WCB ENGINEERING BULLETIN

Vol.31 No1

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

MARCH 2022

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

Membership Fees:
I would like to thank all members who have paid their fees for 2022 thus far this year.
However, a number of payments have been received which do not have clear information on who has made the payment! – **while the invoice clearly states to please use the invoice number as a reference**!
This is not a good state of affairs as such a payment cannot be credited to whoever made the payment. So, **PLEASE** let us know should you be aware of your company making a payment and you suspect an incorrect reference has been used. THANK YOU!

We will be following up with members in the next month or two who have not as yet made the necessary payment.

In this Bulletin, there is an invitation for persons sitting the GCC examinations in June to attend a GCC Masterclass set of sessions on a virtual platform.
We have the normal Questions and Answers for Factories and Mining GCC examinations.
Part 5 and final part of an article taken from the ICMEESA Archives – from The Certificated Engineer volume 39 – 1969. Titled – ELECTRICITY GENERATION AND THE GAS TURBINE.

Any contributions to future editions of this Bulletin from members would be welcome.

I further include a link to a copy of the February ENERGIZE and March 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.

There is also a short item from ECSA, where ECSA is asking for comments. If interested, please follow the link to the ECSA website.

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

Chris Schnehage
chris@icmeewc.co.za

LOCAL BRANCH NEWS

Activities of the Western Cape Branch since the last Bulletin were as follows:

We have not had any Branch activity during the year so far due to the continued COVID Pandemic.

We appeal to members who have an interest to please suggest a topic for discussion and assist with arrangements.

Until next time, Ciao for now!

Chris Schnehage
Tel: 083 326 8023
Email: **chris@icmeewc.co.za**

Plant Engineering: MINES mechanical question

QUESTION:

Give FOUR reasons why the AC electromagnetic testing of winding ropes cannot replace the regular visual inspection by the engineer. [4]

Proposed Solution:

(i) The regulations call for a record of the length of the lay.
(ii) The engineer is required to examine the attachment of the rope to the conveyance.
(iii) The ac testing apparatus will not pick up a broken wire unless the wire is missing over a length comparable with that of the magnetizing and search coils.
(iv) Deformation of the rope due to slight movement of the strands may be detected only by visual examination.
(v) The engineer should pay attention to the state of lubrication of the rope, as the apparatus will only indicate the effect of prolonged lack of efficient lubricating

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A Legal Knowledge: MINES question

QUESTION (November 2021, Question 4):

You are the engineer in charge of a shaft that uses winding plants. A conveyance got stuck in the shaft causing slack rope to occur. What safety precautions need to be taken to rectify the situation, where is it necessary to install a slack rope device, what does a slack rope device do? [10]

Proposed answer

16.9.2.3 The employer must establish an effective and safe procedure for rectifying any slack rope condition.

16.9.2.4 All winding operations in the vertical shaft must cease when a slack rope condition occurs, except such operations necessary for rectifying the slack rope condition authorised by the engineer or person appointed in terms of regulation 2.13.2.

16.9.2.5 No winding operations may resume, except operations permissible in terms of regulation 16.9.2.4, until the slack rope condition has been rectified.

6.9.2.1 The employer must install a device or combination of devices that detect slack rope on every winding plant which the rope is attached to the drum operating in a vertical shaft, excluding a shaft in the course of being sunk.

16.9.2.2 The device or combination of devices contemplated in regulation 16.9.2.1 must on detecting a slack rope condition either automatically halt all winding operations in the vertical shaft safely or warn all winding engine drivers operating in such shaft of the slack rope condition.

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Plant Engineering: FACTORIES mechanical question

QUESTION:

The electrically driven crab of an overhead crane can lift a mass-load of 5 000 kg. Its traversing speed is 0,375 m/s; its own mass is 2 500 kg. The traversing drive has no mechanical brake and depends solely on electrical braking assisted by the resistance of the wheels on the track which can be taken as 1 350 N when the crab is fully loaded.

Calculate the maximum distance the crab will travel when fully loaded if, because of a power failure, there is no electrical braking. The relevant features of the traversing drive are as follows:

Moment of inertia of motor armature:	0,04 kg m^2
Speed of motor:	950 rev/min
Diameter of wheel:	250 mm

The wheels are driven by double reduction gears with ratios of 18 to 110 and 15 to 82 and the efficiency of gearing is 85%.

