

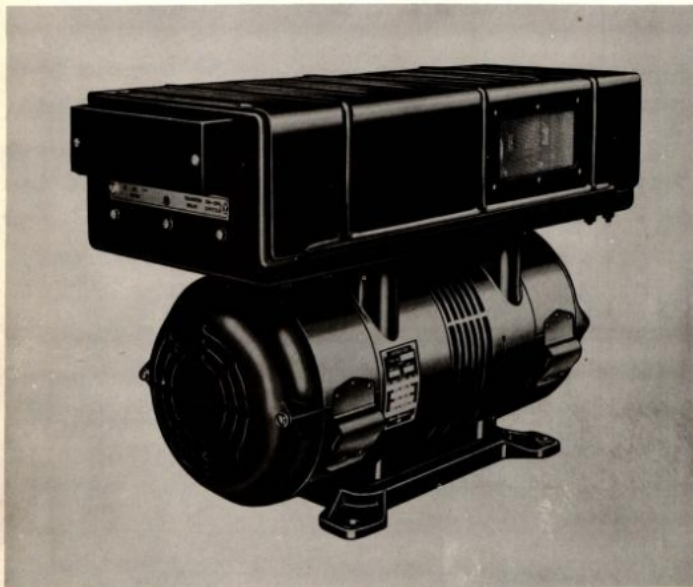


Figure 1-1. Assembled View of Model F145 Inverter

SECTION I
INTRODUCTION

1-1. IDENTIFICATION. This handbook contains overhaul instructions and description for the Model F145 Inverter manufactured by Jack & Heintz, Incorporated, Cleveland, Ohio. (See figure 1-1 for a representative view of the equipment.)

1-2. Section I, II and III of this handbook contain overhaul and test instructions for the Model F145 Inverter. Overhaul and test instructions for additional models are provided in Section IV by use of Difference Data Sheets. The additional models included in Section IV are listed in Section IV index.

1-3. Overhaul and test procedure for models included in Section IV are the same as the procedure given in Section II and III except for the specific differences noted by the applicable Difference Data Sheets.

1-4. The inverter described in this handbook is a self-contained unit designed to produce a dependable, accurately regulated source of 400 cycle, single phase alternating current at 115 volts from an input source of 27-1/2 volts direct current. All airplane accessories requiring electrical power with ratings and characteristics listed in Table I can be supplied by the inverter. Special devices are incorporated in the circuit for automatically controlling the output voltage and frequency. In addition, adjustment means are provided for setting voltage and frequency. Suitable filtering devices are used to attenuate radio noise.

NOTE

The inverter can operate in any position but a general horizontal position is recommended. It is desirable that the equipment be located so that the carbon piles of the voltage and frequency regulator will be perpendicular to the normal travel axis of the airplane and thereby minimize the acceleration and deceleration effects.

1-5. LEADING PARTICULARS.

1-6. Table I lists the leading particulars for the inverter.

1-7. PRINCIPLES OF OPERATION.

1-8. GENERAL. The inverter in principle is a motor-generator. The d-c motor, when connected to a 27-1/2 volt d-c power source, drives the alternating current generator (alternator), which in turn generates an a-c voltage. The generated a-c voltage is proportional to the speed of the rotor and the strength of the generator field flux. At a fixed voltage, the amount of alternating current delivered by the generator depends on the load circuit impedance (combined

TABLE I -- LEADING PARTICULARS

CHARACTERISTIC	RATING
Output Rating--Three phase	
Full Load (volt amperes)	2500
A.C. Voltage	115/200
Line Current (amperes)	12.5/7.5
Frequency (cycles per second)	400
Power Factor--Percent lag	90
--Percent lead	95
Phase Rotation	T ₁ -T ₂ -T ₃
Input--Direct Current	
Rated Voltage	27-1/2
Minimum Voltage	26
Maximum Voltage	29
No Load Current (amperes)	44
Full Load Current (amperes)	158
Altitude Limit (-10°C) (+14°F)	35,000
Ambient Temperature Limits	-55°C (-67°F)
at Sea Level (degrees)	+71°C (+160°F)
Ambient Temperature Limits at Altitude (Continuous operation)	
25,000 Feet Maximum	+10°C (+50°F)
35,000 Feet Maximum	-10°C (+14°F)
Frequency Range--All Environments	
cycles Per Second	380-420
Output Voltage Range--All Environments	
Alternating Current	110-120/190.5-208
Overall Dimensions (inches)	
Length	19.12
Width	7.50
Height	12.00
Weight--Approximate Net (pounds)	58

resistance, capacitance, and inductance). The inverter is designed to provide a-c voltage at a frequency of 400 cycles per second. This frequency is a function of the number of poles in the generator field (rotor) and the speed of the motor-generator combination (rpm).

