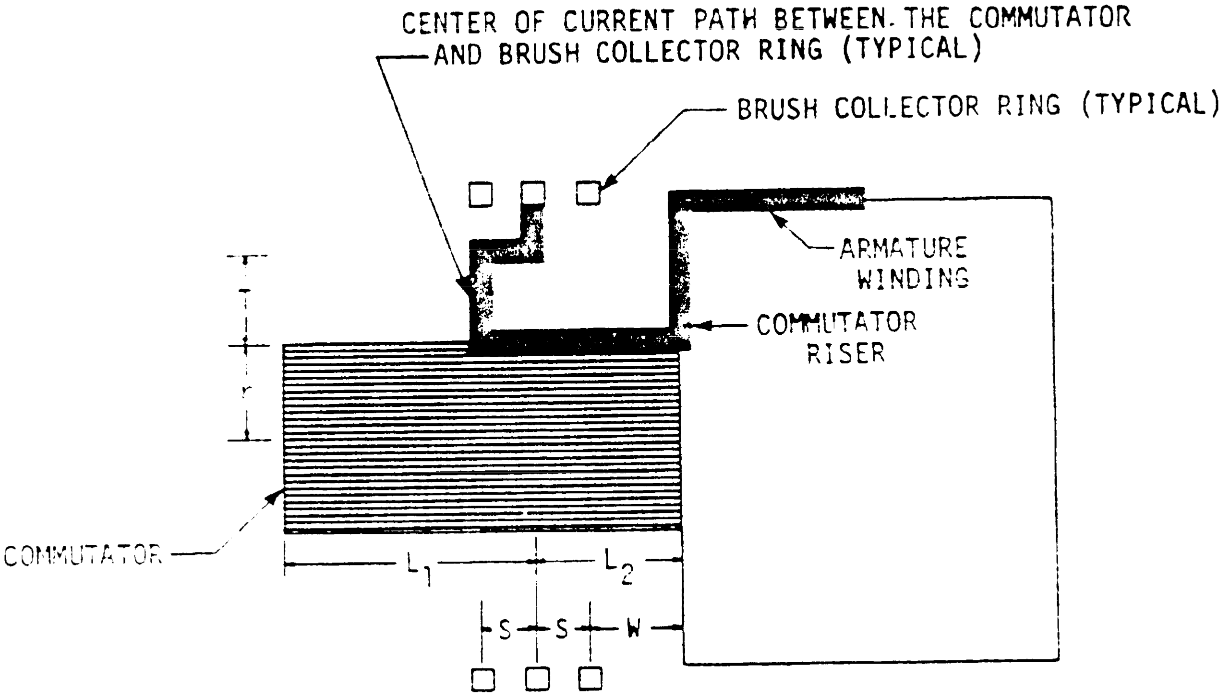
A. Preferred method.



