



WCB ENGINEERING BULLETIN

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The Institution of Certificated Mechanical and Electrical Engineers South Africa
Western Cape Branch (WCB)

DECEMBER 2021

MISSION STATEMENT: 1. To uphold the image and status of the Certificated Engineer. 2. To represent the Certificated Engineer at ECSA and other decision-making bodies concerning legislation, safety & health standards, the environment and the machinery regulations. 3. To promote continued education and training of its members and future engineers. 4. To promote fellowship in the engineering profession.

EDITORIAL



Welcome to the latest edition of the Western Cape News Bulletin

I know that some of our members and friends will be on holiday already, while others may be wrapping up their last day of work and getting ready to start a well earned end-of-year break. If so, I hope you have an enjoyable and safe vacation, with plenty of sunshine, laughter, good food and drinks, in the company of family and friends!

The past year has been a trying time for most of us in some way or other and I hope and trust that you are all managing your situations as best you could. To those of you who have lost a loved one, we wish you condolences and may you find peace and harmony in the future.

In this Bulletin, you will find all sorts of odds and ends plus our normal Questions and Answers for Factories

and Mining GCC examinations.

There is a message from our Institution President/Chairperson and a link to a message from the ECSA's Acting Chief Executive Officer, Mr. Cox Mokgoro [HERE](#).

As we fall under the auspices of ECSA - which is part of the CBE (Council for the Built Environment) I include 3 items of interest shared by the CBE in the last two months. You can access these documents by clicking on the titles of the links.

These are: [CBE CEO Appt Announcement](#),
[CBE Announces COO Appointment](#) and lastly,
the [CBE Bulletin Dec 2021](#).

I further include a link to a copy of the November [ENERGIZE](#) magazine which always makes an interesting read. Note that this download is courtesy of Energize News. Should you wish to subscribe to the magazine - please follow the links within the magazine.

Finally, there is part three of an article taken from the ICMEESA Archives – from The Certificated Engineer volume 39 – 1969.

I trust that you will find the content of this news bulletin interesting enough to pass on to your colleagues and friends.

Chris Schnehage
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MESSAGE FROM OUR PRESIDENT/CHAIRPERSON

Dear ICMEESA Members,

Wow, 2021 that was a challenging year for all of us in many ways but human nature is most resourceful and we have adjusted to Covid constraints and gone virtual via ZOOM with our meetings at Board, Branch level and National talks to members.

The board have successfully made amendments to our constitution which will enable the board to further develop the services to our members, more on this to come.

Unfortunately, we had to cancel the Christmas party but let me take this opportunity to wish you all a super festive season and a successful and fulfilling new year.

Yours sincerely

Bernard Bryers Pr Cert Eng.
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Plant Engineering: MINES mechanical question

QUESTION (June 2010, Question 4)

A clear-water centrifugal pump installation in a gold plant has a negligible suction head. The pump delivers 220 m³/h through a delivery pipe that is 30 m long, 156 mm in diameter and has a vertical lift of 26 m. The friction factor for the pipe, is 0,01.

Approximately midway along the length of the delivery pipe, a short pipe branches out from the delivery pipe. The branch pipe which is closed by means of a valve is at an elevation of 12 m above the centrifugal pump.

The valve is opened to a position where the discharge at the end of the delivery pipe is reduced to 135 m³/h and 100 m³/h of water flow through the branch pipe. At flow rates of 220 m³/h and 235 m³/h the pump efficiency is 78% and 77% respectively.

Determine the following:

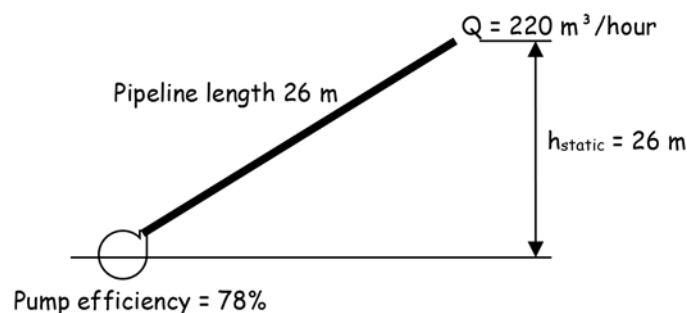
4.1 The power required to drive the pump while the valve in the branch pipe is fully closed (10)

4.2 The power required to drive the pump while the discharge from the branch pipe is 100 m³/h. Assume that the loss in the branch pipe is negligible (10)

[20]

Proposed Solution:

4.1 The power required to drive the pump while the valve in the branch pipe is fully closed



$$h_f = \frac{4fLv^2}{2gd} = \frac{4fL(Q/A)^2}{2gd} = \frac{4fL[Q/(\pi d^2/4)]^2}{2gd}$$

$$= \frac{4 \times 0,01 \times 30 \times [220/60^2 (\pi \times 0,156^2/4)]^2}{2 \times 9,81 \times 0,156} = 4,0079274 \text{ m}$$

$$H_{\text{total}} = h_{\text{static}} + h_f$$

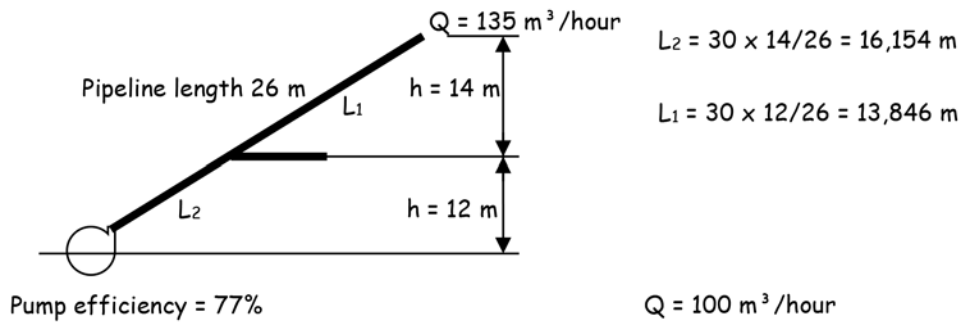
$$= 26 + 4,0079274$$

$$= 30,008 \text{ m}$$

$$\text{Power input to pump} = \frac{\rho g H_{\text{total}} \times Q}{\text{Pump eff.}} = \frac{1 \times 9,81 \times 30,008 \times (220/60^2)}{0,78}$$

$$= 23,064 \text{ kW}$$

- 4.2 The power required to drive the pump while the discharge from the branch pipe is 100 m³/h. Assume that the loss in the branch pipe is negligible.



Friction head through first portion of pipe $hf_1 = \frac{4fLv^2}{2gd}$

$$hf_1 = \frac{4 \times 0,01 \times 16,154 \times [135/60^2 (\pi \times 0,156^2/4)]^2}{2 \times 9,81 \times 0,156} = 0,82473 \text{ m}$$

Friction head through second portion of pipe $hf_2 = \frac{4fLv^2}{2gd}$

$$hf_2 = \frac{4 \times 0,01 \times 13,846 \times [235/60^2 (\pi \times 0,156^2/4)]^2}{2 \times 9,81 \times 0,156} = 2,110636 \text{ m}$$

$$P_{\text{total}} = P_1 + P_2 = \frac{\rho g H_{\text{total}} \times Q_1}{\text{Pump eff.}} + \frac{\rho g H_{\text{total}} \times Q_2}{\text{Pump eff.}} = \frac{1 \times 9,81 \times 30,008 \times (220/60^2)}{0,77}$$

$$= \frac{1 \times 9,81 \times (14 + 0,812645) \times (135/60^2)}{0,77} + \frac{1 \times 9,81 \times (12 + 2,11063) \times (235/60^2)}{0,77}$$

$$= 7,0768 + 11,7352$$

$$= 18,8121 \text{ kW}$$

A Legal Knowledge: MINES question

QUESTION (November 2019, Question 4):

The employer must take reasonably practicable measures to prevent persons from being injured in any hazardous location as a result of fire, explosion, or the ignition of gas, dust, mist or vapour. Mention at least five measures that must be taken by the employer. [10]

Proposed answer

The employer must take reasonably practicable measures to prevent persons from being injured in any hazardous location as a result of fire, explosion or the ignition of gas, dust, mist or vapour. Such measures must ensure that:-

- (a) all hazardous locations are identified, clearly marked and recorded on a plan or register, which must be kept updated and readily available at the mine;
- (b) only explosion protected apparatus and systems certified for use in a hazardous location in accordance with the South African National Standard ARP 0108: 2005, 'Regulatory requirements for explosion protected apparatus', are used in any hazardous location; the selection of explosion protected apparatus used in any hazardous location is done in accordance with SANS 10108:2005 'The classification of hazardous locations and the selection of apparatus for use in such locations'. The normative references as listed in SANS 10108 are not applicable to the employer;
- (c) the installation, inspection and maintenance of explosion protected apparatus used in a hazardous location is carried out in accordance with SANS 10086-1 2005 'The installation, inspection and maintenance of equipment used in explosive atmospheres Part 1: Installations including surface installations on mines' and SANS 10086-2 2004 'The installation, inspection and maintenance of equipment used in explosive atmospheres Part 2: Electrical equipment installed underground in mines' as appropriate;
- (d) any repair, overhaul or modification to any explosion protected apparatus used in any hazardous location does not alter its design characteristics and is carried out in accordance with SANS 10086-3 2005'. The installation, inspection and maintenance of equipment used in explosive atmospheres Part 3: Repair and overhaul of apparatus used in explosive atmospheres';
- (e) explosion protected apparatus used in any hazardous location is installed, maintained, repaired, overhauled, inspected and tested by a competent person;
- (f) only double protected or intrinsically safe type Ex IA explosion protected apparatus remains energized where flammable gas is present in concentrations in excess of 1.4% by volume in the air. All other explosion protected apparatus must be de-energized at flammable gas concentrations in excess of 1.4% by volume in air;
- (g) every battery operated self-propelled mobile machine used in any hazardous location complies with SANS 1654: 2005 'DC powered machines for use in hazardous areas in mines';
- (h) any trailing cable used in any hazardous location is:-
 - (aa) provided with a pilot circuit of intrinsically safe voltage and current which will prevent power being supplied to the cable unless the earth conductor is continuous;
 - (bb) provided with a means (system) to prevent arcing of power contacts of any plug used in conjunction with the cable while such plug is being inserted or withdrawn;
 - (cc) provided with a supply of electricity of which the earth fault current is limited to a value so that there is no significant risk of electrocution;
 - (dd) individually screened on poly phase and collectively screened on single phase power conductors; and
 - (ee) designed for being dragged across the ground;
- (i) measures are in place to verify, as far as reasonably practicable, that electrical circuits and components of such circuits used for explosion protected apparatus have been correctly designed, selected, installed and repaired;
- (j) only internal compression ignition engine system and machines that comply with the South African National Standard SANS 868-1-1 2005: 'Compression-ignition engine systems and machines powered by such engine systems, for use in mines and plants with explosive gas atmospheres or explosive dust atmospheres or both', Parts 1-1 or 1-2, whichever is applicable, are used in a hazardous location;