1-9. The operation of the inverter is controlled by the various electrical devices in the control box. These components are: line relay, shorting relay, voltage and frequency regulator, filters, thermistor and resistors. The voltage and frequency regulator maintains the output voltage (115 volts) within operating limits by automatically controlling the d-c excitation current supplied to the generator field and maintains the frequency within limits by automatically controlling the amount of current supplied to the motor field. To accomplish the voltage control, one of the carbon piles is connected in series with the generator field. The circuits are so arranged that the magnetic force on the carbon stack, and therefore the resistance inserted in series with the field, is a function of output voltage. Similarly, the other carbon pile

is connected in series with the motor field and the circuits are designed so that the magnetic force applied to the carbon stack is proportional to the output frequency. By this means, the resistance of the generator field and of the motor field is automatically varied to provide the desired output voltage and frequency.

1-10. MOTOR. The direct current motor (prime mover) converts electrical energy into mechanical energy to drive the alternating current generator (alternator). The direct current drawn by the motor depends upon the load of the a-c generator.

1-11. Due to low armature resistance, a d-c shunt-motor draws very high starting currents (inrush currents) when connected across the rated d-c power supply. Also, its starting torque (turning force), and consequently its rate of acceleration, is low because of the time interval required by the shunt field to build up to normal strength (due to induction). To avoid undue disturbance to the aircraft d-c electrical system, the motor should accelerate to rated speed in a minimum length of time and should not draw excessive starting current. To accomplish this, a series starting-field winding carrying the armature starting current is connected in the circuit to provide additional motor field flux during the starting cycle. This increases the starting torque causing rapid acceleration of the armature and, in turn, results in generation of a counter d-c voltage which reduces the starting current to normal running value. Thus the starting current is limited to a value not greatly above normal for a short period of time. The series starting-winding is not left in the circuit after the motor has attained rated speed since it would work against the frequency regulator, making it difficult to hold the speed constant. The series starting-winding resistance is relatively high, also aiding in the limitation of starting current; however, if this winding were left in the circuit during continuous operation, the heat produced would be injurious to the machine. Therefore, as the motor approaches its normal rated speed, the operation of a relay shunts out the series starting-field winding, by-passing the armature current around it.

1-12. VOLTAGE AND FREQUENCY REGULATOR. The voltage and frequency regulator is a compact control incorporating two carbon piles to provide voltage regulation and speed control. To minimize the effect of extreme shock and vibration conditions, the regulator is shock mounted in position in the control box.

1-13. VOLTAGE REGULATION. Voltage regulation is obtained by controlling the amount of d-c current (excitation) flowing through the generator field. This is accomplished by sensing the output voltage and automatically varying the generator field circuit resistance in response to output voltage changes thus supplying enough excitation current to maintain the a-c output voltage at its preset value. The carbon pile (variable resistance) is connected in series with the generator field; the operating coils provide magnetic action in such a direction as to relieve some of the spring pressure on the carbon pile, thus changing the carbon pile resistance and increasing or decreasing