[15]

Suggested Answer:

Let linear deceleration = a m/s^2

Deceleration of wheel, $\omega_w = \dfrac{a}{\text{radius of wheel}}$

$$= \frac{a}{0.250/2}$$

$$= \frac{a}{0.125}$$

$$= 8a \text{ rad/s}^2$$

Overall gear ratio = $\text{ratio}_1 \times \text{ratio}_2 = 110/18 \times 82/15 = 33.4$ to 1

Deceletration of armature, ω_a = oveall gear ratio $\times\ \omega_w = 33.4 \times 8a = 267a \text{ rad/s}^2$

Decelerating armature torque, $T_a = I \times \omega_a = 0.04 \times 267a = 10.67a$ Nm

Now calculate the torque on wheels neglecting gearing efficiency

$$T_w = T_a \times \text{oveall gear ratio} = 10.68 \times 33.4a = 357a$$

Force on wheel periphery, $F_w = \frac{T_w}{r_w}$

$$= \frac{357a}{0.125}$$

$$= 2856a$$

Since gearing provides a decelerating force, the required force on the wheel periphery to decelerate the armature is:

$$F_a = F_w \times \eta_{gear} = 2856a \times 0.85 = 2428a \text{ N}$$

Mass subject to linear deceleration:

$$m_{crane} = m_{load} + m_{crab} = 5000 + 2500 = 7500 \text{ kg}$$

Decelerating force, $F_{crane} = m_{crane} \times a = 7500a$ N

Total decelerating force $= F_{crane} + F_a = F_{track}$

$$\therefore 7500a + 2428a = 1350$$

$$\therefore a = \frac{1350}{7500 + 2428}$$

$$= 0.136 \text{ m/s}^2$$

From $v^2 = u^2 + 2as$

but the final velocity $v = 0$

$$\therefore s = \frac{-u^2}{2a}$$

$$u^2_{traversing} = 2as$$

$$\therefore s_{on\ power\ failure} = \frac{-u^2_{traversing}}{2a}$$

$$= \frac{-(0.375)^2}{2 \times -0.136}$$

$$= \mathbf{0.517\ m}$$

Note: a is negative as it is a deceleration

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A Legal Knowledge: FACTORIES question

QUESTION (November 2021, Question 5):

5.1 Define the following terms as given in the Ergonomics Regulations, 2019:

5.1.1 Ergonomic risk (1)

5.1.2 Ergonomic risk assessment (1)

5.2 Where there is a potential ergonomic risk, an employer must, after consultation with health and safety committees or representatives, establish a training programme that incorporates the contents of the Ergonomic Regulations, precautions taken by employees to protect themselves and the necessity for medical surveillance.

Name TWO other aspects which such training programme must incorporate. (2)

5.3 What must an employer do to prevent or at least control that a person is not exposed to ergonomic risks? (2)

5.4 Every employer must, as far as is reasonably practicable, ensure that any ergonomic control provide for the benefits of employees complies with the Ergonomic Regulations.

Name Two other aspects the ergonomic control must comply with. (2)

5.5 An employer must keep various records in connection with ergonomics.

5.5.1 For what period must the records of ergonomic risk assessments be kept? (1)

5.6 For what period must the records information, instruction and training be kept? (1)

Suggested answer:

5.1.1 "Ergonomic risk" means a characteristic or action in the workplace, workplace conditions, or a combination thereof that may impair overall system or performance and human well-being

5.1.2 "Ergonomic risk assessment" means a programme, process or investigation to identify, analyse, evaluate and prioritise any risk from exposure to ergonomic risks associated with the workplace

5.2 (a) potential source of exposure to ergonomic risks;
(b) nature of ergonomic risk;
(c) potential risk to health associated with ergonomic risks;
(d) control measures that are in place to prevent;
(e) procedure for reporting ergonomic risks to the H&S reps or employer.

