RATCLIFFE-ON-SOAR 400kv SUBSTATION

THE SUPERGRID

RATCLIFFE-ON-SOAR 400kV SUBSTATION

Central Electricity Generating Board,
Midlands Region Headquarters,

Second Edition (Metricated)

November 1973

INTRODUCTION

Welcome to Ratcliffe-on-Soar 400kV Substation. I hope that a brief explanation of the equipment you are about to see will add interest to your visit and widen your appreciation of the work carried out by the Transmission Department.

The Grid is a transport system carrying electricity from the power stations to the area where people want to use it. But, unlike any other commodity, electricity cannot be stored; it must be made at the same instant of time as it is used and it must therefore have an instant transport system capable of handling immediately the highest demands made upon it. The overhead lines leaving this substation are the motorways of power which eventually filter off into the lanes, streets and suburban areas serviced by the local lines of the Area Boards' distribution system.

Just as a motorway handles heavy long distance traffic, so our supergrid handles heavy transfers of power across the country.

In our case we are transporting large quantities of power from low cost areas like Ratcliffe to parts of the country where local fuel supplies are more expensive. The grid system also improves the reliability of the supply of electricity by providing an interlocking network of power lines covering the country. Such a network also cuts out unproductive capital investment. It was this function in fact which lay behind the construction of Britain's original grid system over forty years ago. One power station operating on its own would have to carry spare generating plant to guard against breakdown and maintenance periods, and this plant would lie idle much of the time. By interconnecting power plants the grid enables them to act as standby for each other. The value of the grid can be measured by the fact that the average consumer is disconnected from a supply by virtue of the failure of generating plant or a major transmission fault for less than one minute in each year.

There are a few transmission facts I would like to put to you:-

1. The Transmission Department is a kind of 'high speed energy' transport business. One overhead line out of this substation transports energy equivalent to 142,240 tonne of coal each week, without noise or dirt. This would mean:

   7,000 20 tonne coal lorries each week extra on the roads of the Midlands for each overhead transmission line leaving this building.

2. The switchgear is the largest size made, although there are several other installations of equal capacity. Each switch is capable of dealing with 35,000 MVA - the total generating capacity of the country at the end of the war was about 15,000 MVA.

3. This substation is handling more than 10 times the power capacity of the Cross Channel Link.

4. One modern 400,000 volt transmission tower carries 18 times the power of the original 132,000 volt towers. Remember, just one of these towers in the countryside replaces 18 of the earlier towers at 132,000 volts, or 3 towers carrying 275,000 volts.

5. The cost of 'undergrounding' these transmission lines would be 16 times more than constructing overhead lines and would sterilize good land as wide as one carriageway of the M1. The extra cost of putting 100 meters of 400,000 volt cable underground equals the cost of 32 houses or over £1,000,000 per mile.

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To demonstrate the complicated pneumatic servo system used in this switchgear we invite you to see the model of a single interrupter unit. The area of green light represents high pressure air and the area of blue light air at atmospheric pressure. In the time the model takes to complete one operation the actual equipment could have completed 100 operations. The switch itself has 36 interrupters similar to the model.

Please take advantage of the safety equipment provided and use both the ear muffs and the safety helmet. If a switch should operate during your visit there will be a loud 'bang'. There is no need for alarm, this is a normal occurrence.

D. K. Latham,
District Engineer.

Note All the units of measurement are given in metric terms.

RATCLIFFE-ON-SOAR 400kV SUBSTATION

GENERAL

The building is aluminium clad, lined with fibrous board and covers a floor area of approximately 3 hectares.

The low level double busbar is divided into four sections. The main busbar wraps around the reserve bar in the form of an 'H' and consists of 133mm diameter hollow aluminium tube, rated at 4,000 amps.

The first circuit was commissioned in June, 1967.

SWITCHGEAR

This comprises:

6	Overhead Lines
3	Supergrid Transformers 240 MVA 400/132kV
4	Generators 570 MVA 500 MW 400/22kV
3	Bus Sections
2	Bus Couplers
18	TOTAL

Provision is made for extending the substation in the future if required.

