

KS-21501 GAS TURBINE ENGINE ALTERNATOR  
900/750 KW (J-86653)

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|------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1.   | GENERAL                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 1.12 | A full load test at the job site is redundant but usually requested by the operating company and so it is included in this test procedure. The verified full load test results are on file at the factory through the Western Electric - Source Inspection Organization.        |
| 1.1  | Scope                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 1.13 | Record trouble encountered in performing the tests on SD-4-1313.                                                                                                                                                                                                                |
| 1.11 | This section covers installation and test of the automatic or manual KS-21501. Each unit is tested at the factory under Western Electric Company Source Inspection supervision to verify that all Bell System requirements are met, including a full load test. All functioning components, including the Continental Control Companies Integrated Circuit Module are tested to determine they function properly and are correctly adjusted. The field tests covered herein are considered, for the most part, operational tests and are intended (1) to make sure the unit still functions properly after shipment and (2) to verify job made connections and to verify compatibility with job conditions and requirements. | 1.14 | Be sure to read Warnings and Cautions before attempting any tests herein.                                                                                                                                                                                                       |
|      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 1.15 | The functioning of timers, with the exception of the Overload and Powerdown timers, can be determined by indicating lights that flash or blink while the timers are in operation. The interval between blinks in seconds is approximate to the setting of the timer in minutes. |

1.2 4160V And 480V Sets

1.21 4160 volt sets and 480 volt sets are tested the same as the 208, 230, 240 volt sets. The basic difference is the use of transformers to bring the voltage down to 208-240 volts for all sensing or testing purposes.

1.22 The operating company will normally arrange to have the high voltage system (4160V) complete from the turbine alternator to the step down transformer. On occasion, the Western Electric Company Area Manager may agree to assume responsibility for this work in which case Western may subcontract the job or with the assistance of the Bell Telephone Laboratories and the line or equipment engineer, do the work themselves. The details will be included in the job specifications.

1.3 Specifications

J-86653A 208V, 230/240V or 480V, 3Ø, 4W, 60Hz Gas Turbine Engine Alternator Manual/Auto On Set Control.

J-86653B 208V, 230/240V or 480V, 3Ø, 4W, 60Hz Gas Turbine Engine Alternator Manual/Auto Remote Control.

J-86653C 4160V, 3Ø, 4W, 60Hz Gas Turbine Engine Alternator Manual/Auto Remote Control.

1.4 Drawings

SD-80700-01 Power Systems Key Sheets

SD-81223-01 Alarm Circuits

SD-81489-01 Typical Transfer Breaker Circuits - Custom Furnished

SD-82354-01 Low Voltage - Application

SD-82355-01 High Voltage (4160) - Application

SD-82356-01 Low Voltage - Internal Engine Set

SD-82357-01 High Voltage (4160) - Internal Engine Set

SD-82358-01 Low Voltage - Remote Control Cabinet

SD-82359-01 High Voltage (4160) - Remote Control Cabinet

1.5 Supplier's Representative

1.51 As part of the contract with Solar, a supplier's representative will be made available during the initial start and test of the unit if the customer agrees to pay for this service. When the set is shipped with the coupling disassembled between the engine and the turbine and shipped loose, critical realignment and torquing will be required when replacing it.

1.6 Glossary of Abbreviations

|       |                                |      |                                   |
|-------|--------------------------------|------|-----------------------------------|
| ACB   | Alternator Circuit Breaker     | OLT  | Over Load Timer                   |
| ALT   | Alternator                     | OP   | Operation                         |
| AOL   | Alternator Overload Light      | OPD  | Oil Pressure Delay relay (heater) |
| AT    | Alarm Test                     | OS   | Operation Selector switch         |
| AUTO  | Automatic                      | OSS  | Operation Selector Switch         |
| BALOC | Bell Alarm Lock Out Circuit    | OST1 | Over Speed Trip relay             |
| C     | Contactor                      | OST  | Over Speed Trip switch            |
| CB    | Circuit Breaker                | OV   | Over Voltage                      |
| CCO   | Cranking Cut Out relay         | PC   | Purge Crank switch                |
| CDT   | Cool Down Timer                | PDT  | Power Down Timer                  |
| CF    | Crank Failure                  | PF   | Power Failure                     |
| CML   | Commercial                     | PHET | Pending High Exhaust Temperature  |
| COMML | Commercial                     | PLF  | Preliminary Low Fuel              |
| CSCB  | Control System Circuit Breaker | PO   | Proper Operation                  |
| DWN   | Down                           | POT  | Pending Over Temperature          |
| E     | Emergency                      | PSIG | Pounds per Square Inch Gravity    |
| ECB   | Engine Control Battery         | PWR  | Power                             |
| ECB   | Emergency Circuit Breaker      | RMT  | Remote                            |

## 1.6 Cont'd

|        |                                           |       |                                                                    |
|--------|-------------------------------------------|-------|--------------------------------------------------------------------|
| EG     | Equipment Ground                          | RP    | Reverse Power                                                      |
| ES     | Emergency Stop switch                     | RRO   | Remote Routine Operation                                           |
| FC     | Fan Control                               | RS    | Remote Start                                                       |
| FPS    | Fuel oil Pressure Switch                  | RSI-7 | Reed Switch (day tank fuel level)                                  |
| FPSS   | Fuel Pump Selector Switch                 | RT    | Run Timer                                                          |
| FSF    | Fuel System Failure                       | RTL   | Ready To Load                                                      |
| FSFA   | Fuel System Filter Alarm                  | RTS   | Ready To Start                                                     |
| HET    | High Exhaust Temperature                  | SI    | low fuel reset                                                     |
| HF-    | High Fuel relay (high fuel in day tank)   | SDO   | Starter Drop Out (usually around 70 % speed)                       |
| HOT    | Hold Over Timer                           | SDT   | Start Delay Timer (when commercial power fails this starts timing) |
| ICS    | Integrated Control System                 |       |                                                                    |
| LF-    | Low Fuel (in day tank)                    | SEL   | Selector switch, Selector                                          |
| LG     | Low Fuel (in main tank)                   | SEQ   | Sequence                                                           |
| LHF    | Low High Fuel                             | ST    | Starting switch or Start                                           |
| LOC    | Local                                     | SW    | Switch                                                             |
| LOP    | Low Oil Pressure                          | SYS   | System                                                             |
| LOPS   | Low Oil Pressure Switch                   | TA    | Test Alarm                                                         |
| LOWsdo | Reduced Speed Starter Dropout             | TB    | Terminal Board                                                     |
| MA     | Major Alarm                               | TD    | Timed Out, Time Delay                                              |
| MAN    | Manual                                    | Term  | Terminal                                                           |
| MALF   | Malfunction                               | TSS   | Transfer Select Switch                                             |
| MF     | Malfunction                               | T1    | engine intake air Temperature                                      |
| MI     | Minor alarm                               | T5    | engine turbine Temperature                                         |
| NBC    | Normal Circuit Breaker (commercial power) | T7    | engine exhaust Temperature                                         |
| NLT    | No-Light Timer or No Lightoff Timer       | VAT   | exhaust valve Timer                                                |

|      |                        |     |                                            |
|------|------------------------|-----|--------------------------------------------|
| Nos  | Engine Overspeed       | V1N | AC voltages of Lines                       |
| Nsdo | Normal Starter Dropout | V2N | 1, 2 and 3 in respect to the neutral line. |
|      |                        | V3N |                                            |
|      |                        | WUT | Warm Up Timer                              |

1.7 Tools and Test Sets

## 1.71 Tools:

Tool Kit No.3 should be on hand. Few if any additional tools will be required.

## 1.72 Test Sets:

ITE-4442A Multimeter  
 ITE-4785 Test Load (as required)  
 ITE-4782 Test Load (as required)  
 ITE-5516 EMERGENCY ENGINE ALTERNATOR TEST PACKAGE (Total package of the following including combination shipping and carrying case);

ITE-5517 Power Module  
 ITE-5518 RC Oscillator (Signal Generator)  
 ITE-5519 100MH Counter (Frequency Counter)  
 ITE-5520 Digital Multimeter  
 ITE-5521 Temperature Simulator (Recorder Calibrator or Calibration Tester)

R-3076 Manometer (water type) (two)  
 R-3413 Wire and Lug Assembly (see Note 1)  
 R-3404 Phase Sequence Indicator  
 R-4296 Ear Protector (minimum two)

1.8 Records

ID-1275 Lubrication Record  
 ID-1285 Storage Battery Report  
 SD-4-1313 Test Trouble Record  
 SD-4-1315 Summary of Tests  
 SD-97.946 (11-75) Engine Alternator Test Record or old number ID-946  
 SD4-948 (3-64) Turbine Alternator Performance Test Data Sheet may be substituted by altering the KS number to KS-21501 and using columns a to k, p, and, r and s as required. Write in "Power Factor" in column v and "Hertz" in column w.

