THE HONG KONG
INSTITUTION OF ENGINEERS
ELECTRICAL DIVISION
One day Symposium
Wednesday, 15th November, 1989

"In Phase With The 90's"

at
Theatre Ⅱ,
Hong Kong Convention
and Exhibition Centre
Hong Kong

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Symposium Programme

08.30 Registration and Coffee

09.00 Introduction
- Symposium Chairman: Mr. S.T. Tam, BSc (Eng), MHKIE, CEng, MIEE
- Weclomed by: Mr. L.Y. Cheung, MHKIE, CEng, MIEE, Chairman, Electrical Division, HKIE

09.05 Opening Address
- Mr. S.P.W. Wong, BSc, MSc, FHKIE, CEng, FIMechE, FIEE, FIProdE, FCIBSE, MICE, LLD, JP, President, HKIE

1. Applications

09.10 Managing Complex E & M Contracts
- Speaker: Mr. James Chiu, Managing Director, The G.E.C. of H.K. Ltd.

09.30 Trends and Concepts of Medium Voltage Switchgear – A Look into the Future
- Speaker: Dr. Andreas Plessl, ABB Medium Voltage Management Ltd. CH-5401 Baden/Switzerland

09.50 Discussion Period

10.10 Coffee

2. Installations

10.40 Power and Electronic Engineering for the Hong Kong Convention & Exhibition Centre
- Speakers: Mr. Dave K.Y. Wong, Assistant VP, PBA,
  Mr. C.K. Kwok, Associate, PBA

11.00 Electrical System of Bank of China Tower
- Speakers: Mr. H.C. Mak, Partner, ACE

11.20 Chopper and Inverter Technology on Rolling Stock
- Speakers: Mr. David T.S. Cheng, Depot Manager, MTRC,
  Mr. Andrew Moyes, Elect. Eng., MTRC

11.40 Discussion Period

12.10 Lunch

3. Power Supply

14.15 Planning for Electricity Supply for the 1990's
- Speakers: Mr. J. Lui, Chief Planning Officer, CLP,
  Dr. A. Poon, Corporate Planning Officer, CLP

14.35 Emergency Generator and the Environment
- Speakers: Mr. Beverly Y.K. Sham, Manager, E.E. Dept., JEC,
  Mr. Ares T.Y. Siu, Engineer, E.E. Dept., JEC

14.55 Coffee

4. Human Resources

15.10 To Prepare for the Challenge
- Speaker: Mr. Leonard C.P. Lee, VP, PBA & Lead Electrical Engineer, FMCA, San Francisco

15.30 'Reverse Flow' to fill the Gap in Electrical Engineering
- Speaker: Mr. W.H. Wong, Director, BMP Mechanical & Electrical Ltd.

15.50 Human Resources in the 90's
- Speaker: Mr. Peter Barrett, Managing Director, Organisation System Ltd.

16.10 Discussion Period

16.30 Summing Up:
- Symposium Chairman
  Mr. S.T. Tam, General Manager, FED Supremetech Ltd.

Closing Address
- Mr. Miao Chi, JP, Director, Electrical & Mechanical Services Department

SYMPOSIUM ORGANIZING COMMITTEE

Symposium Chairman: Mr. S.T. Tam

Organizing Chairman: Mr. S.T. Tam

Members: Mr. L.Y. Cheung

Dave K.Y. Wong

Peter Y.S. Wong

T.H. Tai

Y.K. Chu

Hon Secretary and Treasurer: Mr. S.K. Ho

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Speakers/Authors

Mr. Miao Chi, JP
Mr. S.P.W. Wong, JP
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Dr. Andreas Plessl
Mr. Dave K.Y. Wong
Mr. C.K. Kwok
Mr. H.C. Mak
Mr. David T.S. Cheng
Mr. Andrew Moyes
Mr. J. Lui
Dr. A. Poon
Mr. Beverly Y.K. Sham
Mr. Ares T.Y. Siu
Mr. Leonard C.P. Lee
Mr. W.H. Wong
Mr. Peter Barrett

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Tridant Engineering Co. Ltd.
Thorn Lighting (HK) Ltd.
Swire Engineering (1988) Ltd.
Wintun Co.

1. Applications

Paper No. 1

Managing Complex E & M Contracts

– **Speaker: Mr. James Chiu,**
Managing Director,
The G.E.C. of H.K. Ltd.

MANAGING COMPLEX E & M CONTRACTS

Fast development of new technologies such as computer and optical fibre, and the increasing size and sophistication of construction projects, are creating some very complex electrical and mechanical contracts: a development which is going to become even more pronounced as we move into the 1990s.

The requirements for ventilation and air-conditioning, surveillance and security, computer, data and telecommunication, lighting and power switching etc cause even an ordinary office building to be a complex project requiring the engagement of a variety of specialists. A large infra structure project such as Metropolitan Rapid Transit, airport or Road Tunnel is at least twice more complex and as an example the Hong Kong Eastern Harbour Crossing consisting two Rail and two Road Tunnels with the 5th ventilation tunnel in the middle include some 20 specialist E & M contracts. Please refer to Appendix 1 for details.

The E & M contracts on this project together totalled some USD 45M representing 10% of the total construction cost. The timescale for the completion of the entire project was originally 3 1/2 years, but in fact the client was under considerable pressure, owing to the rapidly increasing strain on the existing infrastructure, to finish ahead of schedule. This in turn naturally devolved to the contractors and subcontractors, and the success we all achieved in completing 7 months before schedule was I feel due in no small way to the highly effective management skills that were applied throughout the project.

A MANAGEMENT PHILOSOPHY-CARROT AND STICK

A good project developer's objective is always to complete on time, within budget, and to the highest possible quality. Amongst the few options he has with which to achieve the objective is to employ Douglas McGregor's Theory X and Theory Y taking a carrot and stick approach.

The stick in the case of construction industry is a series of stringent contractual stipulations of unlimited liquidated damage for delay and loss of profit, fitness for purpose, latent defects, ultimate parent company guarantee or proprietor's personal guarantee. The most threatening sticks of all are the unlimited liquidated damage for delay and loss of profit and the ultimate parent company or personal guarantee which can cause unexpected unwilling and embarrassing attendance, or site visits by Chief Executive Officers or company Chairman of many multinational conglomerates who accepted contracts without realising the complex technical and contractual requirements.

I must point out many developers have no hesitation whatsoever to invoke the "stick" clauses especially in the case where the project was unlikely to deliver the financial "product" or where the investment climate changed. This means a non-performing contractor, failing to deliver his product after a year or two's hard work, suffer losses both financially and in reputation.

Generally speaking, project failures are caused by both developer and contractor as a competent developer will not award a complex contract to an incompetent contractor simply because of the price is lower. As contractor should not accept complex contracts beyond his capability.

ANOTHER MANAGEMENT PHILOSOPHY

If you accept Douglas McGregor's Theory X, you may agree with me that the Theory Y is also applicable. One of the assumptions of McGregor's Theory Y is that commitment to objectives is a function of rewards associated with their achievement.

It is my own firm belief that any workforce can have an in-born talent, but that it takes skilful management to draw out that talent and use it to the best advantage. In a case where you have 20 separate contracts all underway to some degree or other simultaneously, on what is after all a highly prestigious contract, you are certainly likely to have enthusiasm – but the very complexity of the work, plus a number of other more random factors, means that in terms of human resources, management has to be more skilful than ever.

Broadly, for a project international in its scope, the following points are very relevant and must be taken into consideration:

- **Commitment**

  The team has to be committed both to the project, and to Hong Kong itself. It doesn't matter too much if the team member is a Hong Kong local, or an expatriate here for the term of the contract. A project which is going to have a profound effect on the infrastructure, or on the lifestyle of a significant number of the inhabitants, has its own intrinsic attraction, and each team member should feel he is participating in something worthwhile.

- **Career development**

  Winning a major contract gives each team member a chance to participate in the success, and when the work is finished to the required time and standard, everyone feels that he has played his part. Consequently, the next time a major contract is awarded, there should be the opportunity for each team member to utilise his improved skills, and to move further up to an area of greater responsibility.

- **Cultural differences**

  The team on an international project can include a large number of people of different nationalities. Rather than presenting difficulties in communication, etc, this can be seen as being an advantage: it gives the opportunity to see how other people tackle their tasks, how they react under pressure, how they behave once a problem is solved. Communication skills between different nationalities can be improved immensely during the course of a project: and in my experience, it has a positive effect on the general working atmosphere.

- **Financial rewards**

  This of course has to be the basis upon which you build your successful and happy team; without a suitable financial reward, the other three points will not count for too much. But you cannot operate successfully on a project simply by assuming that if you pay your team well, the job will get done. Without these other three points, you will have a workforce that is only semi-motivated and largely incohesive.

PROJECT MANAGEMENT ROLES

Not so long ago, even large projects were managed along traditional lines. See Appendix 2.

The client had only a small role to play in the project: the work, from the moment of the go-ahead being given, to the handover of the completed project, being divided between the design manager (a consultant,i.e.either the engineer or architect), and a contractor.

However, with the growing complexity of project, the increased use of ever-evolving technology, rising costs of labour and materials, and very often intense pressures being exerted to complete a job ahead of schedule, a new form of management has evolved. Also see Appendix 2.

The project manager, who previously did not exist, has now become the lynchpin of the project. Furthermore, the client now often has a more active role. He will usually employ the project manager, who may be a consultant, or he may be a direct employee of the client. Either way, it means that the job is controlled very closely from the top, and that the pacing of the project is co-ordinated from one central point which refers directly back and forth between client and contractors.

This means that the other roles within the execution of a contract have had to be somewhat redefined. That of the design manager has been shrinking, and there are two reasons for this: one is that many of the management responsibilities he formerly undertook have been taken over by the project manager; but there is also the fact that more of the design work itself is now being carried out by the contractor or his subcontractors and suppliers.

Again, this is possible because of the tighter rein of the project manager, and because many contractors and subcontractors now have more sophisticated know-how and resources to carry out their own design.

SETTING THE CONTROLS

Budget, time and quality as project objectives have been cited but it must be emphasized that they are inter-related and closely affecting each other. Having to adjust budget or cost upward, to extend construction period and to compromise specification and quality are equally symptoms of poor management. Unfortunately people unnecessarily put too much emphasis on budget or cost neglecting the time and the quality factors.

Working within a budget should be attainable on the majority of projects, large or small, assuming the costing was correct in the first place. Part of the task of the management leading a team must be to ensure that the attitude is always in favour of completing the work within the budget: in fact, the most effective way to run a project in order to achieve this is to ensure that all those people making decisions affecting costs believe that the budget is an absolute top limit on expenditure.

In many ways, control of time and quality are the neglected factors in project management – surprisingly enough, given their importance. Yet it is a truism that while drawing up work programmes and specifications can be a very exact science, the science of working to the guidelines is not so well developed.

It is important, therefore, that for each of the divisions or design teams working on a project, or contracts, a series of key dates or completion milestones is regarded as concrete fact, rather than something which comes vaguely under the term "planning". They should, in other words, be milestones which are realistic and which apply to the whole team – not just to "a planner". The team should also be aware that time and cost are very often interchangeable factors in project management.

Quality control is closely tied to specifying. But specifications which are traditionally written for details and description of perfection were often repeated unthinkingly from one project to another because it was too tedious to compose one specifically for the next project. It is therefore extremely essential to forecast realistic quality requirements basing on the level of perfection intended, equipment and materials and workmanship available and budget constraints.

British standards 5750 clearly specifies the responsibility, authority and the inter-relation of all personnel who manage, perform and verify work affecting quality, particularly the authority to initiate action to prevent the occurrence of product non-conformity and in the cases of quality problems provide, verify and ensure unsatisfactory conditions are corrected.

This often means factory or site visit during the course of a project by authorised and reliable third party independent inspectors crossing continents to perform inspection, examination and testing of materials, workmanship and check progress of manufacture. Professional Inspection Services companies are available such as the Hong Kong MTRC and Lloyds of London.

For complex E & M contract, contractor's own inspections are equally indispensable. Defects and problems should be nipped in the bud. I always send my engineers to regularly visit suppliers' premises and talk to foremen on the shop floor while I maintain close contact with the senior management with the objective to ensure quality and delivery dates.

If the time control is deficient, delays result and any lost time has to be made up at a cost. If lapses in quality control occur, defective work can be removed and replaced, but at the cost of lost time and increased expense. In recent years it has become standard practice for the developer's inspectors to work with the contractor at the design stage to establish good quality control procedures, rather than examine and possibly reject after the work has been carried out.

MANAGEMENT INSTRUMENTS-CONTINGENCY AND FLOATS

With contractors and subcontractors carrying out much of their own design work, one of the ways in which the project manager has to exert overall control of the project is by setting budget contingencies and controlling their release.

Each specialist design group must work within the budgets set for them by the project manager, contingencies having been deducted. When each team sees the need to apply for release of contingency, they have to go through the project manager. With all teams acting this way, the project manager maintains overall control and ensures that he is brought into the decision each time an adjustment between the various sectors of the total budget is being proposed.

Our own experience in the E & M field suggests that contingency allowances should be set high in the early stages of the project, which means that the pressure is on our design teams early on to contain the costs and to iron out the problems at the design stage, rather than as they occur.

A sufficiently high contingency figure will allow flexibility towards the end of the contract, which is particularly useful, for example, if the client/project manager is urging for completion ahead of schedule. But this is the time, if any, for extra funds to be released; not before.

Again, there is one aspect of this essentially simple procedure that I cannot emphasize enough: a talented, committed team will be considering these points at the earliest stages of the project.

It is one of the project manager's most important roles to stimulate early decision making. Too often, those who are at the crucial point of making design decisions, due to the pressures under which they may be working, have a tendency to concentrate on the immediate problems, rather than looking ahead. A team working with commitment, conviction and action will be looking out for possible problems on the horizon, and be able to cope with them before they become too large.

PROJECT MANAGEMENT-COMPUTER SOFTWARES

A variety of computer softwares are available as management tools for project managers, and many of them are suitable even for highly complex E & M contracts, even when there is a large number of these contract, as on the Eastern Harbour Crossing.

There are commercial organisations who custom-design these software programs if necessary, but there are a number on the market which are standard yet which offer the necessary flexibility for complex work. Certainly, GEC Hong Kong has been using off-the-shelf software for its critical path, bar chart and cash flow analyses, and found them highly satisfactory. Again, it is very much a case of skilful management, and dedicated attitudes on the part of individuals within the team.

Appendix 3 shows the softwares GEC Hong Kong have undertaken to use:

* Super Project Plus by Computer Associates
* Total Project Manager II by Harvard
* dBASE III

Having told you how complex modern infra structure E & M projects are and the management strategies, I must emphasize there is no substitute for diligent hardwork and experience. The commander in chief, so called project manager or director must be able to conceptually visualize the project, like looking down on to a town from a helicopter viewing the buildings, the roads between them, the river and the bridges. He must be able to manage the interfaces between different sub-contracts and disciplines in order to resolve conflicts.

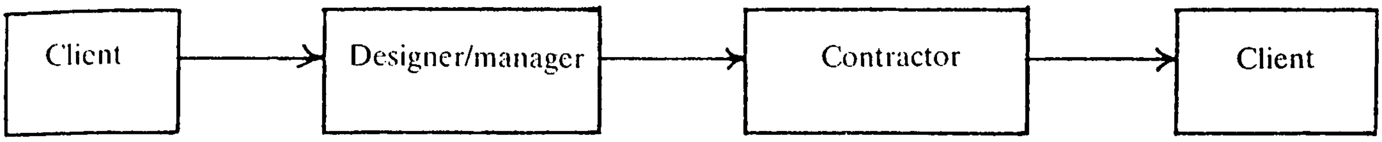
His ability to direct all participants, engineers, contracts staff, quantity surveyors, technicians etc through setting short and long term progress objectives and lead them with friendly persuasion and motivation in indispensable.

To achieve the objective of completing a project within budget, on time and with the desired quality certainly required diligent hardwork by the commander in chief and all his team.

Eastern Harbour Crossing-E & M subcontracts

EM1	Ventilation
EM2	HV and LV Electrical Services
EM3	Tunnel Auxiliaries
EM4	Traffic Control and Surveillance
EM5	Administration Areas (Building Services)
EM6	Central Control System
EM7	Communications
EM8	Toll Collection System
EM9A	ECS Central Control System
EM9B	Environmental Control System
EM10	HV and LV Electrical Services
EM11	Overhead Conductor System
EM12	Station and Tunnel Auxiliaries
EM13	Signalling
EM14	Telecommunications
EM15	Automatic Fare Collection
EM16	Lift
EM17	Power Remote Control
EM18	Escalators
EM19	Support Services Agreement
EM20	Provision of Inspection Services

Formerly



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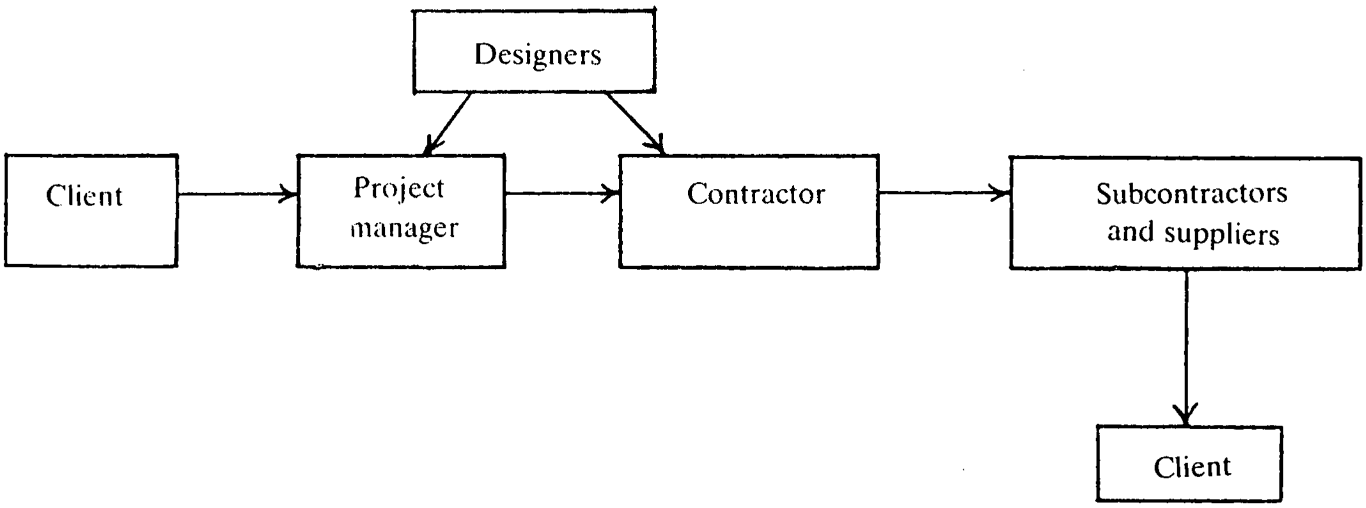

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Paper No. 2

Trends and Concepts of Medium Voltage Switchgear – A Look into the Future

– **Speaker: Dr. Andreas Plessl,**
ABB Medium Voltage Management
Ltd. CH-5401 Baden/Switzerland

TRENDS AND CONCEPTS OF M.V. SWITCHGEAR — A LOOK INTO THE FUTURE

Introduction

An electrical energy distribution network is generally expected to possess a high degree of reliability and with only short and infrequent interruptions to supply due to system disturbances and failures. Therefore, in order to provide the necessary control, protection and switching functions, substations are installed in the feeding and tee-off points of the distribution network. These substations normally follow the principle that all lines are connected to the busbar via a switching device. In primary substations this switching device is a circuit-breaker.

For larger substations with more than one feeding transformer the busbar is divided into two sections by means of a circuit-breaker. Due to this measure a higher degree of availability of the total system results e.g. in the case of the loss of one of the incoming supplies. Double busbar systems are applied in the larger and more important substations to obtain an even higher level of availability, a higher adaptability and more flexibility in balancing the load connected to the transformers.

Many different types of indoor switchgear have been built since metal enclosed switchgear was first introduced. In earlier days the user purchased the necessary components from one or most probably a number of suppliers and assembled the switchgear themselves, which implied an experienced user. But the technical and economical possibilities were not systematically exploited until the introduction of factory-assembled and type-tested switchgear. Manufacturers of switchgear now applied the new technical possibilities in their products and switchboards in order to fulfil the user's requirements for safe and reliable switchgear in a better and more economical way.

This was also the beginning of a specialization of equipment corresponding to its application in primary or in secondary substations. And in modern types of switchgear the use of solid and gaseous insulation as well as oil-free arc quenching devices plays an essential role in meeting the evolution of user's requirements.

Parallel to this development of switchgear there has been a no-less important development of control and protection devices. Currently, electro-mechanical components are being substituted more and more frequently by static electronic ones. This is partly a result of their simpler integration into the environment of electronic data processing as well as the greater possibilities they offer in terms of monitoring and self-diagnostic capacity.

The paper discusses the existing demands on primary and secondary distribution stations and the presently available practical solutions. Future trends are examined and their possible impact on the design of switchgear, including control, monitoring and protection equipment, discussed.