AIR BLAST CIRCUIT BREAKERS (ABCB's Fig. 1)

These are of G.E.C. manufacture, type GSA 12.

They have 12 breaks per phase, giving a total break of 324 mm, a rating of 35,000 MVA breaking capacity and a normal full load current of 4,000 amps.

The average time to open this switch is 45m secs and the close time 98m secs.

The local air receivers have a capacity of $13.6m^3$ at 30 bar and air consumption for trip is $45m^3$ at atmospheric pressure, giving a pressure drop of 3.5 bar and 140 litres with no measurable pressure drop on closing.

Stored air in the breaker is sufficient for make-break-make-break and the pressure switches give lockout to closing at 26 bar and to tripping at 25 bar.

As the contacts are held open by air pressure a pressure switch is arranged to give a forced close at 15 bar. In the event of loss of air compressions whilst at 20 bar, delayed auto reclose is inhibited for the feeders and sequential isolation takes place. On the generators a busbar protection injection clears the section of bars to the machine selected.

The conditioning air on an ABCB is at 700-1400m bar and the breaker has a consumption of $1.7m^3$ per hour.

The total weight of an ABCB is 72 tonne.

EARTH SWITCHES

These may be integral with isolators and are of G.E.C. hand-operated pantograph type RCP. Interlocking is arranged to prevent incorrect operation with circuits alive. There are 49 earth switches in the substation.

ISOLATORS

There are 51 motor-driven hydraulic isolators of G.E.C. manufacture, type MLG05 each with a 3 phase 600 W motor driving an hydraulic motor and a double break isolator with rotary action which locks when the blades are fully closed. The operating time is 15-20 seconds. All the isolators are covered by a comprehensive interlocking scheme using a special key system and a series of electrical bolts.

MAINTENANCE EARTHS

These devices, interlocked with the earth switches, are hand wound with three sections per poker, the top weighing 8kg, the middle 12kg and the bottom 23kg. 78 earth devices are arranged at suitable points throughout the substation.

BUSBARS

The 133mm O.D. 120mm I.D. aluminium tube has a current carrying capacity of 4,000 amps. The busbars have welded fittings with 178mm PCD bolted flanges.

VOLTAGE TRANSFORMERS

These are of A.E.I. manufacture, capacitor type 50 VA per phase.

CURRENT TRANSFORMERS

The current transformers are housed in wall bushings in an air insulated chamber. Ratios are 2000/1000/1 except for the busbar protection which is single ratio 2000/1. The bushings are oil filled, nitrogen pressurised and weigh approximately 175kg.

SUPERGRID TRANSFORMERS

Each of the 3 G.E.C. auto transformers (240 MVA 400/132kV) has a total weight of 306 tonne when filled with oil. The total quantity of oil is 110m^3.

The main windings are auto-star with delta tertiary at 132kV and the tap change is on the LV side with 15 taps of 1.43% (-5% to +15%).

PROTECTION, METERING, ETC.

Each circuit has its own relay block house, which contains open rack type panels for protection, control and local metering. 110 volt supply for this equipment is obtained from a self-contained battery and charger unit.

Feeders Each feeder is equipped with 1st main and 2nd main protection. The latter being of the distance impedance type incorporating its own back-up feature. The first main is either a carrier type, rented pilot type or distance type protection having a unit protection feature. Carrier supplies are obtained from a motor/generator unit adjacent to the block house. This unit is normally driven from an a.c. motor with a d.c. standby machine. A Masson Fault Recorder is installed in each circuit which gives a chart showing a.c. values and equipment operations, triggered off by the trip relays. Delayed auto reclose is obtained for dead line charging or check synchronising on all feeders. Bus zone relays, both a.c. and d.c., are per circuit and mounted in the relay house.