the generator field current as required. To accomplish this, the main carbon pile operating coil is supplied a fixed current from the main d-c supply through a resistor. In direct opposition to the fixed current (bucking action), the main operating coil is supplied a current proportional to the a-c output voltage; the a-c output voltage is supplied to an isolation transformer whose output, in turn, is rectified to d-c and applied to the main operating coil, voltage regulating tube, and voltage adjustment potentiometer all connected in series. The voltage regulating tube is designed to prevent current flow until the applied d-c voltage (proportional to a-c output voltage) has reached a predetermined value. As the inverter is started, the current flow through the main coil of the carbon pile is from the main d-c supply only; this provides for rapid voltage build-up since the fixed current in the operating coil results in maximum force on the carbon pile (minimum resistance) and, therefore, maximum generator field current. When the a-c output voltage increases to the point where the voltage regulating tube fires, bucking current is supplied to the main carbon pile operating coil resulting in a decrease in magnetic force on the carbon pile (increased resistance) and decrease in generator field current until a stabilized condition is reached when the generator field current is just sufficient to maintain the correct output voltage. Occurrence of conditions which tend to decrease the a-c output voltage (decrease in input voltage or increase in load), cause the current through the voltage regulating tube to decrease. This results in more magnetic force on the carbon pile (decrease in resistance) and consequently an increase of generator field current. With conditions tending to increase the a-c output voltage, the action is reversed and field current is decreased.

1-14. FREQUENCY REGULATION. The output frequency of the inverter is directly proportional to the speed of rotation. Frequency or speed regulation is accomplished by controlling the amount of current flowing through the d-c motor field by inserting a carbon pile in series with the field. The carbon pile operating coil provides a magnetic force on the carbon pile, the strength of which is dependent on the current flowing through the coil. This force acts to relieve or increase the pressure on the carbon pile thus changing the carbon pile resistance (decreasing or increasing the motor field current) and consequently the inverter speed. A frequency sensing circuit supplies the current to the operating coil through a glow lamp and a bridge rectifier. The frequency circuit consists of a capacitance, inductance, and resistance connected as a series resonance circuit across the a-c output. It is designed to give an increasing flow of current as the frequency increases. The circuit resonates well above rated frequency so that relatively small changes in output frequency result in large changes in current supplied to the operating coil of the carbon pile. The glow lamp passes alternating current to the bridge rectifier only after a predetermined output voltage has been reached. When this voltage value has been reached, the glow lamp passes current to the rectifier and direct current is supplied to the operating coil. As the inverter starts from rest, the a-c output voltage rises from zero and the inverter picks up

speed. While the a-c voltage is below that required to fire the glow lamp, the operating coil is de-energized with the carbon pile resistance at its maximum value. The motor field current is determined by a resistor connected in parallel across the carbon pile. When the a-c output voltage reaches a value sufficient to fire the glow lamp, a small amount of alternating current is passed to the rectifier and direct current to the operating coil. This results in a decrease in carbon pile resistance and an increase in motor field current. As the output voltage and frequency increases, the direct current to the operating coil increases (decrease in carbon pile resistance). The motor field current increases until a stabilized condition is reached where the motor field current value is that which is required to maintain the rated frequency. Occurrence of conditions causing a decrease in the inverter speed (decrease in input voltage or increase in inverter load) will result in less output from the resonance circuit and subsequent decrease in motor field current. Conversely, increases in inverter speed result in increased motor field current so that the output frequency is maintained within its rated range.

NOTE

The speed of a d-c motor, disregarding the load placed on it, is always inversely proportional to the motor field strength; that is, speed is increased as the field flux is reduced, and vice versa.

1-15. Both the frequency and voltage regulating circuits incorporate negative feedback features to provide stable operation. The frequency regulating carbon pile contains an auxiliary operating coil connected in series with a resistor and capacitor. The combination is connected in parallel across the carbon pile so that current passes through this coil only under transient conditions and supplies a force to the carbon pile resistance which tends to dampen the transient effects. A capacitor and resistor (connected between the voltage regulating carbon pile and the voltage sensing circuit) and an auxiliary operating coil (sensing changes in frequency) also tends to minimize voltage transient effects. Negative temperature coefficient resistors are used as required to provide the necessary temperature compensation. Since the firing voltage of the voltage regulating tube is affected by surrounding light, a source of light is included in the regulator; a spot of radioactive material serves the same purpose on the glow lamp.