Present Demands on Primary Switchgear

The modern types of indoor substations which are installed in load centres are expected, apart from economy, to possess the following standard characteristics:

- high availability
- high reliability
- maximum safety for the operating staff
- reduced maintenance costs
- high short circuit and high busbar currents
- switching devices (circuit-breakers, isolators, earthing switches) suitable for remote control.
- comprehensive protection system

Additional requirements such as:

- multiple busbar systems
- versatile substation control system
- freedom from environmental influences
- small dimensions, low weight

may be necessary to meet specific operating conditions or to adapt the switchgear and hence the substation to the existing network.

The above mentioned requirements which apply to switchgear for primary substations are currently satisfied by two basic design principles; i.e.

- metal enclosed, air-insulated switchgear
- metal enclosed, SF6-gas insulated switchgear

Metal enclosed, Air-Insulated Primary Switchgear

The various types of metal enclosed, air-insulated switchgear as defined by the IEC-Standard 298 are distinguished by the way in which the circuit components are segregated in separate compartments; the main switching devices as well as the other components.

- metal-clad switchgear: this used only metallic and earthed partitions between the separate compartments.

- compartmented switchgear: in which components are arranged in separate compartments as for metal-clad switchgear, but with one or more of the partitions being non-metallic.

- cubicle switchgear: non-segregated or with a smaller number of compartments.

In accordance with the IEC definitions metal-clad and compartmented switchgear have separate compartments at least for:

- each main switching device, e.g. circuit breaker or isolator

- all components connected to the out-going side of the main switching device, i.e. the feeder circuit cable.

- all components connected to the other side of the main switching device, i.e. the busbar system.

A client's decision in favour of metal enclosed, air-insulated switchgear is often influenced by the specific features of this construction principle. The most important ones are:

- draw-out circuit-breakers, which allow the switching device exchanged or replaced without switching-off the whole substation. The reasons for such a change are often the replacement of a device by another one with higher ratings or the substitution of a load break switch by a circuit-breaker.

- spare panels provided for a later extension of the substation can be prepared for commissioning without any service interruption during the installation of the switching and auxiliary elements.

- the use of conventional cable terminations which offers greater flexibility in the choice of different types of cables.

- simpler installation or replacement of instrument transformers and surge arrestors, which assists the adaptation of the panel to changing operating conditions.

Currently there is a wide range of metal enclosed air-insulated equipment with draw-out circuit breakers available. Figure 1 shows as an example the front view of a metal-clad design of type ZS. A particular feature of this panel system is the multiplicity of the draw-out switching devices which it can accommodate. This means that in addition to the vacuum circuit-breakers and vacuum contactors with fuses, SF6 circuit-breakers and SF6 switch disconnectors with fuses can also be fitted. Furthermore, a draw-out busbar-connected potential transformer can be applied instead of a switching device. Figure 2 is a section of the panel and illustrates the arrangement of the components, with the partitions between the separate compartments and over-pressure relief flaps on top.

This design is type tested for internal arcing and allows the isolation of all draw-out switching devices without opening the front doors. In addition the circuit-breaker and the cable terminations are visible through the inspection windows in the front doors.

Metal enclosed, SF6-Insulated Primary Switchgear

SF6-gas insulated switchgear has fixed mounted circuit breakers and isolators and is contained in an earthed, gas-tight, metallic enclosure. Normally the power cables are connected via touch-proof plug-in or fixed bolted terminations.

This type of equipment has been resulted from the application of vacuum and SF6 circuit breakers which are practically maintenance free in respect of their high voltage components i.e. the gas volumes no longer need to be opened for equipment maintenance. This type of switchgear is being applied more and more frequently, especially there, where the advantages of this design are considered as mandatory or are welcome as an additional benefit. The most important benefits are:

- independence from environmental conditions, which means there is no reduction of the insulation level due to chemically aggressive atmosphere, dust, salt spray, condensation or altitude of the installation site. In addition the penetration of vermin and small animals is prevented by the hermetically sealed, gastight encapsulation.

- highest degree of safety for the operating staff, in regard to inadvertent contact with live parts, which results from the totally closed, massive earthed metal enclosure.

- greatest possible security against failures and internal faults due to the use of established routines for manufacturing, assembling and quality assurance in the factory.

- reduced dimensions and weight, explicitly for switchgear for higher rated voltages due to the high electrical insulation strength of the SF6-gas.

- reduction of erection and commissioning time on site, due to prefabricated and factory tested units.

Figure 3 shows as an example, the type BE SF6-gas insulated switchgear. This design has been developed for the range of lower ratings. The cross-section and front view shown in Figure 4 illustrates the integration of a SF6 circuit-breaker into a 500mm wide feeder panel.

Protection and Control Systems for Primary Switchgear

The development of substation control systems for medium voltage installations has made considerable progress in recent years. The present approach is primarily concerned with meeting the customer's requirements for higher degree of integration of the individual devices and functions for protection, control, supervision, indication and metering. The combination of these functions to form complete control facilities offers additional advantages both at the substation level as well as for the individual panel.

These new systems are microprocessor based and the existing requirements on the components and systems have been extended to cover the following points:

- continuous system – internal monitoring and fault diagnosis of all hardware and software system components.

- hierarchically structured two-level system with high availability due to the application of distributed intelligence and the interconnection of the units via a glass fibre optical bus system.

- simple and safe operation, rapid access to information and user oriented presentation of information at the man-machine interface at substation level.

- easy adaptation of the system to suit changing operating conditions without having to take it out of service.

- autonomous protection on the switchgear panel level.

- remote parameter reading and setting of protective relays.

- provision of connections for a conventional protective system or a control system of a different manufacture, or to a higher level system control centre.

Figure 5 explains the structure of the type S.C.S. 100 microprocessor-based substation control system for distribution networks. It is a modular system and permits an optimum adaptation of system functions to changing operating conditions.

Figure 6 shows an example of the layout of a control desk, which at this substation level provides the following technical functions:

- operation
- visual display
- programming
- parameter setting
- event logging
- fault recording
- telecontrol

At the level of the individual panels, the feeder unit (Figure 7) provides the technical functions of:

- protection
- interlocking
- local operation
- parameter setting
- mimic circuit diagram
- measurement
- fault recording

Metal enclosed Secondary Switchgear

Secondary distribution switchgear has lower ratings than primary distribution switchgear and the requirements on its facilities for protection, control and monitoring are less stringent. On the other hand this type of equipment is very often installed in humid, crowded rooms without any particular protection against detrimental environmental conditions and an inspection on site is a rare occurrence.

In additon to the standards for metal enclosed switchgear established by the IEC Recommendation 298 there are certain other requirements, from the user's point of view, which these medium voltage stations must fulfil. This switchgear widely installed in cable ring networks must provide:

- small dimensions
- simple installation and commissioning
- minimum maintenance requirements
- reliability under severe environmental conditions e.g. flooding of the cable terminations.

In meeting these requirements there has been an increasing demand for SF6-gas insulated units. These factory assembled and tested ring main units consist normally of two switch disconnectors for the supply ring and one fused disconnect switch for the transformer connection. Instead of a fuseswitch disconnector combination a circuit-breaker may be used for the transformer protection. In this latter case a protection relay, fed by three current transformer on the T-off cables, trips the circuit-breaker in the event of an overload or a short circuit fault condition. This protection arrangement must operate without external auxiliary supply.

Figures 8 and 9 show the front view and cross-section of a prefabricated ring main unit type CTC. This version is equipped with a vacuum circuit-breaker, however an alternative version with a fused switch disconnector is available.

The majority of the secondary station switchgear presently in service is still of the oil or air-epoxy insulated types and equipped with fused switch disconnectors. But for new installations there is a strong tendency towards SF6-gas insulated units and the use of circuit-breakers for transformer protection.

For the sake of completeness, it should be mentioned here that a great deal of the air-epoxy insulated switchgear is installed in buildings and that this equipment is essentially invulnerable to environmental pollution. A typical example of such applications are large commercial buildings. Here the secondary substation switchgear mostly consists of two switch disconnector panels for the cable ring, a metering panel and a bus sectionalizer on the supply side followed on the consumer side by fused switch disconnector panels for the transformer feeders.

Future Trends and their Possible Impact within the Near Future

At the present time and state of technical evolution it is reasonable to expect that distribution switchgear in the 90's will essentially use the technologies and methods known and applied today.

The application of electronics, data processing and modern communication technology will play an essential role. That is for sure. But on the other hand we cannot expect a revolutionary change in the design of switching elements by the application of power semiconductors or even high temperature super conductors. Both of these technologies have potential and possibilities for future developments – but the decisive break through must first be achieved in the research laboratories!

As mentioned before, data processing, information and communication technologies are becoming more and more important in energy distribution. On one hand there is in some areas a shortage or lack of electrical energy and on the other hand an ever increasing demand for an unrestricted and uninterrupted power supply. This situation can only be settled in the future by using and extending the technical possibilities for priority-dependent load management in the field of electricity distribution.

For the most important primary distribution substations and their connections to the superimposed network control centres, the consequences are clear: All new stations will be fully equipped with comprehensive modern control systems and older or subordinated stations will be re-equipped step by step with advanced systems.

For this process of reconstruction and re-equipment there is an essential prerequisite condition and this demands the definition and standardization of a communication interface. An essential impact on this matter may be expected from the national and international working groups of the IEC.

In secondary distribution substations, the introduction of control systems is still in an early phase. Their wide spread application will proceed with the installation of new power cables with an integrated optical fibre conductor as the backbone of an interference free and a high speed communication system.

Secondary stations will become increasingly automated, the incentive for the supply authorities to pursue this course of development being twofold.

Firstly, energy distribution must be better optimized in relation to load and network conditions, in order to fully exploit the power resources available. Secondly, there will no longer be a need for the permanent presence of operating staff in certain substations. As a consequence there will be an increasing demand for remote controlled units.

This trend infers the greater utilization of motor operated switching devices and also a certain substitution of fuses and/or switch disconnectors by circuit-breakers in order to allow auto-reclosing functions after clearance of fault and rapid re-configuration of the network.

Generally speaking a continuous adaptation and evolution of switchgear will take place to support and exploit the possibilities of modern control systems. Some selected examples will illustrate the possible range:

- arc quenching technologies with low maintenance requirements will achieve greater ascendency, i.e. oil and air as interrupting mediums will be replaced by vacuum and SF6.

- standardization of the dimensions of draw-out switching devices will come, in order to simplify the replacement of the equipment when this becomes necessary due to electrical wear or higher ratings requirement. Stock keeping will become simpler and cheaper because of the reduced number of variations.

- SF6-gas insulated substations will become more common due to the prolongation of the maintenance intervals resulting from the fact that all components are contained in hermetically sealed encapsulation.

- crucial components of the switchgear will be continuously monitored in regards of wear or aging and an alarm will indicate the need for maintenance, overhaul or replacement before the physical limits are exceeded. A practical example in this field is the condition monitor for circuit-breakers (see figure 10).

- battery monitoring and control is also essential because all protection and control functions, in fact the system as a whole are dependent on its energy.

The examples mentioned above, illustrate that the manufacturer of distribution switchgear must allot an ever increasing importance to the economical aspects as seen from the user's point of view. In the past, efforts have been concentrated on improving the products and attempts to reduce the costs of the primary investment. Now we must strive for a reduction of the operational costs, i.e. also costs of supervision and maintenance. It is our aim to substitute the frequent and not always necessary preventive maintenance procedure by essential measures only, these being determined by means of a dynamic monitoring and supervision scheme. By using a central system, fed continuously with condition data, problems will be identified early and suitable remedial measures can be taken. The more detailed information on equipment condition will not only reduce time, material, staff and costs, but also increase the reliability of the system and hence the availability of the power supply.

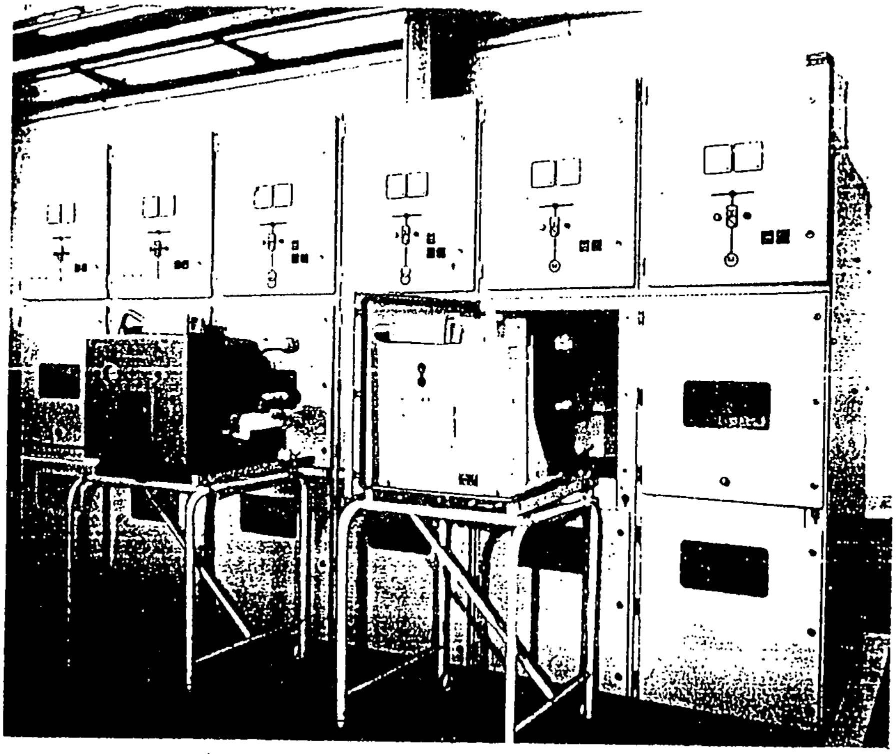


Fig. 1: Metal clad, air-insulated switchgear of type ZS1 with withdrawable circuit breakers.
Left : Type HA SF6 gas c.b.
Right: Type VD4 vacuum c.b.

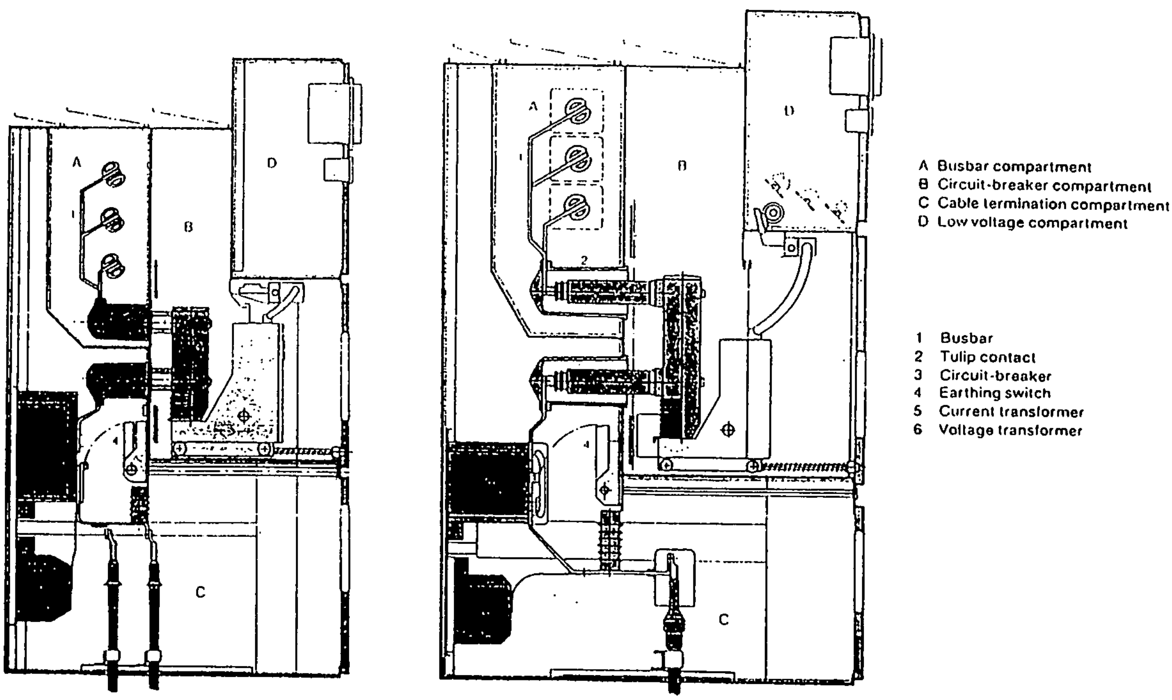


Fig. 2: Section of ZS1 switchgear panels
Left : ZS1 panel for 12 kV, 25 kA
Right: ZS1 panel for 24 kV/25 kA

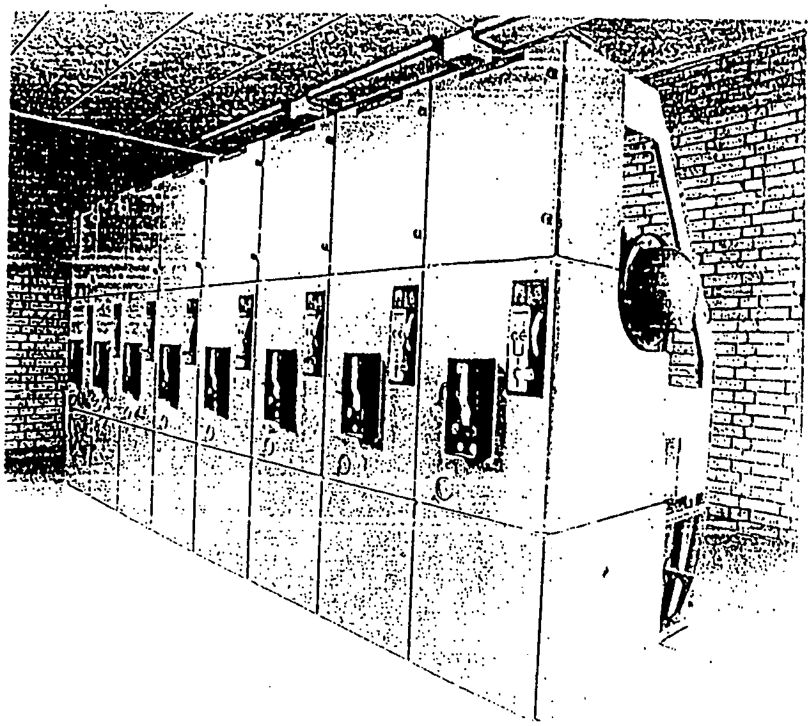
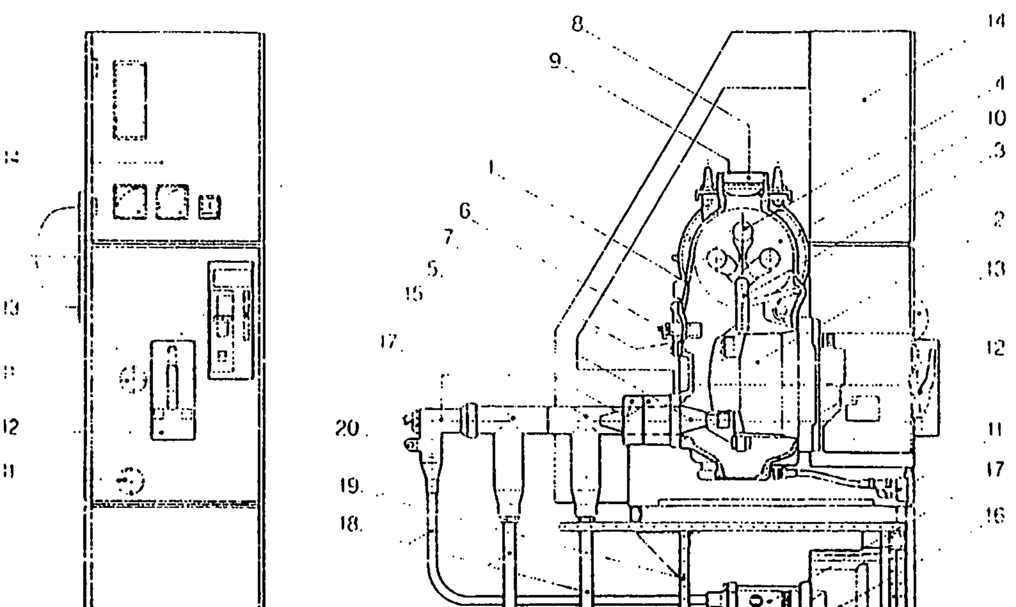


Fig. 3: Metal enclosed, SF6-gas insulated switchgear of type BE with fixed mounted SF6 gas c.b.



1 Aluminium housing
2 Circuit-breaker
3 Selector isolator (3 positions)
4 Busbars
5 Bushing
6 Earth terminal
7 Transparent bushing
8 Adsorber
9 Pressure-relief valve
10 Busbar bushing insulator
11 Pressure gauge
12 Circuit-breaker operating mechanism
13 Selector isolator operating mechanism
14 Relay compartment
15 Current transformers
16 Voltage transformers
17 Cable terminations
18 Cable
19 Support structure
20 Voltage indicator

Fig. 4: Cross-section and front view of a type BE cable feeder panel.

