SECTION 3

PRINCIPLES OF OPERATION

PURPOSE OF AN ALTERNATOR

The purpose of the alternator is to produce electrical energy. This energy is used to maintain the proper state of charge in the battery and supply current to all electrically powered equipment in the aircraft. It performs this function by converting the mechanical energy derived from its moving parts into electricity.

The BATTERY is the source of electrical power for starting the aircraft, and the source of power when the BAT Master Switch is ON. The ALTERNATOR becomes the electrical power source when the engine is running, and the ALT Master Switch(es) is ON.

ELECTRO-MAGNETIC INDUCTION

A belt driven pulley is used to turn the alternator rotor assembly inside the motionless stator core and coil assembly. The slip rings, which are pressed onto the rear portion of the rotor shaft, are connected with the rotor coil winding. A brush holder assembly retains two brushes which are spring loaded in the holder so that they will maintain a desirable contact with the slip rings throughout the service life of the brushes.

Figure 3-1 simulates the physical relationship between the rotor and stator assemblies. Study this illustration-taking particular notice of the following:

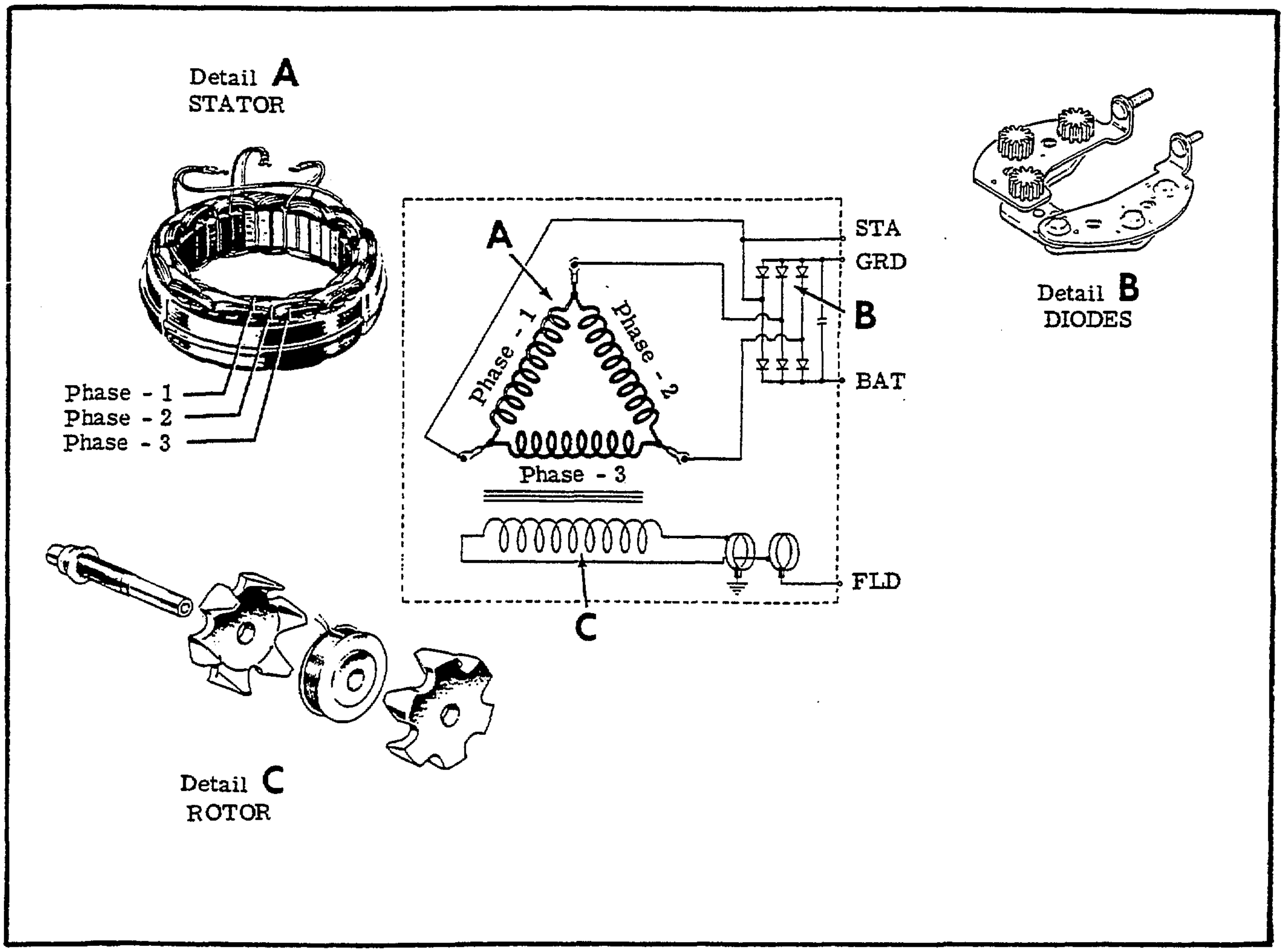

Figure 3-1. Alternator Component Internal Relationship

Three separate series of coils are wound on the same stator core. These windings are arranged in three layers in each stator core slot with their installed position occupying a staggered relationship to each other.

When the winding process is completed, a loose end for each coil remains. These ends are directed through a printed circuit board to a pair of diodes - one is positive; the other is negative.

The diodes are installed in arc-shaped metal plates (heat sinks) which serve as conductors by transmitting current from the diode to a terminal. The positive diode plate assembly includes the battery and stator terminals . . . the negative plate assembly includes the ground terminal. All of these terminals protrude through the rear housing with the "BAT" and "STA" terminals being insulated from the the housing. The stator terminal is also insulated from the positive plate.

In the illustration, we are showing a simulated end view of a rotor assembly. Thus, you can see the tips of one set of magnetic fingers and the wide leading edges of the other set of fingers. (Keep in mind that these fingers envelope the current-carrying rotor coil.)