- (k) all compression ignition engines used in a hazardous location have a valid Inspection (IA) certificate for the components and the complete machine and test reports issued by an accredited testing laboratory (ATL) that must be available at the mine;
- (l) when a compression ignition engine system has any defect which may contaminate the air and cause a significant risk to the safety or health of persons, the use of such engine system is discontinued immediately;
- (m) all maintenance and repairs to diesel-powered equipment is performed by a competent person;
- (n) no apparatus, component or machinery made of a light metal is used in a hazardous location unless such apparatus, component or machinery is-
 - (aa) covered by a housing, sheath, cover or coating (excluding paint) that will prevent such ignition; or
 - (bb) contained, situated or used in such a manner that does not create a significant risk of such ignition; or
 - (cc) complies with South African National Standard SANS 10012: 2004 'The use of light metals in hazardous locations at mines'.

Plant Engineering: FACTORIES electrical question

QUESTION:

The power input to the rotor of a 440V, 50 Hz, 6 pole, 3-phase slip-ring induction motor is 80 kW. The rotor electromotive force is observed to make 100 complete alternations per minute.

Calculate:

- (a) The rotor speed (3)
- (b) The slip (4)
- (c) The rotor copper loss per phase (4)
- (d) The mechanical power developed, and (2)
- (e) The rotor resistance per phase if the rotor current is 65A. (2)

Suggested Answer:

- a) If n = Rotor speed in revs/sec
 $f - pn$ = slip frequency

$$\therefore 50 - 3n = \frac{100}{60}$$

$$\therefore 3n = 50 - 1.7 = 48.3$$

$$\therefore n = 16.1 \text{ revs/sec}$$

$$\text{Rotor speed, } N_r = n \times 60 = 16.1 \times 60 = \mathbf{966 \text{ rev/min}}$$

- b) Synchronous Speed, $N_s = \frac{60f}{p}$

$$\therefore N_s = \frac{(60 \times 50)}{3} = 1000 \text{ revs/min}$$

$$\% \text{ slip} = \frac{(N_s - N_r)}{N_s} = \frac{(1000 - 966)}{1000} \times 100 = \mathbf{3.4 \% \text{ or } 0.034 \text{ pu slip}}$$

c)

$$\text{pu slip} = \frac{(\text{rotor copper loss})}{(\text{rotor input})}$$

$$\therefore 0.034 = \frac{P_{\text{cu}}}{P_{\text{in}}}$$

$$\therefore 0.034 = \frac{P_{\text{cu}}}{(80 \times 10^3)}$$

$$\therefore P_{\text{cu}} = 2.72 \text{ kW}$$

Rotor copper loss per phase,

$$P_{(\text{cu phase})} = \frac{P_{\text{cu}}}{3} = \frac{(2.72 \times 10^3)}{3} = \mathbf{0.91 \text{ kW}}$$

d) Assuming other losses to be negligible

$$\text{Mechanical power developed, } P_{\text{out}} = P_{\text{in}} - P_{\text{cu}} = 80 - 2.72 = \mathbf{77.28 \text{ kW}}$$

e)

$$\text{Rotor copper loss per phase, } P_{(\text{cu phase})} = I_{\text{R}}^2 \times R_{(\text{R phase})}$$

$$\therefore R_{(\text{R phase})} = \frac{(0.91 \times 10^3)}{(65)^2}$$

$$\therefore \text{Rotor Resistance per phase} = \mathbf{0.215 \Omega}$$

A Legal Knowledge: FACTORIES question

QUESTION (June 2021, Question 10.5):

A contractor must ensure that the chute used to dispose rubble from a high place on a demolition site is properly designed.