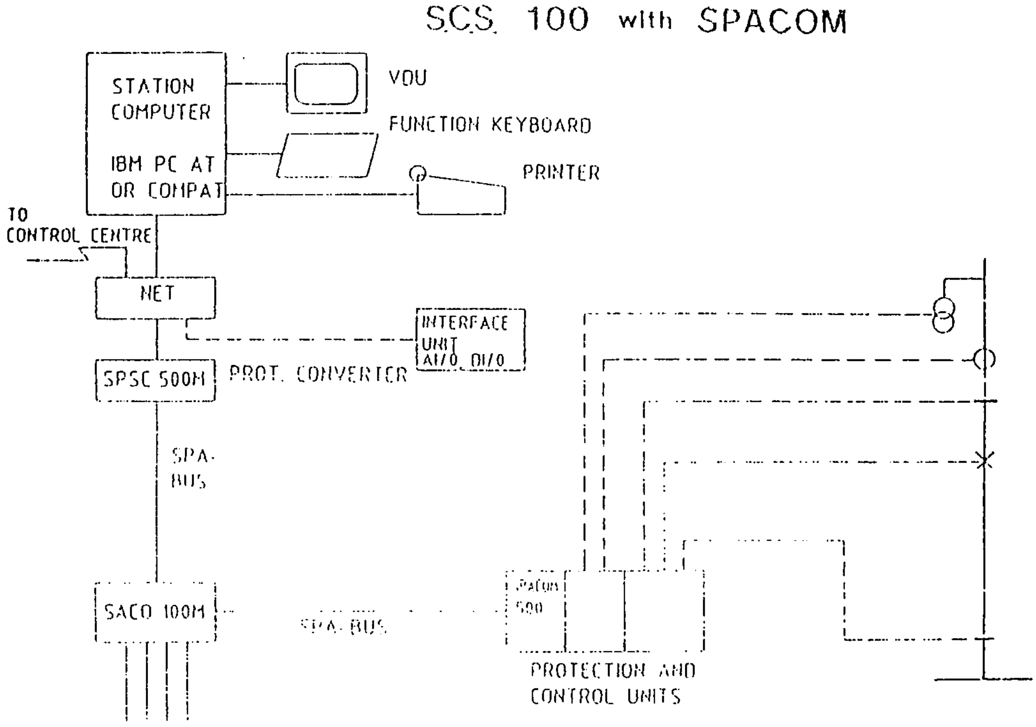


Fig. 5: Structure of type S.C.S. 100 microprocessor-based substation control system for distribution networks.

Fig. 6: Layout of a substation control desk of S.C.S. 100

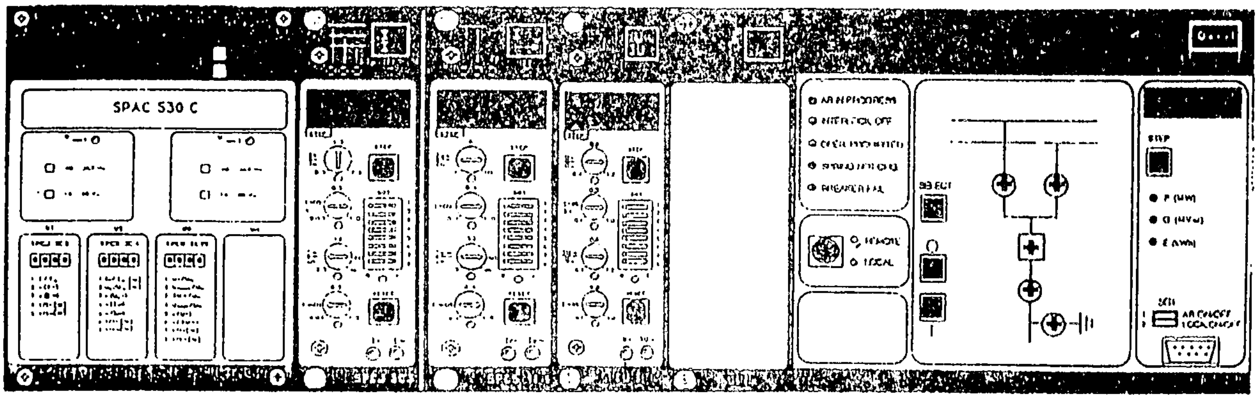


Fig. 7: Protection and control unit of type SPAC 530 C (feeder unit).

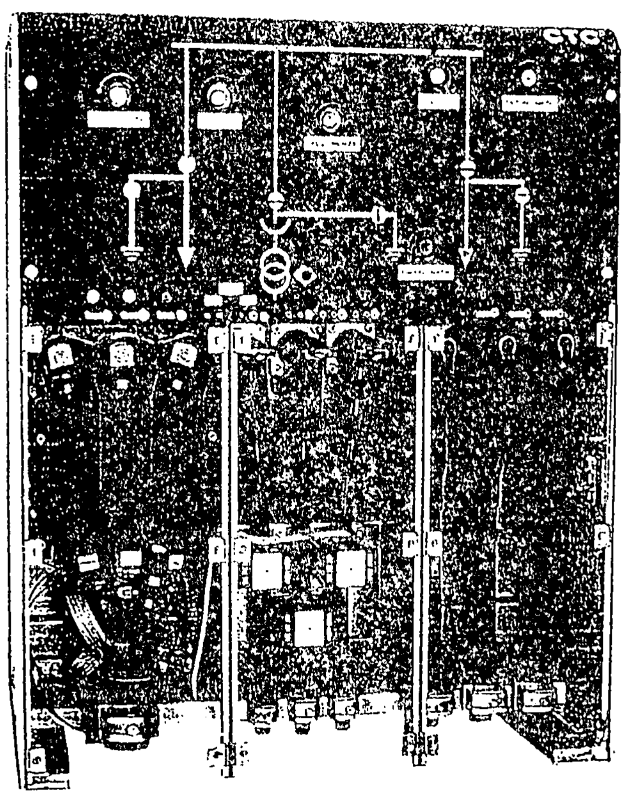


Fig. 8: SF6 Ring Main Unit of type CTC with bushings for sealed cable terminations or oilfilled termination boxes (left).

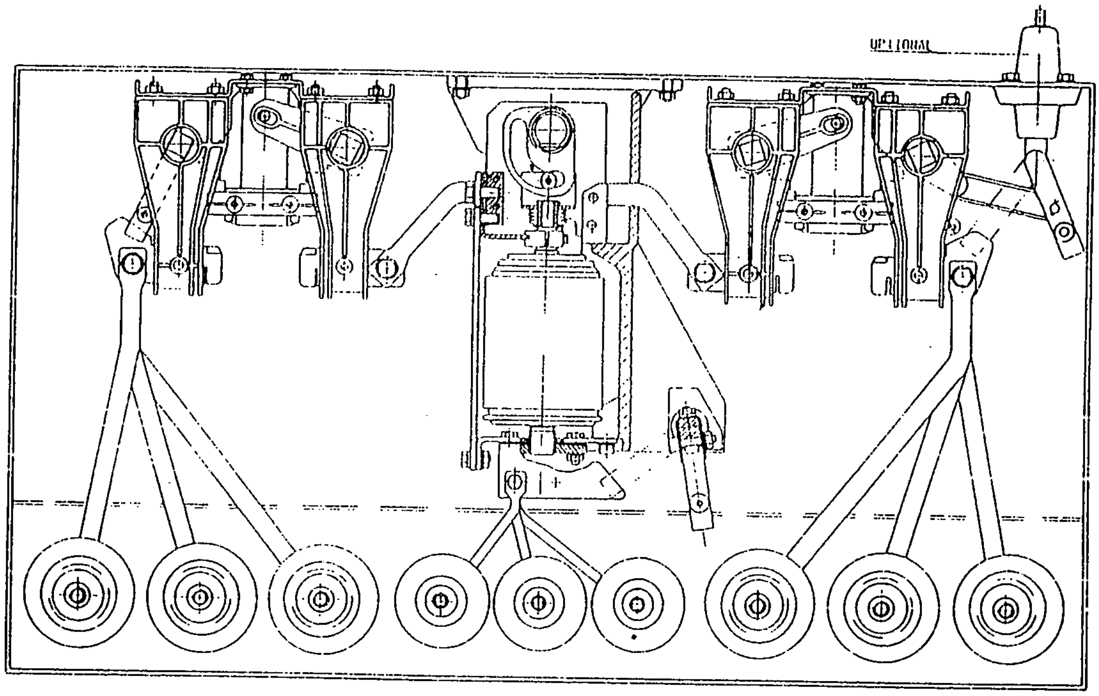


Fig. 9: Cross-section of RMU type CTC equipped with a vacuum c.b. for transformer protection.

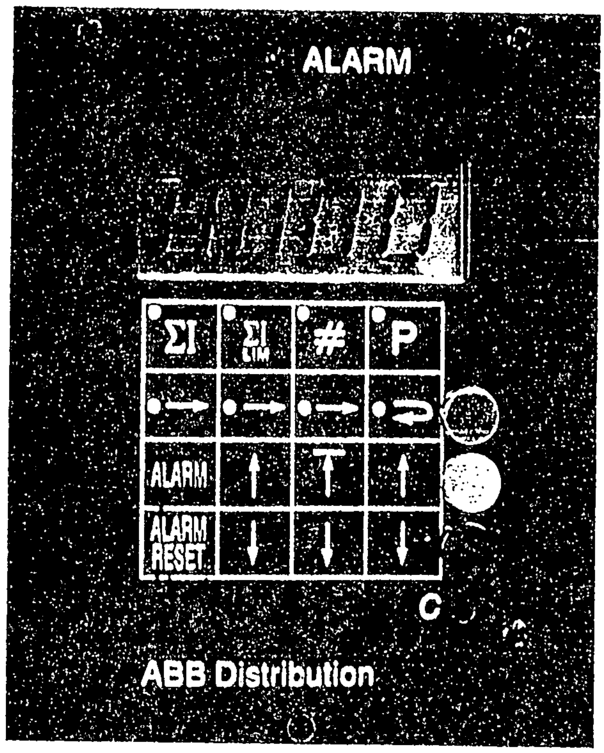


Fig. 10: Display of the condition monitor for a circuit breaker.

2. Installations

Paper No. 3

Power and Electronic Engineering for the Hong Kong Convention & Exhibition Centre

– Speakers: Mr. Dave K.Y. Wong,
Assistant VP, PBA
Mr. C.K. Kwok,
Associate, PBA

POWER AND ELECTRONIC ENGINEERING FOR THE HONG KONG CONVENTION AND EXHIBITION CENTRE

INTRODUCTION

After five years of planning, design, co-ordination and construction, the first phase of the Hong Kong Convention and Exhibition Centre (HKCEC) was officially opened on 25 November 1988. Full completion is envisaged at the end of 1989. The total E&M installation cost of the HKCEC is about 470 million Hong Kong dollars, of which about 30% of that is on the power and electronic systems. This paper presents the salient features of some of the key systems provided.

The HKCEC has a large common podium with four superstructures rising to a maximum height of about 175m. The podium contains the exhibition and conference halls, auditoria, major E & M plants, carparking, shops, restaurants and various supporting facilities. The four superstructures have separate function and contain two hotels, one serviced apartment tower and an office tower, providing a total of 1,500 guest rooms, 600 fully furnished apartment units and an office space of 60,400sq.m.. The floor area is about 409,00sq.m..

Electrical Supply

The total connected electrical load is about 58MVA and the maximum demand is expected to be approximately 49MVA. The power supply to the development is provided by the Hong Kong Electric Co., Ltd. The consumer voltage is provided at 380/220V, except for the central refrigeration plant where the power is taken at 11kV and the office tenants where the power is supplied at 346/220V..

To meet this high demand and to ensure that there will be adequate spare capacity and redundancy to allow load growth and provide a high degree of reliability and maintainability, the power supply to the development is taken from the Wan Chai and Harcourt zone sub-stations in an open loop arrangement. This arrangement provides a high degree of reliability since each sub-station within the development can be fed from either side of the 11kV circuit. A standby feeder is also provided so that the open loop can be fed from either end in case of power supply failure at one of the bulk supply points without reducing the power transfer capacity. Reliability of the power supply system is further enhanced by providing a bus-section for sub-stations having more that two transformers so that power supply can be arranged at a reduced level in case of failure of a busbar or HV circuit breaker. In total, thirty-two 1500kVA and one 1000kVA power transformers were installed and are spread over eleven sub-stations across the site.

To ensure maximum flexibility, bus-section circuit breakers are also provided at the LV switchboards associated with two or three transformers so that if a single transformer fails, supplies for each section of the LV switchboard can be maintained.

A brief summary of the electrical load for the whole development is given below:--

Nature of Load	Maximum Demand
Central Sea Water Cooled Refrigeration Plant	16.8MVA
Lighting & Small Power	11.0MVA
Container Lifts	0.5MVA
Escalators & Lifts	3.8MVA
Exhibition Power	3.9MVA
Office Tenants	2.2MVA
Other Mechanical Loads	10.8MVA

Electrical Metering

The electrical consumption is metered at the LV side except for the HV chillers which are metered at the HV side. Although conventional induction type energy meters have good service record, they are susceptible to both electrical and mechanical failure. It would also be necessary for the power company personnel to visit the site monthly and to manually record the readings from over ten locations within the site. With the help of modern technology, electronic metering is now employed. The analogue signals from the current and voltage transformers are fed to the microprocessor to compute the active and reactive energy consumption and the maximum demand within 30 minute intervals. The processed data can be accumulated for retrieval locally.

An interface is also provided with the development's Building Management System so that the digitized current and voltage signals can also be received by the BMS's computer for the client's own accounting/monitoring purpose. These processed data can readily be transmitted through the telephone line to the power company's control centre for automatic billing shouldthe need arises.

Standby Power Supply

To comply with the local Fire Services Department's requirements, to maintain all essential services within the development during mains failure, and to ensure a safe evacuation of over 8,000 visitors using the exhibition facilities in particular, a secondary power supply in the form of emergency generating plants are provided. These emergency generating plants will support the fire services systems, fireman's lifts, essential lighting, smoke extraction fans, pressurization fans, lift sequential homing, sump pumps and building management and communication system. In total, six standby generating plants are provided at four selected locations adjacent to the load centres with high content of essential load to minimize the oversizing of cables to regulate the voltage drop. Electrical and mechanical interlocking devices are incorporated to disconnect the non-essential sections of the switchboards when the standby power is on. In addition, centralized UPS plants are provided in the exhibition halls for immediate back up of emergency lighting system. The total emergency load for the whole development is about 4.9MVA and a brief summary of the electrical load is given below:-

Nature of Load	Maximum Demand
Fire Pumps	2160kVA
Lift Homing/Fireman's Lifts	500kVA
Sump Pumps	680kVA
Emergency Lighting	780kVA
Smoke Control	340kVA
Miscellaneous	440kVA

Utilities For Exhibition Halls

The focal point of the development is the two exhibition halls which have a total exhibition space of 18,000sq.m.. In order to cater for a wide range of exhibitions without being unduly constrained by the availability of various utilities, utility pits are provided extensively and at a grid of 9m by 9m throughout the halls for the use of the exhibitors. From these utility pits, the exhibitors can tap off the required power supply, potable water, compressed air, drainage, telephone and communication lines to their exhibits and booths. These connections are segregated in the floor into wet and dry compartments by means of dividing walls. Each of the various utilities is provided either in concealed pipework within a floor slab of over lm thick or in trenches with a properly sealed but removable floor cover.

During the design stage, the most importing feature of the electrical installation in the exhibition halls is the flexibility of power distribution. Analysis of the possible requirement for power supplies justified the provision of 4 numbers of 30A single plase and 1 number each of 30A 3 phase and 60A 3 phase socket outlets in each utility pit. It is expected that this combination of power supply points will meet the requirements of most of the exhibitions, including exhibition for moderately heavy machine.

There is also an extensive power busbars system above the false ceiling level in each hall. The busbars are rated at 800A and are provided with plug-in openings at 1.5m intervals. In the event where power supplies from the utility pits are insufficient for exhibitions of heavy industrial machinery, the additional power supply of up to 400A can be tapped off from these busbars via a plug-in device. A flexible cable dropper can be installed along side of the columns or exhibition booth to the equipment or a portable power distribution panel at low level.

In addition to the above, two overhead fume exhaust main ducts are provided for each hall with tee-off points at high level for connection of the exhibitor's fume discharge equipment via flexible hose. The fume extraction rate per hall is about 1 cu.m/s.

BUILDING MANAGEMENT SYSTEM (BMS)

A fully computerized BMS using a total system approach is provided to monitor and control the operation of the entire development in the areas of life safety, property protection, energy utilization, maintenance scheduling, management information system and environmental control. The BMS has about 13,000 control/monitor points and includes fire alarm/detection, closed circuit televisions, burglar alarm,Panic intercom system, petrol touring, sound and public address system, sprinklers, hydrant/hosereels and drencher system,.smoke curtains, lift and escalator, exit lights, lighting, electrical installation, smoke control, dampers and fans, heating, ventilation and air conditioning, sump pumps, etc.

The system is based on a distributed processing architecture with memory and intelligence applied at the point of utilization. The distributed processing system comprises three operating levels, viz. field processing units (FPUs), sub-system processing units (SPUs) and a central processing unit (CPU) interconnected by dedication communication lines. The FPU is at the front-end level and is a basic micro-processor based control unit with direct digital control (DDC) capability. The FPU interfaces with the digital/analog input/output of the E&M equipment and can act as stand-alone system for controlling/monitoring a particular system. The SPU is the next level and is a micro-computer based unit capable of functioning as an independent stand-alone control and monitoring system. It is equipped with all the necessary executive and application programmes to gather and process all data to facilitate time/event start/stop functions, to execute energy management programmes and other specific functions. The CPU (Control Processing Unit) which is a 32 bit mini-computer-based unit which acts as the central supervisor of the BMS as well as the computer-aided manager for the central plant control.

Information for all the SPUS are send back to the CPU for analysis, trend plotting and optimization thus providing the most cost effective solution for both energy saving and comfort control. The CPU also provides a centralized information, logging and maintenance schedule for the various E & M systems.

The BMS has over three hundred microprocessors with the controlling capacity of up to 30,000 I/O points and a brief summary of the point schedule is given below:–

E&M	analogue points	2335
	digital points	5347
	totolisation points	67
Fire and Security	digital points	5081

The BMS for the development is Hong Kong's first installation which is designed to facilitate smoke control and safe evacuation of over 8,000 visitors in a large scale exhibition hall.

In the event of a fire in one of the exhibition halls, the smoke will be picked up by the smoke detectors which will transmit the alarm signal to the Control Room via two independent paths, viz. hardwire and data transmission. Upon receipt of the fire alarm signal, the following events will take place automatically:–

- The fire control computer will start raising a high level alarm at the floor on fire and a low level alarm in other areas, and signal to the Fire Services Department.
- Public address system will broadcast pre-recorded messages.
- The security computer will switch the main TV monitor at the duty operator's console to the appropriate camera to survey the area which is on fire.
- BMS will display the colour graphics and identify the camera code and the area code to enable the operator to identify the area affected.
- Smoke extraction fans over the fire zone will start operating.
- HVAC equipment serving the fire zone will shut down, except the smoke extraction fans.
- Staircase pressurization fans will start operating to prevent ingress of smoke into the staircases.
- Drencher system over the fire zone will operate, if both of the smoke detectors system and the sprinkler system are activated.
- All lifts will home to G/F sequentially.
- All escalators will switch smoothly to downward travel to G/F.
- All TV sets in the hotel rooms will switch on automatically to an emergency page showing the emergency message and escape route graphic.
- Smoke shutters will roll down.

In theory, with the control system fully automated, the duty operator will have nothing to do except monitoring the fire situation through his monitor, paging his supervisor through the telephone coupled radio pager or walkie-talkie system and awaiting for the arrival of the fire brigades.

MISCELLANEOUS MICROPROCESSOR CONTROL SYSTEMS

Other than the BMS as described above, the complex also employs over 3,000 distributed microprocessors with over 20,000 monitor/control points for hotel-guestroom environment control, energy saving control, centralized electronic key access control etc.. These systems enable the hotel management to operate efficiently and the guests to have an enjoyable stay in the hotels and apartments.

INTEGRATED INFORMATION SYSTEM (IIS)

The conventional communal aerial broadcast distribution (CABD) system is further exploited to facilitate interactive man-machine interface at the television (TV) outlets in addition to the usual TV signal transmission. The system comprises a network of co-axial cables designed for VHF and UHF transmission and an array of antenna, modulators, decoders and central computer at the sending end and TV interface cards at the TV sets.

The IIS has six UHF channels, four for local TV stations and two for in-house movies. The signals of the four local TV channels are picked up through the antennae located at the roof and are fed through the channel amplifiers and distributed to each outlet point of the system. The signals of the in-house movies are fed from video cassette recorder and video typewriter. In between video movies, colour text pages from video typewriter will display hotel messages, hotel promotions, exhibition news, F&B menus, movie schedules, etc. When the movie channel is selected, a message is also displayed on the TV screen showing the hotel charge rate of the movie and instruction to accept these charges. Unless the guest presses the button on the remote control to accept these charges, the movie channel will go blank within a pre-set time. The IIS also has several VHF channels for the satellite TV channels and the cable TV channels once it is available in Hong Kong.

An interactive information system is also resident in the IIS to facilitate a two-way communication between each guestroom and the central computer. Two VHF channels are allocated for the upward and downward transmission of the interactive information system to reduce interference. By pushing the buttons on the TV remote control, hotel guests can choose a particular information screen. The system contains the following features:–

- In emergency, such as a fire alarm, all TVsets, regardless of their status and whether on or off, will switch to an emergency page showing the emergency message and escape route graphic which is unique for each guest room location.