Notice that the centerline of the fingers align with the centers of the slots in the stator. (In actual operation, this. or course, would only be a momentary condition. Keep in mind that the rotor is turning inside the stator at a speed which is either 2.7 or 3.36 (See Figure 7.1) times greater than the aircraft engine RPM. The purpose for mentioning this alignment factor is merely to point out that each set of six rotor fingers occupy matching positions in relation to the adjacent stator. Thus whatever one set of fingers is doing at given instant, the remaining five sets are doing exactly the same thing at the same time.

You will also notice in figure 3-1 that there is no visible circuit connection between the rotor and stator assemblies. We've already mentioned that there is a circuit relationship between these two major components, but we haven't indicated how this occurs.

The technical name for the means by which this gap in the circuit is bridged is ELECTRO-MAGNETIC INDUCTION. In effect, this means that an electro-magnetic force is transferring energy from one part of the circuit to the other. The fact that this transfer is taking place indicates that certain design requirements have been met.

The portion of the circuit in the rotor core and coil assemblies includes a current-carrying conductor. This conductor, as evidenced by the fact that it carries a current, is obviously in the form of a complete circuit; and, when this current is flowing, provides a magnetic field around the windings.

The core, around which the coil is wound, although it is not a permanent magnet, will be considered to be a magnetized component for purposes of illustration.

The belt-driven rotor shaft, by rotating the rotor core and coil assembly inside the stator assembly, is creating relative motion between these two portions of a total circuit.

Thus, we have a conductor which forms a complete circuit, a magnetic field, and motion . . . the design requirements for electro-magnetic induction. Now, examine figure 3-2 as a review of how these design requirements for electro-magnetic induction are met in an alternator:

THE CONDUCTOR WHICH FORMS A COMPLETE CIRCUIT

Notice that the coil leads from the core and coil assembly each terminate at one of the two slip rings on the rotor shaft (a separate brush contacts the surface of each of these slip rings). One provides for input from the battery; the other, a ground path or return circuit to the battery . . . A COMPLETE CIRCUIT.

