CHAPTER 3

INSTALLATION OVERVIEW

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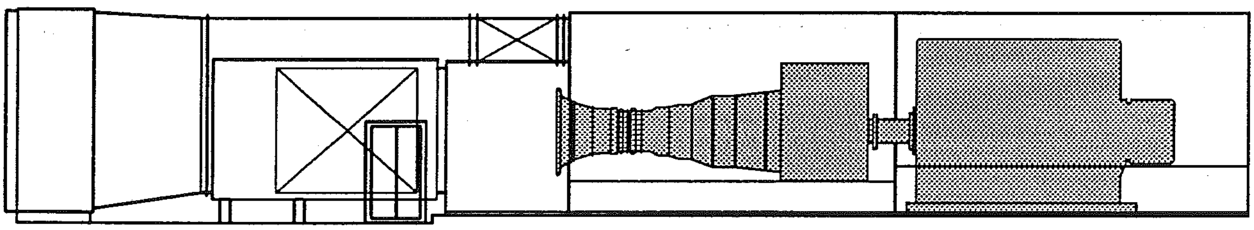

Figure 3.1 - DJ61G Gas Turbine Generator Installation

1 GENERAL

A DR61G Gas Turbine has been installed as the motive power unit for a power generating system with the exhaust emmission from the turbine passed through a boiler to obtain maximum fuel efficiency.

The Gas Turbine has a gaseous fuel system that enables operation on a natural gas supply. To reduce the nitrous oxides components in the exhaust emmissions steam is injected into the combustion chamber whilst the gas turbine is under load.

The intake air for the Gas Turbine is passed through an impulse type filter system to remove all air borne impurities. Where low ambient temperature exist a heat exchanger at the intake of the air filter utilizes steam to raise the intake air temperature to the desired level. This preheating prevents icing and enables additional control over the efficiency of the turbine.

The Gas Turbine drives a 10.5 kV Electrical Generator that feeds into the Main Power Grid at the installation site.

The Gas Turbine Generator Unit is installed as a continuous duty system. No provision is made for a 'black-out' start for where automatic start-up will occur in the event of a power failure.

The Oil Reservoir for the Gas Turbine Unit Lubricating Oil System is mounted on the Skid on which the units are mounted. A thermostatically controlled valve in the Gas Turbine Lubricating Oil System will divert a proportion of the oil through an external Oil Cooler Unit to maintain the oil at an acceptable operating temperature. The Oil Cooler is a heat exchanger that uses water as the cooling medium.

A Main Oil Pump driven by the Gas Turbine provides lubrication once the Gas Turbine is operating.

The Generator has it's own Lubricating Oil System. Prior to starting the Gas Turbine/Generator Unit electrically driven Generator Lubricating Oil Pumps are operated to supply oil to the Generator Bearings. Run-down tanks mounted adjacent to the generator bearings fill with oil to ensure continued lubrication in the event of failure in the oil supply from the Generator Lubricating Oil System. These tanks provide a reservoir of oil that will maintain bearing lubrication by gravity feed during shut-down as a result of interruption of the generator lubricating oil supply.

The Gas Turbine and Electrical Generator are each enclosed within a framework mounted on the respective Turbine - Generator Skid. The enclosure panels are sound-proofed to reduce the operational noise to an acceptable level.

The Gas Turbine compartment is ventilated by an extractor blower fan; this has the effect of reducing the pressure slightly below the ambient. The Generator compartment by comparison is non-ventilated; the internal air is circulated through water cooled heat exchanger elements within the enclosure to remove excess heat. All combustion and ventilation air input is taken from a safe area.

The provision of Gas and Fire Detection Systems with a Carbon Dioxide Gas Fire Extinguishing System within the compartments ensures safety. In the event of fire being detected the Gas Turbine Compartment ventilation blower fans are shut-off by louvre shutters prior to the release of the Carbon Dioxide gas.

The Gas Turbine Generator Unit and Electrical Output System is Controlled by a comprehensive Control System. The installation may be controlled either automatically by software and microprocessor programmes, or full manual control by the Operator from the local Control Room. Normal operation of the units from the Remote Control Desk is acheived by setting the local gas turbine controls to 'Remote' and the Generator and Synchronising functions to 'Automatic'.