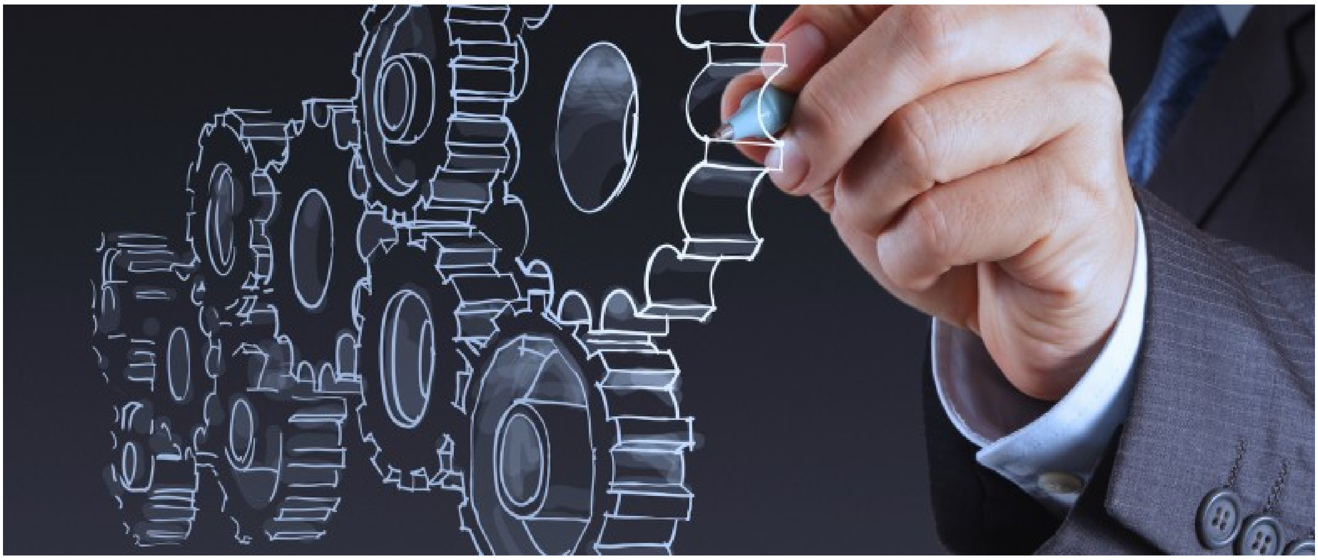
5.3 As far as is reasonably practicably, remove or reduce exposure by implementing control measures in accordance with the hierarchy of controls

5.4 (a) is fully and appropriately implemented
(b) is maintained in good working order

5.5 10(b)(i) 40 years

5.6 10(b)(ii) the length of time the employee remains at the workplace

The Institution of Certificated Mechanical and Electrical Engineers, South Africa



LIMITATION
Online seats are limited (100) and preference will be given to candidates writing their exams in June 2022.

RSVP
Click HERE for registration form or contact the Secretary
info@icmeesa.org.za

LOCATION: Will be a virtual presentations using ZOOM platform.

First National Bank
Eastgate Branch
Branch Code: 257705
Account No: 50390026406
Ref: Use your Identity Number
Amount: R750

https://forms.gle/UdU7ucoFEtL18Mry9

Government Certificate of Competency Pre-Examination Candidate Masterclass 16-20 May 2022

TRAINING SCHEDULE

- **Monday 16/05/2022 18:00 to 19:00**
  Mechanical Exam Question (Willem vd Westhuizen)
- **Tuesday 17/05/2022 18:00 to 19:00**
  Electrical Exam Question (Greg Clack)
- **Wednesday 18/05/2022 18:00 to 19:00**
  Mechanical Exam Question (Willem vd Westhuizen)
- **Thursday 19/05/2022 18:00 to 19:00**
  Electrical Exam Question (Greg Clack)
- **Friday 20/05/2022 10:00 to 11:30**
  Legal Matters (Greg Clack) &
  Department of Labour and Employment presentation

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ECSA

Please take a look at the items on the following link to the ECSA Website on which a request for comment before 29 April is requested. It would be appreciated if interested members take time to peruse the Electrical and Mechanical Codes of Practice and submit responses direct to ECSA.

Thank you
ECSA LINK

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ELECTRICITY GENERATION AND THE GAS TURBINE Part 5

DECENTRALIZED POWER STATIONS

The basic concept of peak load generation implies a low annual utilization with the minimum capital investment and any benefits which may be thought to accrue from an extension of the gas generator overhaul period at the expense of the engine rating will be offset by the lower thermal efficiency and higher specific capital costs. Conversely it is vitally important to keep the expenditure on buildings and civil engineering to the minimum commensurate with adequate silencing and a sound weatherproof covering for the electromechanical equipment.