THE PROVISIONS FOR CREATING A MAGNETIC FIELD

The core and coil portion of the assembly shown is an electro-magnet. The rotor pole finger halves are positioned at each end of the core and coil. These integral pole fingers, which are 30° out of point-to-point alignment extend upward and over the coil windings to form alternately north and south polarity fingers. (Notice that a design gap exists between each finger).

When current is introduced into the rotor coil, the strength of its magnetic field as a straight conductor is greatly multiplied. The core further intensifies the strength of the magnetic field; and, by the design of the assembly, concentrates the field in the rotor fingers.

THE PRESENCE OF RELATIVE MOTION AND ITS EFFECT

An assembly of the type shown in the illustration is belt driven in a clockwise rotation. As a result of this rotation, the magnetic fields concentrated in the alternate north and south rotor fingers are moving past the stator windings. Thus, between the rotor finger gaps mentioned previously, the stator windings are exposed to a build-up and collapse of magnetic field. This, in effect, results in the production of alternating current in the stator windings.

This explains the process of energy transfer in an alternator, the mechanical power to drive the rotor, changing in effect to electrical power output from the stator windings.

AMMETER IN CIRCUIT

Battery current is supplied to the field of the alternator through a "bias" diode, and power transistor in the voltage regulator. A second diode, connected from the field terminal to common ground, absorbs undesirable field voltage peaks. Thus, when both sections of the Master Switch are turned ON, the battery voltage causes a current thru "F" terminal of the regulator to the alternator field, ie. field current to initiate altern output.

3-PHASE ALTERNATOR CURRENT

Up to this point, we have developed that portion of the charging circuit which is involved in energizing the field. We know that a magnetic field surrounds the rotor coil due to field current in the coil. It is concentrated by the design nature of the rotor fingers. As the rotor turns, the magnetic field induces a potential into the stator windings, which causes a current through the closed circuit.

We are now ready to describe the paths of current in the alternator as the rotor fingers turn past the triple-wound, three-phase windings in the stator, (Refer to figure 3-2.)

First study the symbol located in the center of the stator and rectifier assembly. It shows three coils joined to form what is known as a "delta" winding. Each of these coils represent one of the three windings which is wound through the stator slots. For convenience and ease of identification, we have named and numbered them . . . Phase 1, Phase 2, and Phase 3. As a further identification aid, we have coded the wiring with solid and dashed lines; solid being output, and both dashed being returns.

Notice that each winding leads to a terminal soldered between a pair of diodes connected in series. Each of the three pair of diodes is connected in parallel with the GRD and BAT terminals of the alternator. By studying figure 3-2, in each condition of operation, one can understand the alternating nature of internal current, and the direct, one direction, nature of the external current. Remember that the rotor fingers are producing alternating current as they pass the windings in the stator. However, the battery and other electrical components in the aircraft require direct current. Thus, with a negative ground circuit, the insulated side would obviously be positive and require a positive D. C. input. Accordingly, the diode serves as a form of electrical check valve which will allow current to flow in one direction only.