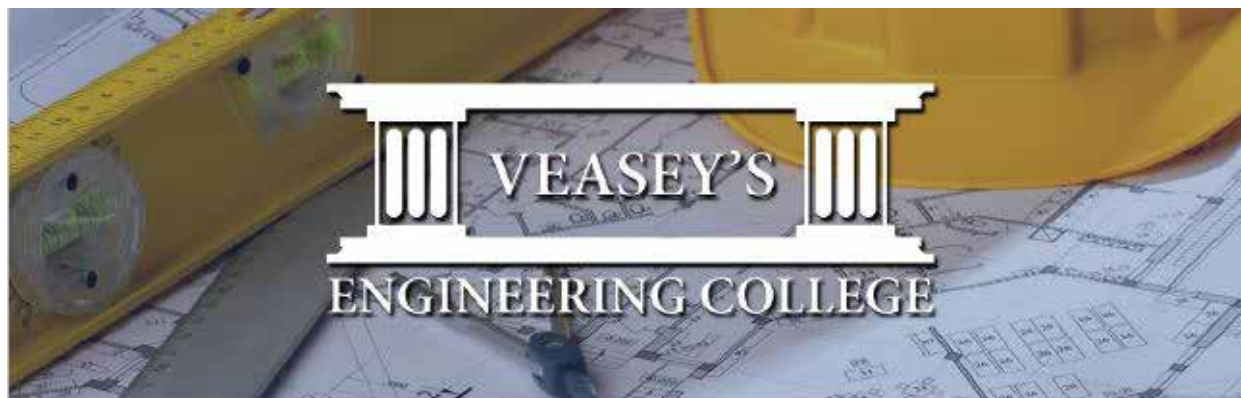
Name TWO requirements the chute must comply with?

Suggested answer:

14(6)

- a) adequately constructed and rigidly fastened
- b) if inclined at more than 45° to the horizontal, is enclosed on all sides
- c) if of the open type, inclined at an angle of less than 45° to the horizontal
- d) where necessary, fitted with a gate at the bottom to control the flow of material
- e) discharge into a container or an enclosed area surrounded by barriers





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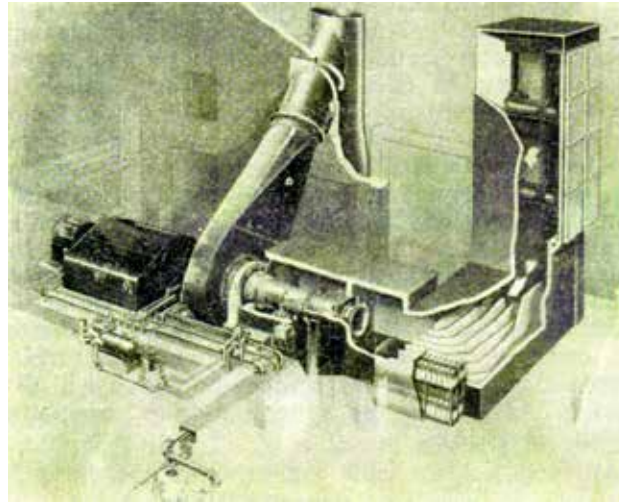
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PART 3

PRACTICAL APPLICATIONS

The prototype 17½ MW turbo generator purchased by the Central Electricity Generating Board for test and evaluation was installed in a corner of Hams Hall power station. In July, 1962, the engine was started at the first attempt. Commissioning trials followed at a rating of 15 MW, commercial duties were commenced on December 5th continuing through the winter and on August 29th after about 450 hours of operation the rating was increased to 17½ MW. The installation at Hams Hall met every operational requirement specified by the Board, achieving an overall thermal efficiency of 27 per cent at maximum load (Fig. 17).



During these trials the overspeed characteristics of the power turbine alternator system and, aided by an extremely rapid fuel cut-off and a low value of residual heat in the gas generator, this was demonstrated to be well within the 10 per cent limit specified. Automatic control of the engine was maintained throughout and 15 seconds after the load shed the set was spinning at the correct frequency ready to accept instructions to resynchronize. Further tests to demonstrate cold starts at sub-zero temperatures to full load in two minutes including automatic synchronization onto a system frequency falling to 40 c/s at a rate of 2 c/s per minute were satisfactorily concluded (Fig. 18).

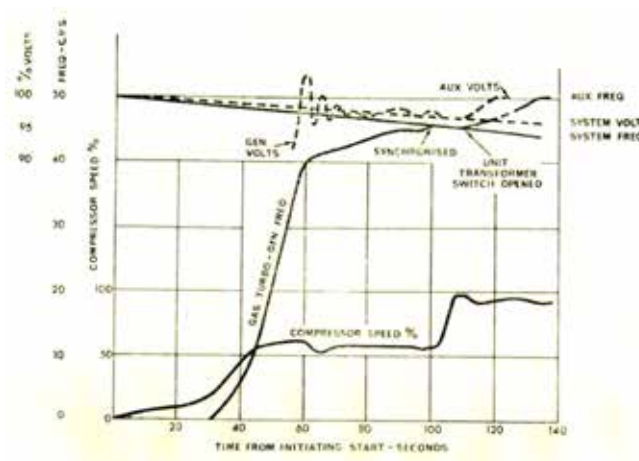


Fig. 18
Automatic synchronizing sequence

The original rating of 15 MW at the standard conditions of 760 mm barometric pressure and 15° C ambient temperature was related to an estimated annual usage of 500 hours. However, the overall performance of the gas turbine exceeded these figures, an output of 17½ MW being achieved at the specified top cycle temperature. It was decided to adopt this higher power for peak loads retaining the more conservative

rating of 15 MW for operation at a higher annual utilization with a maximum short period output of 20 MW to be used in a case of emergency only.