1-16. A-C GENERATOR. The a-c generator (alternator) converts the mechanical energy received along the shaft from the d-c motor into alternating current electrical energy. The principle of operation is similar to that of a direct-current generator except that the alternating current generated in the armature winding is supplied directly to the output leads instead of being rectified (changed to direct-current) by the commutator. Unlike the direct-current generator, the d-c field poles on the shaft rotate inside of the stationary armature windings. This makes it necessary to supply the direct current, which excites the

rotating field poles through slip rings mounted on, but insulated from, the shaft. Direct current, controlled by the voltage regulator, is supplied from the 27-1/2 volt main d-c aircraft power system to the rotating field winding. If the speed (rpm) of the (field rotor) is increased, the rate at which polarity changes (frequency) increases. Likewise, if the speed is reduced, the frequency is reduced. Since it is necessary to hold the frequency to 400 cycles per second within very close limits, the frequency regulator which controls the motor speed is set to hold the speed at approximately 8000 revolutions per minute.

1-17. By the above method, the voltage generated in the a-c armature (alternator stator windings) depends upon the strength of the rotating magnetic field, which in turn depends upon the amount of direct current supplied to the alternator field windings through the slip rings (the higher the field current, the higher will be the a-c voltage generated, and vice versa). It is the function of the voltage and frequency regulator to automatically vary the alternator field current to the value required to maintain rated voltage from no load to full load at the a-c output terminals.

1-18. FILTERING DEVICES. The main positive power supply of the d-c system is fed through a d-c radio noise filter. This prevents any high frequency currents, some of which are generated in the d-c motor, from being fed back through the d-c or a-c power systems where they would cause interference with radio or radar reception. Each of the a-c output leads are also suitably filtered.

1-19. LINE AND SHORTING RELAYS. The operating coil of the line relay is energized from the 27-1/2 volt d-c system through an external control switch. When the control switch is closed, the relay closes its contacts to furnish the main d-c power to the motor.

1-20. The shorting relay shunts out the motor series starting field winding as the inverter approaches rated speed. Its operating coil is energized through a resistor across the motor brushes. Since the counter d-c voltage across the brushes is small during the initial moments of starting, the voltage supplied to the operating coil of the running relay is not sufficient to close the normally open contacts. As the inverter accelerates and the magnitude of the generated counter d-c voltage increases, the voltage supplied to the operating coil is sufficient to close the contacts when the unit approaches rated speed. Then, the shorting relay closes and shunts out the series starting field winding.

1-21. OPERATING INSTRUCTIONS.

1-22. Close the "CONTROL SWITCH" to turn on the inverter. Open the "CONTROL SWITCH" when the inverter power is no longer required.

1-23. If any abnormal conditions of voltage, frequency, current, or noise are noticed, the inverter should be turned off immediately and the cause investigated and corrected.

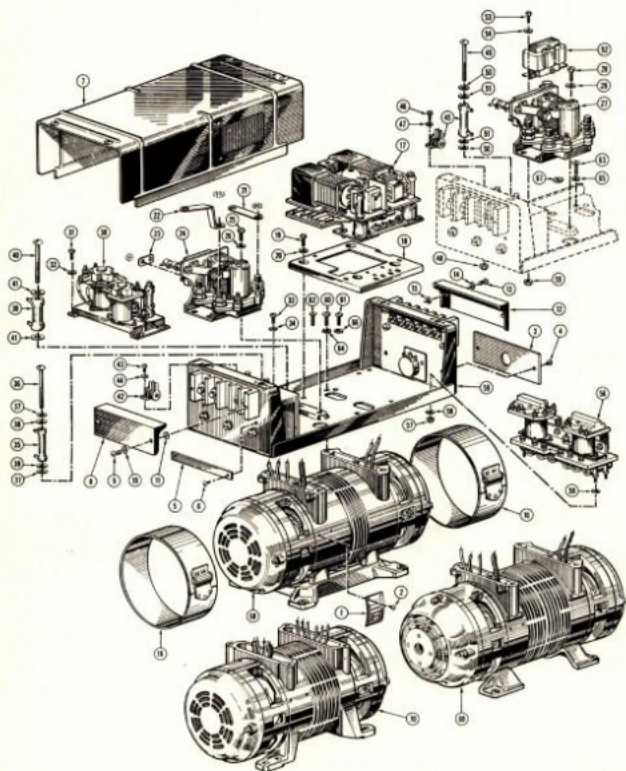


Figure 2-1. Exploded View of Inverter