- Five different languages can be chosen for text display.

- On-line information text display such as airport schedule, financial data, Reuter news etc., can be received through the central computer which is linked to the outside. Due to its interactive characteristic, electronic shopping from the guestrooms is also possible.

- Message can be sent instantaneously and easily to one or groups of rooms. The message can be displayed on the guest's TV screen until its reception is affirmed.

- By connecting to the hotel computer, the system can enable the guest to view his hotel charges from the TV screen and confirm acceptance for express check-out.

- One or more TV channnels are reserved for the conference organizers to transmit the information concerning the conferences to pre-selected rooms where conference participants stay to assume privacy and confidentiality.

Satellite TV disk is installed at tower roof to pick up satellite TV signals, downward converted to a frequency of 1 GHz and incorporated into the system. At the present moment, two Japanese channels have been chosen by the hotels.

VIDEO CONFERENCING

A rather simple but flexible video conferencing set-up is provided for the exhibition centre. Video/audio plugs are provided at possible tele-conference locations such as convention halls, meeting rooms, function room etc., throughout the exhibition centre. Signals to and from these plugs are linked up to a patch panel in the Central Apparatus Room via co-axial cables. These signals are then encoded into digital form and compressed to 1.544 Mbit (T1) or 2.048 Mbit (T2) for transmission to outside network. The reverse operation is used to decode signals from the outside network. Four duplex full video bandwidth optic fibre cables are also available to link up the HKCEC to the Cable and Wireless (HK) Ltd. at the New Mercury House, for distribution to the world's network.

During a teleconference event, cameras, microphones, video projectors and speakers can be set up at any location provided with video/audio plugs. Hot line telephones are also provided at event locations, the Central Apparatus Room/Telecable Room (where the codec equipment is located) and the New Mercury House for communication between these locations. The advantage of this set-up is its flexibility of event locations and the improved video bandwidth requirement.

At present, the integration of the PABX switching circuit and video conferencing circuit is being investigated. The intended system will integrate the voice/data output from the PABX, the statistical multiplexer system for high speed data link, digitized video/audio data from the HKCEC to the New Mercury House by high speed gateway through optic fibre or T1, T2 links. THe advantages of this system will be the eliminatiôn of narrow band telephone wiros and a reduction in the cost of data transfer because of this sharing concept.

CONCLUSION

The increasing demands made upon exhibition centres today necessitate the provision of more attractive facilities, supported by more advanced and flexible engineering systems for management, security, safety, communications, comfort and convenience. The Hong Kong Convention and Exhibition Centre is an excellent example and will increase the attractiveness of territory to the international conference circuit in the 1990s.

Paper No. 4

Electrical System of Bank of China Tower

– Speaker: Mr. H.C. Mak
Partner, ACE

Electrical System of Bank of China Tower

INTRODUCTION

The Bank of China Tower situated in Central is 70 Stories high and is the tallest building ever to have been constructed in Hong Kong. The design for the building reflects the smooth integration of the electrical system with other services into this sophisticated complex and structural systems. The designers of the services system recognize the function of the Architect as the design leader who integrates the effort of several disciplines into a single building. Through the leadership of I.M.Pei & Partners, optimized designs were achieved by applying existing knowledge and technology into a building that fully meets the constraints imposed by local conditions, yet within a realistic budgetary limitation for a first class building.

Special Design Consideration

From the perspective of the electrical system, the architectural design, in conjunction with local constraints, created a set of major issues that needed resolution in the conceptual stages of the design. The building, as designed by I.M.Pei & Partners, is a magnificent piece of sculpture that is geometrically integrated with the utmost precision. The local regulations were fully complied with and further complicated the design. Major concerns were as follows:

- The geometric nature of the building design is such that the locations of substations for general power supply and generators for essential supply became a significant issue. The whole building follows a logical disciplined vertical/horizontal module. The 4 metres floor-to-floor height makes the vertical span of the building over 300 metres above ground. The traditional centralised substation arrangement implies significant energy loss in the power distribution system. The consideration given to the basements was also impractical due to the need of space for banking purpose, as well as for government parking regulations.

- There was a need for the building systems to complement the developing office-of-the future technology not only for the Bank of China occupancy, but also for the leasing to other tenants.

- The unique innovative structural design provided a very efficient and cost saving structure for the building. However, achievement in the above structural design was accomplished by the elimination of the floor screed which in effect, made the usage of the very popular underfloor trunking wiring system, impractical. In this regard, a poke through system was provided on the office floors to facilitate internal power distribution and communication wiring to cope with the need in developing our office-of-the future.

- Uniform light distribution and adequate illumination were the most important aspects of lighting design. Attention should be drawn particularly to the light distribution in relation to computer VDU screen reflection.

- The height of the building and the use of a curtain wall system made the building the largest lightning discharge air terminal in the Central area. The building should be protected from not only high sky lightning discharge but also low level lightning attacks.

MAIN DISTRIBUTION SYSTEM DESIGN

There were two major considerations in finalising the electrical system design:

1) the selection of electrical distribution scheme ; and,
2) the location of the power distribution sub-stations.

Clearly, the building served by the Power Company's substations would be the simplest and cheapest solution. However, the 346/200V supply may not be compatible with most European motors for chillers and pumps: they are normally rated at 380/220V. The finalised scheme enabled the building office area to be served by the Power Company's substation at 346/200V, whilst the building service plants were being powered by the Owner's 11KV/380V substations.

The major load centres inside the building were air-conditioning plant rooms, located on 4th, 18th, 31st, 44th & 45th floors respectively. To enable the positioning of the power distribution substations as close to the load centres as possible, the Owner's 11KV substations were also located on CP/1, 18th, 31st, 44th & 45th floors. However, these upper floor substations created a problem in provision of transportation and maintenance access to the transformers. The solution was to employ 667KVA single phase transformers such that 2000KVA three phase transformers could be formed by wiring up three single phase transformers in star connection. As the physical dimension of a 667KVA single Phase transformer is very much smaller than that of a 2000KVA three phase transformer, the single phase transformer can then be delivered from ground floor to the upper floors by a specially designed service lift.

Regarding power supply to tenants, the Power Company would normally request to locate their substations on the ground or basement. levels. However, this was impractical due to the remoteness of the consumers on top floors, who may be over 300 metres above ground.

Eventually, the Power Company agreed to split their tenant's substations into three separate levels the 18th, 31st & 45th floors respectively. Each substation supports a block of floors with a 346/200V level to satisfy the requirements for lighting, socket outlets and mechanical equipment for individual consumers. Inside each substation, three 500KVA single phase transformers were wired in star-connection forming a three phase 1500KVA transformer. The single transformers could also be delivered to the upper floor substations from the ground floor by its unique service lift.

SUB-MAIN DISTRIBUTION SYSTEM DESIGN

All of the Bank-Occupied-floors and tenable floor areas were served by different groups of busbar risers. The readily accessible plug-in window on the busbar duct provided the greatest flexibility in tapping-off the power supply for different loading conditions.

Since two-thirds of the power consumption of the Owner's building services equipment was motor load, a three phase three wire system was adopted for Landlord Services Supply with a view that most motor circuit were in three phase balance condition. The elimination of such a neutral conductor could save up one quarter of copper cost in the distribution system. However, it further created two other problems:

1) The primary control voltage was then 380V instead of 220V. The 380/24V voltage transducer is currently not readily available in the market, and,

2) No single phase supply is available for single phase circuits of general lighting and small power.

In order to provide single phase supply for control circuit of mechanical equipment and general lighting and power in public areas, 9/45KVA 380/380V delta-wye transformers were installed in the plant rooms at ten different levels, each serving a block of floors.

ESSENTIAL POWER SYSTEM DESIGN

For a 70 Storey high rise building, life safety would, of course, be one of the most important aspects in the electrical system design. Diesel generators were installed to back-up all essential loads of the building. However, the location of the generator room presented a major design limitation to the architect. This architectural difficulty coupled with the uninterrupted curtain wall facade design did not permit the existance of any louvre area except on 4th and 5th floors which were already fully occupied by air-conditioning plants. Therefore, the generator room could only be located on ground level or basement. Extra excavation and building construction had been done at the south-west corner in 1st basement level to erect a suitable generator room inside in which two 750KW generators were installed.

As the whole building was to rely on this rather remote back-up point, the following equipment had been provided in order to improved the security of the essential supply:–

1) MICS cables were used for essential power distribution,

2) Each essential distribution panel was fed by two supply sources via an automatic transfer switch. This automatic transfer switch is equipped with a load shedding device such that when one of the two generators fails, the lower priority essential loads will be cut out automatically to maintain the higher priority essential service, and,

3) A 20,000 litre under ground fuel oil tank was installed in to support 24 hrs operation of the standby generator system.

WIRING SYSTEM

With a "steel deck" floor slab construction, hangers for air duct, trunking and piping were fixed to the ceiling by means of inserting fasteners inside the V-groove of the steel deck ceiling. The horizontal distribution of power and communication systems on each floor is conducted by means of trunking/conduit provisions inside the ceiling void. Where floor-mounted outlets were required in open office spaces, the ceiling void of the floor below was utilized, in which case a hole was drilled through the slab at each floor outlet location and suitable "poke-through" fitting with 2 hrs F.R.P. rating is inserted through the hole. With the "poke-through" fitting, the conduit penetrated through the slab into the ceiling cavity of the floor below. All wiring was run below the floor slab. The "poke-through" wiring system offered the advantages of virtually unlimited flexibility for power, data and communication cables, and minimum initial construction expenditure.

However, this type of distribution system was not acceptable to the Power Company for multi-tenancy premises. Therefore, this system was provided only to the bank occupied floors where it was under the control of the Bank. The major draw back of the "poke-through" system was the need to work in the ceiling of the floor below, thus it required coordination with obstructions in the hung ceiling of the floor below before location outlets.

Since the floor screed was not provided, the underfloor trunking system could not be installed on other tenable floors. Other alternative wiring systems such as Power Poles, Flat Wiring or Raised Flooring were considered which did not require any inital capital investment and may be used in any combination within the building as required.

LIGHTING DESIGN

The aim of any lighting system in a building is to achieve maximum output and quality of illumination with least energy consumption. The Bank of China Tower was provided with an efficient, high quality Lighting system to minimize both the energy consumption by the fixtures and the air conditioning needed to remove the heat given off by those fixtures. In order to cope with the need in developing the office-of-the-future, the lighting system should also be suitable for automatic/computerised office environment. The standard fitting for the office area was a 300 x 1200mm light box with parabolic louvre reflector, two 40 Watt fluorescent lamps and low energy-loss ballast. Spacing the fittings 2.5 meter on centre in both direction produced an averge illumination level of 500 lux at a wattage density of approximately 15 Watt per square meter. The special-design parabolic louvre reflector offers a "Bat-Wing" light distribution which minimized the glare and light reflection from VDU monitors. With the aid of local task lighting provided by the fitting-out design, a 750 lux illumination level was achieved at each desk top location to support general clerical work.

LIGHTNING PROTECTION AND EARTHING

Considering the height and volume of the Bank of China Tower, provision should be made to protect the building from both high sky lightning discharge (in an order of 100KA) and low level lightning attack (in an order of 10KA). The curtain wall system makes the building the largest air terminal in Central area. In order to protect the building from lightning discharge, two Australian-design non-radioactive lightning control terminals were installed on top of the two high masts atop the building. The newly developed triaxial cable was used to carry the discharge current to earth. However, the dead zone of the above protection system was in the space between roof level to ground level. By linking up each member of the curtain wall framework, the curtain wall system became a large "Faraday Cage". On each floor a 120mm^2 copper cable was used to connect the curtain wall framework to the structural steel column. Thus, all metal parts of the building structure were electrically earthed.

For the earthing of electrical systems, a 240mm^2 copper cable was installed inside each electrical riser duct as protective conductor. Four earth pits were constructed in 2nd Basement of the building for electrical, telephone, generator and lightning systems respectively. In order to improve the effectiveness of the earthing provision, these four earth pits were further interconnected and linked to each structural column by 120mm^2 copper cable using the Cadwelding method.

CONCLUSION

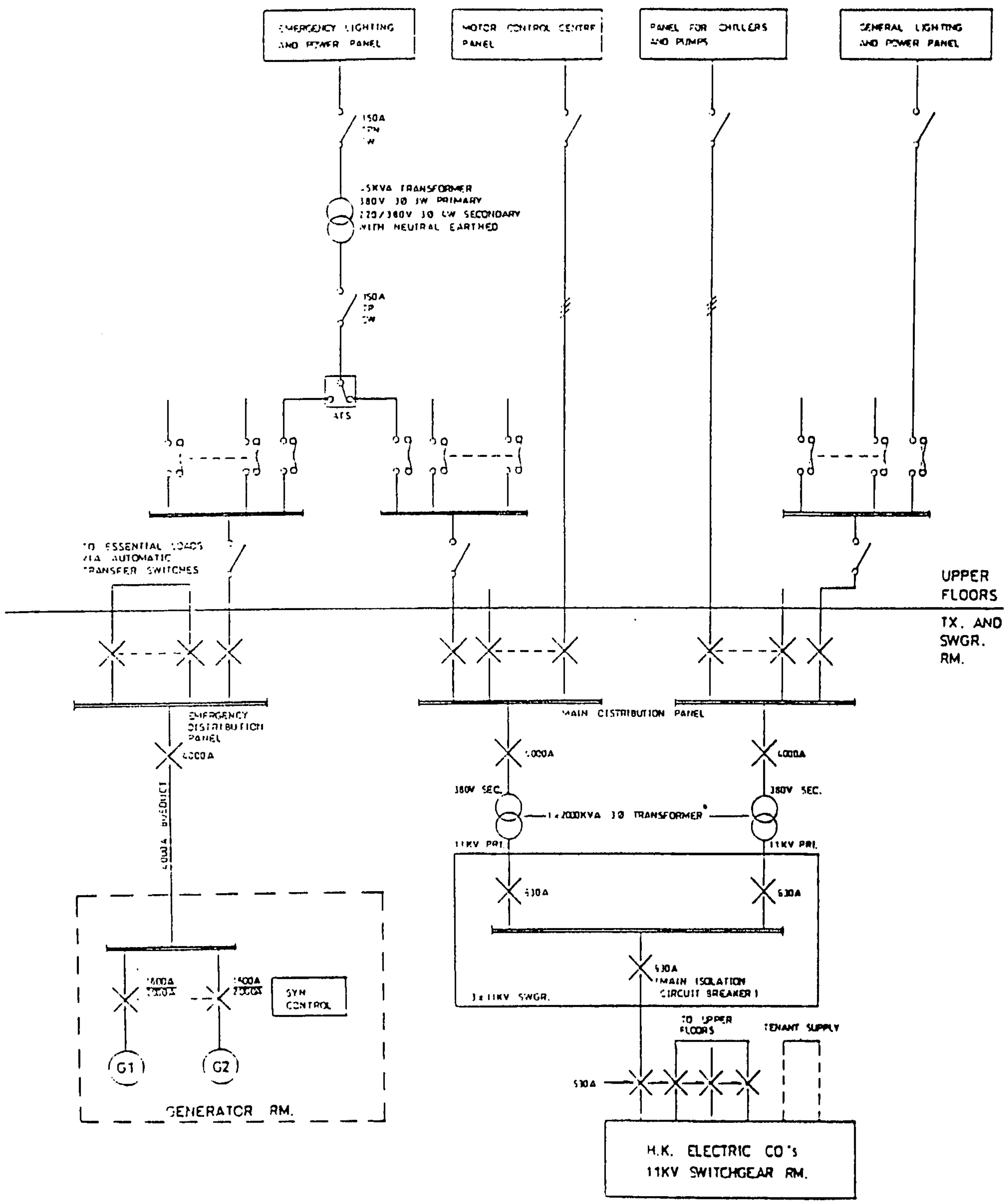
The project team members have taken up their individual responsibilities properly. The design and construction process was successful. The unique considerations in Hong Kong have been addressed and resolved within the project. The integration of local Hong Kong construction practices with alternative techniques developed in the United States of America proved to be successful. The amalgamation of both technologies further enhanced the project overall.

ACKNOWLEDGEMENTS

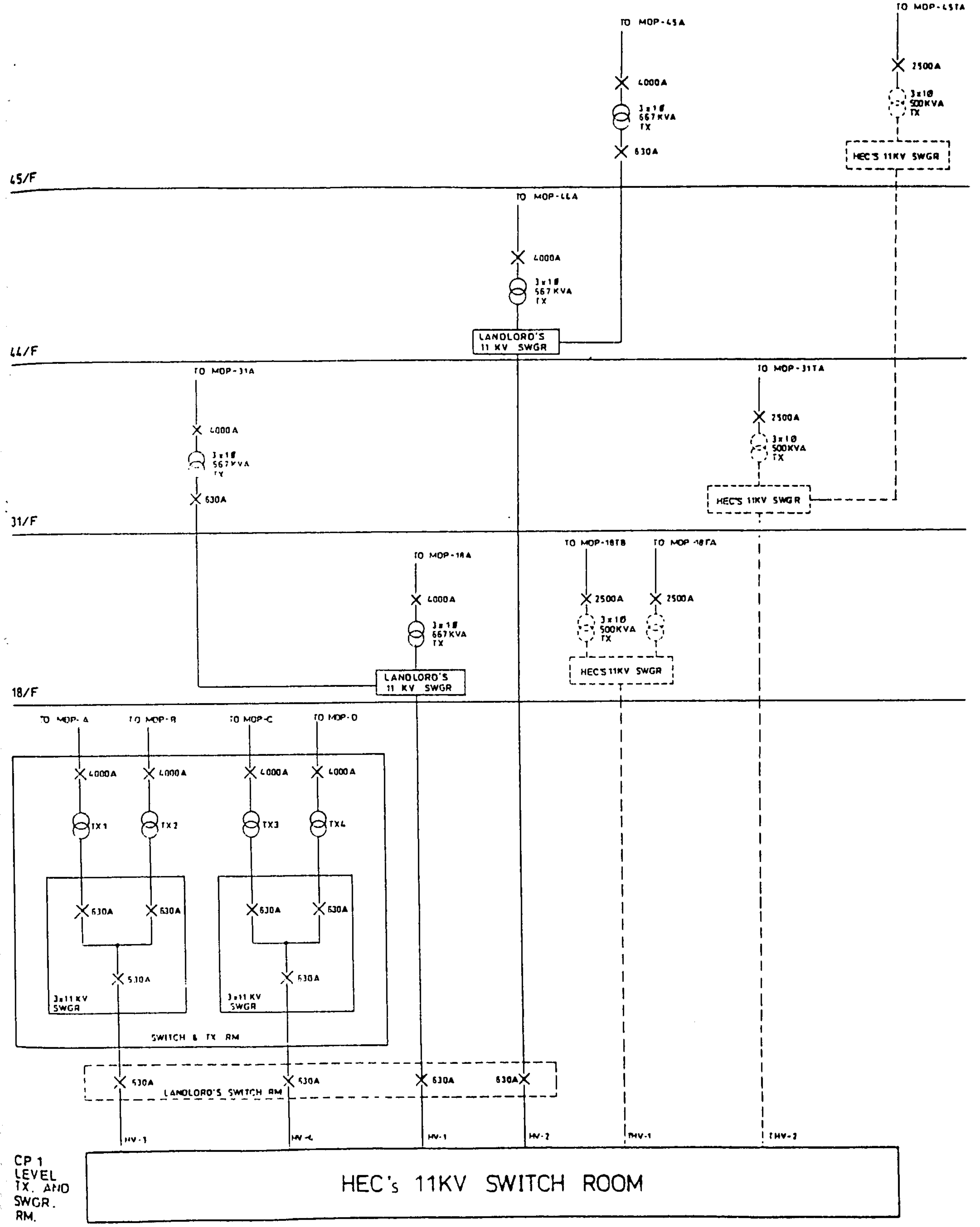
As presenter of this paper, I am indebted to Mr. Philip K. S. Chan-former Senior Electrical Project Engineer, for overseeing the electrical installation of this building and supplying such detailed information.

NOTES:

1. 3x667KVA 1Ø TRANSFORMER IS USED ON UPPER FLOORS FOR LANDLORD SUPPLY (220/380V)
2. 3x500KVA 1Ø TRANSFORMER IS USED ON UPPER FLOORS FOR TENANT SUPPLY (200/346V)



GENERAL AND EMERGENCY SUPPLY ARRANGEMENT
BANK OF CHINA TOWER



ELECTRICAL SYSTEM DIAGRAM - BANK OF CHINA TOWER

Paper No. 5

Chopper and Inverter Technology on Rolling Stock

– **Speakers: Mr. David T.S. Cheng, Depot Manager, MTRC**
Mr. Andrew Moyes, Elect. Eng. MTRC

CHOPPER AND INVERTER TECHNOLOGY ON ROLLING STOCK

INTRODUCTION

The Mass Transit Railway Corporation has recently taken delivery of 38 power cars and 11 trailer cars to provide for increased patronage of the Island Line and the opening of the Eastern Harbour Crossing. The power cars use gate turn off (GTO) thyristor control for the d.c. traction motors and GTO thyristor inverters for the auxiliary supplies.

The project started in 1986 when agreements were reached with two potential suppliers to convert two existing camshaft units to GTO chopper control and to replace the motor alternator (MA) sets by auxiliary inverters. Trials commenced early in 1987 and resulted in the placing of a contract with GEC in September 1987 for delivery in early 1989. The mechanical parts were supplied by Metro-Cammell Limited.