The term peak load duty was not clearly defined by the customer but was generally understood to mean intermittent operation of two to four hours per start at a utilization of about 25 hours per week during the winter months -- November to March inclusive. However, in order to clarify the position and to answer numerous enquiries regarding the effect of power output on the recommended period between gas generator overhauls, it was decided to establish five ratings to cover the whole operating range each related to a recommended period between overhauls.

These were combined into a comprehensive empirical formula as follows:

$$100H(x) + 2H(1) + H(2) + \frac{1}{2}H(3) + S = 3\,000$$

where S is the number of starts and H the number of running hours at the following engine ratings reduced to standard conditions accordingly-

- (1) Normal maximum rating 15 MW to 17½ MW recommended for average peak load duties.
- (2) Intermittent rating 12 MW to 15 MW recommended for semi-continuous operation.
- (3) Continuous rating up to 12 MW recommended for continuous operating up to the limit of the recommended overhaul period.
- (4) Maximum rating 17½ MW to 20 MW to be used only in emergency and limited to one hour in anyone period, each incident to be reported to the manufacturer.

From this it will be seen that an absolute maximum of 30 hours only is recommended at the emergency rating of 20 MW while the recommended overhaul period at the peak load rating of 17½ MW is 1 500 equivalent operating hours, and 6 000 hours continuous operation can be expected at powers below 12 MW. The power turbine is designed to the same industrial standard as the alternator and should require inspection at 10 000 hour intervals only (Fig. 19).

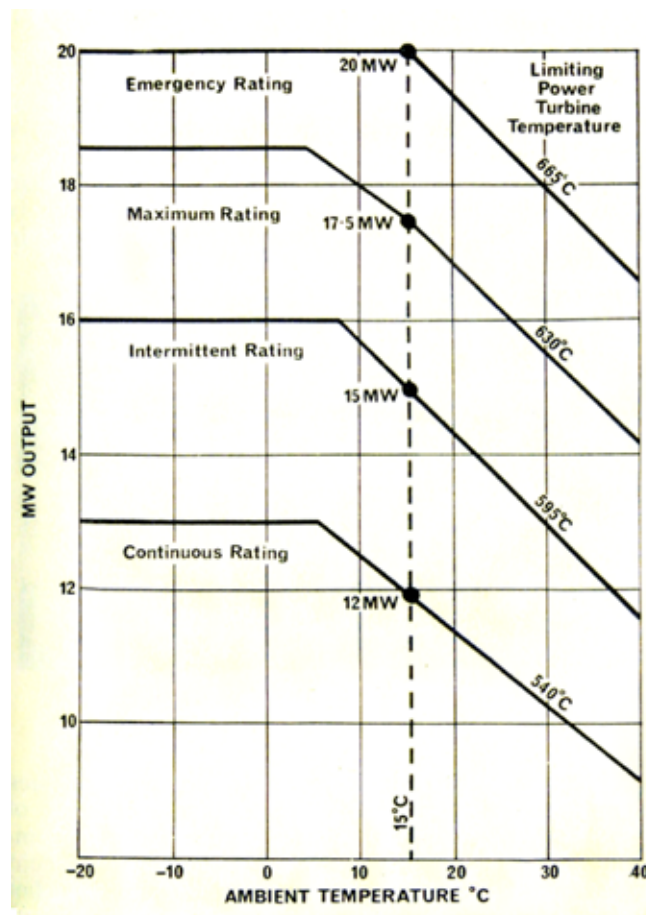


Fig. 19
Rating and overhaul period

By December 31st, 1965, the installation at Hams Hall had completed a total of 1 639 hours operation under commercial conditions embracing 370 hot and cold starts and achieving a specific fuel cost of 0.989d. (.824c) per kWh running on light diesel oil at one shilling (10 cents) per gallon to specification BSS 2 869 at the lower calorific value of 18 530 Btu/lb. The performance of subsequent production units supplied to the Generating Board and other customers has been consistently within the same bracket and a fuel consumption of 0.708 lb per kWh is guaranteed at the peak load rating of 17½ MW. All the Olympus gas generators in service are running on light distillate fuel oil to this specification but the engine will operate equally well on natural gas and other approved fuels.

Filtration of the air taken into the engine is indispensable on the normal industrial site. The units developed on the Hams Hall installation are of the dry roller type designed to remove 98 per cent of the dust particles above 5 microns. The normal air velocity through the intake ducts is 30 ft/s and should the pressure drop across the filters exceed 3 inches water gauge the loaded section is automatically replaced. Shutters set at a slightly higher pressure difference open to prevent the filters being sucked into the intake should this mechanism fail. Silencing presents no difficulty and the use of standard type splitters constructed as perforated sheet metal partitions enclosing fibrous mineral packing have proved acceptable in practice.

The exhaust gas velocity is diffused to about 135 ft/s before leaving the stack which has to be of sufficient height in relation to surrounding buildings to prevent down draught. Acoustic splitters of annular construction concentric within the stack and manufactured from fibrous mineral wool sandwiched between perforated steel sheet have given every satisfaction. A compromise between the exit velocity and the diameter of the silencer is necessary. If the diameter is too large noise from the power turbine will pass undamped into the atmosphere. A high exhaust velocity will generate aero-dynamic noise at the periphery of the exit as a result of rapid acceleration of the entrained free air (Fig. 20).