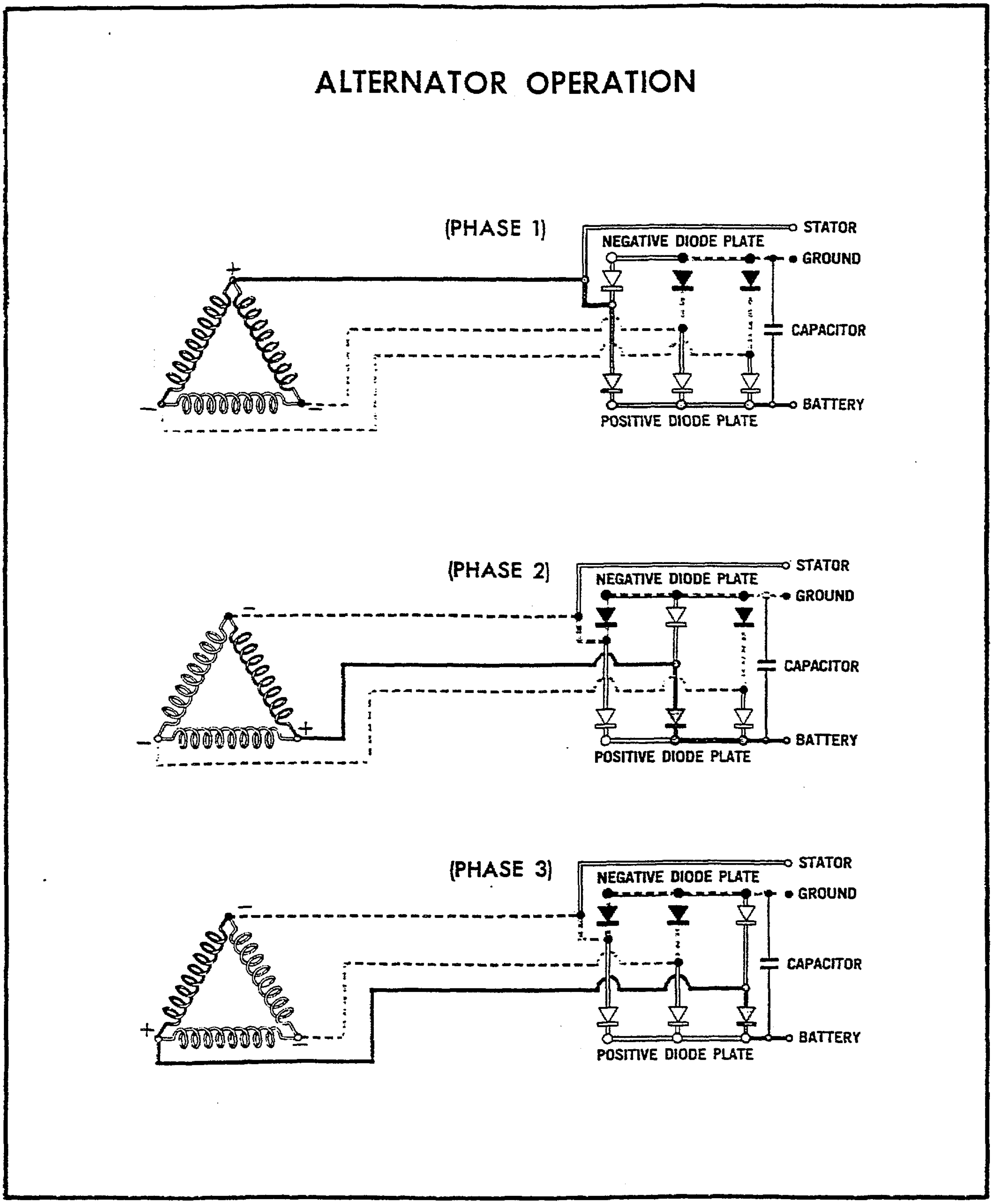

Figure 3-2. Three Phase Alternator Output

DIODES

Controlling current direction with a diode, as well as other types of rectifiers is known as "rectification" - the active device is the diode.

The actual "rectifying" component of the diode is a very small wafer of pure silicon treated with a controlled impurity. The manner in which the wafer is installed in the diode assembly determines the polarity of the assembly. Inverting the disc in a positive diode would change it into a negative assembly. This disc is only .008" to .010" thick and approximately one-eighth inch square, depending on current rating. The 95-amp alternator uses exposed type diodes, as shown in figure 3-3.

CAUTION

> The chemical composition of the silicon wafer or disc is such that it passes current in one direction only. Thus, if battery polarity is reversed, full battery voltage will impress excessive current on the diodes causing their destruction. The damage can also extend to wiring harness, because it is in effect a shorted circuit (No resistance to the current flow).