NOTE 1: Due to the heat produced by the loads they should be placed outside whenever possible or in a well-ventilated area. This distance will determine the number of R-3413 leads required for connecting them.

1.9 Job Connections

1.91 Standing at the rear of the set and facing the control panel, the majority of the installer run wire is on the left side directly behind the control panel. Terminal strips are numbered from the front of the set TB21 to the rear TB29. Directly above them are three auxiliary relays K301, K301-1 and K301-2 which are energized when the alternator circuit breaker closes. Adjacent are two more relays. K300 and K300-1 which are energized when the OSS (Operation Selector Switch) is in the AUTO mode or AUTO LOAD TEST mode.

1.92 This engine alternator and the 200 KW are very similar in appearance and operation. Refer to Section 253 for photographs if desired.

## 2. DESCRIPTION OF OPERATION

NOTE: The OPERATION SELECTOR (OSS) Switch has four positions, OFF, MANUAL, AUTO and AUTO LOAD TEST. The TRANS SEL (TRANSFER SELECT - TSS) Switch has a MANUAL and AUTO position "Press to select". The following is a description of the operation of the OSS and TSS switches.

### 2.1 OSS Switch to OFF

With the OSS switch in the OFF position, the set is not available for operation. The red SWITCH OFF NORM (SON) lamp is lighted when the OSS switch is in the OFF position informing the operator that the set is not available for starting.

### 2.2 OSS & TSS Switches to MANUAL

2.21 When the OSS and TSS Switches are in the MANUAL position, to transfer the load to the engine the operator must; depress the MANUAL START pushbutton; depress the ALT CB IS CLOSED "Press to close" pushbutton to close the engine's circuit breaker (provided no other set is on the line at the time); and manually operate the customer-furnished transfer device for transferring the load.

2.22 To restore the load back to commercial power and stop the engine, the operator must either manually operate the customer furnished transfer device or depress the READY TO RESTORE pushbutton to provide signals to retransfer the load when this is connected as an automatic feature.

### 2.22 Cont'd

Next the operator must either depress the ALT CB IS OPEN "Press to open" pushbutton or if the operator holds the READY TO RESTORE pushbutton depressed until the load is transferred back to commercial, the engine's circuit breaker will open automatically. Then either depress the SHUTDOWN SEQUENCE pushbutton which will allow the set to operate for a three minute cool down period and then stop the engine or operate the OSS switch to the "OFF" position after which the engine will stop.

### 2.3 OSS Switch to AUTO

2.31 When there is a commercial power failure and the OSS is in the AUTO position, the set will power-up the circuit; automatically start; close its breakers (provided no other set is on the line at the time) and provide signals to operate (through a supplementary customer-furnished relay) the customer-furnished transfer device to transfer the station load to turbine power. When commercial power returns, the set will, provided it has operated for at least 25 minutes, run for a HOLD OVER (HOT) timer period of 15 minutes. After this period, the subsequent events of operation depend upon the position of the TSS switch.

### 2.4 TSS switch to AUTO

2.41 Upon completion of the HOT period, the set will automatically provide signals to operate (through a supplementary customer-furnished transfer device) to transfer the station load to commercial power. The set will also open the engine circuit breaker; operate for a two minute cool down period; automatically stop the turbine; and power-down the circuit.

### 2.5 TSS Switch to MANUAL

2.51 Transferring load back to commercial power the operator must manually depress the READY TO RESTORE pushbutton to provide signals to operate (through a supplementary customer-furnished relay) the Customer-furnished transfer device to transfer the station to commercial power.

2.52 If the operator holds the READY TO RESTORE pushbutton depressed until the load is transferred back to commercial power, the turbine's circuit breaker will open automatically.

- 2.53 If the READY TO RESTORE pushbutton is not held, the operator must (after load is transferred) depress the Circuit Breaker, Operate ALT CB IS OPEN "Press to open" to open the turbine's circuit breaker then either allow the engine to shut down automatically after the end of the cool down period or, operate the OSS switch to the "OFF" position until the engine stops rotating.
- 2.6 OSS Switch to AUTO LOAD TEST
- 2.61 Operation of the OSS Switch to the "AUTO LOAD TEST" position simulates a power failure. The turbine, will automatically start; close its breaker; and provide signals to operate (through a supplementary Customer-furnished relay) the customer-furnished transfer device to transfer the station load to turbine power.
- 2.62 When it is desired to restore the load back to commercial power (provided the set has operated for a 30-minutes period), the operator must operate the OSS Switch from the AUTO LOAD TEST position to the AUTO position. The turbine will then continue to operate for an additional 15 minutes HOT period. After the completion of this HOT period, the subsequent events of operation will depend upon the position of the TSS Switch.
- 2.7 Remote Starting
- 2.71 When starting and operating the turbine from the Remote cabinet, it is necessary to depress the REMOTE/LOCAL pushbutton to REMOTE.
- 2.8 Trouble Shutdowns - Major
- 2.81 Regardless of the position of the OSS, i.e., whether it is in the MANUAL or AUTO position, the major troubles listed below will stop the turbine, transfer the load back to commercial power if it is available, bring in a MALFUNCTION MONITOR lamp, light the associated alarm lamps and signal any connected alarm circuits. The horn also sounds unless it is cut off.
1. Alternator overvoltage
  2. Cranking failure
  3. Emergency stop switch at various locations
  4. Overspeed
  5. Fuel system malfunction
  6. High exhaust gas temperature
  7. High lubricating oil temperature
  8. Low lubricating oil pressure

2.81 Cont'd

9. Major control circuit breaker open. (one or more breakers CB6 through CB16 and CB18 open or tripped)
10. Alternator overcurrent with TRANS SEL (transfer selector) switch in AUTO or MANUAL or short circuit.
11. Reverse power back into the alternator

#### 2.9 Caution - Minor

- 2.91 The following minor alarms light the associated alarm lamp but no shutdown occurs. A minor alarm will be provided to connected alarms circuits.

PHET: The exhaust gas temperature reaches 900 F  $\pm$  10 F

Rect. Failure: Battery charge failure.

CSCBO MINOR: Any or all of the Minor Control System Circuit Breaker open (CSCBO MINOR).

### 3. ALARMS

- 3.1 The ALARM CONDITION "Press to test alarm" annunciator light is integral with the ALARM CONDITION "Press to test alarm" switch and will illuminate when either a Major or Minor malfunction occurs. With the exception of the minor "Control Circuit Breaker is Open" and the "Rectifier Failure" all other malfunctions are processed through the malfunction monitor module.
- 3.2 Throughout the section, when the Major or Minor alarm comes in, operate the ALARM SILENCED Press to Silence pushbutton until the created or real trouble can be cleared.
- 3.3 The test for proper operation of the alarm lamp is covered in Paragraph 18.33.

### 4. WARNINGS

- 4.1 When necessary to work within the engine alternator unit and on the control circuits, hazardous voltages are present. It is necessary to render the control system inoperative because the set may be arranged to start automatically.

Move OPERATION SELECTOR switches to OFF on local and remote control panels.

Switch off all control circuit breakers located in the alternator set control panel.

Determine that the ACB (alternator circuit breaker) located on the set is open by manually triggering it to open.

4.2 If any work is contemplated on the ACB Alternator Circuit Breaker, make sure the breaker springs are discharged (unloaded). The springs are automatically charged by a motor which is connected directly to alternator power, and upon command, the spring closes the switch. The charged springs, if accidentally tripped, has sufficient stored energy to cause serious bodily injury. Also verify for absence of LINE AND LOAD potential on the main breaker terminals before attempting any work operation thereon.

4.3 Commercial power may still be connected to the set at TB28 Terms 20, 21, 22 and 23. With the ITE-5520 or equivalent, check all ac points, line to line, line to neutral and line to ground. Some high voltage components store and maintain a residual voltage for hours after power has been disconnected. Check and discharge with a lamp or resistor.

4.4 Avoid contact by removing potentials or when impractical, provide adequate personnel protection.

4.5 Short circuit hazards exists with the starter battery and its controls as well as the control battery, even when CB15 CB16 and CB17 are switched off. Disconnect cables from TB4 Terms 17, 19, 20, 21 and 22, or the battery cables if working with CB15, CB16, CB17 or with the starter contactor. Avoid contact by removing potentials or when impractical, provide adequate personnel protection.

4.6 Ear Protectors must be worn during operation of the turbine set.

4.7 The ignition system is a high voltage system so avoid any contact until the ignition exciter has been rendered inoperative. Do not operate exciter with out the igniter plug connected and grounded.