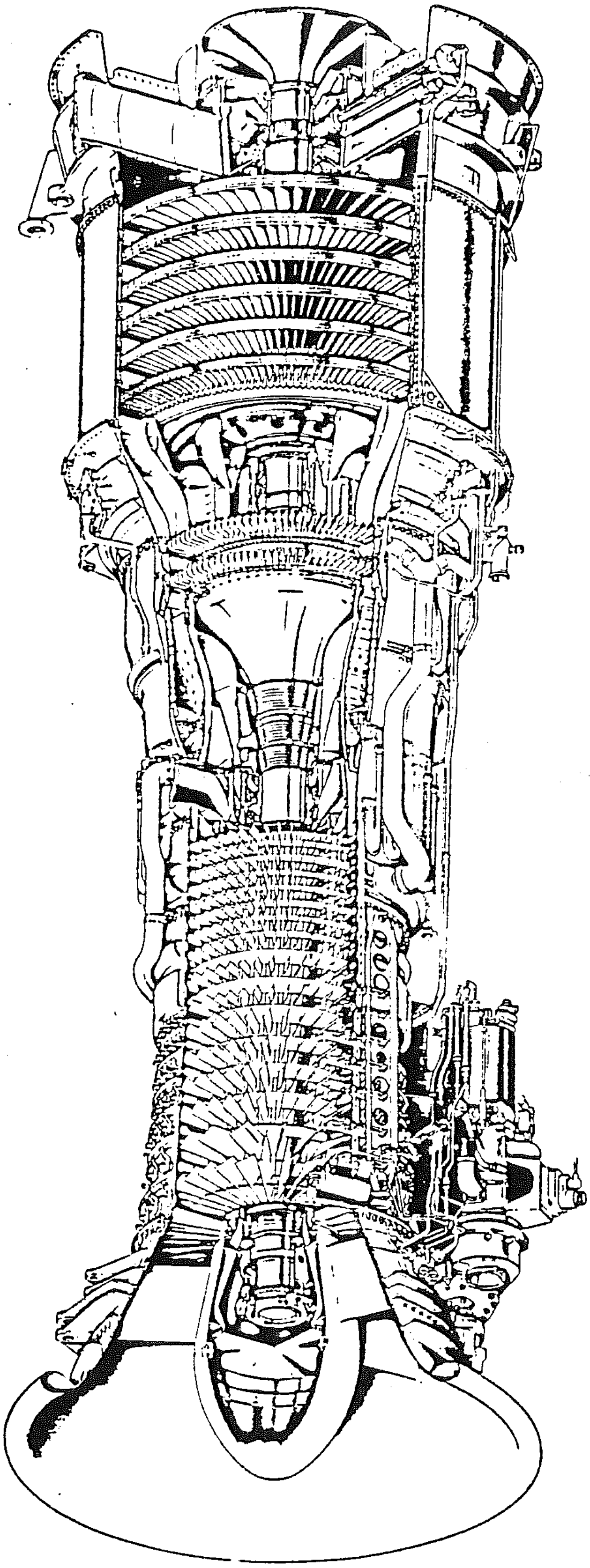

Figure 3.2 - DJ300G Gas Turbine Sectional View

2 DJ300G GAS TURBINE

The Turbine is a two-shaft unit with axial Gas Generator and Power Turbines. For a full description of the Gas Turbine refer to the manufacturer's information provided within Volume 2 - Technical Manual of this documentation supply.

The basic outline of operation is discussed below.

2.1 PRINCIPLES OF OPERATION

At start initiation, the gas generator rotor is rotated by an hydraulically operated starter motor that engages with the accessory gearbox. The rotating gas generator rotor draws air in through the air inlet filters and ducting to the turbine air inlet. As the air is drawn in through a bellmouth inlet and flows through the compressor stage where it is compressed and accelerated.

The air is then directed into a combustor stage. During the initial stages of turbine start-up the gas generator is accelerated to 1200rpm. It is then maintained at that speed for three minutes to expel any residual flammable gases from the combustion chamber; latter stages of the turbine; exhaust system, and ducting. This precaution will prevent detonations or fire at the time of light-up.

On completion of the purging stage, the acceleration of the gas generator is continued, and the fuel and ignition systems are activated. The selected fuel (liquid or gaseous) is injected into the combustor. A series of nozzles spaced around the annular combustion chamber ensures even mixing of the fuel with the air from the gas generator. Initial ignition of the fuel is by electronic spark. Once fuel ignition has taken place it is self-perpetuating and the electronic ignition will be switched off. The rise in the exhaust gas temperature (T5.4) above 204°C, indicates to the control system that ignition has been achieved.