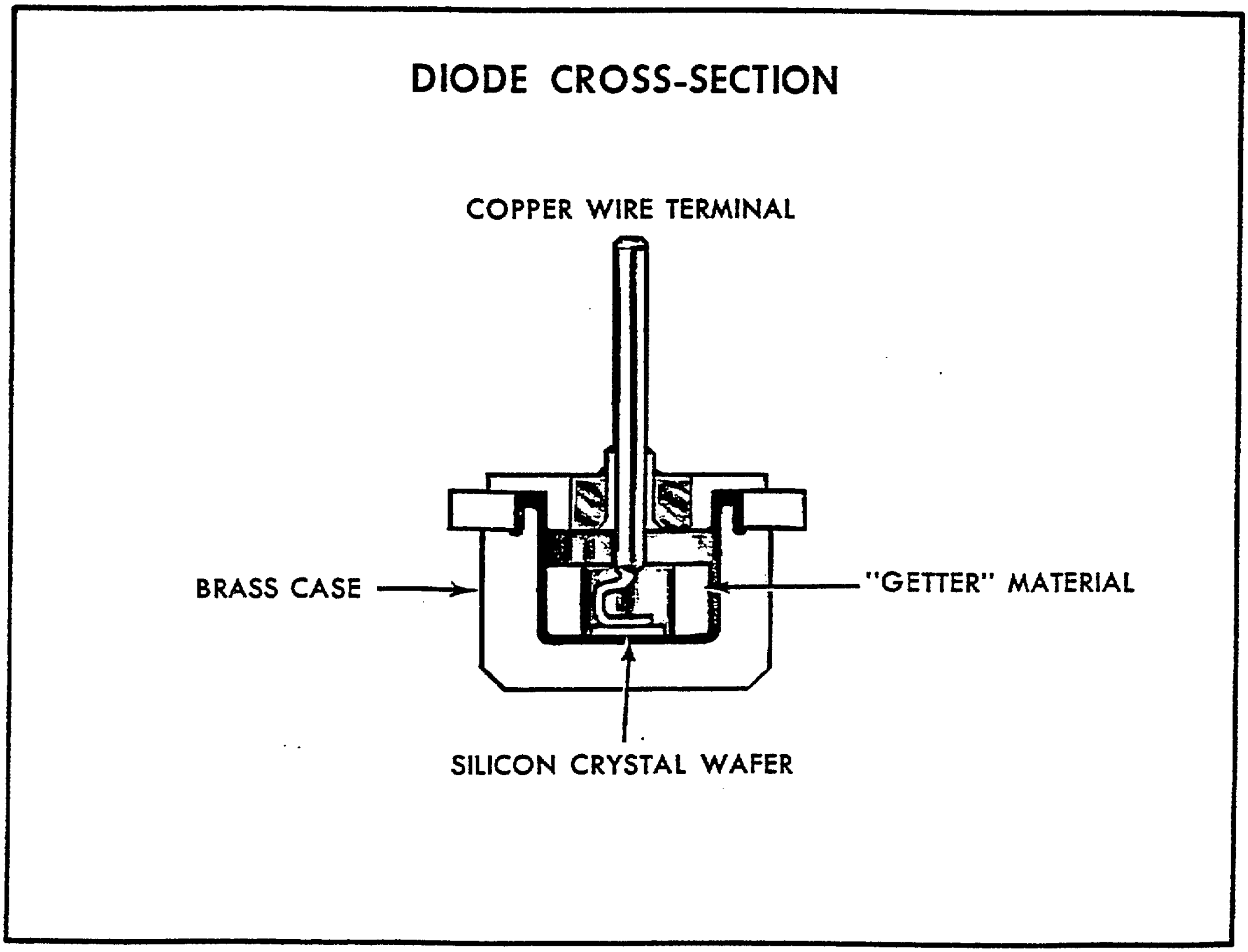

Figure 3-3. A typical Diode Construction