ADVANTAGES

1. Traction control

The following table summarises the relative advantages of chopper control when compared with the camshaft control used on earlier cars:–

	Chopper control	**Camshaft control**
Traction energy	Motoring resistance losses are eliminated, saving approx 10% energy. Regenerative braking recovers approx 40% energy.	Energy is wasted in resistors during initial accelerating. Regenerative braking is not practicable.
Station environmental control system (ECS)	Heat input into tunnels and stations is reduced, saving ECS energy in summer.	Waste heat from motoring and braking resistors must be extracted by the ECS.
Performance	Chopper on-ratio is smoothly varied, giving jerk-free acceleration.	Switching of resistors gives jerks during acceleration and braking.
Maintenance	Fewer moving parts. Contactors operate off-load. Routine maintenance is greatly reduced, reliability and availability are increased.	Wearing parts require regular maintenance and replacement.

Signalling interference	Care is required to avoid signalling interference. Protection must be fitted in case the chopper accidentally operates at the wrong frequency.	Does not generate interference.

2. Auxiliary inverter

The purpose of the auxiliary inverter is to convert the 1500 volt d.c. supply at the pantograph to a 440 volt 60Hz three phase supply for use by the air conditioners, lights, battery charger etc. This function was previously performed by a motor alternator set. The advangages of the inverter are:–

Quiet operation
High efficiency
Absence of moving parts

The most significant advantage to MTRC is the reduction in maintenance when compared with the existing MA Sets.

POWER CIRCUIT

An eight-car train comprises six power cars plus two trailer cars; an arrangement which meets performance requirements with the minimum of equipment whilst operating within the adhesion limits of the motored axles. Further economy of control equipment is achieved by forming the power cars in permanently coupled two-car units with one set of power control equipment for the eight traction motors.

The power circuit is shown in Figures 1 and 2. When the equipment was designed in 1986, large GTO thyristors of 4500 volt, 2500 amp rating had just become commercially available. The 1500 volt d.c. supply and motor configuration used on MTRC's cars fully exploit the voltage and current capabilities of these devices. A single 75mm GTO thyristor controls the motoring and regenerative braking of each power car. All the service braking is provided by the power cars in order to maximise regenerated energy and the air brakes fitted to trailer cars are used only for emergency braking. One rheostatic brake GTO chopper serves two cars and provides a smooth transition to air braking when the overhead supply becomes unreceptive. It is short time rated and can sink up to 1.44 megawatts of braking power.

Several items of equipment used on MTRC's earlier forced-commutated chopper cars have been omitted from the new GTO chopper cars. A chopper shorting contactor is not needed as the GTO thyristor can be switched to full conduction. This in turn has led to the replacement of inductive field diverts by simple resistive diverts because the GTO chopper is always available to protect the motors from upward surges in line voltage. A single high speed circuit breaker with a fault rupturing capacity of 58KA/10.5ms replaces three contactors previously required for fault clearance. The motor smoothing chokes have been omitted which gives a substantial saving in energy as well as capital cost. The force-communtated chopper cars used a field pre-excitation circuit to start commutation of the series motors during braking but the GTO chopper cars reliably excite using only residual magnetism.

FIELD EXCITATION SYSTEM AND THE EFFECT ON ENERGY CONSUMPTION

The computed specific energy consumptions of MTRC's cars are:–

Type of control	Year of introduction	Specific energy consumption (Watt-hours/tonne-km)
Camshaft	1978	51
Reverse conducting thyristor (RCT)	1981,	29
Gate turn off thyristor (GTO)	1987	24

Most of the energy saving of the chopper cars, of course, results from the use of regenerative braking instead of rheostatic braking. Figure 3 shows the electric braking performance envelopes of the camshaft, RCT and GTO chopper cars. The camshaft cars are able to provide rheostatic braking over almost the full range of braking effort at high speed and need only a small amount of supplementary air braking. This is because motor generated voltage is not limited to that of the overhead line and substantially exceeds it at high speeds and braking efforts.

When regenerative braking is used, maximum line voltage becomes a serious limitation. The RCT choppers use a permanent field divert resistance during braking to reduce the generated e.m.f. to below line voltage and the chopper acts in a 'step up' mode. The reduced e.m.f. is compensated by increased armature current to maintain the desired braking torque. The increased current in turn requires the use of a higher machine rating on the RCT chopper cars.

The GTO choppers use a different technique to reduce the generated e.m.f. at high speeds in braking. As shown in Figure 4, an extra power diode D2 is added to the basic step up chopper circuit. At high speed, when armature generated e.m.f. exceeds line voltage, the diode becomes forward biased and the armature generates directly into the line instead of via the field. This leaves the chopper free to control the field only and the motor operates in a separately-excited mode. The microprocessor control then varies the field strength so that the armature current is within the motor commutation limit, which is a function of speed and current. At lower speeds, the circuit reverts to full field operation, avoiding the need for an increased motor rating. To further raise braking performance, a series resistor is inserted into the armature circuit at high speeds. It is switched out as soon as possible by the microprocessor which predicts the point of closure to ensure that the commutation limit will just not be exceeded when the resistor is switched out of circuit. The high field strength at low speed allows full electric braking to be maintained down to 4km/h, at which point the motors are virtually short circuited and all the available energy has been regenerated. Typical curves of current versus speed are shown in Figure 5.

The circuit therefore operates with series excitation during motoring and a hybrid of separate and series excitation during braking. This arrangement gives the major benefit of a true separately-excited scheme in MTRC's application but with several further advantages of a series scheme. The equipment is smaller, lighter, cheaper and simpler because no field chopper is required. It is not necessary to used a high chopper frequency, with increased switching losses, or motor smoothing chokes in order to reduce motor ripple current to an acceptable level because field inductance provides all the smoothing necessary whenever the armature current is being chopped. A true separately-excited scheme, on the other hand, would use less electro-mechanical control gear and could achieve a slightly higher motoring performance or alternatively lower motoring energy consumption than the equivalent series motor scheme. This latter benefit is not available to

MTRC whilst multiples operation with camshaft cars is a requirement; the separately excited motoring characteristic would have to imitate a series motor to achieve load sharing.

The GTO chopper cars use the same type of d.c. traction motors as the camshaft cars and were designed with a fleet conversion to chopper control in mind. The substantial saving in energy and maintenance, together with the retention of the existing motors and many items of conventional control gear, makes the conversion an attractive proposition even though the camshaft equipment is far from being life expired.

The availability of high power GTO thyristors and microprocessor control has recently made a.c. motor drives a viable proposition. An a.c. drive is not attractive to MTRC for a fleet conversion because of the high cost of replacing traction motors. The energy consumption would be similar to that of GTO chopper equipment whilst the number of GTO thyristors would rise from three to thirteen per two-car unit. In 1986, when the prototype circuits were designed, it was considered that the techniques for the avoidance of signalling interference by variable frequency drives were not sufficiently well developed. It is recognised that advances have been made since that time, especially in inverter PWM switching algorithms. MTRC will assess the use of a.c. drives in depth when the need for new rolling stock arises.

MICROPROCESSOR CONTROL

The new cars are the first on MTR to use microprocessor control. Functions handled by the microprocessors include:–

- Chopper control
- Inverter control
- Regenerative/rheostatic/air brake blending
- Wheelslip/slide correction
- Fault diagnostics
- Kilowatt-hour meters
- Kilometre counter

If a fault occurs, the microprocessor control automatically resets or permanently isolates the circuit, or permits the driver to reset the fault, depending on the nature and frequency of the fault. Comprehensive LED indication is provided on the electronics frames and a portable terminal can be connected to download additional information. Fault data is stored in memory, and includes time, speed, motor/brake selection, line voltage and currents in the period leading up to and including the fault. The portable terminal includes a printer and can be linked to an IBM personal computer.

Speed is measured by magnetic probes mounted on the gearboxes.Wheelslip and slide is detected by calculating the rate-of-change of speed of individual axles and also by comparing the speeds of axles. The measured diameter of axle 1 is set on a thumbwheel switch in the electronics frame. The diameters of axles 2, 3 and 4 are then automatically calibrated to axle 1 by the electronics when the car is coasting, permitting a very accurate speed comparison. Wheeelslip correction is adaptive, that is the tractive effort at the instant of slipping is stored in memory so that power is quickly reapplied until the available adhesion level is almost reached. Thereafter, the reapplication of power is more gradual. This greatly reduces the number of repeated wheelslips. A similar system is used in regenerative braking. Wheelslide protection is also opperative during emergency air braking in order to avoid wheel flats and an independent monitoring circuit on each car intervenes if the proportion of wheelslide becomes excessive.

INVERTER

The inverter output waveform is a near sine wave and is therefore suitable for the existing air conditioners and other loads without any alterations. The circuit is shown in Figure 6. A front end chopper maintains a constant output voltage when the line voltage varies. The inverter stage is pulse width modulated to eliminate the fifth and seventh harmonics. The transformer connection eliminates the third harmoniic and its multiples. In order to reduce switching losses and thereby permit natural ventilation of the semiconductors, higher harmonics are not removed by pulse width modulation. The lowest harmonics theoretically present are therefore the eleventh and thirteenth. An L-C filter on the output attenuates these and provides power factor correction at fundamental frequency. The total harmonic, distortion of current is typically 2 to 3% which leads to a high efficiency of the overall system. Figure 7 shows the relative efficiencies of the inverter and MA set.

The inverter output frequency is smoothly reduced from 60Hz to 50Hz when the train is in stations. The purpose is to reduce the background noise level of the air conditioners. The inverter itself is virtually silent in operation.

The continuous rating is 65KVA with a short time rating of 80KVA for the additional duty of charging a flat battery.

COMPUTER SIMULTATIONS OF TRAIN PERFORMANCE

The Corporation has developed single-train simulator programs for and IBM PS2 computer which cover camshaft, RCT chopper and GTO chopper equipment with series and seperately-excited motors. The programs accurately model the control techniques used by each type of equipment together with the automatic train operation (ATO) data, track gradients and curvature, tunnel and open air train resistance. The energy calculations have been found to be accurate to better than 5% by practical verification.

The programs have been particularly useful in assessing different manufacturers' tender proposals, ensuring that a fair comparison is made under identical input conditions. The programs are also used to determine the most energy efficient option of track profile on new railway extensions.

The railway's timetables were recently revised when simulations showed that adjustment of the ATO coasting points could give a saving in energy for no increase in total run time. A file was first built up of results of energy calculations with different percentages of coasting in each section. A further program was then written to select the combination of results that gave the desired run time with the lowest energy consumption. The coasting was therefore concentrated in those sections which gave the best saving. The theoretical saving was 10% of the traction energy. In practice, a saving of about 3–4% has been achieved due to various constraints, principally in the areas of signalling and passenger comfort.

A multiple train simulator is currently being developed for MTRC by the University of Birmingham in the UK. Unlike MTRC's present simulator, it simultaneously models all the trains on a given line. It calculates line voltage variations and allows for loss of receptivity if the motoring cars are unable to absorb all the regenerated energy at a given instant. The models are necessarily less detailed than those in the single train simulator and the latter will still have its uses in the detailed analysis of rolling stock design.

During extensive testing of the prototype GTO chopper, it was found that between 42 and 46% of motoring energy was consistently recovered by regeneration. The figure computed on the single train simulator was 48%, assuming full receptivity. The multiple train simulator will be used to estimate the reduction in these figures as the fleet is progressively converted to chopper control. It is expected that receptivity will remain relatively high due to MTRC's nearly ideal conditions of short headways, relatively high nominal line voltage, high auxiliary loading, an inverter substation at a central location and an overhead conductor system which has few gaps and, for the purpose of regeneration, has all lines fully interconnected.

CONCLUSION

The new GTO chopper cars achieve a level of efficiency which is high by any standard. The circuits used are well suited to the cost effective upgrading of the existing fleet.

ACKNOWLEDGEMENTS

The authors wish to thank MTRC and GEC Transportation Projects Limited for permission to publish this paper and acknowledge the efforts of the many staff involved in the design and commissioning of the new equipments.

