THESIS

on

THE DESIGN AND CONSTRUCTION OF A 5 K.W., D. C. GENERATOR

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[redacted]

Approved: [redacted]

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THE DESIGN AND CONSTRUCTION OF A 5 K.W. GENERATOR

Since this treatise is to deal only with the construction of one special machine it is unnecessary to go into an extended discussion of dynamo electric machinery in general. Some of the parts common to all electric machinery of this character will be mentioned and then a short account of the design and construction of this particular machine will be given.

The two essentials of a generator of electricity are the field and armature. In direct current machinery some method must be adopted to take the current all off on one side and keep it flowing in the same direction, otherwise it would be reversed one or more times in each revolution according to the number of poles. This is accomplished by means of a commutator. A commutator consists of several copper bars well insulated from each other with mica. These bars are all set radially to the axis of the armature and turned smooth so the brushes may press on them as the armature revolves, with as little friction as possible.

What is known as the field of a generator is merely a magnetic field caused by passing a current through a wire wound around an iron or steel core.

These turns may be connected either in series or parallel with the armature terminals. These are called respectively series and shunt windings. If both are used it is known as a compound winding.

The armature is mounted on a shaft and is composed of an iron core with wires laid longitudinally with the shaft, on the periphery of the core. The ends of these wires are connected to the commutator which is mounted on the same shaft.

Construction of the Machine

YOKE

The yoke is of cast steel one inch in thickness nine inches wide, and seventeen inches inside diameter. The base and yoke were cast in one piece, and the bearing housings, turned to exact size, fit into grooves cut in the ends of the yoke thus making a very compact machine.

BEARING HOUSINGS

These are made of cast iron and are of the semi-inclosed type. The bearing itself is four inches long and is made of babbit. This bearing was carefully turned to exact size and then slipped into the opening made for it and fastened in place with a small set-screw which enters into a hole in the bearing. The oil receptacle is just below the bearing and the oil is carried over the bearing by a ring oiler.

FIELD POLES

The poles are of soft steel three and one half inches in diameter and four inches long. They are bolted to the field yoke with two half inch bolts two inches long. The poles were made by bolting the pieces of steel radially to a face-plate and then turning the ends to fit the curvature of both the yoke and the pole shoe.

POLE SHOES

The pole shoes are of soft steel laminations one thirty second of a inch in thickness, four inches in length, and varying in width from one half to one eighth of an inch. These laminations are riveted t together to form a shoe five and one fourth inches in length.

ROCKER ARMS

This is of cast iron and is turned to fit over a shoulder on the inside of the front bearing-housing. It is held in place by two screws which run in a slot in the shoulder.

ARMATURE

The armature is eight inches in diameter and is made up of laminations fifteen mils thick. There are three flues, one at each end and one in the middle. The total length of iron is five inches. There are thirty five slots on the face of the armature and each slot contains twenty four #13 wires.

SHAFT

The shaft is thirty and three eighths inches long and two and one eighth inches in diameter in the largest place. There are two brass thrust collars just inside the bearings to catch the end play.

COMMUTATOR

The commutator spider and ring are of cast iron and the ring nut, is of wrought iron. The segments are of hard drawn copper and are one hundred five in number. A quarter inch key was placed between the spider and the ring to prevent turning. The diameter of the commutator is seven inches and the length of the rubbing face is one and one fourth inches. The spider was shrunk on the shaft with a shrink fit of fifteen ten thousandths of an inch.

BRUSHES

There are four sets of brushes and two brushes to each set. The brushes are of medium hard carbon and each has a rubbing surface of five eighths of a square inch.

FIELD

The machine as yet has not been compounded but if it is desired to use it as a generator the series turns may easily be added. The field as at present designed contains fifty two hundred shunt turns of #17 wire.

COMMUTATOR CONNECTIONS

In order to secure sparkless commutation a three part winding was chosen which calls for three times as many segments on the commutator as there are slots on the armature. Three separate coils of four turns each were, therefore, wound together as a single coil thus leaving six free ends from each coil. These were brought to the commutator and all of the coils were soldered in in series with each other.

FIELD DESIGN

Owing to several complications entering into the construction it was found to be more satisfactory to find the field ampere turns by trial than by actual design. To do this one hundred turns of large wire were wound on the field and current from another source was sent thru them. As soon as the right voltage and current were registered by the instruments, the current flowing in the field was noted and the number of ampere turns easily calculated.

DESIGN OF ARMATURE WINDING

Effective length of armature = 4"

4 poles

4 circuits

35 slots

165 commutator bars

Assume 12 turns per coil of #13 wire

Two coils in each slot = 24 wires per slot

$$E = \frac{\phi Z n p}{p' 10^8}$$

Z = 35 x 24 = 840

$\phi = 10^8/35$ = 71,500 lines per pole

$$E = \frac{71,500 \times 840 \times 20 \times 4}{4 \times 100,000,000} = 120 \text{ volts}$$

$$R = \frac{11.5 \times 840 \times 5}{4100 \times 6} = .122 \text{ ohms}$$

I = 50 amperes, I^2 = 2500

I^2R loss in armature = 2500 x .122 = 305 watts

Field current = 2 amperes

Resistance of field = 76 ohms

I^2R loss in field and rheostat = 165 watts

Hysteresis and eddy current losses in armature = 300 watts

$$\text{Efficiency of machine} = \frac{5,000}{5,000 + 300 + 305 + 165} = 86\%$$

DIMENSIONS

Outside diameter of yoke	19"
Inside diameter of yoke	17"
Full height	21.375"
Length, center to center of bearings	20.375"
Full length of machine	26."
Length of shaft	30.375"
Diameter of armature	8"
Air gap	1/8"
Diameter of shaft at bearing	1.5"
Length of armature conductor over iron	5"
Length of rubbing face of commutator	2.5"
Length of wire used in armature	920'
Polar arc	75%
Revolutions per minute	1200
Peripherial velocity in feet per minute	2516

RESULTS

As soon as the field had been wound the machine was connected up and given a few short runs. Owing to lack of time a full set of tests have not yet been taken but in the tests that were given the results were highly satisfactory.