B. Non-preferred method.

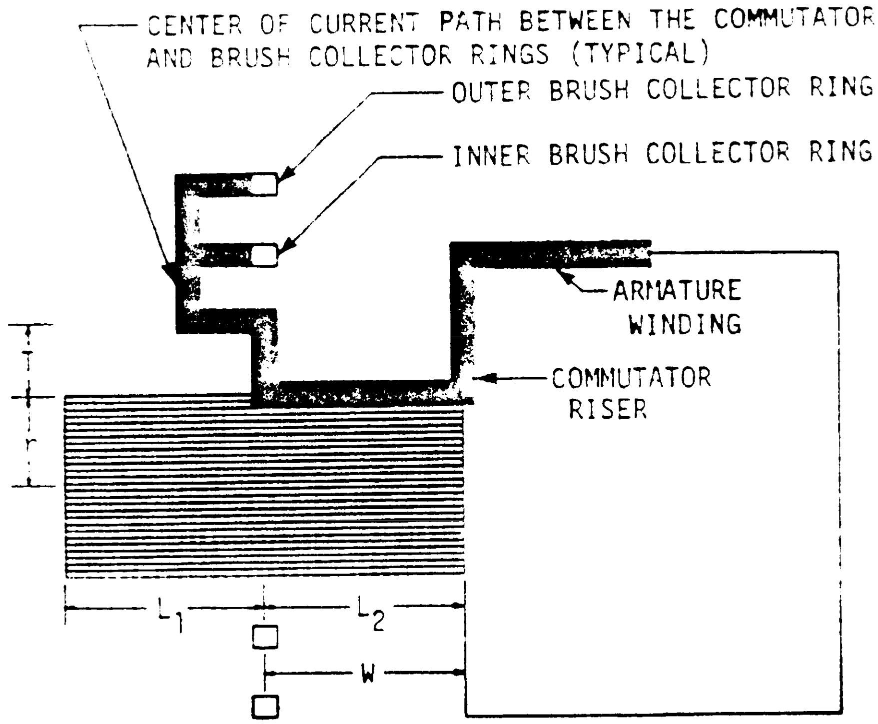
SH 12239

FIGURE 2. Preferred and non-preferred methods of making connections to the field coils.



(Longitudinal section through half of machine)

A. Position for three-brush collector ring arrangement.

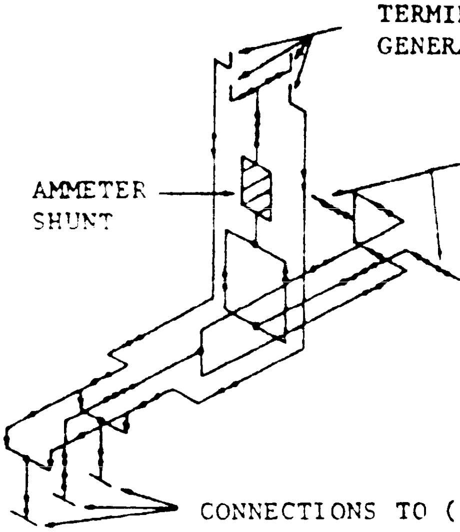


(Longitudinal section through half of the machine)

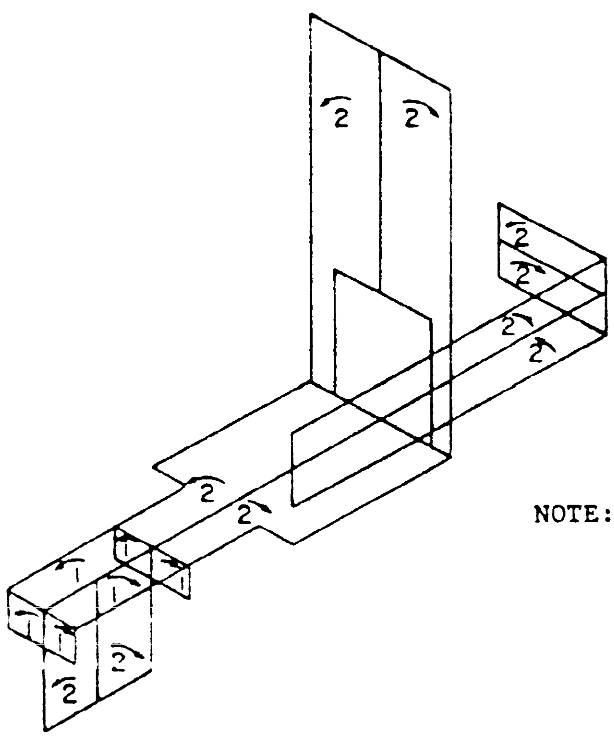
B. Position for two concentric brush collector ring arrangement.

SH 12240

FIGURE 3. Position of brush collector rings.



A. Connections for a machine with three brush collector rings.



NOTE: Number in loop indicates relative magnitude of current in each loop.

B. Resulting current loops for the connections in A.

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FIGURE 4. Typical connections and resulting current loops for machines with three-brush collector rings.