At a utilization of 400 hours per annum a reduction of ten shillings (R1.00) per kW in the cost of civil engineering and ancillary works is equivalent to a reduction of 30°C in the gas generator first stage turbine entry temperature or an increase of five times in the creep life of the blade. The power station structure has a limited useful life and should be subject to the same economic strictures as the electromechanical gear. Unwarranted expenditure on civil engineering works acts as a deterren t to the adoption of these specialized power stations.

It is fitting that a modern power plant like the gas turbine, on which an enormous amount of research and development has been expended, should be housed in a structure designed to take advantage of the latest acoustic technology and constructed of standardized prefabricated factory-built components facilitating preplanned assembly on site to reduce outside erection time and costs (Fig. 30).

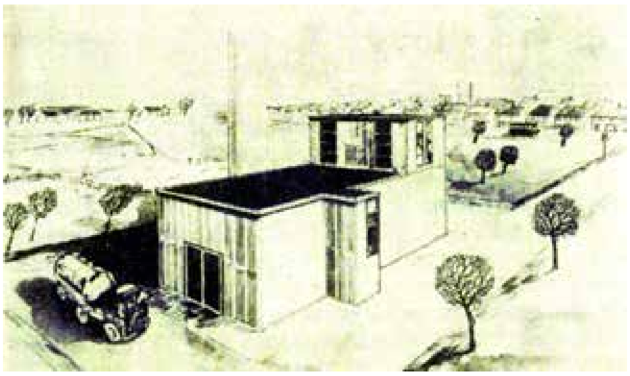

Fig. 30
Modern prefabricated power station.

Packaged power stations complete with all auxiliaries are now available which can be completed on prepared foundations in a matter of weeks rather than years. The structural and civil engineering costs are about one-third of those associated with more conventioned building practices and there seems to be no reason why a 70 MW gas turbine peak load power station should not be completed for an all-in cost including land of £20 (R40.00) per kW, dependent upon its location (Fig. 31).

The systematic generation of the peak load at the point of usage should assist materially in the improvement of the operating economics of the electricity utilities of the future. A logical development of these decentralized generating stations would be to increase the overall economics and utilization by distributing the otherwise waste heat from the exhaust for district heating. The most modern steam plants and the best diesel engines alike convert only about 40 per cent of the heat supplied into useful work. In this respect they are far superior to the gas turbine in which the energy in the exhaust is about 75 per' cent of that. consumed. The heat rejected, however, is of a high quality and the gases at a temperature of about 450°C can be released at pressures adequate to pass through a heat exchanger of reasonable specific cost without unduly impairing the performance of the gas turbine itself. Moreover, the products of combustion when using distillate oil or natural gas are singularly free from corrosive or other undesirable elements.

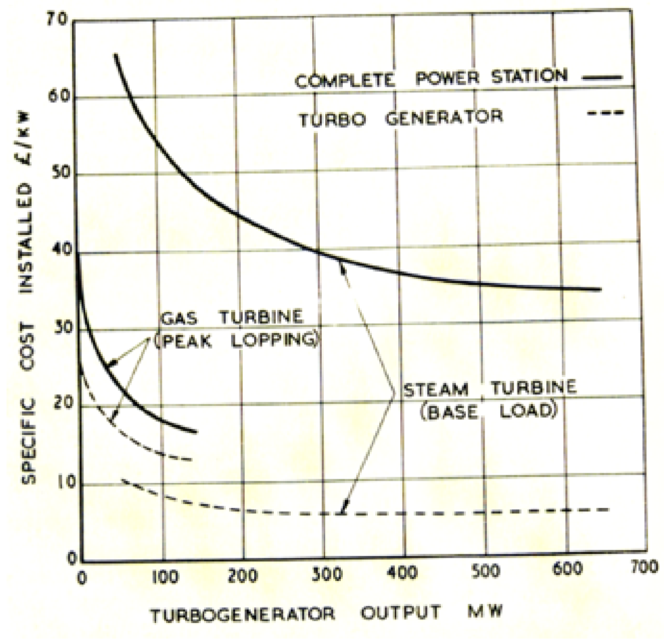

Fig. 31
Relative capital costs-steam and gas turbine.