#### 5. CAUTIONS

5.01 Make sure all control circuit breakers CB1 through CB18 are off before removing or inserting solid state circuit packs, otherwise, damage to circuit packs can result.

5.02 Static electricity picked up by the body can easily ruin the integrated circuit chips. Never touch these terminals unless all static has been discharged from the body, especially on a low humidity day or in a low humidity area.

5.03 Never open the secondary windings on the current transformers with the set running as high voltages are present. If it becomes necessary to disconnect the circuit, be sure it is deenergized and then short circuit the secondary transformer terminals after disconnecting the circuit leads.

5.04 Check for and remove shorting straps on the turbine control cabinet meters before starting the set. The straps electrically dampen the meter movements during shipment.

5.05 Disconnect the Rectifier by removing an ac input fuse from the rectifier before disconnecting the charge battery leads if this is found to be necessary.

5.06 After five successive starts wait about one hour before making another start. The starting motor will cool during this period and some charge will be given to the batteries.

5.07 DURING THE ASSEMBLY OF AIR INTAKE AND EXHAUST, MAKE CERTAIN THAT NO LOOSE ITEMS, DIRT OR DEBRIS ARE LEFT IN THE SYSTEM.

5.08 Before starting the turbine make certain that all tools and loose items are removed from the set.

5.09 The engine shall not be rotated in any manner for any purpose in a reverse direction.

5.10 The engine is shipped void of LUBRICATING OIL. Approximately 30 gallons of oil must be added before cranking or before attempting to start the engine for the first time. See Paragraphs 14.02, 14.03 and 23.

#### 6. SET POINTS

6.1 The following System Set Points are approximate and are listed for general information. When different or more precise values are referred to in this test method, the subsequent values shall be used.

Fail to crank timer(overload timer)15 sec

Fail to ignite timer(no light timer)35 sec

Fail to accelerate(overcrank timer)90 sec

Cool down timer 3 minutes

Warm up timer 8  $\pm$  1 sec

Run timer 25  $\pm$  2.5 minutes

|                                          |                      |
|------------------------------------------|----------------------|
| Holdover timer                           | 15 $\pm$ 1.5 minutes |
| Main fuel solenoid open                  | 10% speed            |
| Engine lightoff                          | 13 to 15% speed      |
| Reduce Speed setting                     | 58% speed            |
| Starter drop out (electrically)          | 70% speed            |
| Alternator excitation                    | 90% speed            |
| Overspeed shutdown                       | 108% speed           |
| Generator reverse power protection       | 150 KW $\pm$ 15 KW   |
| Impending high exhaust temperature (T7)  | 900 $\pm$ 10° F      |
| High exhaust temperature (T7) (shutdown) | 935 $\pm$ 10° F      |
| Impending high turbine temperature (T5)  | 1250° F              |
| Fail to start (T5)                       | 400 $\pm$ 12° F      |
| Temperature topping (T5) (limiting)      | 1330 $\pm$ 10° F     |
| High turbine temperature (T5) (shutdown) | 1390° F              |
| Oil temp shutdown                        | 179°F $\pm$ 1°       |

## 7. INSPECTION

- 7.1 As soon as possible after receiving the set on the job, remove the shipping materials and make a complete physical inspection. Inspect for damage, defects of finish, missing parts, etc. Note any damage on the driver's copy and job copy of the shipping papers, when possible to detect such damage, before signing for receipt of the set. Report defects, damage and missing parts in accordance with established routines.

## 8. PURPOSE

- 8.1 This KS unit is designed to furnish 60 hertz a.c. power service on an emergency basis to supply essential power circuits in a telephone office when the regular commercial power fails. Various options are available and may be furnished at the operating companies request. Depending on the commercial supply voltage to the office and the distance the set is away from the main switchboard, a choice of the following voltages may be furnished; 208V, 230/240V, 480V or 4160V from the generator through a transformer to supply various voltage requirements of the customer. The unit is rated at 750 KW BASE. This takes into account some elevation of air intake temperature above + 20°F and some restrictions in air intake and exhaust ducting as well as altitude. Its dual rating of 900KW PEAK is based on ideal conditions such as operation at sea level and at + 75°F or lower intake air temperature.

## 9. DESCRIPTION

- 9.1 Independent of ducting and attachments, the unit is rectangular in shape, rests on the floor on isolating pads and measures 5 feet wide, 6 foot 2 inches high and 16 foot 6 inches long. The unit weights 14, 425 pounds.
- 9.2 The engine is a 1200 horsepower "SATURN" gas turbine manufactured by Solar (Division of International Harvester), and drives a 1,000 KVA (nominal) 60 hertz 3Ø, 4 wire Alternator manufactured by the Electric Machinery Manufacturing Company. The control cabinet is built by Continental Controls. Solar assembles the package. The engine is located in the front of the cabinet away from the control panel. It operates on white kerosene, JP5, or Diesel 1 or 2 fuel. It starts with a 24V electric starter, lights off with an igniter plug at 13 to 15% speed and accelerates to its operating speed of 22,300 RPM within one minute. The engine shaft drives the Alternator at 1800 RPM through a two-stage planetary reduction gear box. The engine picks up air through the combustion air intake at the accessory drive end of the engine and compresses it to 6.5 to 1 through an 8 stage axial vane type compressor. The air is forced into the combustion chamber where it is mixed with fuel from the 9 nozzle locations and then ignited. The hot expanding gasses are forced through three stages of turbine blades fixed to the rotor and then pass into the exhaust manifold.
- 9.3 The package is completely enclosed with removable panels of sound deadening material.
- ## 10. BATTERY CHARGING RECTIFIER
- 10.1 The charger recommended is manufactured by La Marche. It is connected to both the 24V engine start battery and the 24V control battery with blocking diodes in the circuit to prevent interaction between the two batteries when their state of charge is not the same.
- 10.2 Verify the output taps and determine the voltage and polarity matches that of the batteries. Also verify the input requirements and the applied ac power before fusing and initial TURN ON.
- 10.3 Install the batteries and bring electrolyte level up to minimum level with approved water. Make all connections and verify for tightness. Completely connect and fuse the output before applying the ac power. Start the charge in accordance with Installation Engineering Handbook 18, Section 19 as soon as possible and record results on ID-1285 Battery Report. Once the charge is started it should not be removed or shut off as the testing procedures, static and dynamic, are demanding enough to necessitate a continuous recharge.

## 10.3 Cont'd

Usually, at the conclusion of the tests the batteries still require additional charge, furthermore, a small overcharge will cause no harm.

11. PARALLELING

11.1 When two sets are paralleled, one set must be in the MANUAL operation mode.

11.2 See Section 130 of this Handbook for paralleling procedures and Paragraph 19 in this section. Proper phase sequence is required along with correct voltage and simultaneous sine wave peaking of the two sources of power before paralleling can be accomplished. A phase sequence indicator, voltmeter and three synchronizing lights will be required.

11.3 See Para. 19.

12. PLACING THE UNIT

12.1 Furnished with the set are three isolating pads which are located between the structural base and the floor. The pads are of a two piece design. The isomode or upper portion of the pad is in place on the bottom of the set when shipped. The bottom portion, shipped loose and placed by the installer, is a vibration absorbing isolator pad.

12.2 The floor area designated for the set shall be checked to make sure it is level within 1/4" in 10'.

12.3 The floor should be laid out in agreement with the job drawing which corresponds with the outside dimensions of the set. As the rigger brings the set into its final location, the pads should be slipped in under the Isomodes. Verify dimensions. Two of the pads measure 10" x 10" and are placed near the front or generator end. The other pad measures 14" x 14" and is placed slightly past center toward the engine end.

12.4 The three pads may be placed directly on the concrete floor or on top of asphalt or vinyl tile covered concrete.

12.5 Since vibration is very low, no floor fastening is required in soft sites. Anchor bolts are required (two per pad) for fastening the unit to the floor in Earthquake Areas.

12.6 Hardened areas such as in 50 PSI sites or Disaster Control buildings, will require special retaining and/or hold-down arrangements. The material and instructions will be provided by the line or equipment engineer.

13. STATIC TESTING13.1 General

13.11 The beginning of these tests assumes the OSS (Operation Selector Switch) is in the OFF position and all circuit breakers are OFF. After each test, turning off the OSS and CB-1 to CB-18 (Circuit Breakers 1 to 18), and, before the next test, turning ON the OSS and the CB's has been or can be eliminated in some instances to save time and unnecessary exercising the apparatus. To reset the alarm circuit, however, it is necessary to turn the OSS to OFF and then back to the same "on" position. The CB's (breakers) are sometimes referred to as CSCB (Control System Circuit Breaker). When it is necessary to stop testing for a period of time, it should be remembered to turn the OSS to OFF on both the local and remote cabinets and all CB's to OFF, restoring them before continuing the next test.