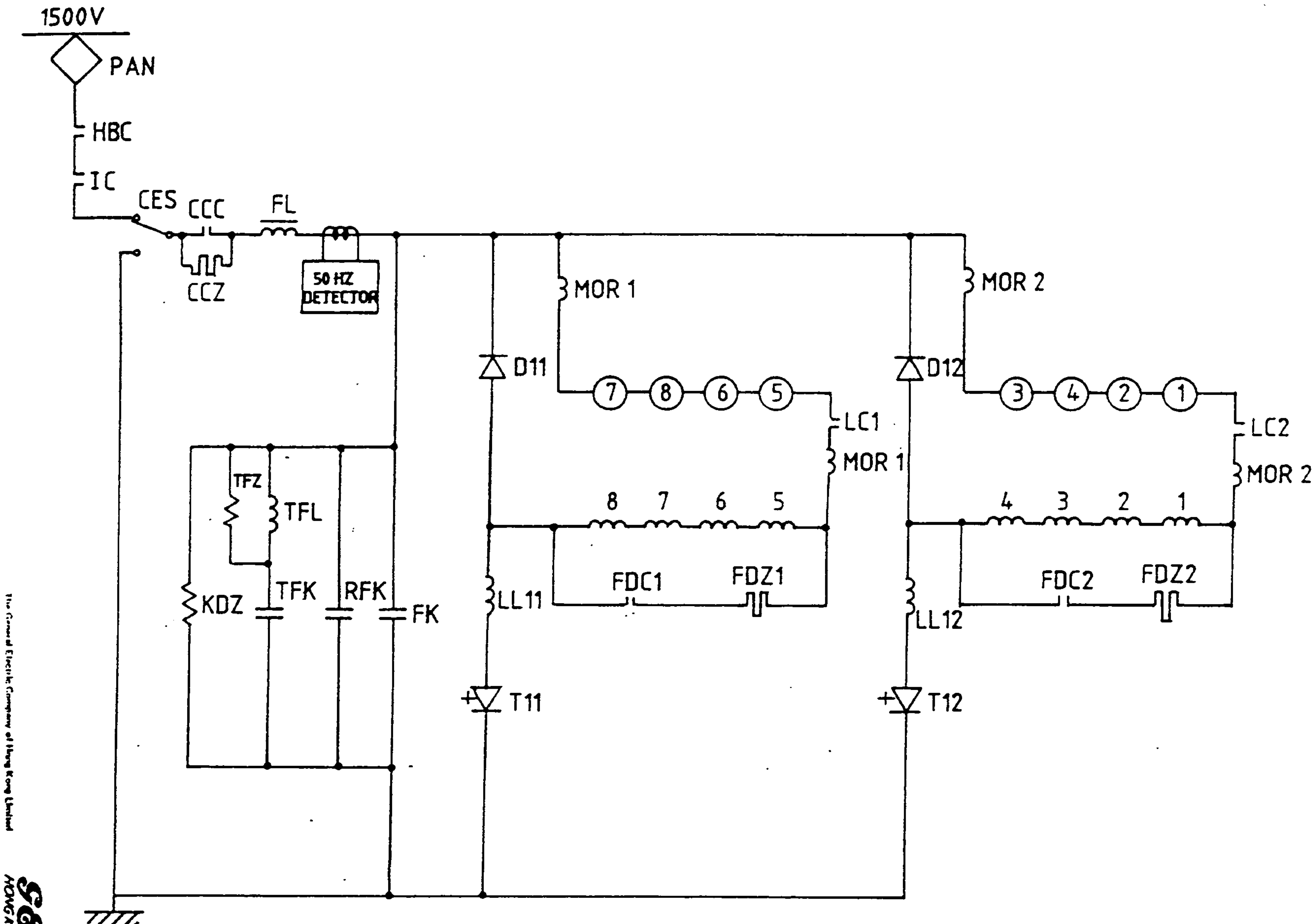


FIGURE 1 MOTORING SCHEMATIC

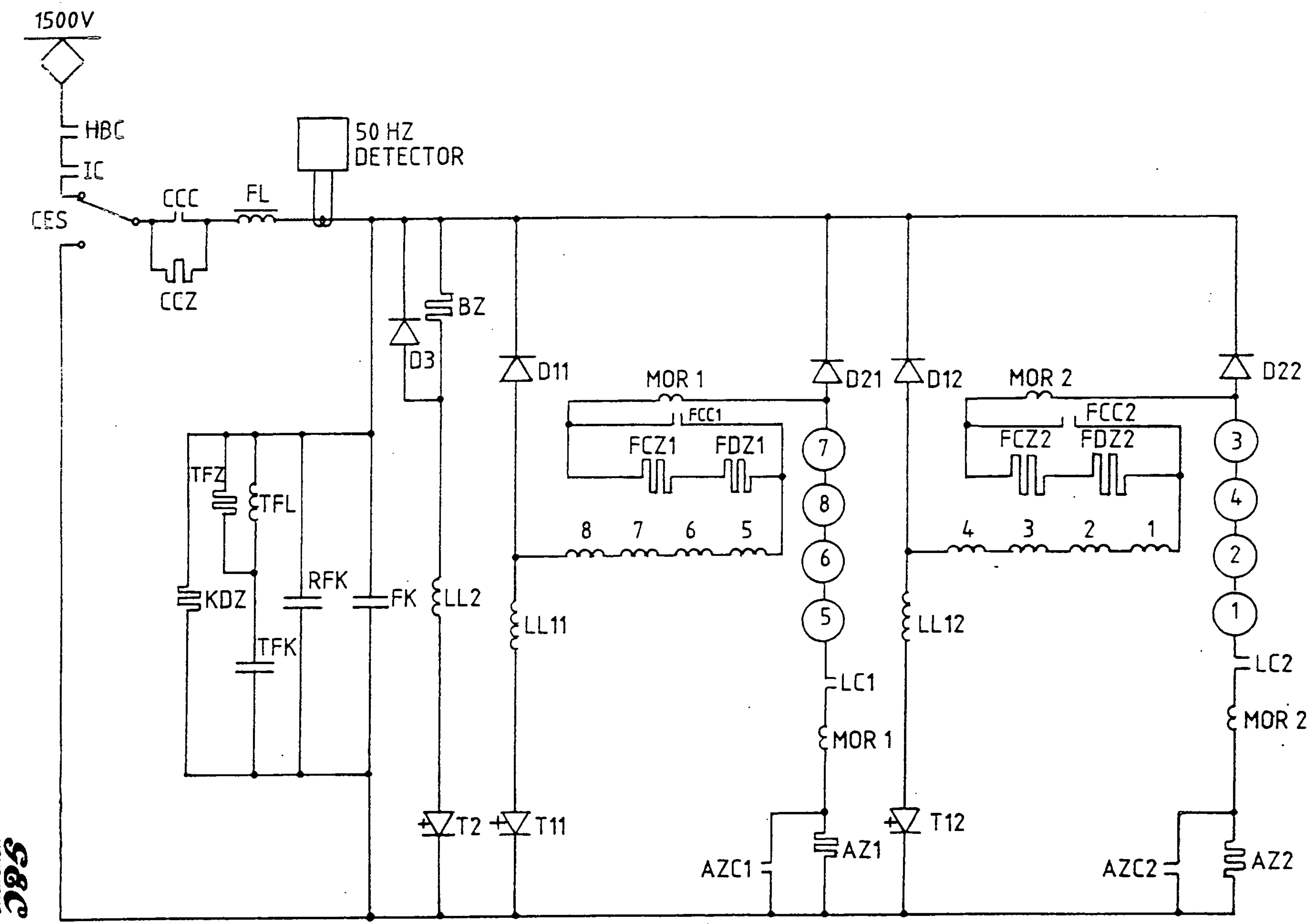


FIGURE 2 BRAKING SCHEMATIC

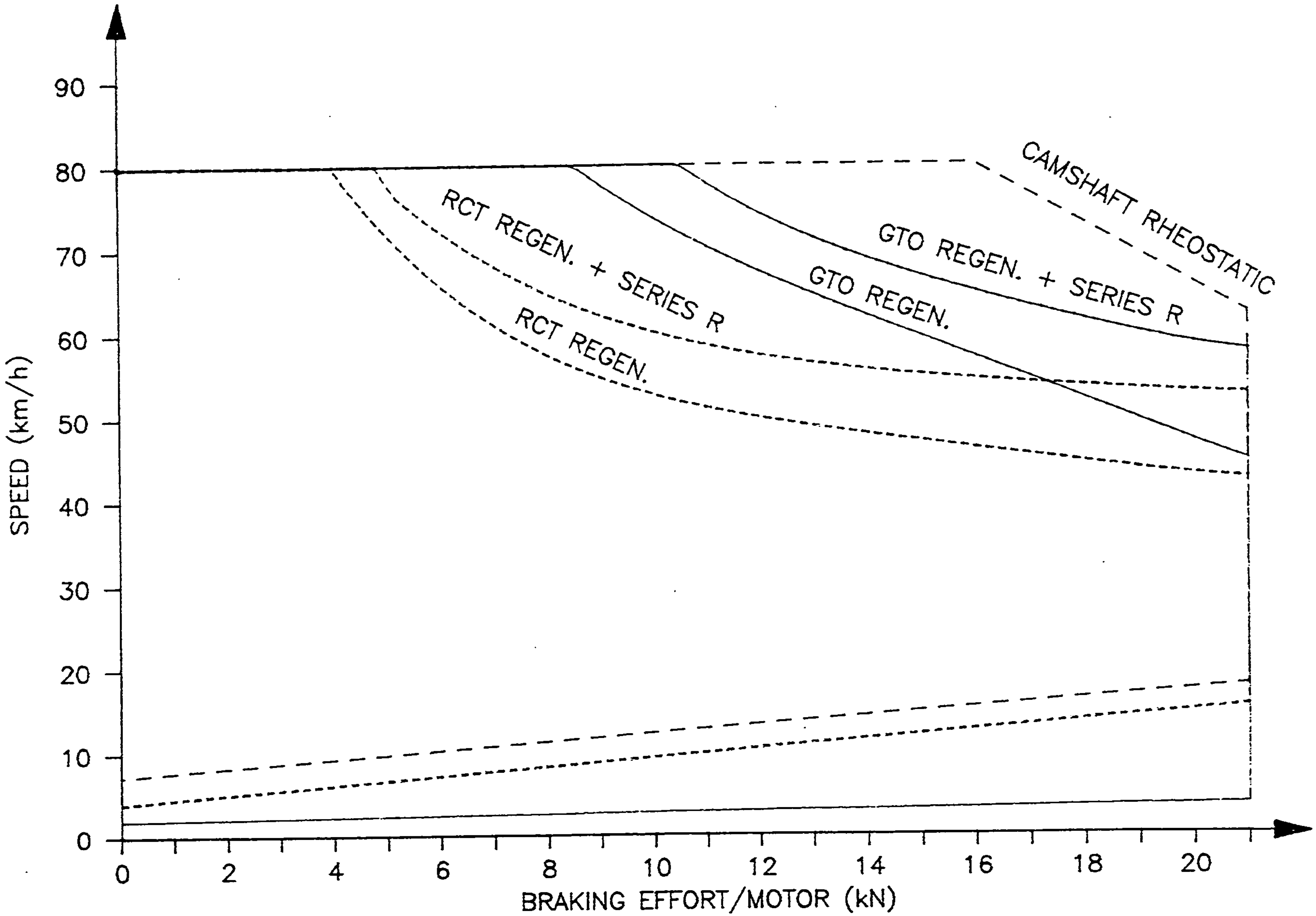
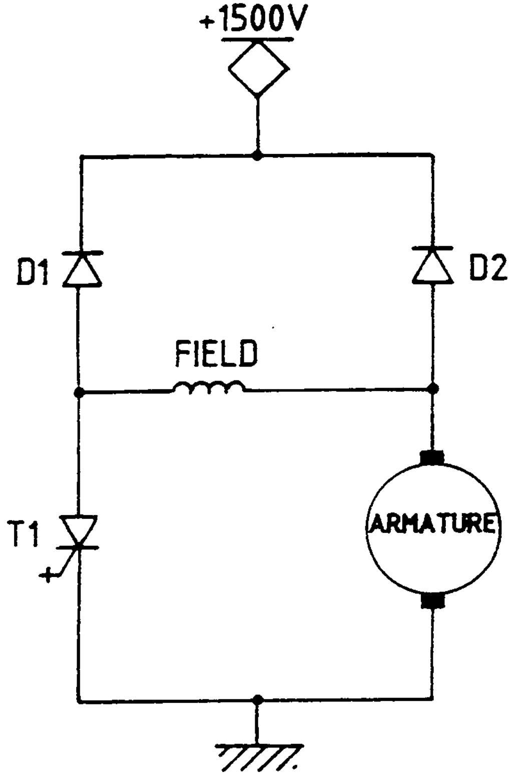
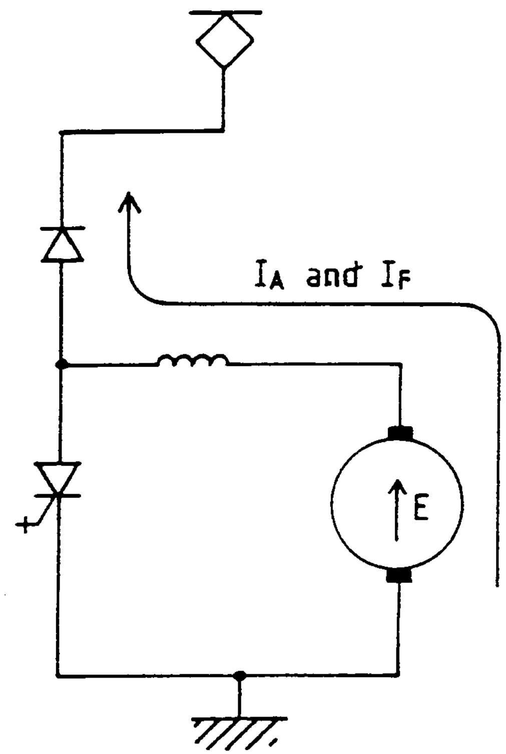


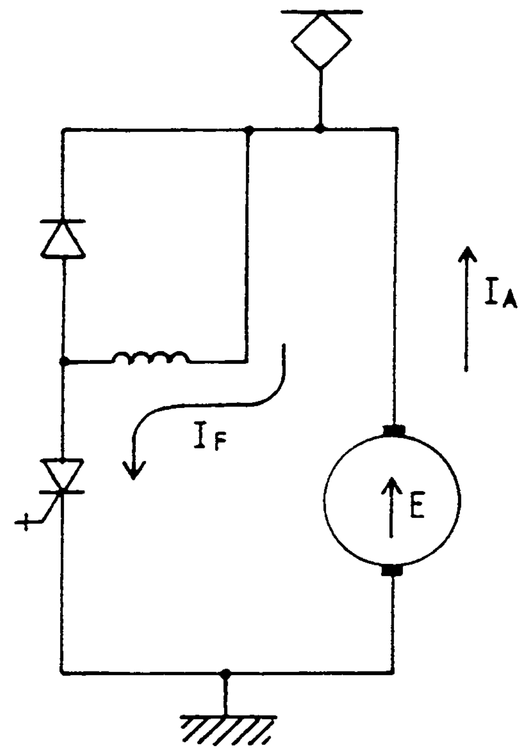
FIGURE 3. ELECTRIC BRAKE PERFORMANCE ENVELOPES



SIMPLIFIED CIRCUIT



EFFECTIVE CIRCUIT AT LOW SPEED (SERIES EXCITED MODE) WITH D2 REVERSE BIASSED



EFFECTIVE CIRCUIT AT HIGH SPEED (SEPARATELY EXCITED MODE) WITH D2 FORWARD BIASSED

FIGURE 4 SIMPLIFIED BRAKING CIRCUIT

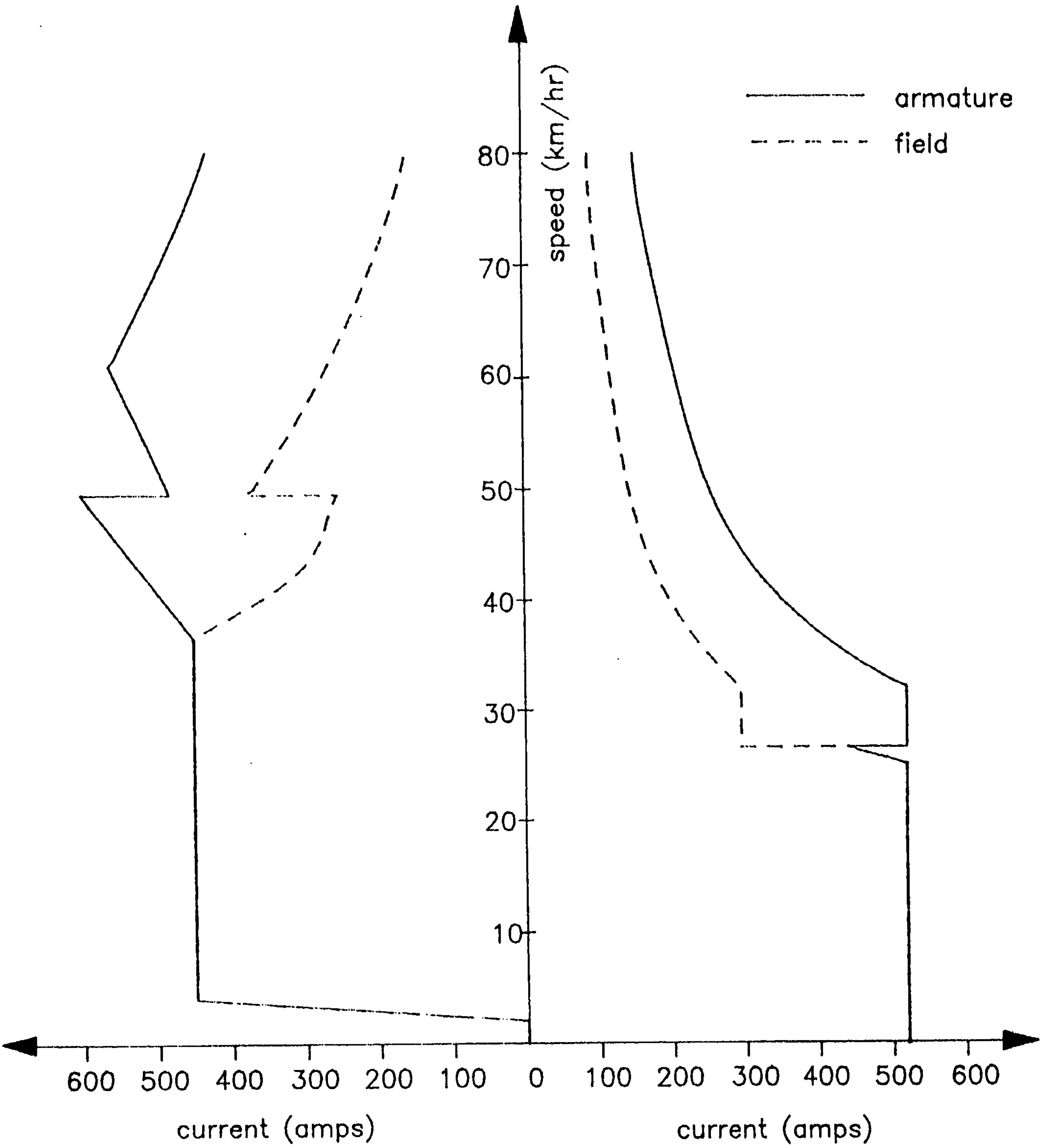


FIGURE 5. TYPICAL MOTORING AND BRAKING CURRENTS

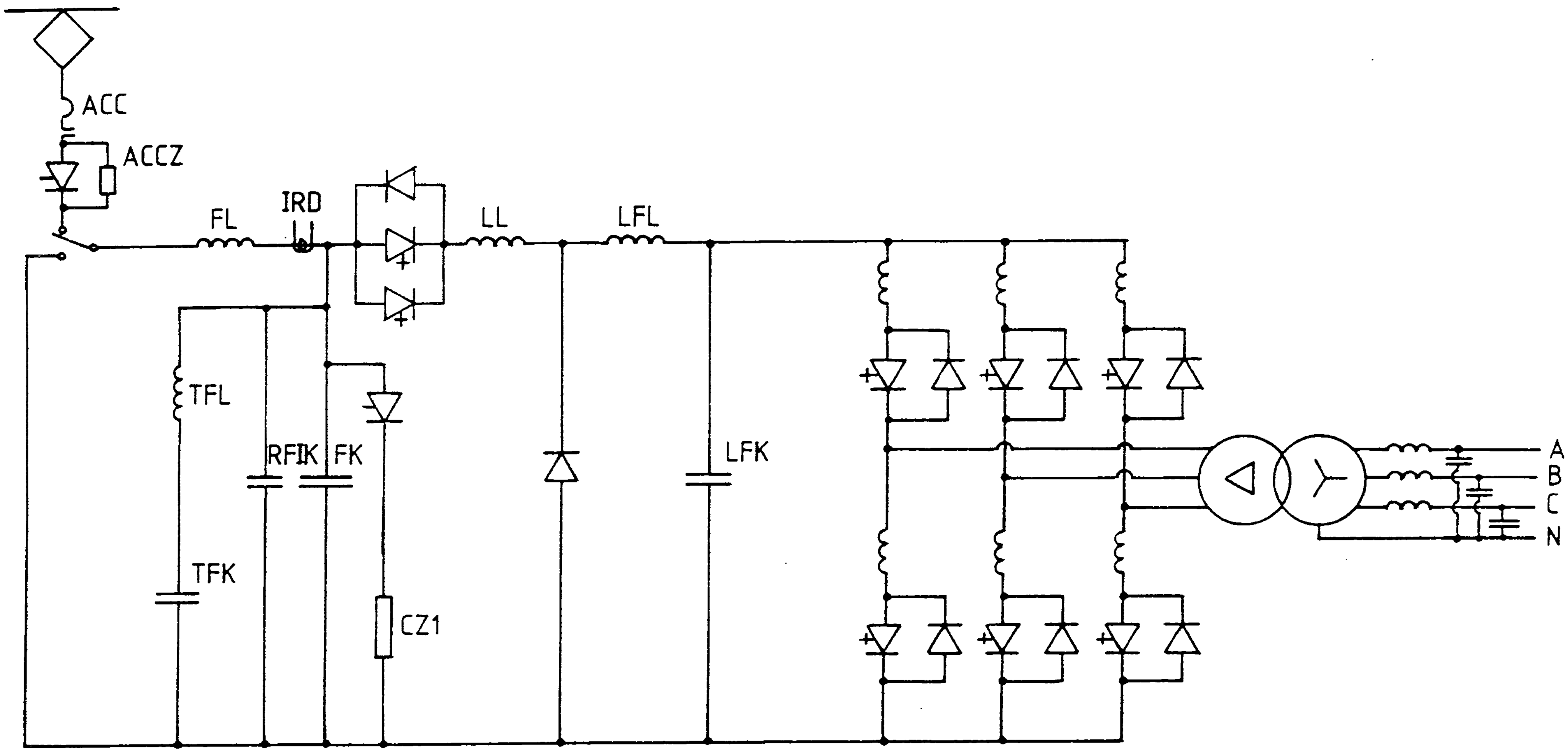


FIGURE 6 INVERTER SCHEMATIC

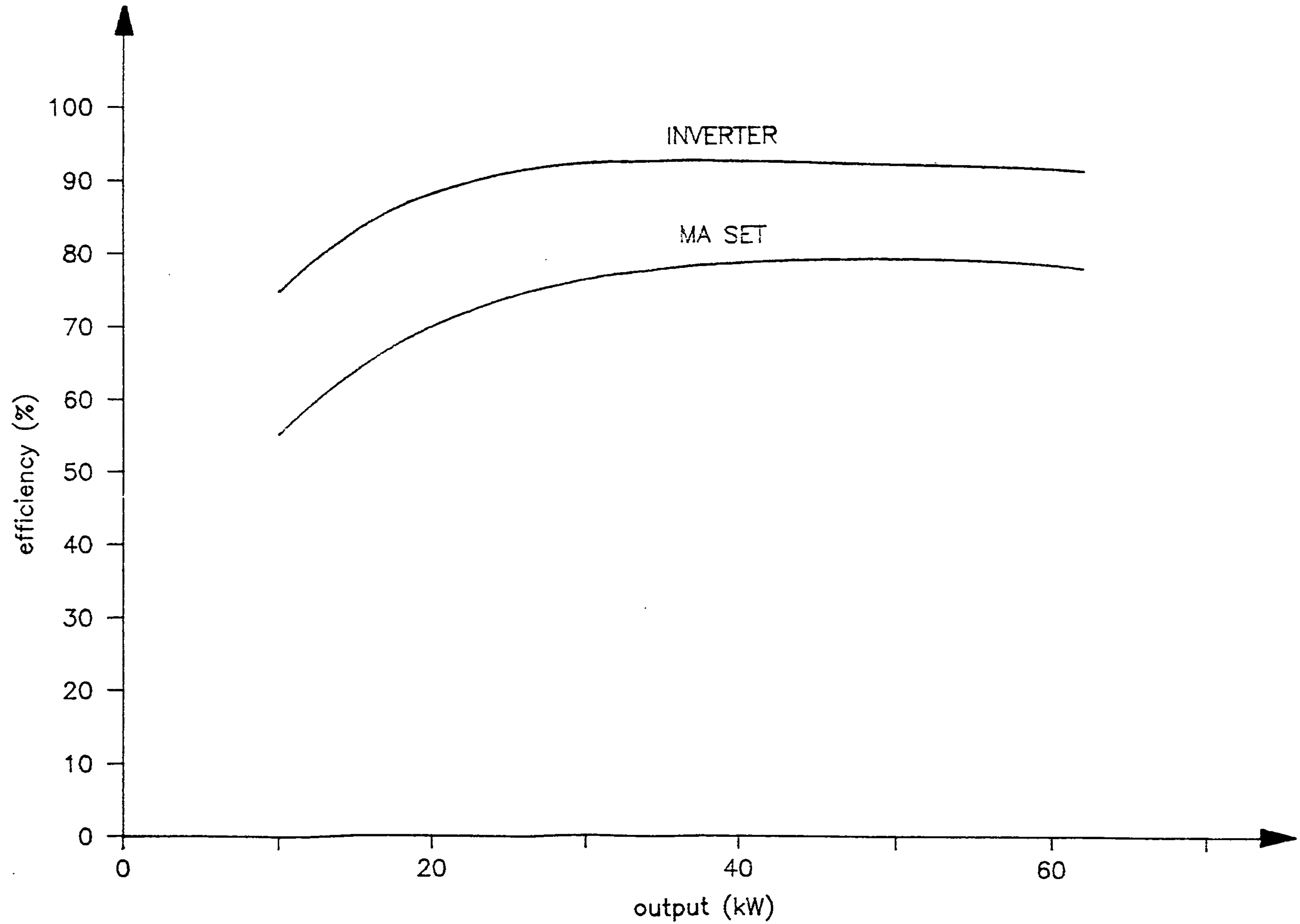


FIGURE 7. INVERTER AND MA SET EFFICIENCY

3. Power Supply

Paper No. 6

Planning for Electricity Supply for the 1990's

– **Speakers: Mr. J. Lui,**
Chief Planning Officer, CLP
Dr. A. Poon,
Corporate Planning Officer, CLP

PLANNING FOR ELECTRICITY SUPPLY FOR THE 1990'S

1. Introduction

The China Light supply system has undergone significant changes since the development of the Castle Peak Power Station in the late 1970's. These developments encompassed all aspects of the supply system, including power stations, transmission and the distribution systems. In Section 2 of the paper, a brief account on these developments and the present status of the China Light's supply system will be presented. Looking ahead, Hong Kong will continue to grow. In order to ensure adequate and reliable electricity supply to support the future growth of Hong Kong, China Light is now Planning and designing its supply system for the 1990's. These new challenges will be presented in the remaining part of the paper.

2. Description of the Present China Light Supply System Power Stations

There are three power stations in the China Light supply system. These are the Castle Peak, Tsing Yi and Hok Un power stations. Their locations are shown in Fig. 1 for reference.

At present, 98% of China Light's electricity are generated from the coal-fired Castle Peak Power Station, situated at Tap Shek Kok, Tuen Mun. It is the latest and biggest power station of China Light, and is one of the most modern power stations in the region. The last generating unit will be put on commercial load in January 1990, completing the development of the Castle Peak Power Station project. When completed, there will be over 4,400 megawatt capacity on one single site at Castle Peak.

The Tsing Yi Power Station which is situated at the southern tip of Ting Yi Island was built in the late 1960's and early 1970's. It is an oil-fired power station with a total capacity of about 1,500 megawatt. At present, it is serving as an intermediate load power station and supplements the production of electricity during the morning and afternoon peak load periods, and is often used to provide the spinning reserve to ensure the reliability of the supply system.

The Hok Un Power Station, situated at Hung Hom, is the oldest power station of China Light in existence. Most of the generating units have been decommissioned. The remaining gas turbines, of about 250 megawatt in total capacity, are normally run as peaking plants and help to meet the demand of electricity during the short periods of peak demand when it is more economical to utilize gas turbines. These gas turbines are also run during emergency situations to enable prompt restoration of supplies.

The Transmission System

For technical, economic and environmental reasons, electricity is often produced at the relatively remote locations, far away froom the load centres. A power transmission system is therefore necessary. In the case of CLP, the electricity generated at Castle Peak Power Station is transmitted to the load centres in Kowloon and the New Territories through an Extra High Voltage 400KV grid system and, after voltage transformation, the 132KV network. The China Light transmission system is depicted in Fig. 2 for reference.

The 400KV grid system consists of a ringed configuration to improve the security of electricity supply. The primary ring is made up of double circuit 2 X 1,850 MVA overhead lines running through the New Territories and New Kowloon. The secondary ring runs through the Kowloon Peninsula, and for environmental reasons, is made up of 2 X 750 MVA underground cables.

Seven 400KV substations are strategically located along the 400KV grid system to tap power off from the grid to feed into the load centres. Voltage is stepped down to 132KV at these 400KV substations before feeding into the 132KV area transmission networks. A standard 132KV area transmission network is designed to supply two to three primary substations. Each primary substation is fed by a dual-source supply and handles some 70 to 100MVA load. The security of supply to these primary substations is provided by an automatic switch-over scheme so that when supply from one supply source is interrupted, the other source will be automatically switched in to maintain the supply.