As the gas turbine exhaust contains about 18 per cent of unburnt oxygen it may also be used as a preheated air supply for further combustion, so the gas turbine is certainly superior in terms of usable heat output per horsepower hour than either steam or diesel engines. This characteristic, if exploited, could raise the equivalent thermal efficiency of the turbo generator set by about three times (Fig. 32).

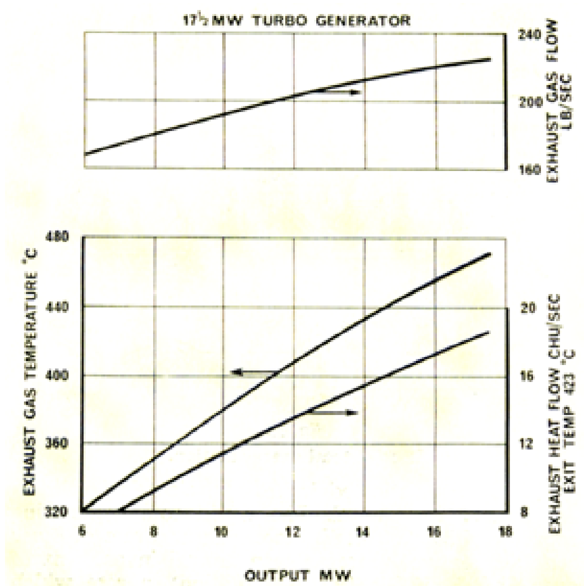

Fig. 32
111 MW electrical output and heat rejected.

The concept of total heat utilization is already an established practice in the United States of America, where all services in modern hotels, laundries, bakeries, etc., can be supplied from one source of primary energy-oil or gas. Small gas turbines of robust construction driving generators and vapour compressors working in conjunction with waste heat boilers and absorption type coolers satisfy the demand for electric power, fluorescent lighting, space heating, hot water and refrigeration. The output of these "on site" generating sets ranges between 100 hp and 1 000 hp and it is predicted that the number of operational units will have grown from six in 1960 to three hundred by the end of 1966.

A total heat scheme utilizing an after boiler designed to operate with an Olympus gas turbine coupled to a 15 MW generator for base load electrical supply is expected to provide 68200 lb/h of steam at 250 psig and 500°F when the gas turbine is at full load. The plant is completely automatic in operation and will accommodate fluctuations in the industrial load and variations in climatic conditions, modulating the supply of electricity and steam independently over a wide range to meet the following conditions:

(a) Waste heat boiler alone working in conjunction with turbo generator.
(b) Auxiliary oil fired unit working alone with turbo generator shut down.
(c) Both units working in parallel, the oil fired burners being used to boost the steam supply to meet the heating load at reduced electrical output.

A steam accumulator is included to meet the need for space heating at times of low electrical demand while at high electrical loads and a modest demand for steam the turbine exhaust gases may be by-passed direct to the exhaust stack (Fig. 33).

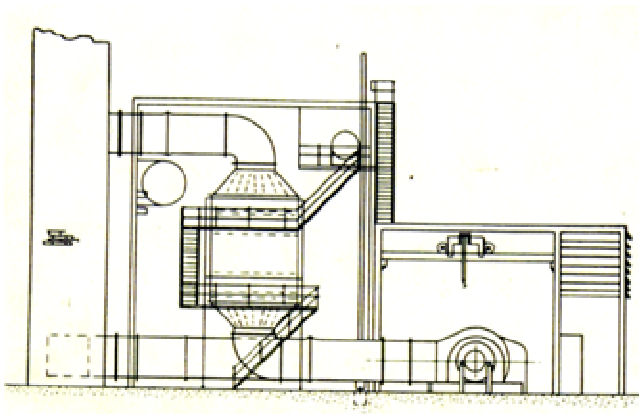

Fig. 33
15 MW total energy station.