13.12 The beginning of these test also assumes all wiring is complete and verified including the remote cabinet, when provided. Make sure all circuit modules are installed and fully seated as they provide an interlock to the POWER-UP BUS.

13.13 Throughout the test, when the audible alarm is activated, under System Status, operate the ALARM SILENCED Press to Silence pushbutton as necessary to quiet the alarms. Turning the OSS to OFF and back on will reset the alarm circuit after the trouble has been cleared.

13.14 For static testing, inhibit starting as follows; Disconnect Starter Contactor K530 from power by removing lead SC-X2 from TB3 (Terminal Board 3) Term 19 (Terminal 19). This prevents battery from K15 Starter Relay from operating the Starter Contactor and Starter Motor.

13.2 Cranking Failure

13.21 The Crank Failure light appears on the Malfunction Monitor and can be actuated by any one of three conditions. The three triggering devices are shown on the Engine Sequence Module as OLT (Over Load Timer), OCT (Over Crank Timer) and NLT (No Light Timer or No Lightoff Timer).



- 13.22 Turn OSS to OFF and CB's 15,16 and 17 to OFF.
- 13.23 The OL condition exists if the engine fails to reach 5 to 10% speed in 15 seconds. As necessary, operate ALARM SILENCE Press to Silence to light lamp and inhibit or silence horn.
- 13.231 Remove, tag and tape Magnetic Pickup No.1 leads from TB3 Terms 13 and 14. Make sure the mag pickup leads are lifted and not the internal wiring to the circuit packs.
- 13.24 Connect the output of the ITE-5518 Oscillator between TB3 Terms 13 and 14 using the clip lead adapter.
- 13.25 NOTE: The Oscillator requires no patch cords to the ITE-5520 Digital Voltmeter or to the ITE-5519 Frequency Counter as they are internally connected. Be sure to operate the switches on the Test Sets to "Internal". The Digital Voltmeter reads the voltage output of The Oscillator and the Frequency Counter reads much more accurately, the frequency output of the Oscillator than can be read on the oscillator dial.
- 13.26 Turn the oscillator to 500 Hz. Set the output to approximately 3 volts as read on the digital multimeter. Operate CB15 to CB17 to ON and operate the OSS to MANUAL.
- 13.27 Depress the STARTING SEQUENCE Press for Manual Start pushbutton and the OL timer should time out in approximately 15 seconds at which time the OVERCRANK TIMER lamp and OVERLOAD TIMER lamp lights on the Engine Sequence module. The CRANK FAILURE lamp lights on the Malfunction Monitor module in approximately 5 to 15 seconds. The ENGINE FAILURE lamp lights on the remote cabinet. The Major Alarm sounds.
- 13.271 If the engine had been running instead of this simulated test this crank failure would have aborted the start.
- 13.272 Clear the alarm by turning OSS to OFF and back to MANUAL. The READY TO START lamps on both the local and remote cabinets should light.
- 13.28 The OCT condition exists if the engine does not reach 70% speed (starter power shut-off) before the overcrank timer times out in approximately 90 seconds.
- 13.281 Set the oscillator to 6,900 Hz at a level of 3 volts and turn off Test Package Power Supply Switch.
- 13.282 Depress the STARTING SEQUENCE pushbutton and immediately turn on Test Package Power Supply Switch. The OVERCRANK TIMER lamp should light immediately and the CRANK FAILURE lamp should light before an elapsed time of 100 seconds. Ignore other lamps at this time. The Major alarm should sound. Operate the OSS to OFF. Turn OFF oscillator and turn OFF CB's 15, 16 and 17. Disconnect oscillator and reconnect leads from Magnetic Pickup No. 1 to TB3 unless it is desired to complete the Overspeed Tests in Paragraph 13.5 next.
- 13.29 The NLT condition exists if the engine exhaust temperature fails to reach 400°F in 25 seconds.
- 13.291 Disconnect and tag the thermocoupler T5 from TB3 Term 10 and 11. Make sure thermocouple leads are disconnected and note internal wiring to the circuit pack modules.
- 13.292 Connect ITE-5521 Temperature Simulator to TB3 Term 10 and 11  
Term 10=RED=ALUMEL=-  
Term 11=YELLOW=CHROMEL=+  
and set simulator to 350°F.
- 13.293 Turn on CB's 15, 16 and 17 and plug simulator in to 115V ac with the cheater cord furnished.
- 13.294 Operate the OSS to MANUAL and depress the STARTING SEQUENCE pushbutton and hold momentarily. The NO LITE TIMER lamp should light immediately on the Engine Sequence module. The CRANK FAILURE lamp should light within 39 seconds. The Major Alarm should sound.
- 13.295 Operate the OSS to OFF, CB's 15,16 and 17 to OFF and disconnect the 115V ac to the simulator.
- 13.296 Disconnect the simulator from TB3 and reconnect the T5 Thermocouple leads observing the correct polarity.
- 13.3 High Exhaust Temperature
- 13.31 These tests simulate Pending Hight Exhaust Temperature and High Exhaust Temperature.
- 13.32 Disconnect thermocouples T7 from TB4 Terms 12 and 13 and tag. Make sure the thermocouple leads are disconnected and not internal wiring.
- 13.33 Connect the ITE-5521 Temperature Simulator to TB4 Terms 12 and 13.  
Term 13=RED=ALUMEL= -  
Term 12=YELLOW=CHROMEL= +
- 13.34 Set the Temperature Simulator to 400°F and plug the simulator in to 115V ac.

- 13.35 Turn on CB's 15,16 and 17 and operate the OSS to MANUAL.
- 13.36 Increase the temperature setting on the simulator to determine the PEND OVER TEMP lamp No. 2 on the Temperature Monitor lights between 904°F and 916°F. The PENDING HI EXH TEMP lamp lights on the Malfunction Monitor and the PENDING OVER TEMP lamp lights on the remote cabinet.
- 13.37 Continue to increase the temperature setting on the simulator until a value of 920°F to 941°F is reached. The OVER TEMP lamp No. 2 will light on the Temperature Monitor, the HI EXHAUST TEMPERATURE lamp will light on the Malfunction Monitor and the OVER TEMP lamp will light on the remote cabinet.
- 13.38 Operate OSS to OFF and CB's 15, 16 and 17 to OFF.
- 13.39 Disconnect the temperature simulator line cord and the leads from TB4 and reconnect the T7 thermocouple leads observing the proper polarity.
- 13.4 High Lubricating Oil Temperature
- 13.41 On TB3, connect a jumper between Terms 6 and 7.
- 13.42 Turn ON CB's 15,16 and 17 and operate OSS to MANUAL.
- 13.43 Observe that the HIGH OIL TEMPERATURE lamp lights on the malfunction monitor and that the ENGINE FAILURE lamp lights on the remote control panel. The Major alarm will sound.
- 13.44 Turn OSS to OFF and open CB's 15,16 and 17. Disconnect jumper from TB3 Terms 6 and 7.
- 13.5 Overspeed
- 13.501 Again disconnect Magnetic Pickup No. 1 from TB3 Terms 13 and 14 and tag. Do not disturb the internal wiring to the control cabinet.
- 13.502 Connect the oscillator across Terms 13 and 14 and adjust to 10,000 Hz at approximately 3 volts.
- 13.503 Disconnect the lead to the oil pressure switch from Term 9 on TB3.
- 13.504 Turn ON CB's 15,16 and 17 and operate the OSS to MANUAL.
- 13.505 Adjust the oscillator to 11,520 Hz. This should correspond very nearly to 100% speed as indicated on the Speed Meter.
- 13.506 Increase the frequency of the oscillator slowly from 12,096 Hz to 12,787 Hz and observe that the ENGINE OVERSPEED lamp lights.
- 13.507 The Major Alarm will sound.
- 13.508 The 108% lamp lights on the Speed Monitor and the ENGINE FAILURE lamp lights on the remote control panel.
- 13.509 Turn OSS to OFF and disconnect the oscillator after turning it off. Exercise care since the terminal strips still have power applied. This test simulates an open mag pickup probe.
- 13.510 Turn OSS to MANUAL and observe that the ENGINE OVERSPEED lamp lights.
- 13.511 Turn OSS to OFF and CB's 15,16 and 17 to OFF.
- 13.512 Reconnect Magnetic Pickup No. 1 to TB3 observing proper polarity.
- 13.513 Reconnect oil pressure lead to Term 9 on TB3.
14. PREPARATION FOR INITIAL START
- 14.01 After approximately 10 engine starts, remember to drain the fuel oil accumulator tank. When the pressure on the fuel line drops down in the range of 160 to 100 PSIG the purge valve opens and combustion chamber air pressure forces fuel from the nozzles and lines, through the valve and into the accumulator tank.
- 14.02 Drain lube oil residue and close drain plug or cap on line from oil reservoir tank.
- 14.03 The dip stick is marked "30 GAL FULL". Add approved oil until oil reaches full mark. Do not add 30 gallons as experience has shown this to be excessive. After the set has been run at the job site for the first time and then shut down, add oil as necessary to keep level at the full mark. Record type, quantity and date on ID-1275.
- 14.04 Test associated systems for proper operation such as the Auxiliary Room Ventilating Circuit.
- 14.05 Verify with an ITE-4442A, ITE-5520 or equivalent that the Emergency Buss is dead. Then determine with an ohmmeter, the absence of continuity between the busses and from the busses to neutral or ground.