The hot gases from the combustion chamber are directed to the first and second stage turbine nozzles and blades. The high pressure turbine is directly connected by a shaft to the gas generator rotor and so was rotated in the initial stages by the starter system. After ignition the expanding hot gases impart energy to rotate the first and second stage turbines, so driving the the gas compressor rotor. A high proportion of the energy produced by the fuel is absorbed by these turbine blades to drive the gas generator compressors.

Once the gas generator rotor has exceeded 4500rpm the starting system is discontinued as acceleration will continue unaided. Varying the fuel supply enables the speed of the gas generator rotor to be controlled. The rotational speed of the gas generator rotor will increase with an increase in fuel supply; and conversely will reduce with a corresponding reduction in the fuel supplied.

The remaining energy in the hot gases is directed into a power turbine stage. There is no direct mechanical connection between the gas generator and the power turbines. The hot gases from the gas generator impart energy to the turbine wheels which causes them to rotate, providing main shaft power. Spent gases are expelled through the exhaust duct.

Discussion of engine operation has, so far, been confined to stabilizing the engine speed under a condition called 'idle'; that is, running at speed but not supplying power to any external load. At idle, the engine develops only enough power to run itself with none left over to do useful work. So long as the unit is in idle condition only a small amount of heat energy need be added at the combustion chamber. It is desired that the power turbine be maintained at a constant speed for the directly driven equipment (generator).

When a load is placed on the power turbine it has the effect of slowing it down. If power turbine speed is to be maintained, more heat energy must be added to the power turbine. This extra heat comes from increased fuel flow into the combustion chamber; which increases speed of the gas generator and thereby increasing the flow of gases through the power turbines. Varying the fuel consumption rate, will, therefore, allow compensation to be made for the loading on the power turbine; although no direct mechanical link is provided between the gas generator and power turbines.