Like all sophisticated industries, electrical utilities are hungry for capital. The world total generating capacity of 850000 MW, increasing at a ra:te of 8 per cent per annum, represents an annual investment of over £8 000 million (R16000 million), a rate which will have more than doubled by 1976. Current expenditure on the electrical utilities in Great Britain alone is over £700 million (R14 000 million) per annum. Although an expanding electrical system is essential to enable industry in general to contribute to the overall increase in the nation's economy, the expenditure of such a large proportion of the gross national product can only be achieved at the expense of other industrial activities. Indeed, the cost of providing electrical energy is becoming a major problem and the difficulties of transmission are by no means incidental. The capital cost of the network keeps pace with the increasing cost of the power station and just as a point has been reached where improvements in the thermal efficiency of generation show diminishing returns as size, temperature and pressure are increased, the time is near when little relief can be expected from significant gains in transmission efficiency.

The cost of land and the difficulty in obtaining suitable sites as well as a falling water table close to many large industrial load centres will make it necessary to locate these large power stations remote from densely populated areas. The advent of nuclear plant will not alleviate the difficulty as safety considerations may well inhibit their construction close to the major cities in spite of the rising cost of right of way and an articulate and growing public resistance to a multiplicity of transmission lines which cost with their appendages just as much as the generating stations themselves. Moreover, the comfort load of the modern city is becoming of greater relative importance and it seems wrong to go through all the difficulties of converting expensive primary energy into still more expensive secondary energy only to dissipate a major portion in the form of heat. The creation of new townships in the developing areas pre-planned around a variety of industrial and social activities could well provide an opportunity for all the energy requirements to be supplied by a decentralized total heat gas turbine power station operating at an equivalent thermal efficiency of say 75 per cent with the minimum distribution losses.

The availability of natural gas as a competitive fuel piped direct to automatically controlled total energy distribution centres could have a profound effect on the electrical systems of the future, providing a classical example of automation in energy extraction, transmission, conversion and distribution.

Appendix A

ESTlMATED TOTAL COST OF GENERATION FROM LONGANNET THERMAL POWER STATION

(4 sets of 600 MW)

Year of operation	Load factor	Unit cost
1	74%	0.588d.
11	41 ~~	0.624d.
14		0.675d.
21		0.762d.
26	16%	0.589d.

Overall thermal efficiency 38.9% at 75 % load factoraccounting life 25 years.
(Report of Scottish Development Department, Edinburgh, 5th October, 1964.)

Appendix B

17t MW OLYMPUS TURBO GENERATOR (Performance at NTP (15°C 29.92" Hg)

Assuming a pressure drop of 9.4 in water gauge through the air Intake filters and a static pressure of 2.5 in water gauge at the power turbine exit the following statistics apply:-

Gas turbine power ...	24 500 Shp
Gas turbine speed	3 000 rev/min
Gas turbine LP compressor speed	6 300 rev/min
Gas generator air mass flow	230 lb/s
Gas turbine HP compressor speed	7 800 rev/min
Gas generator pressure ratio	10 : 1
Gas generator turbine entry temperature	887°C
Inter turbine temperature	630°C
Inter turbine pressure	36 psi
Power turbine exhaust temperature	470°C
Power turbine exhaust pressure	15.3 psia
Alternator output	17 500kW
Alternator efficiency	96%
Turbo generator specific fuel consumption	.708 Ib/kWh
Turbo generator overall thermal efficiency	26%

Appendix C .

NATIONAL PHYSICAL LABORATORY

Symposium No. 12

NOISE RATINGS

No.c values related to sound pressure level in db measured at mld-f:~quency band of 1 000 cis and weighted for pitch acceptabiljjy,

Broadcasting studio	15
Concert hall, legitimate theatre 500 seats...	20
Class room, music room, TV studio, conference room 50 seats....	25
Sleeping room (see corrections below)..	25
Conference room 20 seats or with public address system, cinema, hospital, church, courtroom, library............................	30
Living room (see corrections below)..	30
Private office..	40
Restaurant	45
Gymnasium..	50
Office (typewriters)	55
Workshop	65
Corrections for dwellings	
(a) Pure tone easily perceptible	-5
(b) Impulsive and/or intermittent	-5
(c) Noise only during working hours..	+5
(d) Noise during 25 % of time	+5
6% ....+10	
1.5% ....+15	
0.5% ....+20	
0.1% ....+25	
0.02% .....+30	
(e) Economic tie	+5
(f) Very quiet suburban	-5
Suburban	0
Residential urban	+5
Urban near some industry	+10
Area of heavy industry	+15