Generators (Fig. 2) Most of the generator protection is accommodated in the Generating Station. In the 400kV Substation relay room we have overcurrent, interlocked overcurrent and busbar protection. The sequential isolator control circuitry is also found in this relay room. The generator auto-synchronising unit is located in the substation relay room and is of the solid state type. It automatically adjusts the governor, excitation and tap change position of the main transformer. The synchroniser checks a few Hertz of synchronism for voltage matching and phase angle before closing the 400kV ABCB. Should the air pressure in the ABCB fall due to air leaks either with the breaker open or closed a pressure switch set at 20 bar causes a voltage to be injected into all bus zone relays of circuits selected to the same busbar as the generator, thereby opening all switches connected to this busbar.

Supergrid Transformers Overall balance and two stage overcurrent form the main and back-up protection on these circuits. Busbar protection is similar to other circuits. The Buchholz and winding temperature is of the type usually associated with transformer circuits.

Bus Section and Bus Couplers These circuits are equipped with overcurrent and bus zone protection only.

COMPRESSORS AND AIR PLANT (Fig. 3)

The air used in the circuit breakers is supplied by two Hamworthy type 4TH8 compressors each driven by a 90 kW three phase motor. The compressor has a speed of 500 r.p.m. with a delivery pressure of 230 bar at 4.5 m^3 per minute. Water cooling is by radiators and forced circulation.

Stage pressure	1st	2.75 bar
	2nd	14 bar
	3rd	55 bar
	4th	227.5 bar
Lubricating oil pressure		2.75 bar

In addition there is a small 3 stage double ended compressor capable of providing the losses of the total air system. This limits the number of operational stop/starts on the larger machines and improves their availability by reducing the maintenance required.

The air is dried by 'Rimer' drier banks which pass air through activated carbon to remove oil, and through alumina (aluminium oxide) to remove water.

The four main air receivers each weigh 7 tonne at 207 bar, each holding a 1.5 m^3 supply reservoir. Air is throttled to 30 bar in order to service the switches at their operating pressure and also to assist in removing moisture from the air supplies.