- 14.06 Connect the ITE-4782 or ITE-4785 Test Leads. Refer to TMO-4782 or TMO-4785 in Handbook 100 for connecting and operating information. The temporary loads may be connected to the output side of the ACB (Alternator Circuit Breaker) or to the Emergency Bus. Loads should be set at zero.
- NOTE:** Since the engine cubicle will have to be closed during these operational tests, the load leads should be run in such a manner so as not to interfere with any mechanically operating or rotating parts. This can best be accomplished by properly dressing the leads and running them under the base of the set.
- 14.07 Verify the following:
- 14.0701 All output leads from the alternator are properly tightened, no interference or points of potential chafing. Redress when possible or provide a minimum of two layers of Sheet Fiber and secure with sewing twine.
- 14.0702 Control leads and other customer connections secure.
- 14.0703 Batteries are fully charged and polarities correct.
- 14.0704 Lubricating system drain valve closed and lube oil at proper level. Condensate drain valve in exhaust system closed if provided.
- 14.0705 Fuel line connections tight.
- 14.0706 Day Tank clean.
- 14.0707 Verify with the operating company that the fuel meets Bell System requirements for this set.
- 14.0708 All inlet and exhaust ducting secure and cleaned. This is a very important operation and check as dirt or debris drawn into the air intake is the greatest hazard to seriously damaging the turbine engine.
- 14.0709 Room sufficiently ventilated.
- 14.0710 Shipping covers removed from engine inlet and exhaust duct.
- 14.0711 Engine exhaust duct properly supported.
- 14.0712 Internal area around control panels (local and remote), engine and alternator clean.
- 14.0713 Wiring of boost pump, fuel shut off and control valves, ignition exciter, magnetic pickups No. 1 & No. 2, temperature sensors T1, T5 & T7, low oil pressure switch and temperature switch, starter mounting bolts tight and insulating blankets on the compressor and the exhaust system in place and secured.
- 14.0714 Air intake screen over compressor intake in place, clean, secure and free of any obstructions. This air intake area behind the engine door handles large volumes of air and experiences high turbulence which will pickup any dirt or debris present which may cause serious engine damage. See Paragraph 14.0708.
- 14.08 Disconnect and tag the external leads CB9 on TB22 Term 14 and TR15 on TB22 Term 15. These are the control leads that operate the NCB Normal Circuit Breaker (commercial power).
- 14.09 Disconnect and tag the external leads LB6 on TB22 Term 16 and TR16 on TB22 Term 17. These are the control leads for the ECB Emergency Circuit Breaker.
- 14.10 For single set operation, operate Cross Current Compensator switch on Voltage Regulator to OUT. Verify that contacts are closed with an ohmmeter. JUT=Closed and IN=Open. In the absence of this switch on some sets, make sure that a strap is in place between TB2 Term 7 and TB2 Term 8. For parallel operation, see Paragraph 19.
- 14.11 Reconnect starter control lead TB3 Term 19. See Paragraph 13.14.
- 14.12 Place local and remote cabinet OSS in OFF. Operate REMOTE/LOCAL "Press to select" to LOCAL. Operate the TRANS SEL AUTO/MANUAL "press to select" switch to the MANUAL mode at the local or remote cabinet when provided. Close all CB's or CCB's control circuit breakers, 1 to 18.
- 14.121 SWITCH OFF NORMAL LAMP should light.
- 14.13 Set REDUCED SPEED SWITCH to NORMAL.
- 15. BLEEDING FUEL SYSTEM**
- 15.1 To ensure proper operation of the turbine the fuel system must be primed to fill the day tank, filters and lines and the system must be free of air.
- 15.2 The low-pressure fuel filter is a circular container located just below the starting motor. Loosen the vent cap to provide an air bleed. Circle (not cover) vent with a rag to collect vented fuel. Hold PURGE/PRIME Switch S1 down in the PRIME position and the boost pump will start. When filter is full and all air is exhausted, close vent cap and then release switch to center OFF position.
- 15.3 Remove the dust seal or cap from the end of the FUEL PURGE valve connected to the output side of the high pressure fuel filter and located adjacent to the low pressure fuel filter. Furnished with each set is a short length of hose with a quick-connect coupler on one end. Attach this to the FUEL PURGE valve.

## 15.3 Cont'd

Place a suitable container under the free end of the hose. Open the valve (usually accomplished by turning the handle 90°).

15.31 Turn OSS to MANUAL. Hold PURGE/PRIME Switch S1 up in the FUEL PURGE position. The engine cranks and the fuel boost pump operates. Allow the engine to crank until fuel flows steadily and without bubbles into the container. Close valve and then release PURGE/PRIME Switch S1 to center OFF position. Disconnect hose and replace dust cap.

15.4 See Figure 2. Place rags around the Fuel Control Differential Pressure Valve. Remove Bleed Screw from the top of the assembly taking care not to damage the "O" ring. Hold PURGE/PRIME Switch S1 to PURGE. Again the engine will crank and the boost pump will operate. Allow the system to bleed until completely free of bubbles. Replace bleed screw taking care not to damage "O" ring and release PURGE/PRIME Switch S1 to center OFF position. Clean up any spilled fuel.

15.5 Turn OSS to OFF.

16. READY TO START CONDITIONS  
(ENGINE SEQUENCE MODULE)

16.1 The engine sequence module contains logic to start, sequence and shut down the engine. It contains five electronic timers; WUT Warm Up Timer, CDT Cool Down Timer, OLT Overload Timer, NLT No Lite Timer and OCT Over Crank Timer. For the READY TO START lamps to be lit at the local and remote locations, all of the following ready to start logic must be true and the following conditions must be met;

1. OSS in any position except OFF.
2. CB's Circuit Breakers closed (CSCB Control System Circuit Breakers).
3. ACB Alternator Circuit Breaker has not been tripped. See Par. 18.17.
4. Inlet shutter and exhaust vents are open.
5. Major Alarm (shutdown condition) does not exist.
6. Blast Shutdown signal is not present.
7. PURGE/CRANK switch is in OFF position.
8. Engine speed is less than 5%.

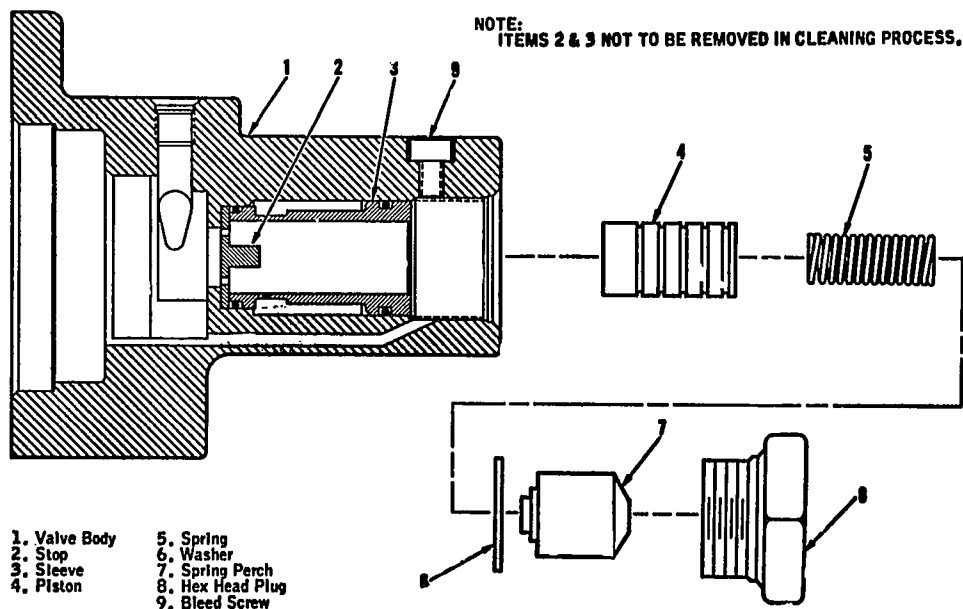


Figure 2. Fuel Control Differential Pressure Valve Assembly  
PAR. 15.4

## 17. EMERGENCY STOP SWITCHES

17.1 The EMERGENCY STOP pushbutton are located on the left side of the engine control cabinet, on the remote cabinet when furnished and just inside of the doors to the power room and/or emergency engine alternator room.