Fig. 20
Gas generator exhaust stacks at atomic power station.

Readings taken around the second 17½ MW gas turbo generator to be built at St. Helier, a residential district in the Channel Islands, indicated a lower noise pressure level above a mid-frequency band of 125 c/s from the gas turbine than from adjacent diesel plant running at 10 MW load (Fig. 21). The annoyance rating of noise is subject to an impressive list of variables but in general a high-pitched sound is more irritating than one of a lower note. Noise criterion curves established by the International Electro-Technical Commission weighted for acceptability with suggested environmental corrections indicate that at worst the noise from this power station measured at a point 100 yards distant is about the same as that inside a gymnasium (Fig. 22).

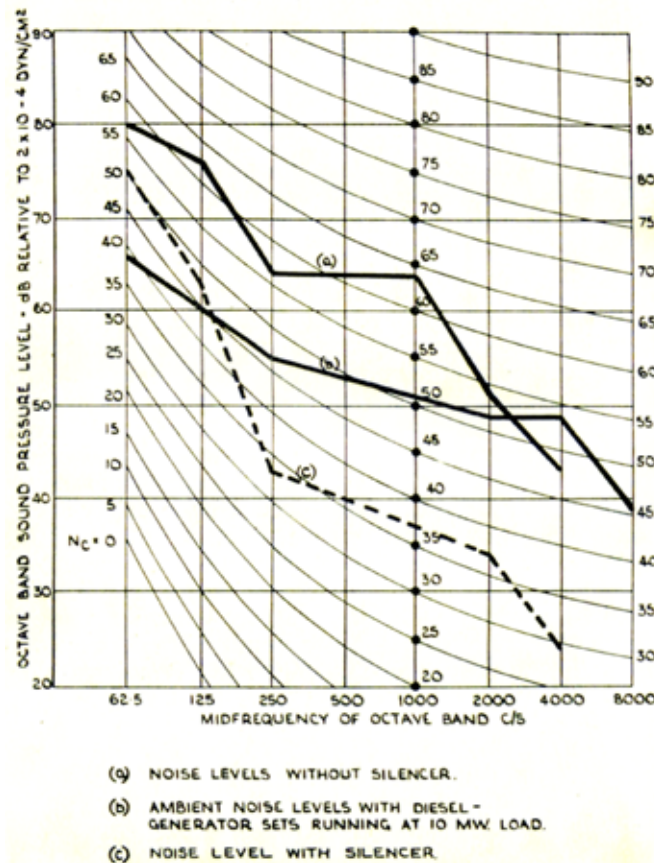


Fig. 21

Noise levels 100 yd from stack-Jersey station.

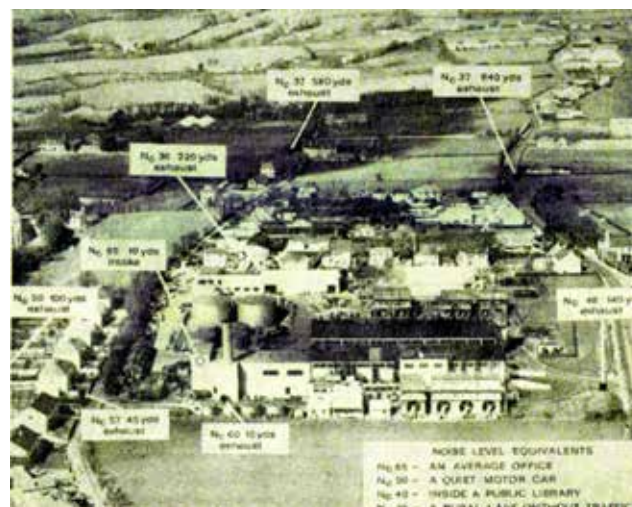


Fig. 22

Diesel and gas turbine station

The experience gained in the successful operation of these installations demonstrated that industrial gas turbines based on the aero jet type of gas generator were a viable proposition and that any modifications required to adapt them to power station use were within the scope of normal industrial technique and not unduly expensive. Consequently the Central Electricity Generating Board decided that peak load gas turbo generators should be installed in the London area which constituted the largest power consuming district in the country, containing about one quarter of the total population with the highest rate of increase in gross consumption and importing almost all its electricity from the large power stations situated on the rich coalfields of the Midlands, 100 miles distant. Two sites were chosen north and south of the city, each station to consist of two 60/70 MW units. It was decided to use as much as possible of the 17½ MW design because all vibration checks had been satisfactorily concluded on the rotating assembly and the tooling for blades, stators and discs was in existence (Fig. 23).

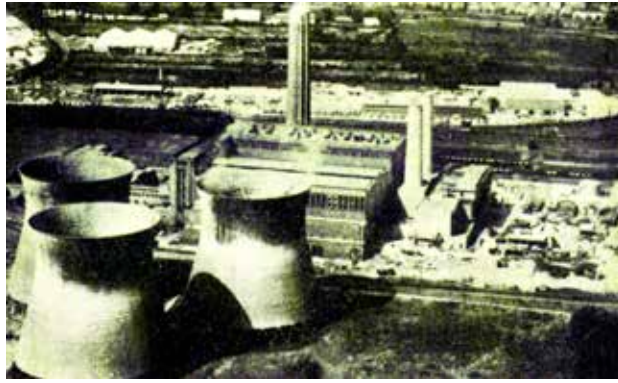


Fig. 23
Rye House steam and gas turbine station.