Appendix D

171- MW TURBO GENERATOR

Energy conversion

Specific consumption	0.708 Ib/kWh
Fuel consumption	12390 Ib/h
Heat input	127.62 x 106CHU/h
Shaft horsepower	24400
Electrical output	17500 kW
Heat equivalent of Shp	34.56 x 106CHU/h
Heat equivalent of electrical output	33.18 x 106CHU/h
Gas flow	820800 Ib/h
Power turbine exhaust temperature	470°C
Boiler outlet temperature	150°C

Available heat	67.00 x 106CHU /h
Transfer loss	1.7%
Useful heat	65.8 x 106CHU/h

Efficiency of conversion

Electrical output	26%
Useful heat	51.6%
Total useful energy	77.6%

Appendix E

OLYMPUS GAS GENERATOR
LIST OF LIQUID AND GASEOUS FUELS

LIQUID

Fuel	Specification	Remarks
Diesel	BS.2869 Class A, F75 DEF. 2402B, DIES0.47/0	
Gas oil		
Domestic fuel oil	DEF.2403A	Fully distillate
Kerosene	DEF.2494. A VTUR, JP I	
Naphtha		Additive required
Furnace fuel oil	DEF.2406A	Emergency use only
Diesel fuel	Class B	

GASEOUS

	LCV BTU/LB	LCV K CAL/KG	Remarks
Natural	21 800	12 100	Used by Proteus at Schachtbau-Lingen
Natural	12 100	6 700	Contains 16% inerts
Refinery	21 200	11 800	H2C1C2C3C4 700 BTU/FT3
Minimum requirements	10 000	5 500	6 200 K.CAL.M3

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VOTE OF THANKS

Mr L. L. Brinkworth (Visitor): It is not merely a pleasure, but certainly a privilege, to propose this vote of thanks to Mr W. U. Snell. The paper is certainly complete, so much so that it is difficult to add further useful comment, except perhaps to draw some comparisons between conditions in Europe, on which the data in the paper is based, and conditions in South Africa where the influence of low cost of coal, coupled with higher ambient temperature and, in the Transvaal, higher altitudes, can be important.

For instance, owing to the tremendous amounts of cheap coal available in the Transvaal and, to a lesser degree in the O.F.S. and Natal, I feel that our corresponding dotted curve on Fig. 9 for steam power generation will lie more to the left and will probably cross the gas turbine peak load line at a value less than at 700 hours, especially for our inland power stations.

On the general question of power generation, our first thoughts turn to ESCOM who provides 80 per cent of the Republic's needs for electricity. Whilst ESCOM's rate of growth is about 7½ per cent annually, which is just about the same as that given in Fig. 1 for Europe, an interesting consideration is that ESCOM's rate of growth is about 7½ per cent annually, given in the paper, having grown from 60-70 per cent in 1920 to around the 80 per cent mark today. In the Rand and O.F.S. areas the daily load factor is even better, being as high as 88 per cent due to the large block of power taken at a high load factor by the mines, though this will no doubt drop in the future to possibly 75 per cent over the whole country as the mining load diminishes.

Due to our high load factors, coupled with the cheaper coal in this country and assuming that our oil should not be different in cost from that in the U.K., I think that the capacity utilization curve in Fig. 10 will be higher in relation to maximum demand and that the peak shown for gas turbine application will be rather smaller in area.

Nevertheless, I am sure we all agree with Mr Snell that each case for the possible application of a gas turbine for peak load lopping, or for standby service, must be considered in detail, as there may well be economic applications on careful study, not forgetting the advantages of quick starting and the facility for remote control. Additionally we must remember that cooling water is becoming precious in South Africa and this factor alone is a big advantage in favour of the gas turbine.

Despite our higher ambient temperature compared to Europe and the high altitude here, both of which involve de-rating factors, a striking South African example of an economic application of the gas turbine occurs in Johannesburg, which will have the first gas turbine generating plant to be installed in this country. The Johannesburg Municipality are shortly to install two 22MW gas turbine generating sets which are to go into the old President Street "City" power station. Here the steam side of the existing equipment has completed its useful life and has been shut down. All the electrical equipment is good for many years of service and, more important, these gas turbine sets will be situated in the heart of the city, where the load is most needed, either in an emergency or for peak load conditions. Thus the gas turbines will drive existing alternators which are coupled to existing switchgear. This was an important economic factor when considering their purchase. These Johannesburg sets will each have twin Avon engines, which are rather simpler though less efficient than the Olympus engines described by the author.