17.2 The test consists of operating each switch at least once to determine it is functioning properly and will always shut the set down. This test can be performed any time during the testing procedure when it is desired to stop the set and the set is not automatically stopped because of testing of a major malfunction.

## 18. STARTING AND DYNAMIC TESTING

### 18.1 General

18.11 WARNING: R-4296 Ear Protector must be worn during operation of the set.

18.12 NOTE: This first start should be made at the turbine. When a Remote Control Cabinet is furnished and if two men are available, station one man at the turbine and one at the remote cabinet. Allow the operator at the turbine to make the initial start. At this start, or on any start, the operator should be ready to shut down the turbine with the EMERGENCY STOP button if one of the following malfunctions occur and the engine does not shutdown automatically:

18.13 MISFIRE: This is caused by the fuel igniter failing to ignite the fuel. Engine does not accelerate beyond about 20% speed and exhaust temperature does not rise. In this case the NLT would normally shut down the turbine.

18.14 SURGE: Caused by momentary malfunction of fuel or air supply systems. At low speed the engine may fail to accelerate but exhaust temperature may rise, accompanied by a sudden high-pitched pulsating sound. At higher speeds a surge may cause the engine to fail to reach rated speed accompanied by a loud roar and/or popping noises.

18.15 Observe instruments and indicator lamps carefully during the initial run. Depress the EMERGENCY STOP switch and/or turn the OSS to OFF to stop the turbine should a malfunction occur that fails to automatically stop the set.

18.16 When instructions throughout the section refer to their performance from the remote cabinet and no remote cabinet was furnished then all controls will be found on the turbine control cabinet.

18.17 The alternator circuit breaker has three positions; closed, normal open and tripped open. The set will not start if the breaker has been tripped open. It must be in the normal open position. If it was previously tripped it must be manually reset.

18.18 Verify that the proper amount of lubricating oil is in the "reservoir" tank. See Paragraph 14.03.

18.19 The events following occur in a rather rapid sequence so it is suggested the remaining information in this main paragraph be read and reviewed before starting the set. When all of the lamps can not be observed by those present, small pieces of masking tape can be placed adjacent to the lamps that should come on, or, additional starts may be necessary to make the verifications called for.

### 18.2 Starting Operation Sequence

18.201 On the turbine control, operate the OSS to MANUAL.

18.2011 SDT begins to time out if actual or simulated commercial power failure exists and the COML POWER FAILURE lamp lights.

18.2012 READY TO START lamp lights.

18.202 Operate the STARTING SEQUENCE "Press for manual start" switch, and observe the lamp lights.

18.2021 The OLT, NLT and OCT timers begin to time out.

18.2022 Starter relay K15 is energized and the engine begins to turn over. ENGINE CRANKING lamp lights.

18.2023 ACCEL SCHEDULE lamp lights on the fuel control module.

18.203 Engine attains 10% speed deenergizing OLT before it times out. Observe 10% lamp is lit on the speed monitor module.

NOTE: If engine fails to reach 10% speed before OLT times out the crank failure term generated in the engine sequence module will abort engine start. A logic signal is sent to the malfunction monitor module illuminating CRANK FAILURE light, ALARM CONDITION light on local and remote panels and ENGINE FAILURE light on the remote control panel.

18.204 READY TO START lamp is extinguished, Ignition relay K2 and fuel valve relay K1 are energized, MAIN FUEL VALVE OPEN and IGNITION lamps on the engine sequence module light. The fuel will ignite and the engine lights off. The exhaust gas temperature reaches 400°F deenergizing NLT before it times out. The LITE OFF lamp lights on the temperature monitor module.

NOTE: If exhaust gas temperature fails to reach 400°F before NLT times out the crank fail term generated in the engine sequence module will abort the engine start. CRANK FAILURE lamp lights, ALARM CONDITION lamp lights on the local and remote panels and the ENGINE FAILURE lamp lights on the remote panel.

18.205 Observe that the oil pressure reaches 25 PSI as engine continues to accelerate. 50% light illuminates on the speed monitor module.

NOTE: If engine attains 50% speed before oil pressure builds up to 25 PSI, the low oil pressure term in the malfunction monitor module will abort the engine start. LOW OIL PRESSURE lamp lights, ALARM CONDITION lamp on local and remote panels light and the ENGINE FAILURE lamp lights.

18.206 Observe that the engine attains starter-power drop out speed of 70% deenergizing the OCT before it times out.

NOTE: If the engine fails to reach starter power drop out speed before the OCT times out the crank failure term generated in the engine sequence module will abort the engine start. The CRANK FAILURE lamp lights, the ALARM CONDITION lamp on the local and remote panels light and the ENGINE FAILURE lamp lights on the remote panel.

18.207 Observe that the RUNNING lamp is lit and that the STARTING SEQUENCE lamp, ENGINE CRANKING and IGNITION lamps are extinguished.

18.208 Observe that the engine continues to accelerate to 90% speed and that the 90% lamp lights.

NOTE: Assuming commercial power is present and the RUN TIMER switch is ON, time out of the RT will cancel the remote routine term, if present, and start the HOT (hold over timer).

18.209 When HOT times out the READY TO RESTORE lamp lights. Also the WUT (warm up timer) begins to time out. When this has occurred, assuming alternator power is present, and the ACB is open, the READY TO LOAD lamp will light.

18.210 Observe that the ALT FIELD ENERGIZED lamp lights as the field is automatically flashed, that the ALTERNATOR POTENTIAL lamp lights and the SYNC CHECK is extinguished on the synchronizer module, when furnished.

18.211 Observe that the engine reaches 100% speed as indicated by the 100% lamp, and that it governs at that speed. The GOVERNOR lamp will light on the fuel control module.

18.212 Verify that the FREQUENCY ADJUST controls on both the local and remote panels can be altered to control the frequency (speed) and can be set at 60 hertz.

18.213 Verify that the VOLTAGE ADJUST controls on both the local and remote panels can be altered to control the voltage up and down from the nominal value.

NOTE: When a remote cabinet is furnished the frequency meter and volt meter are not duplicated at the engine control location and the results of changing the potentiometers at the engine will have to be noted at the meters on the remote cabinet.

18.214 Observe that the exhaust temperature increases steadily to about 480 to 600°F. Many variables, some depending on the actual job site, will determine the final unloaded temperature so a precise value cannot be predetermined.

18.215 Adjust alternator voltage with the VOLTAGE ADJUST potentiometer to normal value (same voltage as read on the commercial bus with the voltmeter switch).

18.216 Set the correct no-load speed by adjusting the FREQUENCY ADJUST potentiometer. Depending on whether the operating company wants the engine speed set at isochronous or droop determines the speed (frequency). Set the % DROOP ADJUST on the fuel control module. In the Isochronous mode the speed should equate to 60 hertz (turbine speed 22,297 RPM) and in 4% Droop mode the speed should equate to 62.4 hertz (turbine speed 23,189 RPM).

- 18.217 Readjust the alternator voltage to the normal value.
- 18.218 Verify the absence of potential on the Emergency Bus. Absence of continuity checks were previously made in Paragraph 14.05. DEAD EMERGENCY BUS lamp should be lit on the alternator instrumentation module.
- 18.219 Press ALT CB IS CLOSED Press to Close and observe that the alternator circuit breaker closes and the EMERGENCY BUS ENERGIZED lamp lights.
- 18.220 With alternator voltage available check phase sequence of the alternator voltage at the emergency bus with R-3404 Phase Sequence Indicator. See Figure 1. Refer to Section 135 in this handbook for method. 1-2-3 is required. Tag buses.

**CAUTION:** For 4160 volt sets make this test on the low-voltage side of the step-down transformer.

- 18.221 Check the set over carefully for fuel and lube oil leaks.
- 18.222 See Paragraph 18.3.
- 18.223 Go to Paragraph 18.3 before continuing.

- 18.224 After a short run at no load, operate the EMERGENCY STOP switch on the remote cabinet, when furnished, to shut the turbine down. When not provided, operate EMERGENCY STOP switch on the set. See Paragraph 17. Should either fail to stop engine, operate CB15 and CB16 to OFF and clear the trouble.

- 18.225 Turn OSS to OFF.

### 18.3 Proper Operation

- 18.31 When set is functioning properly module lights are all green when load has been on and then removed. Otherwise, all eleven green lamps are lit except READY TO RESTORE.