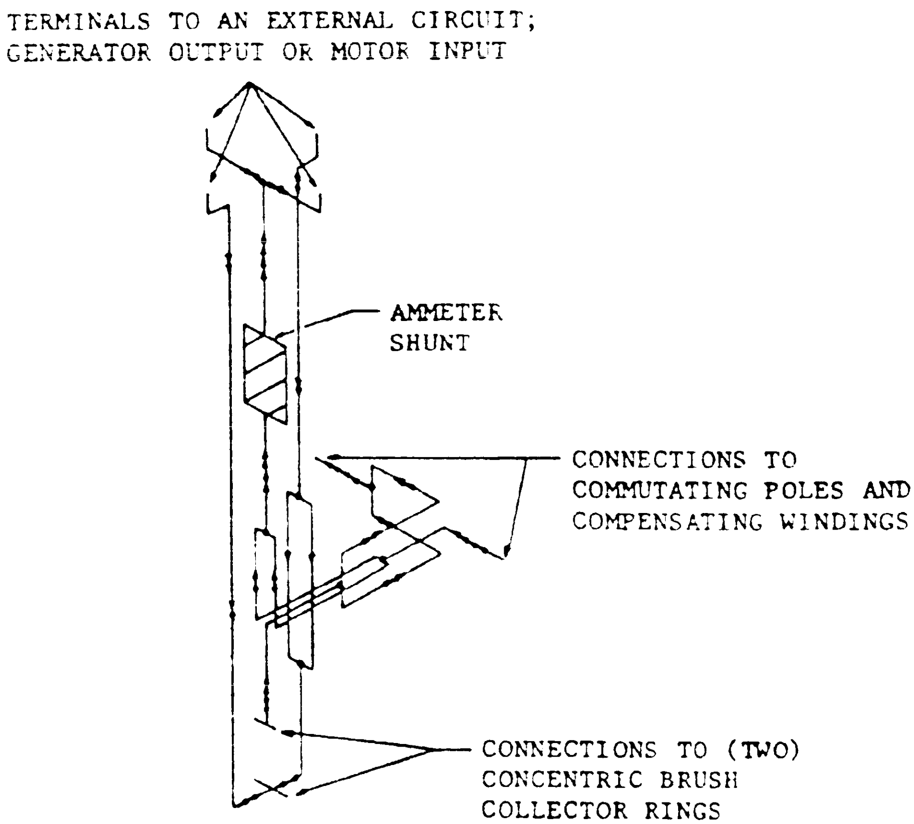

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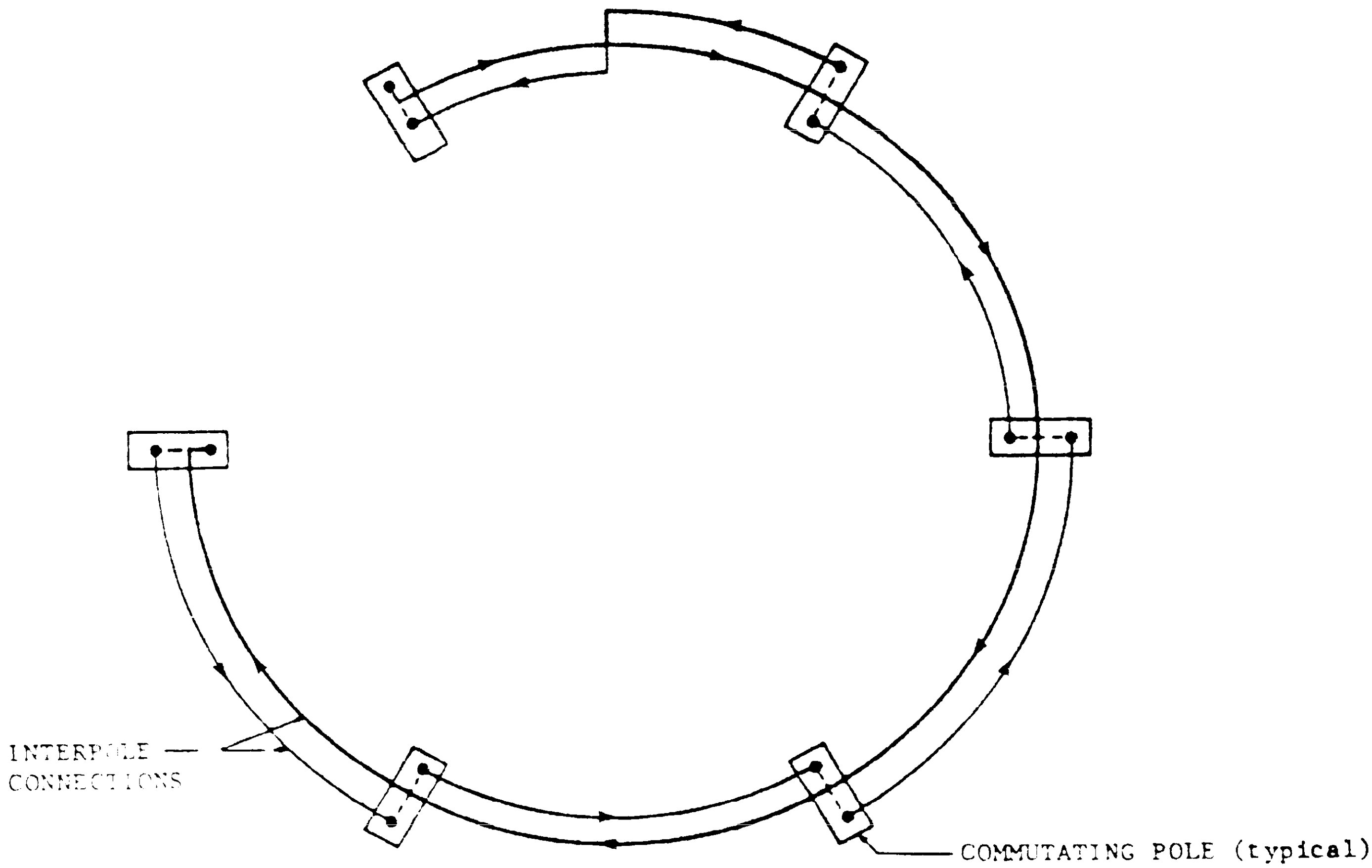
FIGURE 5. Typical connections for generators with two concentric brush ring collectors.



NOTE: The commutating circuit is shown completely closed on itself. It is tied to the rest of the armature circuit by cutting one of the connections between coils and connecting to the brush collector rings and terminals at points indicated on figures 4 and 5. Only the compensating poles are shown; the main poles are omitted since they are not connected in the commutating circuit.