The power turbine system of these large engines is made up of two 35 MW units each consisting of two $17\frac{1}{2}$ MW turbines mounted either end of a common shaft supported in white metal bearings adjacent to each two-stage wheel assembly overhung either end of a common pedestal, two of these duplex turbines being connected by a gear tooth coupling to form a 70 MW power unit. Two pairs of gas generators are mounted at right angles to the axis of the main shafting and individual gas ducts join each unit to one of the power turbine inlet volutes fixed to the four stator casings (Fig. 24).

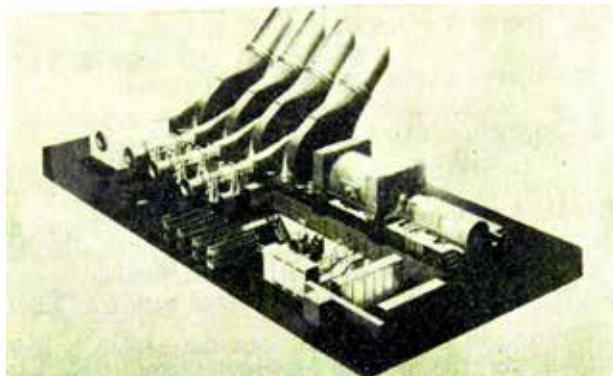


Fig. 24
70 MW gas turbine.

The oil pumps and other accessories such as the speed signal generator, overspeed trip and the barring motor are all mounted on a gearbox driven from the free end of the power turbine shafting. An automatic clutch is incorporated into the drive from the power turbine system to allow the alternator to run disengaged for power factor correction. One section of the turbine is sufficient to spin the alternator to the correct speed, while the other three “windmill” during the operation, the losses of each spinning power turbine wheel being of the order of 1 MW. The generators are the same in all essentials as those developed for steam power stations in the 1940s which materially assisted in obtaining the delivery so urgently required.

To meet the demand for a 35 MW turbo generator of more compact construction a single stage power turbine on the same lines as the original $17\frac{1}{2}$ MW unit has been designed but it is energized by two Olympus gas generators operating in parallel. Two of these 35 MW gas turbines can be arranged to drive into either end of a single 70 MW alternator with clutches in the drive shafts to enable either one or the other or both engines to be operated at will, resulting in a material improvement in the part load performance of the installation. Clutches in each drive shaft ensure uninterrupted operation on one engine should trouble be experienced on the other and without impairing the use of the alternator for power factor correction (Fig. 25).

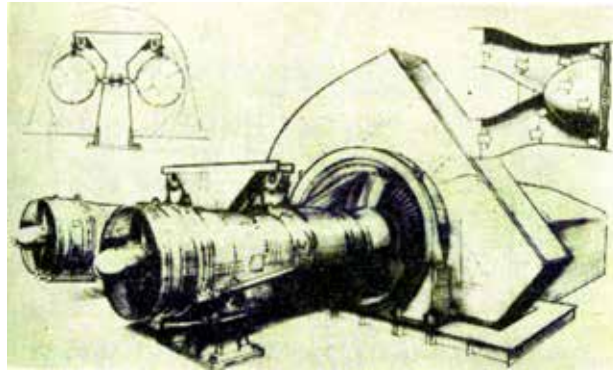


Fig. 25
35 MW turbo generator.

This effected a significant reduction in the specific capital cost of the mechanical equipment and the resultant layout has enabled the grouping of a number of 35 MW turbo generators in a building of conventional materials in which a power density of 9 kW/ft² of superficial area is attained and must be unique in power station construction (Fig. 26).

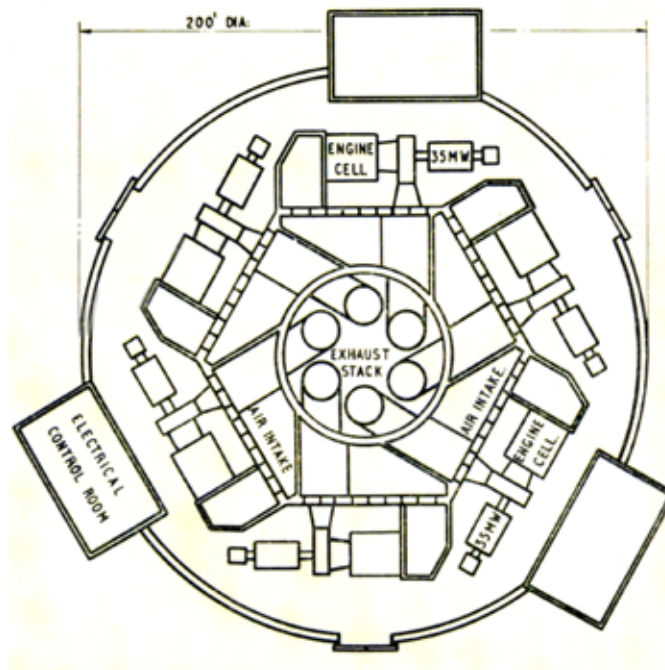


Fig. 26
Plan of 210 MW gas turbine station.