#### ALTERNATOR SEQUENCE MODULE

(1) READY TO RESTORE

#### SPEED MONITOR MODULE

(2) 10%

(3) 50%

(4) 70%

(5) 90%

#### ENGINE SEQUENCE MODULE

(6) ALT FIELD ENERGIZED

(7) RUNNING

(8) MAIN FUEL VALVE OPEN

#### TEMPERATURE MONITOR MODULE

(9) LITE OFF

#### MALFUNCTION MONITOR MODULE

(all lamps off)

#### FUEL CONTROL MODULE

(10) GOVERNOR

#### AUTOMATIC SYNCHRONIZER MODULE

(not used)

#### ALTERNATOR INSTRUMENTATION MODULE

(11) ALTERNATOR POTENTIAL DEAD EMERGENCY BUS (AMBER LAMP)

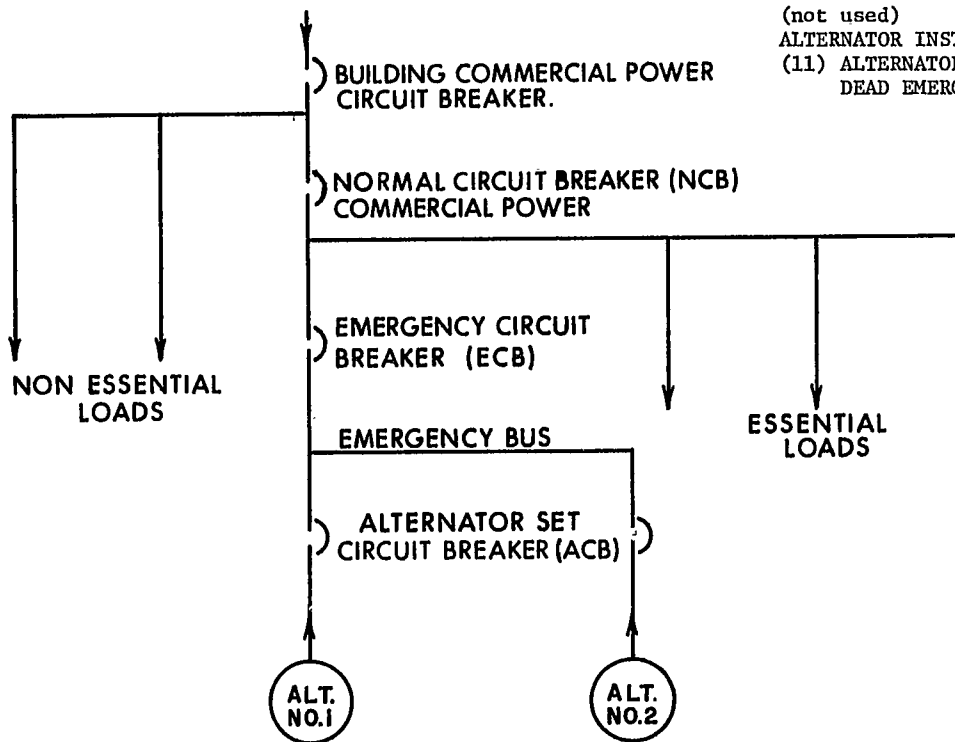


Figure 1

Typical Operating Company Breaker and Bus Arrangement. Par. 19.52

- 18.32 On the left side of the control panel the green REMOTE and green READY TO LOAD lamps will be lit.
- 18.33 When the set is not functioning properly one or more of the Malfunction Monitor lights will come on. To simulate all malfunctions on all alarm channels, Minor and Major, as well as determining that all lamps are operational, perform the following test;
- 18.331 Whether set is running or not, as necessary turn on CB's 15,16 and 17 and turn OSS to MANUAL. Depress ALARM CONDITION Press to Test Alarm and observe that all 13 Malfunction Monitor lamps light. When the pushbutton is released all circuits are cleared and all lamps are extinguished provided no actual malfunction exists.
- 18.34 Refer back to Paragraph 18.223 where test was momentarily suspended.
- 18.4 Low Oil Pressure
- 18.41 In normal operation, if the engine reaches 50% speed before the lubricating oil builds up to 25 PSIG, the LOW OIL PRESSURE lamp will light and the malfunction monitor will abort the engine start.
- 18.42 Connect a jumper across TB3 Term's 8 and 9 (low oil pressure switch contacts).
- 18.43 Operate the OSS to MANUAL on the remote cabinet. On the set, operate the REMOTE LOCAL Press to Select switch to REMOTE and on the remote cabinet to LOCAL.
- 18.44 On the remote cabinet, start the set by operating the STARTING SEQUENCE Press For Manual Start switch.
- 18.45 The set will start and attain partial speed (approximately 50%) and shut down and the ENGINE FAILURE lamp will light. On the Malfunction Monitor, the LOW OIL PRESSURE lamp lights. Observe the Major alarm sounds and after the set comes to rest, turn the remote OSS to OFF which will clear the alarm. Remove the jumper across TB3 Term's 8 and 9.
- 18.5 Overcurrent and Short Circuit
- 18.51 A meaningful simulated overcurrent or short circuit test cannot be readily performed. An actual overcurrent or short circuit test should not be performed on this set.
- 18.511 Such a test would subject the set to undesirable and unnecessary electrical stresses and mechanical shock. The ACB has already been adjusted and tested at the factory in the presence of, and in accordance with, the W.E. Source Inspection people. The short term and long term trip data on the ACB is available at the factory and can be traced by serial numbers should this ever be required.
- 18.6 Reverse Power Test
- 150 KW of artificial load is required for this test.
- NOTE: This set is provided with a Reverse Power Test Switch located on the front of the Alternator Instrumentation Module.
- 18.61 Operate the OSS on the remote cabinet to MANUAL.
- 18.62 Depress the START SEQUENCE pushbutton. Observe that the turbine starts, accelerates and comes up to speed.
- 18.63 With the READY TO LOAD lamp lighted close the ALT CB IS CLOSED Press to close and apply 55-60 KW of artificial load.
- 18.64 On the engine, operate and hold the REVERSE POWER TEST Switch. The set continues to operate with no shutdown or malfunction indication.
- 18.65 Increase the artificial load to 150 KW.
- 18.66 The engine shuts down and the following indications should be noted:
- 18.661 REVERSE POWER lamp lights.
- 18.662 ENGINE FAILURE lamp lights on the remote panel.
- 18.663 ALARM CONDITION lamp lights.
- 18.664 ACB Circuit Breaker trips.
- 18.67 Release REVERSE POWER TEST switch. Manually reset the ACB.
- 18.68 Operate the OSS on the remote cabinet to OFF.
- 18.69 Operate load switches on the artificial load to OFF.
- 18.7 Overvoltage



- 18.71 If the set is equipped with a remote panel the voltmeter will be located on it, otherwise, it will be on the engine. The following start-up should be performed where the voltmeter is located.
- 18.72 Operate the appropriate REMOTE/LOCAL Press to Select switches.
- 18.73 Connect the ITE-5520 Digital Multimeter (500V range and internal function switch released) across TBI Terms 1 and 2.
- 18.74 Start up the engine by depressing the STARTING SEQUENCE pushbutton.
- 18.75 Mark the setting of the VAR potentiometer on the voltage regulator and loosen the locking nut.
- 18.76 Adjust the VOLTAGE ADJUST potentiometer on front of the engine control or the VOLTAGE ADJUST switch on the remote cabinet to the nominal value desired.
- 18.77 Note this value and increase the voltage slowly with the VAR potentiometer until the engine shuts down (approximately 120 % of the nominal value).
- NOTE: For the 416-480V sets the voltage readings at TBI-1 and TBI-2 will be in the range of 173-200 volts due to the potential transformers in the line which are rated at 2.4:1.
- 18.78 Operate the OSS to OFF and remove the ITE-5520 from terminals TBI-1 and TBI-2.
- 18.79 Vary the VAR potentiometer to original position and tighten the locking device.
- 18.8 Fuel System Malfunction
- 18.81 A distinct test is not included for the fuel system since its proper operation is demonstrated by the running of the set during other tests. Its proper operation is reflected in
- (1) the lack of a malfunction lamp FUEL SYSTEM MALFUNCTION. (the operation of the lamp is tested elsewhere).
  - (2) a smooth acceleration to 100% speed (response of the fuel control valve to the fuel command signal from the fuel control module).
  - (3) the absence of a buffeting sound or fluttering air sound or surging at or near operating speed.
  - (4) its ability to carry full load under the paragraph on Full Load Test.
- 18.9 Fail Safe Controls
- 18.91 Place OSS in AUTO LOAD TEST.

- 18.92 With Engine running, open CB-16 and observe that engine stops. After set comes to a complete stop, close CB-16.
- 18.93 With engine running, open CB-15 and observe that engine stops. After set comes to a complete stop, close CB-15.