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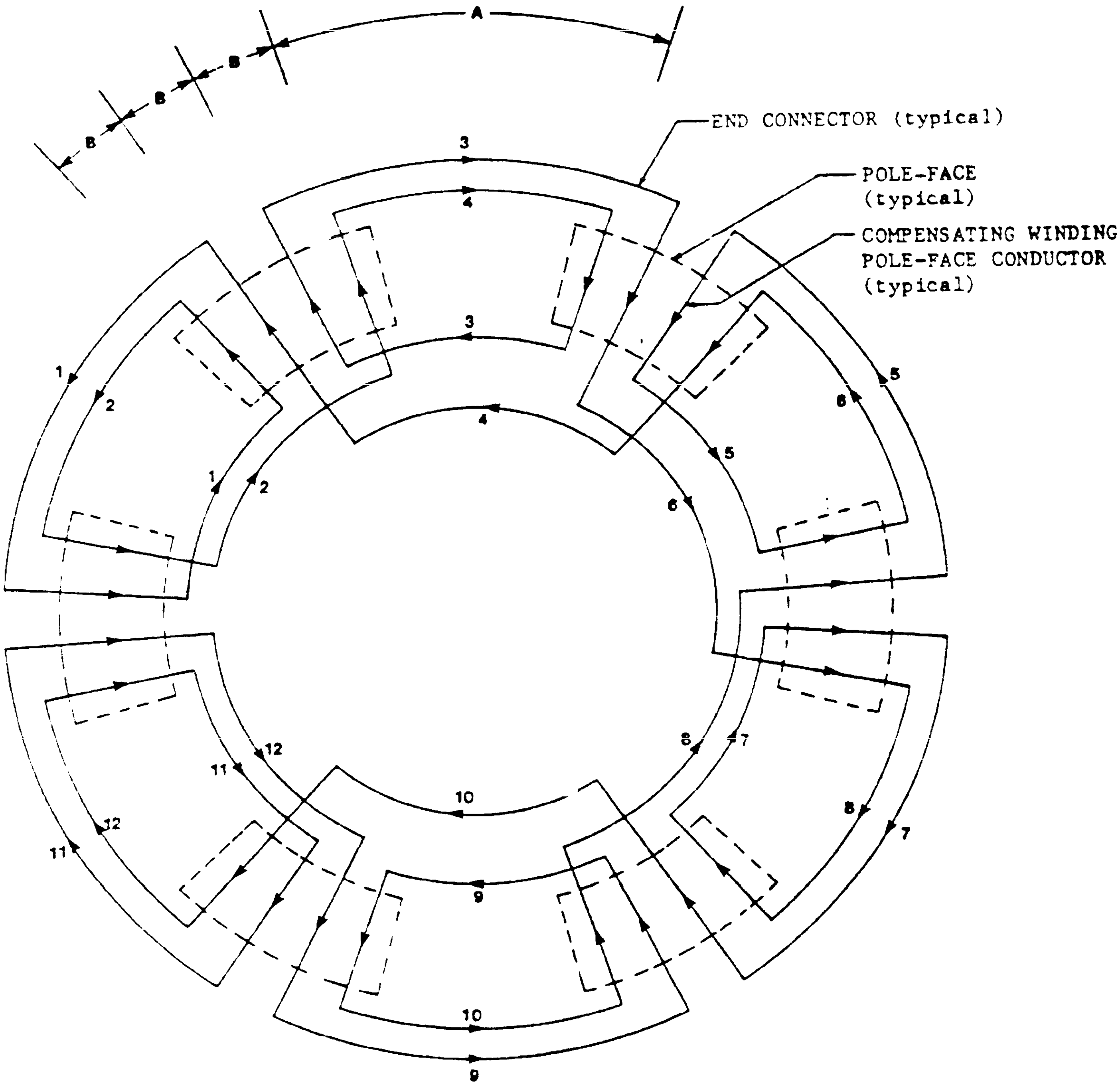
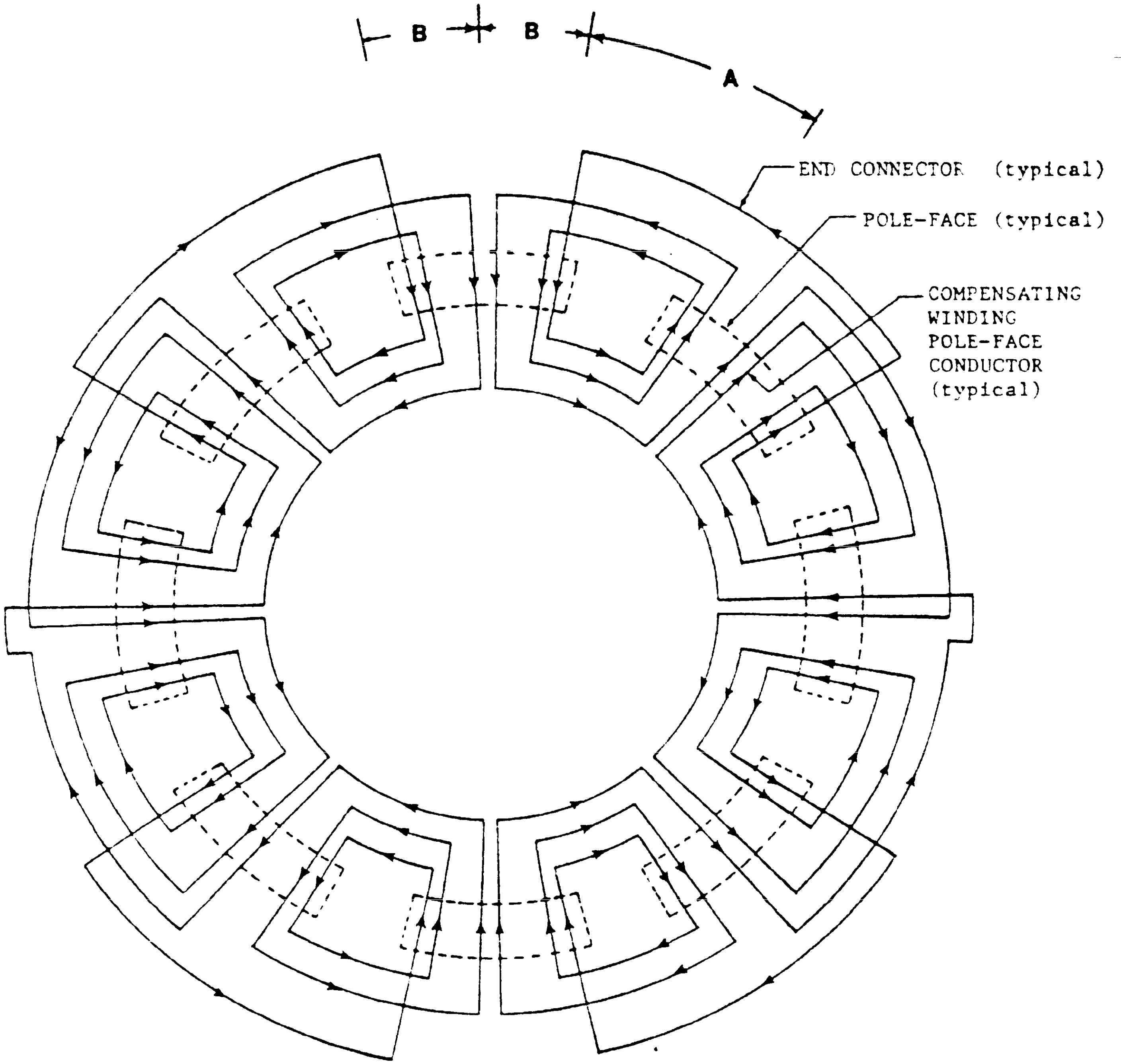
FIGURE 6. Arrangement of connections to commutating poles (interpoles) for low stray magnetic field.



NOTE: The compensating circuit is shown completely closed on itself. It is tied to the rest of the armature circuit by cutting one of the connections between poles and connecting to the brush collector rings and terminals at points indicated on figures 4 and 5.

SH 12244

FIGURE 7. Compensating winding for a six-pole machine with four slots per pole-face.



NOTE: The two parallel parts of the compensating circuit are shown completely closed on itself. It is tied to the rest of the armature circuit by cutting one of the connections between poles for each of the parallel parts and connecting to the brush collector rings and terminals at points indicated on figures 4 and 5.

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FIGURE 8. Parallel circuit compensating winding for an eight-pole machine with three slots per pole-face.

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

(See Instructions – Reverse Side)

1. DOCUMENT NUMBER
DOD-STD-2146(SH)

2. DOCUMENT TITLE

3a. NAME OF SUBMITTING ORGANIZATION

b. ADDRESS (Street, City, State, ZIP Code)

4. TYPE OF ORGANIZATION (Mark one)

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5. PROBLEM AREAS

a. Paragraph Number and Wording:

b. Recommended Wording:

c. Reason/Rationale for Recommendation:

6. REMARKS

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