The Distribution System

From the primary substations, power is distributed to customer substations at 11kV. Again, in order to secure the supply of electricity to customers, ring networks are utilized. Rings with up to four legs are common in the urban areas where the density of load is high.

Customers usually obtain their supply of electricity at 200 volts or 346 volts after voltage transformation at the local distribution substations. Bulk customers may obtain the supply directly at 11kV or at higher voltages up to 132kV.

3. Load Forecast for the 1990's

Since it normally takes about 8 years to plan and build a new power station and about 5 years to build a major transmission facility, it is important to be able to forecast the electricity demand of the system at least 10 years ahead. A reliable and accurate load forecast is crucial to the proper planning of the supply system.

At China Light, load forecast is conducted in a very stringent manner twice a year. All development plans have to be reviewed after every load forecast update to ensure that they are fine-tuned to meet the latest load forecast requirements.

In brief, China Light employs a micro analysis technique to produce its load forecast. In this approach, the China Light customers are catagorized into some 30 sectors for load forecast purposes. Load forecast for each of these sectors is performed based on the social and economic assumptions that will affect electricity consumption of the sector. The aggregate of these 30 odd load forecasts produces the overall electricity demand forecast of the whole China Light system. This is further ascertained by means of macro analysis techniques, to ensure that such load forecast is consistent and reliable for system planning purposes.

The latest forecast indicates that China Light electricity demand will continue to inccrease at an average rate of 6–7% per year during the 1990's period. This is considered moderate when compared to the average of 10% p.a. growth in the past decade.

4. Generation Planning for the 1990's

Economic Plant Mix

The load curve of each power system has its own characteristics. The CLP system load curve has high peaks, low troughs and a load factor of only around 50%. The maximum demand would typically be more than two times the minimum system load. Therefore some generating plants will only be run for a short time of the day. In order to provide an economic supply, there need to be a good mix of base-load plants (which runs throughout the day) and peaking plants (which only runs to meet the peak load).

With the forecasted average 6–7% annual growth in the demand of electricity in the 1990's, there is a clear requirement of additional base-load plants and peaking plants to be built in the system to augment the existing installed capacity in order to maintain a reliable and economic supply.

The addition of the last generating unit at Castle Peak in January 1990 will enable China Light to supply its customers at a high reliability level until 1992, when an additional 300 megawatt capacity is planned with the installation of three gas turbines to the system.

A major addition of capacity to the China Light system comes in 1993 and 1994 when the two generating units at the guangdong Nuclear Power Station are put into commercial operation. China Light would purchase about 70% of the output from this power station. Such an arrangement would provide an additional installed capacity of 1,400 megawatt for meeting the ever-increasing demand in Hong Kong.

During 1993 and 1994, the load pattern of the China Light system would demand an additional 600 MW of peaking plants to ensure a reliable and economic supply to customers. This can be achieved with gas turbines and is being considered.

With the forecasted rate of growth of electricity demand, further generation capacity will be required in 1996.

After careful and detailed studies of various alternatives, it was concluded that the construction of a new coal-fired power station of 5,000 MW capacity in Hong Kong is the best solution for acquiring additional capacity for Hong Kong.

Challenge of the New Coal-fired Power Station

The basic requirements of the site for the new power station are minimum environmental impacts, little infringement with government development plans, availability of adequate cooling water, easy access for transportation, adequate wayleave for transmission circuits and low site formation costs.

Site selection studies have identified several alternative locations for the development of the new power station. The location at Fan Lau, at the south-western tip of Lantau Island, presents the least environmental impacct when compared with the other locations, such as that at Gruff Head is Sai Kung. Fan Lau is the most remote site one can possibly find in Hong Kong for the construction of a power station.

The requirement for environmental reasons to locate the new power station in remote area presents a challenge to power system design engineers. Suitable transmission circuits have to be installed to enable the power produced by the new power station to be delivered to load centres in Kowloon or new towns in N.T. However, taking into consideration the geographical limitations, congestion of overhead line circuits, system security requirements and the possible development along the route of the transmission circuit, the design for the transmission outlet of the new power station will no longer be straight forward. A combination of overhead line, underground cable, submarine cable or gas insulated ductings installed in tunnels will have to be considered. Suitable modification of the existing 400kV network will also be necessary to accommodate the additional circuits from the new power station.

5. Transmission Planning for the 1990's

Extension of the 400kV System

In order to meet the increasing demand at the various load centres, both in the well developed urban areas as well as in the new towns, the transmission system will need to be developed in conjunction with the expansion of generation capacities in the 1990's. In addition to the existing seven 400kV substations, four additional substations have been planned; at Shatin, Tai Kok Tsui, Junk Bay and Sham Tseng. Depending on the final decision on the transmission outlet for the new power station, A fifth additional 400kV Substation may be required.

Expansion of the 400kV network has been planned to construct two double circuit overhead lines to China, one directly to the Guangdong Nuclear Power Station, and the other to a substation at Shenzhen for the delivery of power produced at the nuclear power station to the China Light network. New 400kV circuits have also been planned to integrate the proposed new 400kV substation into the 400kV grid, maintaining the ringed configuration for a high level of supply security. A new 400kV circuit is also planned to interconnect the 400kV substations at Yuen Long and Lai Chi Kok to improve the balance of power flow through the 400kV network.

6. Challenge in Distribution for the 1990's

High Load Density

With the growth of population, and the continuing build-up of economic activities especially in the well developed urban areas, the demand for electricity has outgrown the available locations for electric substations. In order to cope with the increasing load density, China Light has been designing bigger electric substations; from the 2 X 20MVA and 3 X 20MVA substations in the early 1960's to the 3 X 35MVA substations in the 1970's and the present 2 X 50MVA and 3 X 50MVA substations.

The possibility of using substations with larger capacities has been the subject of constant study and monitoring, having regard to new technologies and practices of other utilities worldwide.

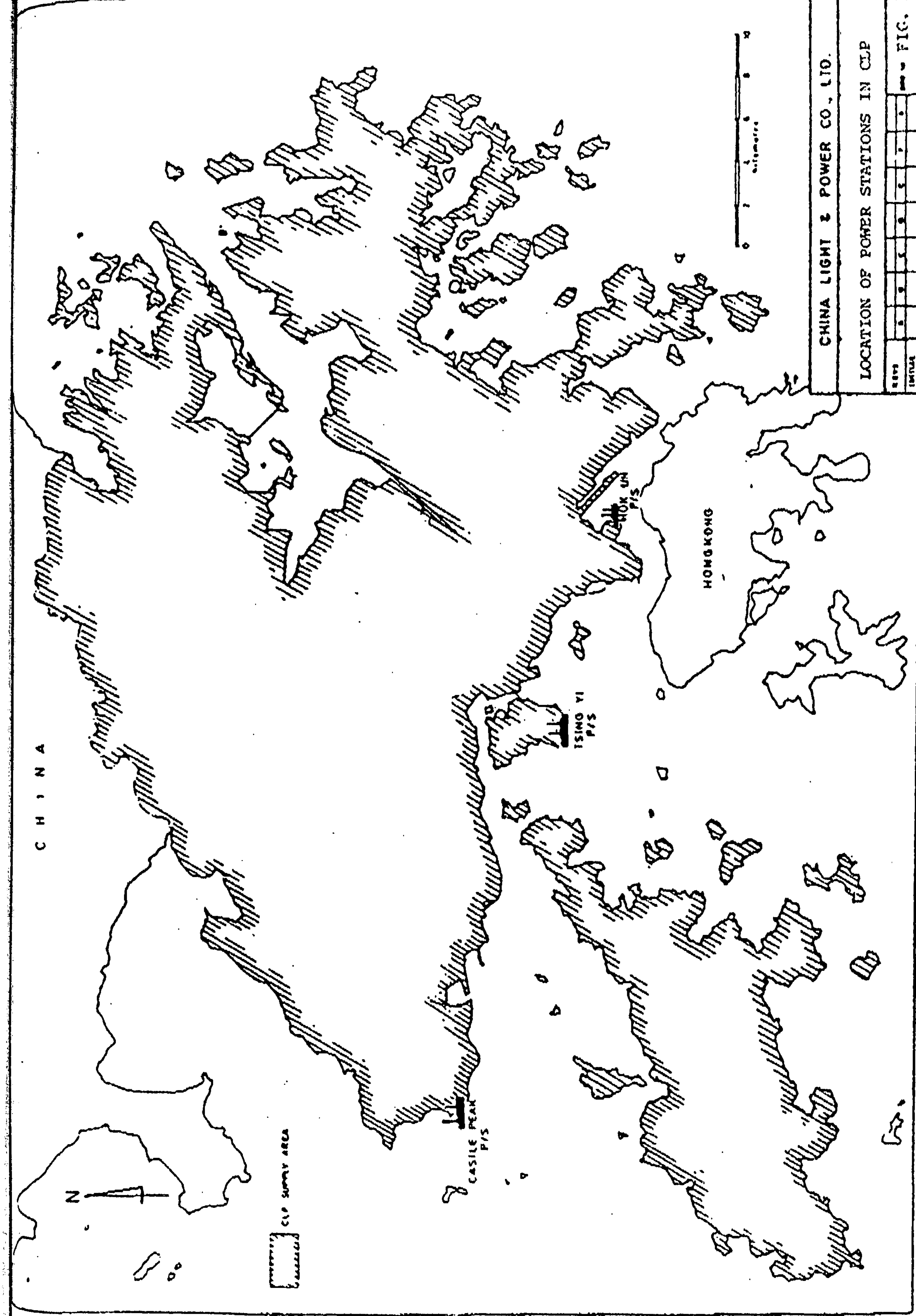
Underground Substations

When suitable sites above-ground become unavailable or very costly, constructing substations underground is a promising alternative. In many major cities worldwide, like Toyko, the shortage of substation sites above-ground has become so acute that underground substations are being utilized for the distribution of electric power.

When required, the underground substations can be designed to be incorporated into Government or public facilities, such as underneath parks, and with large scale commercial-residential developments where the design can be made at an early stage. Although some of the equipment used will be of special fire-proof design, which means additional cost, the opportunities for benefit are real. In terms of blending with the environment, these underground substations are invisible except for the access and ventilation facilities, which are necessarily above-ground.

7. Conclusion

The Castle Peak Power Station development has brought about significant developments in the supply system of China Light. Looking ahead into the future, the development of the new coal-fired power station and the associated transmission and distribution network to provide a reliable and efficient electricity supply to our customers will mean another big leap forward for China Light again. Some of the preliminary planning and design works have already begun. Given the additional constraints in 1990's as described above, system planners and designers in China Light are eager to accept the challenges to meet the electricity requirement of a growing Hong Kong into the 1990's.


CHINA LIGHT & POWER CO., LTD.
LOCATION OF POWER STATIONS IN CLP
FIG. 1
CHINA
HONGKONG
HOK UN P/S
TSING YI P/S
CASTLE PEAK P/S
CLP SUPPLY AREA
N

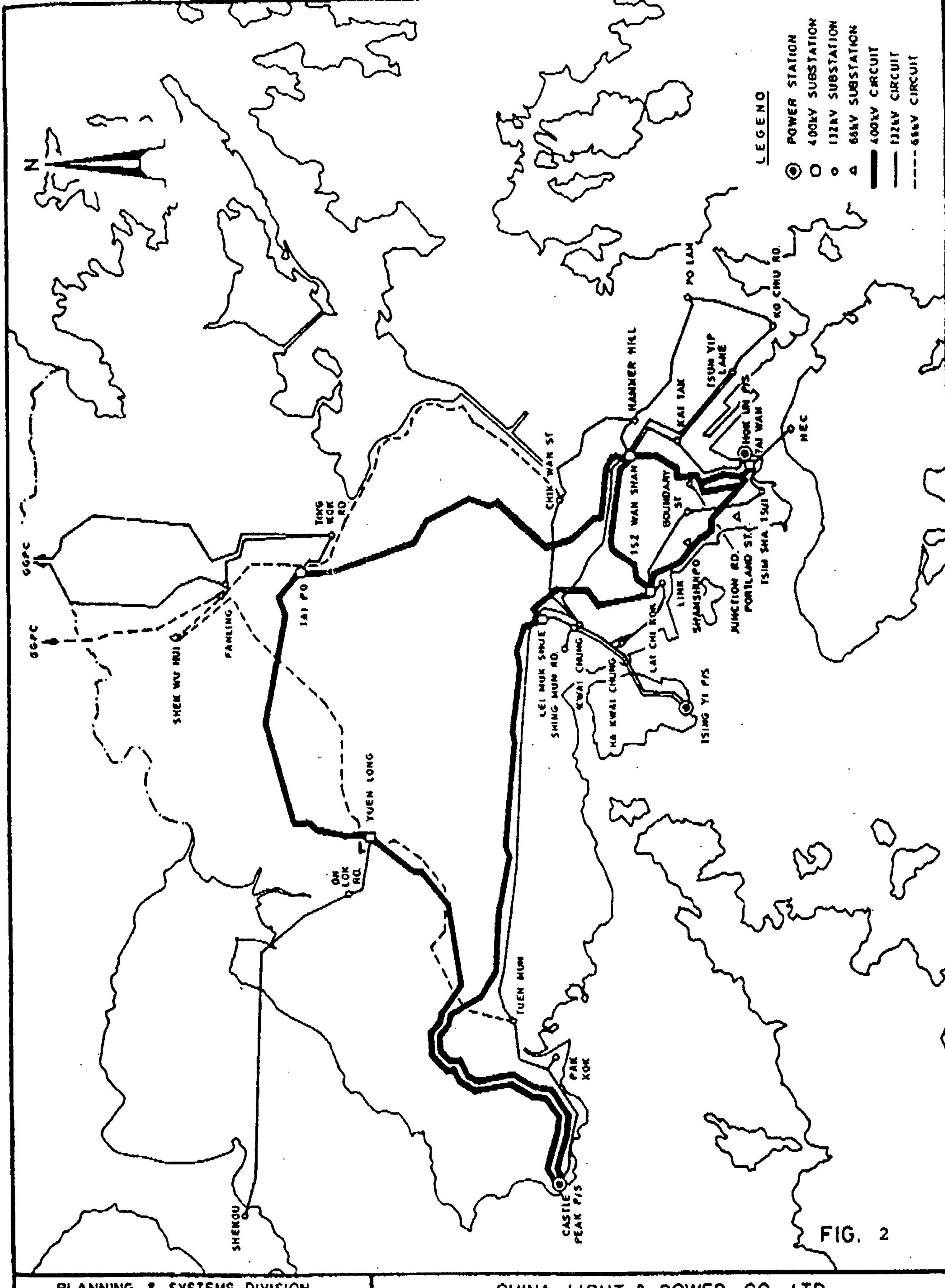


FIG. 2

PLANNING & SYSTEMS DIVISION		CHINA LIGHT & POWER CO., LTD.
DRAWN BY	K. C. YEUNG	TITLE PROPOSED TRANSMISSION SYSTEM - 1989 (GEOGRAPHICAL)
CHECKED BY	P. WONG	
APPROVED BY		
DATE 28-4-89	SCALE 1 : 200,000	REVISION A B C D E F G — DRG. NO. BTI 001
PLANNING DEPT. / SYSTEM PLANNING		DATE REV

Paper No. 7

Emergency Generator and the Environment

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EMERGENCY GENERATOR AND THE ENVIRONMENT

Introduction

As Emergency generators are required for almost all buildings under local statutory requirement, there are hundreds of emergency generators installed in different buildings each year.

Previously, engineer s' design only concerns with basic criteria such as ventilation requirement, starting ability etc. of emergency generators in order to fulfill its desired functions. However, environmental impacts of emergency generators became a new concern in recent years. Before we proceed to assess the environmental pollution produced by the generators, we will go through some points on generator installation design because they affect our environment improvement work.

Local Fire Services Regulation regarding Emergency Power for Buildings

Nearly all types of buildings require emergency generator under the 'Code of Practice of Minimum Fire Service Installations and Equipment'. Emergency generator is responsible for providing standby power during mains failure for fire fighting equipments such as water pump of sprinkler system, emergency lighting, fire lift etc.

Other than statutory requirement, emergency generators are also important for other essential services which make the building alive and function properly as desired during mains power failure. Hotels, hospitals, banks and telephone exchange are some examples.

Although mains failure is rare in Hong Kong, a well-designed and properly maintained emergency generator will be most helpful during mains power failure. In order to upkeep reliability of emergency generators, proper maintenance scheme shall be adopted. In general. exercising generators once to twice a month with duration of 15 to 30 minutes each time is the simplest way to ensure the generators are at work.

Typical Diesel Generators Installation and its Impact to the Environment

The following aspects have to be taken into consideration in the choice of location of a generator room:-

- Size of the room
- Height of the room
- Engine cooling method
- Fresh air intake
- Cooling air discharge
- Exhaust flue

Size of the room

A diesel generator in general consists of engine and alternator coupled together. There shall be at least 800mm to 1000mm space all around the generator for easy maintenance (Fire Service Dept. require not less than 600mm). Fig. 1 & 2 are the most ideal generator room.

Height of the room

Height of the room will much depend on the rating of the diesel generator. There shall be at least 1m clear headroom above the highest part of the genset. In general, the highest part is the set-mount radiator.

The 1m clear headroom is required for exhaust flue arrangement and cabling in addition to maintenance requirement.

Engine cooling method

There are mainly two categories of cooling methods. The first one is to use a radiator solely for the engine cooling which is simple and reliable. The second one is to use centralised cooling system, e.g. common cooling water with chiller system. In order to maintain the reliability of the system, a heat exchanger to separate the primary circuit for the engine and a secondary circuit of the centralised cooling system is highly recommended, Fig.3.

In the first cooling method, either set-mount radiator or remote radiator is used. Set-mount radiator will be cooled by an engine-driven fan while remote radiator will require a separate motor to drive a fan. Set-mount radiator is simple and well-tested while remote radiator may not be available in some engines.

Whenever remote radiator is used, cooling water circuit between the engine and radiator shall be well checked to ensure that it is within the working limit of the engine driven cooling water pump, otherwise, a separate motor driven water pump shall be installed in the circuit, Fig.4. The technique of using heat exchanger to separate primary engine cooling circuit and secondary radiator cooling circuit as mentioned above can be employed and the system will be much more under designer's control, Fig.5.

Fresh air intake

This includes the air for engine combustion and generator cooling. If set-mount radiator is used, cooling air will be mobilized by the engine driven fan, otherwise, a separate ventilation fan shall be installed.

All fresh air intake must be drawn from outside to ensure sufficient oxygen content for combustion and cooling effect to the generator.

Cooling air discharge

This refer to the hot air through the radiator after cooling. Since the amount of cooling air is high, discharge louvre with sufficient effective area is required. The air discharge shall be directed to open air with minimum length of ductwork. The cooling air discharge shall be at sufficient distance from the fresh air intake to prevent short circuit.

Exhaust flue

High temperature of exhaust flue is dangerous and shall be discharged to open air without possible contact with human beings. Because of the high temperature of up to 600 degree C, it should not point to or be erected close to any concrete surface or cladding. Exhaust pipe shall be well-insulated and protected for the indoor area.

Environmental Pollution by Diesel Generators

A diesel generator may produce the following environmental problems:–

- Thermal pollution
- Air pollution
- Noise pollution

Thermal pollution

Thermal pollution refers to the possible adverse environmental effects resulting from man-made heat addition to a water or air body. As diesel engine's thermal efficiency is around 38% to 40% and alternator efficiency will be 88% to 94%, the heat energy dissipated from a running generator will be around 2.7kW to 3kW per kW electrical output (assuming both engine and alternator run in maximum efficiency).

Unless there is great improvement in engine efficiency, such as cogeneration, thermal pollution cannot be diminished.

Air pollution

Heavy black smoke is always observed during starting of diesel engine and sudden change of loading due to insufficient transient combustion.

Under steady state operation, the pollutant from exhaust gas of diesel engine can be summarised as follows:–

NO_x	=700 ppm
SO_x	=150 ppm
CO	=500 ppm
Carbon	=500mg/m

Exhaust effluent control equipment like filters, electrostatic precipitators, scrubbers etc. may be used if we want to minimize the pollution.

Noise pollution

Sound pressure level (SPL) of a diesel generator (200kW to 1000kW) at 1500RPM will be around 103dBA to 109dBA at 1m from the engine measured in free field. The most dominent noise source is the diesel engine. Without any treatment, the noise level inside generator room will be 3 to 5dBA higher due to reverberation by the concrete wall.

Noise from exhaust outlet is much higher and noise attenuator is a must for all exhaust outlet of the engine. Residential type silencer close to the engine and a secondary silencer installed close to the outlet of exhaust outlet in series can reduce the outlet noise level as low as 70dBA at one metre, a much acceptable level. As high reduction silencer will impose high pressure drop, larger pipes shall be used to minimise further loss. Pressure drop along the whole exhaust pipe routing shall be checked to be within engine manufacturer's given limit and a safety factor of at least 1.5 shall be applied to the calculation.