## 19. CROSS CURRENT COMPENSATION - DROOP

- 19.1 The voltage regulator and cross current compensator provide for a voltage droop of from 1 to 5% so this set can be paralleled with other sets. A potentiometer marked REACTIVE CURRENT COMPENSATION on the voltage regulator may be adjusted for isochronous operation (usually single set operation) or it may be turned in the direction shown as INCREASE to effect a 0 to 5% voltage droop for parallel operation. Both sets should be in droop for parallel operation. See Par. 11.
- 19.2 Current transformers on phase 2 of each automatic set run in parallel, CT4, has their secondary windings in series. The output of each transformer feeds a sensing signal into its voltage regulator but when the set is not running the output is automatically shorted (shunted through) through the A set of contacts on the ACB relay K301-2.
- 19.3 The series interconnections between two sets are shown on SD-82354-01-B14 Figure 20 and identified as TB2 Terms 7 and 8. Three set interconnections are shown on Fig 21, sheet B15. For single set operation, these two terminals must be shorted with a strap unless provided with a Cross Current Compensator switch which accomplishes the same function. See Paragraph 14.10.

## 20. FULL-LOAD TEST

- 20.1 Time: Make a Preliminary Full-Load Test of one hour duration before a Final Acceptance Test. The Final Acceptance Test is 2-1/2 hours in length, and a customer's representative must witness the test. Two hours of the Final Acceptance Test will be at full-load and the last half-hour should be at the usual office load, or at full-load, or a combination of the two.
- 20.2 Parallel: If the set will be paralleled an additional Acceptance Test, in parallel, will be required, in accordance with Section 130 in this handbook.
- 20.3 Records: Record the results of tests on the forms listed in Paragraph 1.8.

20.4 Exhaust Back Pressure and Inlet Vacuum (Restriction):

20.41 Whether the Operating Company accepts responsibility for, W. E. accepts responsibility for, or, W.E. subcontracts the exhaust and inlet duct work, it should be installed per ED-82118-30. The drawing shows air flow attachments to the ducts for use in taking pressure and vacuum (restriction) readings with R-3076 Manometers. Be sure these attachments in the ducts are not blocked or otherwise covered when the ducts are lagged (insulated).

20.42 If the attachments are not furnished, this omission shall be called to the attention of the operating company. The inlet air vacuum (restriction) and exhaust air pressure is a function of duct design and has been calculated by the line or equipment engineer on a job basis to meet requirements.

20.43 Drilling, tapping and fitting the air intake is an involved procedure and shall not be undertaken by the installer unless specifically requested. If requested on a job basis, the metal particles from the drill and tap must be collected and contained on the inside of the duct and the duct carefully vacuumed after the fittings have been attached. Failure to remove all particles can cause the engine irreparable damage.

20.44 When the attachments are furnished, attach the water manometers and adjust the liquid in each in line with the zero reading. Since the other end of the manometer is open to the atmosphere, be sure there is free air pressure exchange between the turbine room and the outdoors, otherwise, the readings taken during the full load test will be in error.

20.5 Normal (Commercial power) and Emergency Circuit Breakers:

20.51 Job conditions dictate the breaker arrangement for each office. The operating company will determine the options as to whether certain breakers are manually or automatically controlled.

20.52 Reconnect breaker leads disconnected in Paragraph 14.08 and 14.09 as required for Automatic operation and test for proper operation and interlock. See SD-81489-01 listed in Paragraph 1.4 and refer to the job block schematic drawing. A typical circuit breaker arrangement is shown in Figure 1, however, a wide variety of arrangements are possible.

20.6 Preliminary Operations:

20.61 Operate the ITE-5520 Digital Multimeter to EXTERNAL and connect to TB102 Terms 3 and 15 (CB's 14 and 18 closed) to read the alternator output voltage (500V ac range)

NOTE: These readings across phases 1 and 3 are to be taken only on the 208V, 230/240V and 480V sets. They will not be taken on the 4160 volt set.

20.62 Be sure all side covers are in place and secure.

20.63 Start any manually operated Auxiliary Room Ventilating Fans, etc. Open doors to provide ventilation if this will be the normal method of ventilating the room.

20.7 Preliminary Full Load Tests

20.71 Turn OSS to MANUAL and start the set.

20.72 When the READY TO LOAD lamp appears, close the ACB.

20.73 Add about 750 KW of load.

20.74 Take a set of readings at full-load, which includes Time, Frequency, Volts, Amperes, KW, Power Factor, Inlet Restrictions (inches of water), Exhaust Back Pressure (inches of water), Exhaust Temperature, Ambient Temperature at the turbine, and external Voltmeter readings.

20.75 Take readings every 30 minutes until the set has run one hour at full-load.

20.76 With the ACB closed, check for correct voltage and phase sequence of alternator at the Emergency Breaker in the Remote Breaker Circuit.

NOTE: Refer to Section 135 in this handbook for information on "phasing-out" at transfer switch circuits. Whichever voltage (commercial voltage or alternator voltage) is connected first will be the reference for phase sequence, and the other source voltage must be "phased-out" to match this sequence. At this point, alternator voltage will appear on one side of the emergency breaker from the emergency bus and commercial power to the essential load on the other side.

20.77 Reduce the load to 100 KW and press the SHUTDOWN SEQUENCE push button.

21. POWER FAILURE TEST - AUTO

- 21.1 Turn the OSS to AUTO and operate CB 3 to off simulating a commercial power failure.
- 21.2 After a series of delays (timers) the set should start up and assume the load on the emergency bus.
- 21.3 Operate CB 3 to ON and in time the set should shut down.
- 21.4 Turn the OSS to OFF and remove load.

22. FINAL ACCEPTANCE TEST

- 22.1 In the presence of the operating company acceptance person, perform the Final Acceptance Test.
- 22.2 Turn OSS to MANUAL. Start the set and adjust speed and voltage as necessary.
- 22.3 Close the ACB and add artificial load until the set is loaded to full-load.
- 22.4 Take a set of test readings at full-load. Then take readings every 30 minutes until the set has run two hours at full-load.
- 22.5 After two hours at full-load reduce load to the value of load normally carried by the set, or, continue at full-load. Take another set of readings if load is reduced from full-load.
- 22.6 After 30 minutes at the normal load value (or at full-load) take a set of readings. Then decrease artificial load to zero. Open the ACB.
- 22.7 Allow the set to run about 3 minutes. Then shut down the set by pushing an EMERGENCY STOP Button not yet tested. The set shuts down.
- 22.8 Turn OSS to OFF and disconnect artificial load.
- 22.9 Remove manometer connections and cap lines into ducts.

23. LUBRICATING OIL REQUIREMENTS

- 23.1 The minimum temperature anticipated in the engine room will determine the viscosity of the oil to be used. Obviously, the oil should be a high grade and should meet American Standard for Testing Materials specifications, (ASTM D-97). Acceptable oils are as follows;

|        |        |                    |
|--------|--------|--------------------|
| - 55°F | MOBILE | SHC-824 (KS-21273) |
| 25°F   | HUMBLE | Terestic           |
| 30°F   | MOBILE | DTE                |

- 23.2 The oils listed are taken from specification J-86653 (BSP 802-980-153) Issue 1.

24. MAINTENANCE

- 24.1 Maintain lubricating oil at the full mark. Check oil level when the set is not running.
- 24.2 Check electrolyte level in both the engine start battery and the control battery and maintain at the full mark by adding approved water.
- 24.3 Visually check security of all self-locking nuts, capscrews and other fastenings. If lockwires are broken, tighten the nuts or bolts and replace the lockwire. Use stainless steel lockwires, and not a zinc-coated lockwire. Lock-wires are generally .032 inch diameter except for #8 or smaller screws and on electrical harness coupling nuts, where .020 inch diameter wire is used.
- 24.4 The turbine must be run at least 30 minutes a month. The minimum routine running is 30 minutes at no-load each month and one hour every 3 months carrying the office load. Running at no load or short runs, such as demonstration runs have no adverse effect on the turbine.
- 24.5 During the one hour load run automatic Transfer Breaker Circuit should be exercised, when provided, to transfer the office load to the set.
- 24.6 No load starting and running is done by turning the OSS to MANUAL and starting the turbine with the STARTING SEQUENCE pushbutton.

24.7 The load test can be done on an automatic basis by turning the OSS to AUTO LOAD TEST and the TRANS SEL pushbutton to AUTO. After load has transferred to the turbine turn the OSS to AUTO. The turbine will then run through the Run Timer and Hold-Over Timer and transfer load back to commercial power after the Hold-Over Timer times out. The set will then shut down.

25. TROUBLE SHOOTING

- 25.1 Refer to the manual provided by the manufacturer for an extensive section on trouble shooting.
- 25.2 Circuit packs that are found to be defective should be exchanged for new ones rather than to attempt field repair. Some circuit packs do provide for certain adjustments.

Manager, Product Engineering