DIESEL STANDBY GENERATORS AND M.V.A.C. SUPPLIES

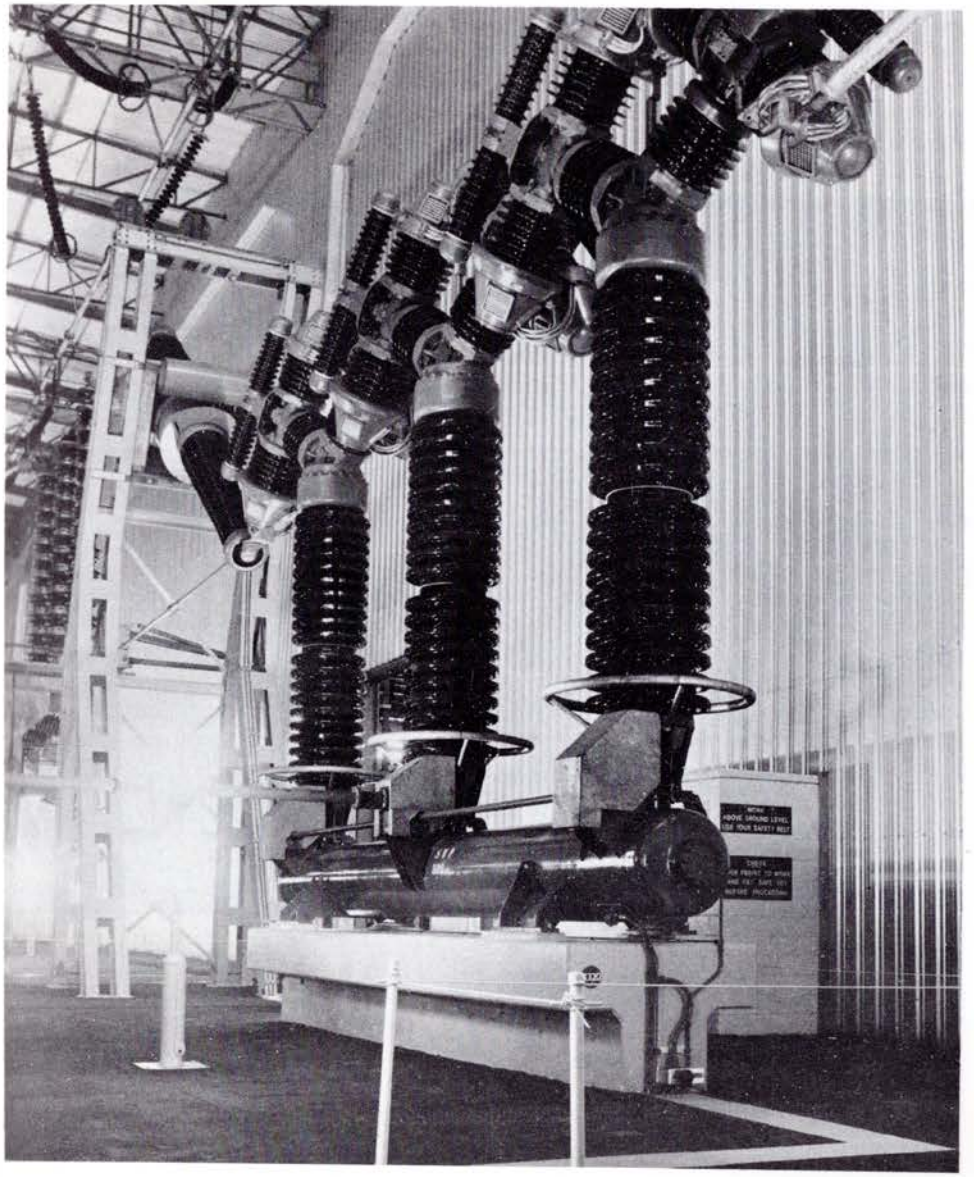
The 415 volt auxiliary supplies are normally derived from two 2 MVA 3kV/415kV transformers. In the event of a complete failure of supplies, the diesel standby generators are arranged to supply the essential services load. They are run-up and loaded automatically. The six cylinder diesels are of English Electric Co. manufacture type 6RK 390kW, the compressed air start is supplied by the auxiliary compressors which can be operated from a battery of 800 Ah capacity.

Each engine is governed to 750 r.p.m. and the fuel tank holds 2 m^3, suitable for about 30 hours running.

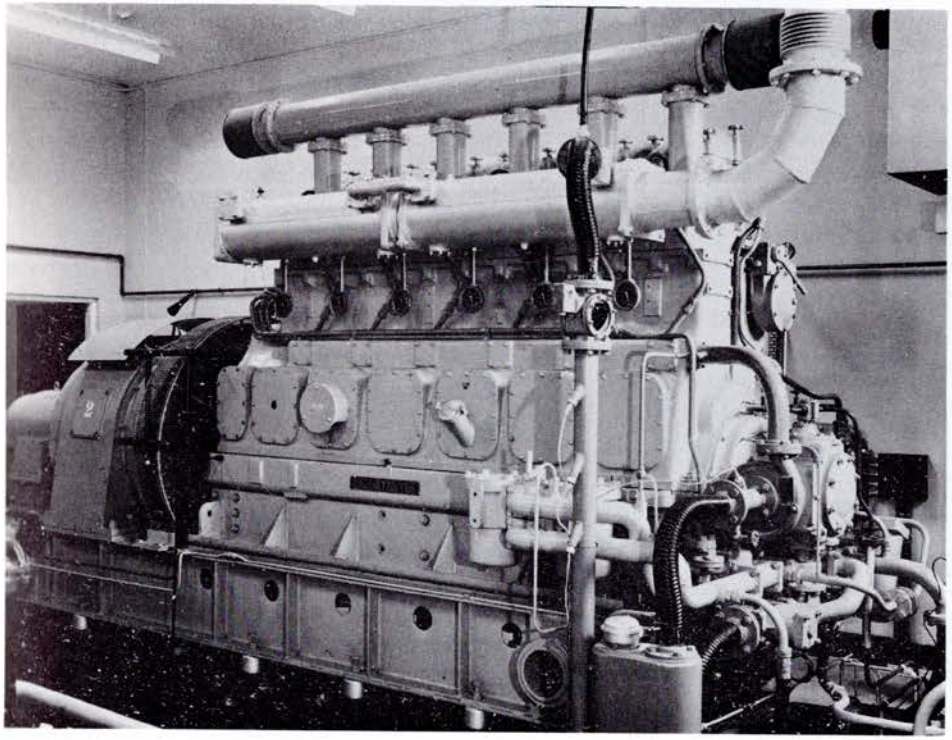
The generators are 8 pole machines of 330kW capacity fitted with bushless exciter and solid-state AVR.