De-rating of the gas turbine due to altitude can be about 3½ per cent in output per 1 000 feet, but de-ration due to high ambient temperature, which is about 18 per cent from 5°C to 30°C, is not as bad as it might at first seem. For instance, taking average values 15°C to 25°C for Johannesburg, the drop in output is only about 7½ per cent, but more important is the fact that peak loads are more likely to occur when the temperature is low, which is when the gas turbine output is greatest.

Another possible application of a gas turbine generating set can be where there is a long single radial transmission line running away into the country, with no interconnection with any other power source. If a gas turbine be installed at the far end, it can not only feed power back to the point of supply disconnection in an emergency, but it can also be useful when sections of the transmission line have to be taken out of service for maintenance. Then only the consumers in the section that is out are affected, not those at the far end.
In conclusion, we in this Republic much appreciate the benefit of a paper by such a specialist and experienced author as Mr Snell and on behalf of you all I would like to thank him for personally presenting his paper tonight.

Mr K. Hedley (Visitor): Mr Snell has covered his subject in great detail, and has made out a strong case for the use of gas turbines to meet peak load demands.
The high capital cost and our all too frequent dry seasons, coupled with our topography, would appear to rule out the possibility of pumped storage as a means of meeting peak load demands. The great advance in the development of heat resisting steels and improvements in turbine and turbo compressor design has brought the modern gas turbine into the limelight. The simple open cycle plant consisting of a compressor, a combustion chamber and a turbine is able to provide energy to drive generators because the hot combustion gases passing through the turbine are of considerably greater volume than that supplied by the compressor. The quantity of air through the turbine varies from between 5 to 8 times the quantity theoretically required for combustion, and thus there are considerable waste gas losses, but this excess air is necessary to limit the

combustion gas temperature to within the region of 1 250°F. The limiting factor is the material. No doubt, as the metallurgist improves heat resisting steels, these gas losses may be further reduced. Coupled with these gas losses are the mechanical and aerodynamic losses which result in a rather modest thermal efficiency of 18 per cent for the open cycle gas turbine. There are several installations of this nature in operation on the Continent. This type of unit is used on oil pipe line booster duties where cheap fuel renders efficiency not of prime importance.

The addition of the recuperator to the cycle whereby the waste gases are used to heat the compressed air before entering the combustion chamber effects a saving in the fuel required to heat the gases to the required temperature, and, depending upon the size of the recuperator, this may boost the efficiency to about 28 per cent as is the case of the Hams Hall installation quoted by Mr Snell. However, a recuperator increases the cost of the plant quite considerably, and its introduction into the cycle must be considered in conjunction with the duration of peak demand and fuel costs.

The more recent inclusion of waste heat boilers, fired or unfired, in the cycle further considerably enhances the case for the gas turbine. In Switzerland a plant now being installed incorporates a gas turbine and generator of 19 MW capacity, and an unfired waste heat boiler driving a steam turbine and generator of 6 MW capacity. This plant is designed for an operating time of 6 000 hours per year. A preliminary exercise proved that the combined plant would generate power at a cheaper rate than either a diesel, steam or gas turbine plant of similar size.

In this exercise the following assumptions were made:
1. Turnkey projects complete with high tension equipment.
2. The diesel and the gas turbine are to be without recuperation of waste heat and without process steam generation.
3. European conditions.
4. Amortisation over 15 years.
5. Interest on capital of 6 per cent.
6. Ambient temperature of 5°C.
7. Heavy oil fuel at Sw. Frs. 65 per ton (R10.00)

Then based on an operating period of 6 000 hours per year the calculated cost per KWh is:
(a) Diesel 0.65 cents;
(b) Steam 0.65 cents;
(c) Gas turbine 0.63 cents;
(d) Combined gas turbine/steam turbine 0.56 cents.

Perhaps the most interesting observation in this exercise is that this plant proves to be economical over a period of 6 000 hours per year.
With these few observations that I have pleasure in seconding this vote of thanks to Mr Snell for his most interesting and informative paper.