There is a growing interest in the Central Electricity Generating Board for gas turbo generators of still greater output for reasons quite apart from the economics associated with size. The Board's total generating capacity is now over 30 000 MW and it is evident that peak load stations of still larger capacity are required if they are to make noticeable contribution. On the other hand, existing switchgear and transformer capacity on the 132 kV system limits the acceptable output of single alternator sets to 120 MW. This is within the scope of six Olympus gas generators at the present rating on a cold winter's day when electricity is at a premium and peak load generation a necessity. An engine conforming to the same design philosophy as the 70 MW unit previously described but using three Olympus gas generators to drive two power turbines rated at 52½ MW each meets this requirement representing about the present limit of established gas turbine design and manufacturing technique (Fig. 27).

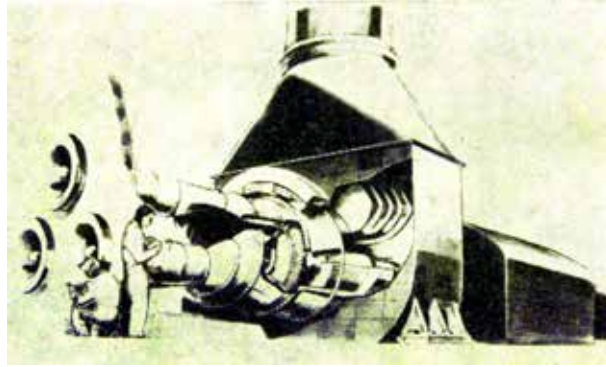


Fig. 27
52½ MW gas turbine.

A characteristic of the British electrical system is the growing importance of the domestic load which is more unpredictable in the short term than either the industrial or commercial demand. It is well known that the termination of a popular television programme will check the normal decay in consumer demand towards the end of the day and instances of a surge of 1 000 MW in six minutes concentrated in the London area are on record (Fig. 28).

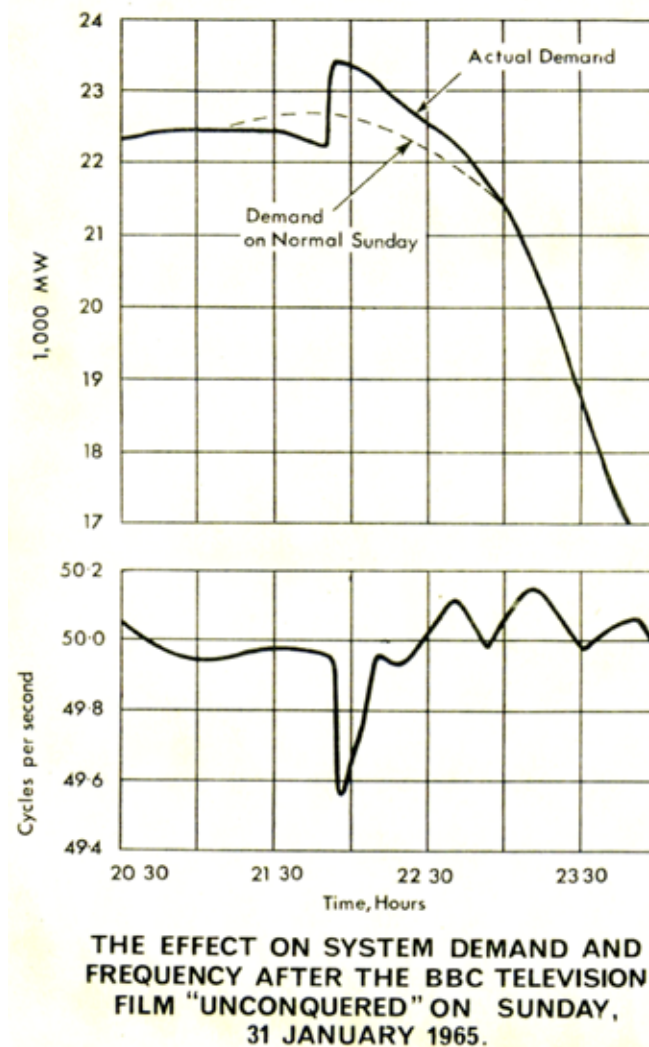
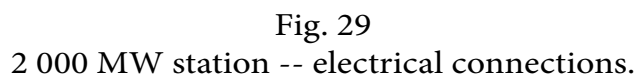


Fig. 28
Consumer demand-evening decay.

A sophisticated automatic and interconnected electrical system without adequate local and independent sources of power available on demand is susceptible to serious dislocation following a rapid increase in load of this magnitude as was instanced in the London area on May 15th, 1961. The consequential drop

In the modern 500 MW boiler turbine alternator sets these auxiliaries are connected to a unit board which is interconnected with the station board for starting purposes but is normally serviced from the terminals of the alternator through a unit transformer. It is now standard practice on all new construction to arrange for one gas turbine set to be directly connected to each unit board (Fig. 29).



To be Continued....