MISCELLANEOUS

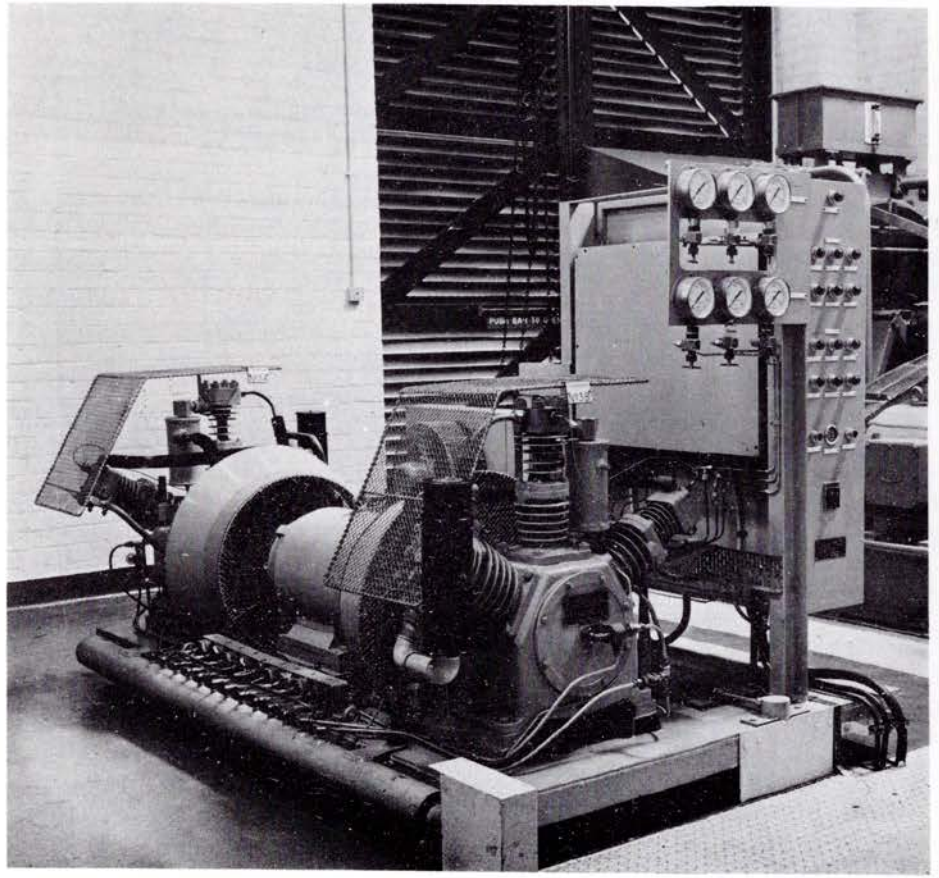
The total lighting load in the substation is 450kW and the General Services 110V Battery is of 800 Ah capacity