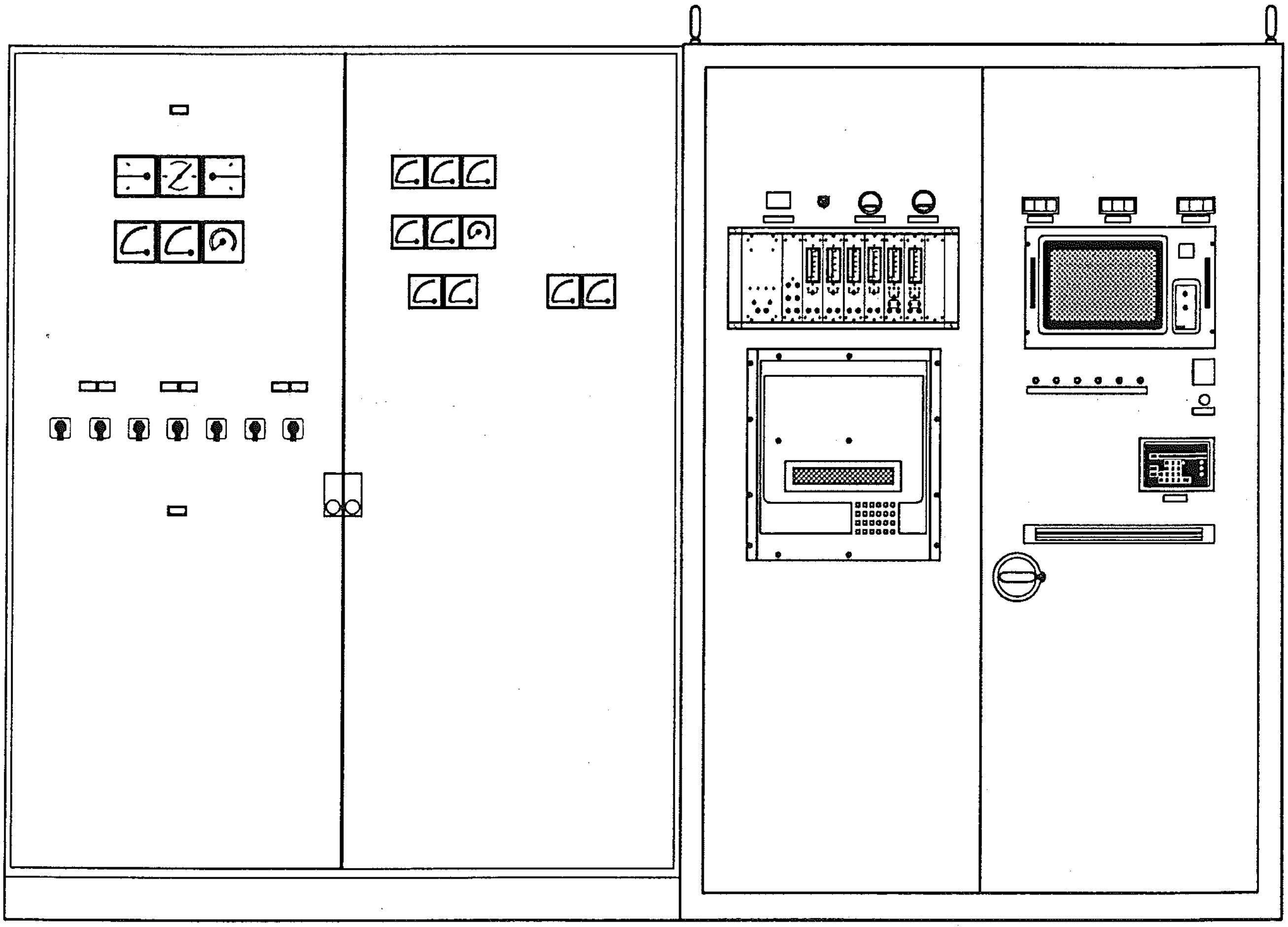

Figure 3.3 - Turbine and Generator Control Cabinets

It is desirable that a fuel flow change occur automatically as load is applied. This is accomplished by a fuel governor unit controlling a fuel valve. The turbine control unit and its valve are arranged so that when a load is applied and the power turbine starts to slow down, it admits more fuel into the combustion chamber. This increases the speed of the gas generator (which provides more energy to the power turbine) to match the load requirement.

At full speed, the gas generator pumps a relatively constant volume of air to the turbine. As extra heat is added to compensate for external loads, temperature at the turbine inlet increases. As the turbine turns, 'centrifugal force' acting on the turbine blade attempts to pull the blades from the wheel. Heating the wheel weakens its resistance to this stress; therefore, at some load, the turbine inlet temperature will become high enough to weaken the turbine wheel blades excessively, causing damage.

Turbine inlet temperature depends upon two things:

(1) amount of fuel added, and

(2) quantity of air to which fuel is added.

If air is 'thin', a given quantity of heat added to it will result in a high temperature. If air is very dense, the same quantity of heat added to it will not raise its temperature so much. Thus, the amount of load which the gas turbine may safely carry is influenced by density of air flowing through the gas generator compressor. Density of air is determined by altitude, pressure, temperature, and humidity of air drawn into the compressor. Therefore the power, that an engine can safely deliver, will decrease as ambient humidity or temperature increases or pressure drops. Low power output results if hot exhaust gases are allowed to re-enter the gas generator compressor inlet. Any obstruction to free flow of air into or out of the gas turbine engine will also result in a power loss. Sensors in the turbine and systems are used to identify the operating conditions to the turbine and generator control systems. Thermocouples located at the power turbine inlet will identify to the control system if gas temperatures are excessive and cause the engine to be shut-down.

3 CONTROL SYSTEM

Contained within the local Control Room is the Control Systems for the Gas Turbine Generator Unit and auxiliary Systems. The Control Cabinets are all of modular construction. Each module presents the majority of the controls, instruments and protection systems, relating to its respective area of the operating controls for the Gas Turbine Unit and Ancillaries or the Generator and Circuit-breaker as appropriate.

The Cabinets are constructed of high-grade corrosion-resistant, or protected, materials.

The Control Systems utilize microprocessor technology wherever practicable to obtain 'state-of-the-art' control for the installation. All systems are fully protected by fuses and protection devices.

A Video Display Unit enables the Operator to follow the progress of programmed sequences. The ability to display many analogue values on the Display economises on space in reducing the requirements for conventional instrumentation. The Operator can therefore maintain a closer watch on the operating status by reference to a more compact panel arrangement.

Gas Detection and a Fire Detection and Extinguishing System for the Gas Turbine Generator Unit are provided. A unit containing Carbon Dioxide Gas Cylinders is located close to the Turbine/Generator Enclosures with the associated sensors located within the Turbine/Generator Enclosures. These are linked into the Fire Detection System so that in the event of an alarm being generated the appropriate action will be taken without the intervention of the Operator.

For a full description of the Operator Facilities available refer to Part 2 of this Operating Manual.

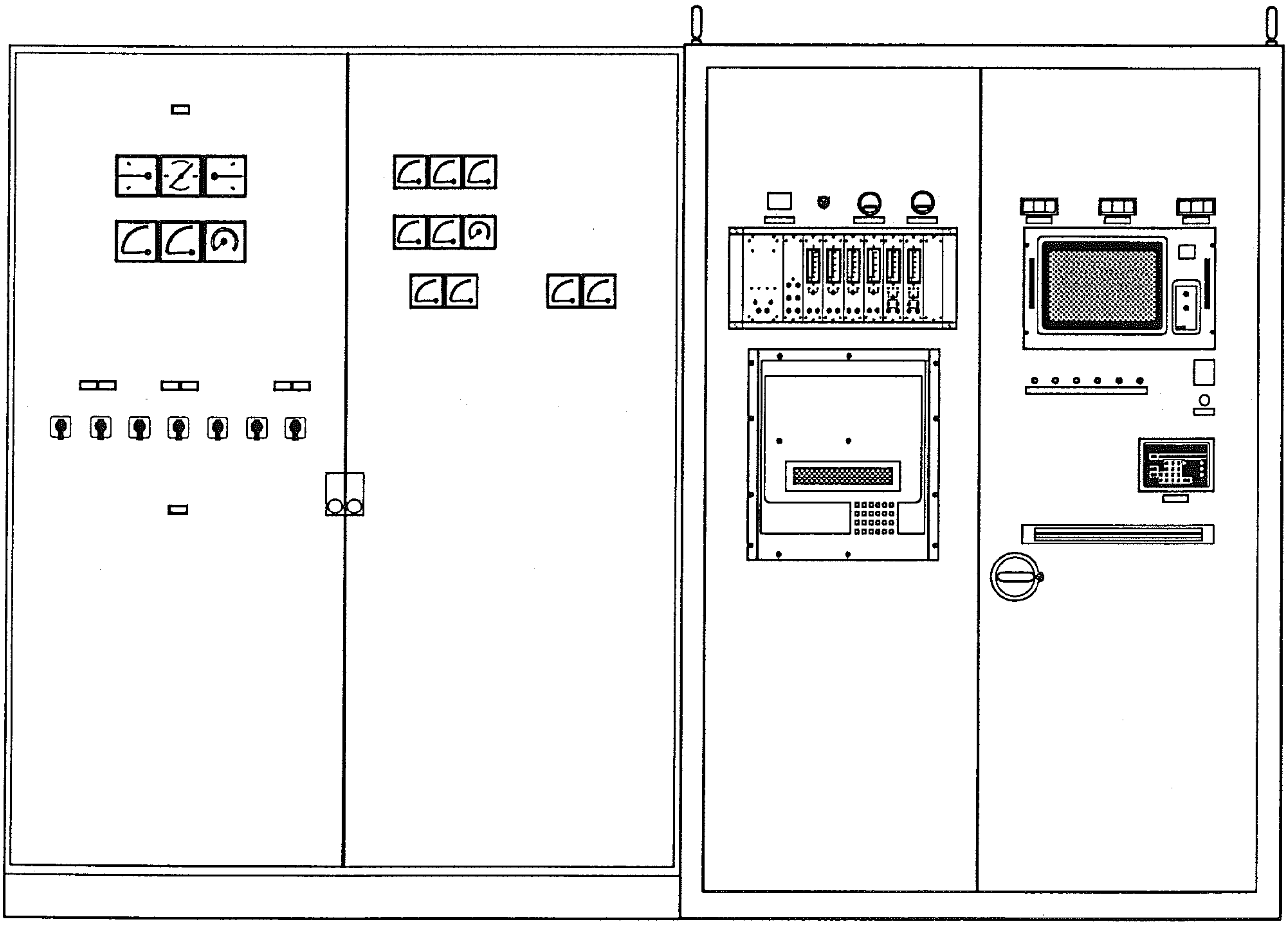

Figure 3.3 - Turbine and Generator Control Cabinets

4 STEAM INJECTION

To comply with local regulations on the percentage nitrous oxide component in the exhaust emmissions a steam injection system is supplied for this installation. Whilst the gas turbine is 'idling' or under light load the exhaust emmissions comply with the local requirements.

As the load on the gas turbine is increased a computer control system will monitor the turbine load and adjust the steam metering valve to control the quantity of steam to be injected into the combustion chamber. The quantity of steam injected and the load level at which injection commences is determined by the set-point value for the nitrous oxides level that is set by the operator.