ONE PHASE OF 400KV SWITCH TYPE GSA 12



DIESEL GENERATOR FOR STANDBY OPERATION



SMALL DOUBLE ENDED COMPRESSOR

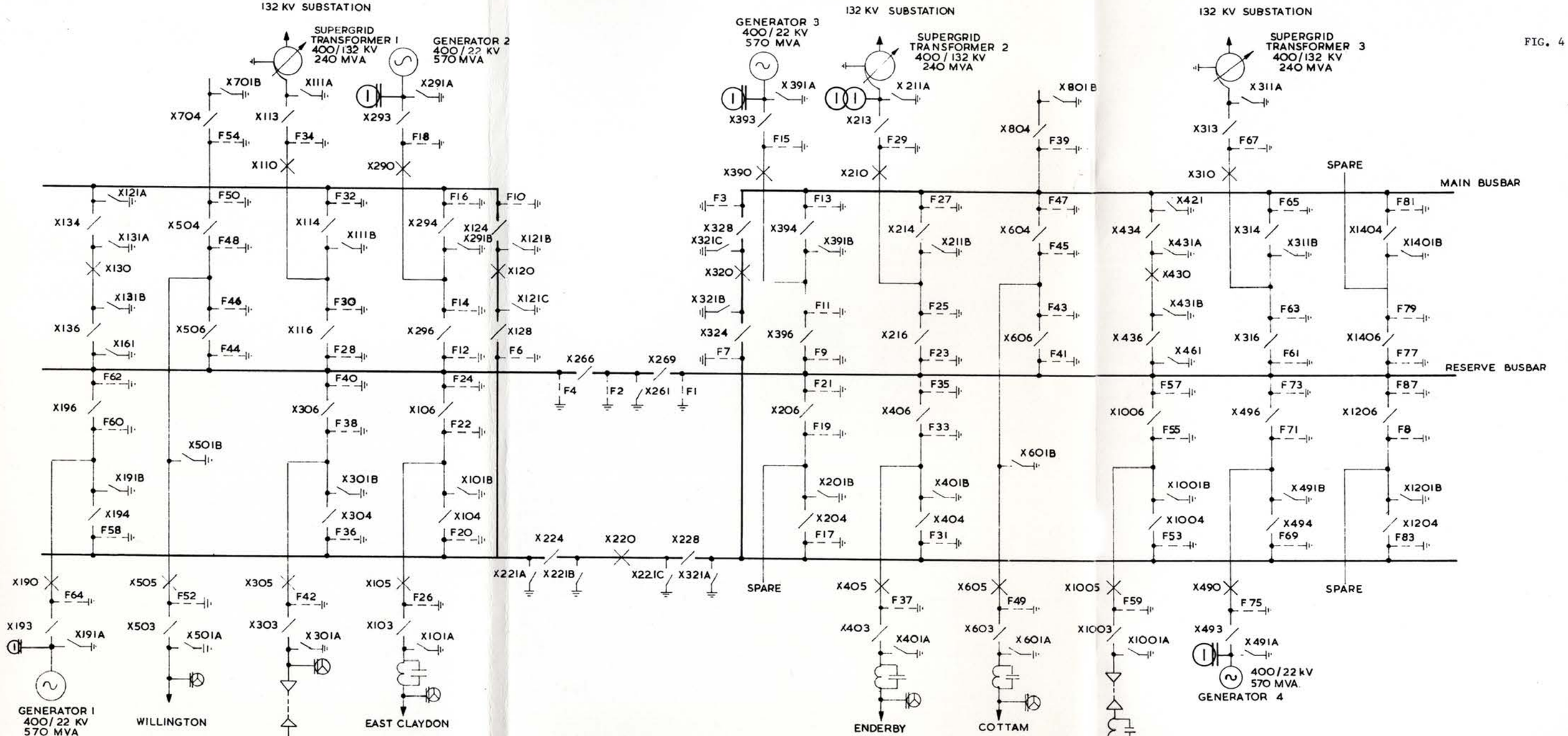


FIG. 4

SCHEMATIC LAYOUT OF RATCLIFFE-ON-SOAR 400KV SUBSTATION