Return to the engine noise, you will find that it is the most difficult part. Transmission loss of a 150mm thick concrete wall will be around 35 to 40dB. However, noise emitted through air intake and discharge louvres are most thorny problems. The following acoustic treatment may be employed:–

- Factory-made acoustic enclosure to house the whole generator;
- Intake and discharge noise attenuators; &
- Acoustic absorption wall lining.

a) **Acoustic absorption wall lining**

The purpose of such lining is just to minimise the reverberation which will further increase the noise level inside genset room by reflection of engine noise on the concrete surface of wall and ceiling. It also increases the transmission loss through the concrete wall though the level is low. Fig. 6 shows some construction details of acoustic lining.

b) **Intake and discharge noise attenuators**

They are basically splitters arranged in parallel to the air flow direction. Each splitter is constructed by punched metal surface with noise absorption material inside such as fiber glass. When cooling air flows through, the noise will be absorbed by the noise absorption material inside the splitter through the punched holes on the splitter surface. The noise reduction effect can be enhanced by the following arrangement also:–

(i) increase the length of splitters.
(ii) increase the width/thickness of splitters.
(iii) decrease the separation between splitters.
(iv) put more splitters in series at certain angle or offest in latitude direction as Fig. 7 & 8.

However, all these methods will increase the pressure drop at same air flow rate and the high speed air flow will generate the self-noise from the splitter surface.

In the market, noise attenuators are manufactured in standard design module each has been well-tested to find out the exact insertion loss at different octave frequency band. Different models will have different effects on different frequency bands. Some are more effective at low frequency while some may be more effective at high frequency.

Detailed analysis of the whole octave spectrum by adding different model noise attenuators in order to achieve specification's requirement can be done by specialist consultants or suppliers.

In order to cater the workmanship variance on workmanship and environmental factor such as room size, room shape and internal arrangement of a generator room, all calculations must allow sufficient margin.

c) **Factory-made acoustic enclosure**

Many generator manufacturers can produce acoustic enclosure to house the generator to achieve certain noise level, Fig.9. The merit of using such proven design is that all the treatment including ventilation and aspiration inside the enclosure will be under manufacturer's total control. A more efficient design can be achieved to minimise the dimension, weight and to ensure proper performance of the generator.

Such acoustic enclosure can reach noise level of 70dBA at 1m for 300kW or below. For up to 600kW, 75 to 80dBA will be achieved with reasonable size. Above 600kW, 85dBA to 90dBA can be reached with affordable size. If lower noise level is required, the enclosure will be too bulky to deliver and higher floor loading will be imposed.

With acoustic-enclosed generator, there may not be sufficient external static for you to do further treatment.

With slightly further modification, acoustic-enclosed generator can be installed as an outdoor unit without any generator room.

Although acoustically enclosed generator will simplify the acoustic design work inside generator room and performance can be guaranteed by manufacturer, there are still some drawbacks such as too bulky, heavy and expensive.

Gas Turbine Generator as an Alternative

Although gas turbine engine was first developed by English and German respectively in the Thirties, gas turbine engine was not even common for aircraft propulsion until late Fifties, Fig. 10. Gas turbine engine was introduced in industrial use in the Sixties as prime mover for power plants, large air compressors and large water pumps. Gas turbine generator was first developed for power plant due to its high power and compact size. After around twenty years' development, gas turbine rated from 100kW to 200MW are available in the market. For standby application, our interesting range is only upto a few MW.

Differences between gas turbine engine and reciprocating type diesel engine are compared in Table 1 for 1MW class.

Installation of Gas Turbine Generator

Installation of a gas turbine generator will be similar to diesel generator and can be categorised in the following aspects:-

Fuel system

If light diesel is used, fuel system is basically the same. Due to higher fuel consumption, larger fuel tank is required.

Moreover, gas turbine can use grade 'A' heavy oil and gaseous fuel with minor modification while reciprocating type engine will be of total different design.

Exhaust system

Exhaust pipe is bigger in size as most of the waste heat will be discharged through exhaust pipe. If eductor type design, Fig. 11, is employed, cooling air for engine/alternator will be sucked and discharged through exhaust pipe also.

Cooling system

Cooling of lubrication oil is mainly by means of a small radiator type cooler of area 0.1 to 0.2 sq m. Cooling air is mobilised by a small motor driven fan.

Cooling to the engine body by the air stream inside enclosure will be driven by high speed exhaust gas in eductor type design or by separate ventilation fan in independant type, Fig. 12. Actually, eductor type and independant type of gas turbine generator are similar to set-mount radiator type and remote radiator type of diesel generators. Tables 2 and 3 compared the similarities and differences in 1MW class.

Foundation

Dynamic loading of gas turbine generator is 10% in addition to the static weight while diesel generator is 30% to 50% more. Lower dynamic loading makes the foundation easier to design and more flexible in selecting generator room. Roof top installation become possible even for large gas turbine generator. Gas turbine can even rest on a structural steel frame to transfer the major loading to the main column or main beam instead of much weaker floor slab which is especially important if additional generator is required in existing building.

Environmental Impact of Gas Turbine Generators

Thermal pollution

Although thermal efficiency of gas turbine generator is lower, its potential to recover the waste heat can be further explored in the cogeneration system.

Air pollution

Exhaust gas content of gas turbine generator and diesel engine is compared as below:

Gas Turbine Engine		Diesel Engine	
NO_x	=85ppm	NO_x	=700ppm
SO_x	=31ppm	SO_x	=150ppm
CO	=12ppm	CO	=500ppm
Carbon – negligible		Carbon	= 500mg/m

Gas turbine engine produce much lesser pollutant to atmosphere. Even during starting, no black smoke will be observed from the exhaust outlet of gas turbine generator. In general, diesel engine will emit black smoke during starting, low load (below 20% of rated load) and change of loading. When load is suddenly changed, black smoke will be discharged from diesel engine due to insufficient transient combustion while gas turbine will not.

Noise pollution

Although gas turbine may be noisier than diesel engine when comparing the bare engine, the main frequency of the noise from gas turbine engine will be at high frequency band which are much more easy to be attenuated. Transmission loss of a 150mm thick concrete wall is approximately as follows:

HZ	63	125	250	500	1K	2K	4K
dB	34	39	45	50	55	61	66

The noise level is relatively high in frequency band of 1kHz to 4kHz in gas turbine engine and 150Hz to 300Hz in 12 cylinder diesel engine running at 1500RPM. As transmission loss of concrete wall is higher in high frequency bands, the overall resultant noise level outside a gas turbine generator room will be comparatively lower.

For an acoustic enclosure with resultant noise level of 80 dBA at 1m, the size for a 1000kW gas turbine generator will be 5.5m (L)×2m (W)×2.2m (H) while a diesel generator will be 11m (L) ×3.5m (W)×3.5m (H) Fig. 13. The static weight of the enclosed diesel generator will be more than 20 tons and dynamic weight will be more than 25 tons. A gas turbine generator with such an acoustic enclosure weighs only 12 tons and of dynamic weight 13 tons, nearly half of a diesel generator. Because of the low vibration, gas turbine generator can rest on structural steel frame which transfer the major load to columns and beams of a building instead of floor slab. This is of most importance in installing extra generators in existing buildings.

Electrical performance

As gas turbine is running at very high speed (22,000PRM at 1MW class) and the high ratio gear box turning the alternator at 1500PRM, a very high torque is required to turn the gas turbine at the alternator side. With such high inertia, frequency regulation and voltage regulation performance of a gas turbine generator are much better than a diesel generator, Fig. 14. With 100% step load switching on/off to a gas turbine generator, the transient frequency drop is around 4% and recovery time is less than 2 sec. A diesel generator can take 75% step load in general with transient frequency drop as high as 10% and recovery time more than 10 sec. 100% dummy load applied to a gas turbine generator will only result 4% voltage drop while 75% dummy load application will produe as high as 15 to 20% voltage drop in a diesel generator.

Since sizing of a standby generator will be determined by its step load acceptance and maximum transient power encountered because the continuous running load will be in general much lower, a smaller gas turbine generator will be sufficient in most cases which of course further reduce its environmental impact.

Cogeneration

Cogeneration means other than electricity generated from a generator, some other energy sources are generated in parallel. In general, steam and hot water are the cogenerated products by using a waste heat recovery boiler, Fig. 15.

Steam can be used for the following aspects:–

- Drive steam turbine and generate more electricity (combined cycle power plant).
- Produce chilled water with an absorption chiller.
- Provide heating to the building.
- For laundry, cleaning, sterilization etc.

Hot water can be used for:-

- Heating
- Pre-heating the water before passing to boiler and saving the fuel used.

As over 70% of the heat energy is discharged by the exhaust gas from a gas turbine generator, around 70% of this waste heat can be recovered by the waste heat recovery boiler and produce super-heated steam for other purposes. Steam is much more flexible and energetic than hot water as an energy source.

In general, diesel generator can only produce hot water of 70 to 80 degree C through engine body cooling but not much from the exhaust gas. In case where steam can be produced from a diesel generator, steam quantity is only around 15% of a same rating gas turbine engine because heat value from diesel engine's exhaust flue is much lower.

In order to let us understand the actual operation of a cogeneration system, the following installation is selected for our study:-

Project:	Mercy Hospital, a 350-bed facility in Toledo, USA
Gas Turbine Generator:	1180kW electrical output at ISO condition
Steam Production:	Up to 6350 kg/hr at 34.5 bar
Steam Turbine:	280kW backpressure steam turbine generator set
Absorption Chillers:	2×450 ton absorption chillers

The system is shown in Fig. 16.

The gas turbine generator produces 1180kW electrical output. Exhaust gas go through a waste heat recovery boiler and produce steam upto 6350 kg/hr 34.5 bar with supplementary firing from the duct burner. The steam is expanded through a 280kW output backpressure steam turbine generator set that supplies additional electrical power to the system.

The steam pressure is reduced to 7.9 bar after passing through the steam turbine and steam is then used for other thermal loads through the hospital's steam distribution system, such as two 450 ton absorption chillers and other heat loads in the hospital.

The system is designed to provide 75% of electrical load requirements and 85% of the thermal load needs for the hospital. The entire system is installed in an existing building at the hospital with a small addition built to house the heat recovery unit.

Two existing diesel generator sets, rated 900kW each, have been connected electrically to the gas turbine unit and the diesels will automatically come on line for peak sharing or to assume primary power generation responsibilities during gas turbine service or maintenance periods.

The control system has been modified to parallel the outside electrical grid and also to automatically start the diesel stand-by generator sets if the turbine set goes down.

Overall thermal efficiency of the new gas turbine cogeneration system is calculated at 82%. The project is expected to save the hospital USD 7.8 million over a period of 15 years.

Reference

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5. 'Petbow Installation Manual for Generating Sets', Manual No. 906, by Petbow Limited, Sandwich Kent, England.

TABLE I

Item / Engine	Gas Turbine	Diesel
Principle of operation	Continuous combustion Rotating movement	Intermittent combustion Reciprocating movement
	Intermittent combustion sometimes cause flame-out and produce carbon powder on part-load run due to insufficient combustion.	
Dimensions/Weight	Compact/3 tons with gearbox	Large/8 – 10 tons
Construction	Simple	Complicated
Nos.of components	20 – 40% of diesel	Many
Rotating speed	22,000 rpm	700-1800 rpm
Material of prime mover	Nickel-alloy, Cobalt-alloy, etc.	Casting iron, Carbon steel, etc.
Cooling method	Self-air cooled	Water cooled
Fuel	Kerosene, Diesel oil, Heavy oil, Natural gas	Diesel oil, Heavy oil
Fuel consumption	550 litres/hr	300 litres/hr
Lube oil consumption	0.08 litre/hr	0.7 to 3 litres/hr
Thermal efficiency	20%	33%
100% load application	OK	Normally 75% except for naturally aspirated engine
	Due to dead time of turbo-charger, diesel with more than $9kg/cm^2$ mean press have limit of load application.	
Friction part	2-place (bearings)	More than 20-place
	Piston valve, piston pin, cylinder, crank shaft, crank pin, etc are included in 20-place.	

Engine / Item	Gas Turbine	Diesel
Inertia moment	Large	Small
	Larger inertia moment provide larger instantaneous overload capability and stable rotation but need larger starting equipment.	
Reverse power absorption capacity	30-40% or more rated power	Normally 10% rated power

Electricity Generated

Frequency Regulation	– transient ±4% with 100% load on – steady state ±0.3% – Recovery time: within 2 sec	– transient ±10% with 75% load on – steady state ±5% – Recovery time: within 10 sec
	GT have no delay in response in fuel control system. Due to delay response of fuel injection valve and dead time of turbo charger, freq dip of diesel is much larger than that of GT.	
Voltage regulation	– steady state ±1.5% – recovery time: within 3 sec for full load application.	– steady state ±2.5% – recovery time: within 7 sec at 75% load.
Voltage waveform at no-load (distortion)	Sine wave (3% or better)	Including high-freq components (10%)
	GT is rotating machine. Torque is transmitted to alternator smoothly but diesel is to convert from reciprocating movement to rotating one.	
Load application capability immediately after starting	100% rated load	75% rated load
	The capability of diesel depend on mean pressure of engine.	

Table 2

	Eductor Type Gas Turbine G/S	Set-mount Type Gas Turbine G/S
Ventilation air mobilisation	high speed exhaust gas	Engine driven fan
Volume of ventilation air intake	600 cu m/min	1600 cu m/min
External static permissible	60 to 70mm water gauge	12 to 15mm water gauge
Total hot air discharge	1100 cu m/min	1700 cu m/min (exhaust flue 280 cu m/min)
Temperature of discharge air	350 degree C	70 to 80 degree C (exhaust flue at 550 to 600 degree C)

Auxiliary System

Engine / Item	Gas Turbine	Diesel
Alternator driving method	Through flexible coupling	Direct drive
	Flexible coupling can absorb torsional vibrating, peak torque, etc transmitted from alternator.	
Cooling water	Not Applicable	30 tons/hr for drain type 1 ton/hr loss for cooling tower type 100 ton/hr internal flow for radiator
	GT do not require water piping and additional supply of water when operated for long time.	
Fuel system	Simple (1 nozzle)	Complicated to distribute equal fuel to each cylinder
	Complicated fuel system will cause delay in combustion which results larger dip of engine speed.	
Exhaust duct	700–800mm dia.	300–350mm dia.
Electricity for heater under cold weather	Not necessary	5.5kW for cooling water 3kW for lube oil line
	Diesel consume much electricity at standby condition.	
Starting reliability	99.6%	95%
	Start failure of diesel is sometimes caused by insufficient oil film between piston and cylinder resulting insufficient compression heat for starting. Starting reliability also much depends on maintenance of the generators.	

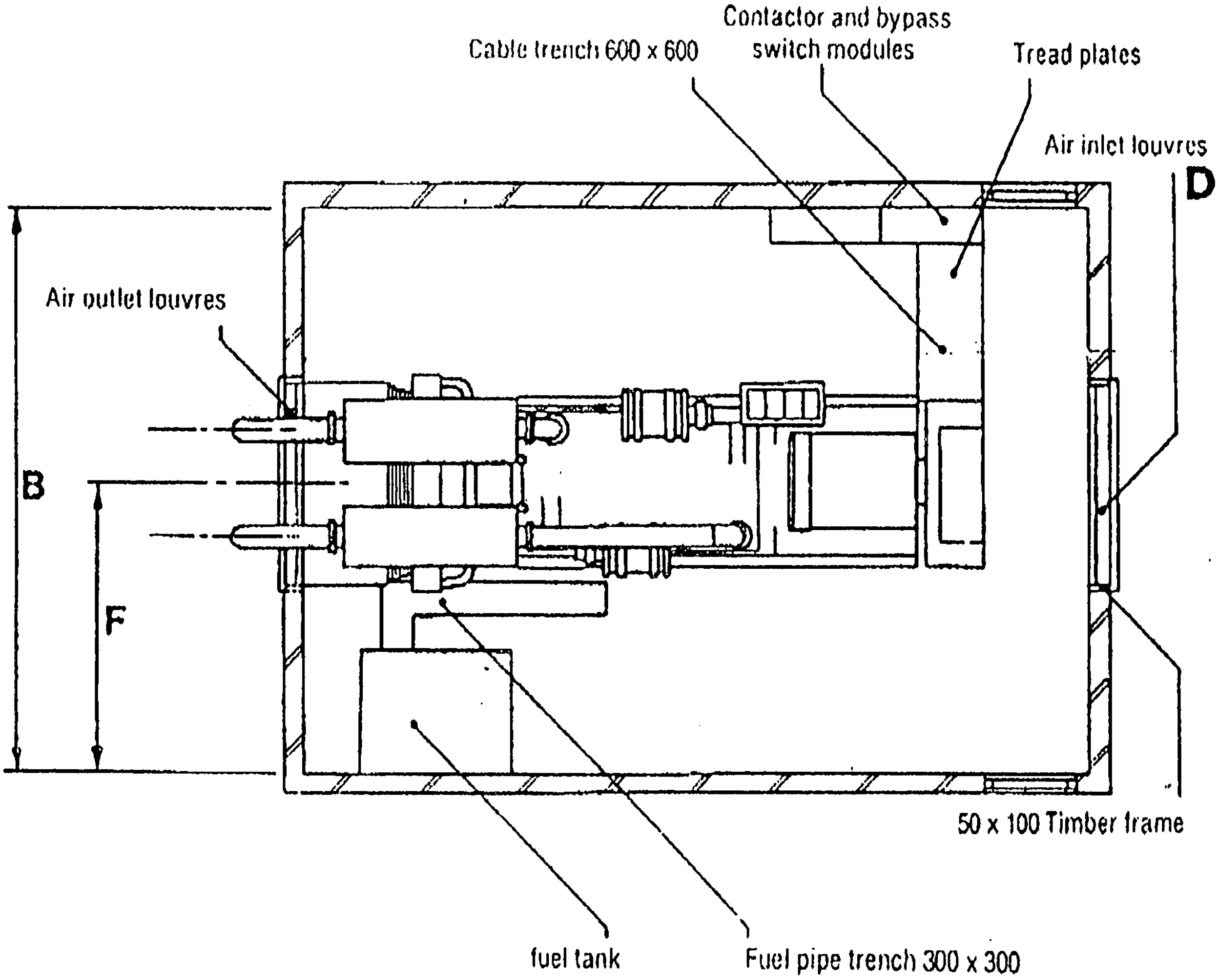


Fig. 1

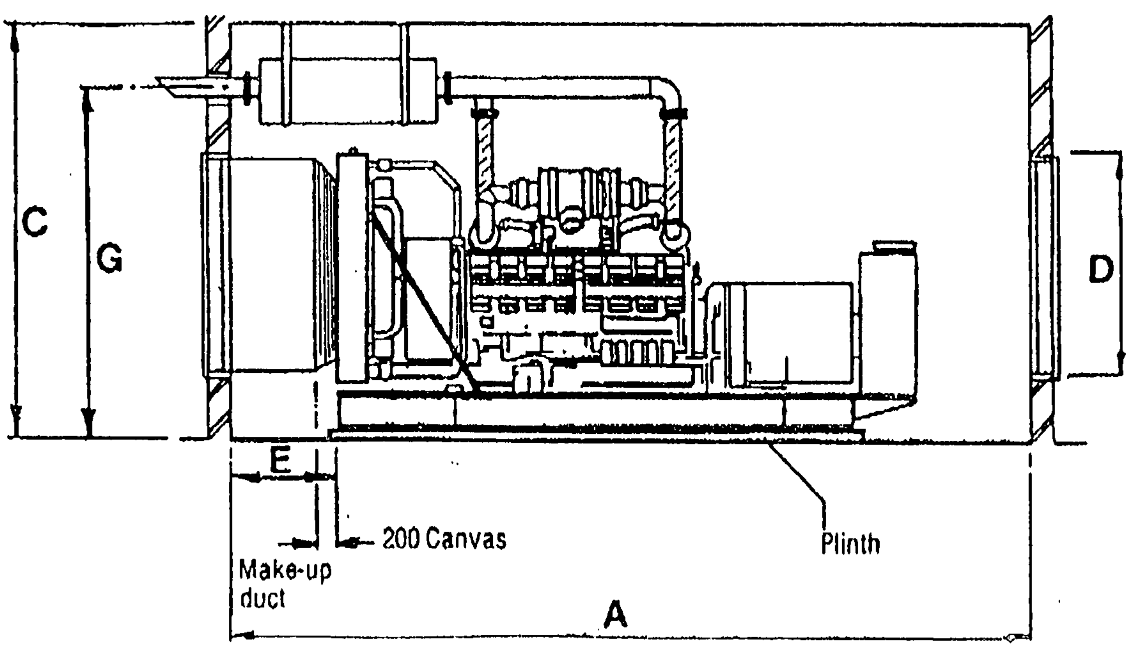


Fig. 2

The General Electric Company of Hong Kong Limited

GEC HONG KONG

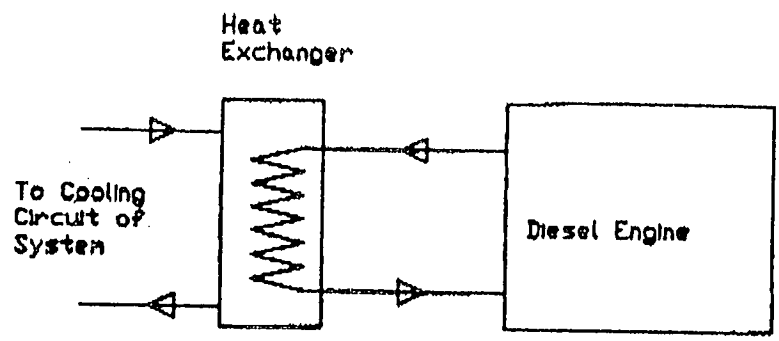


Fig. 3

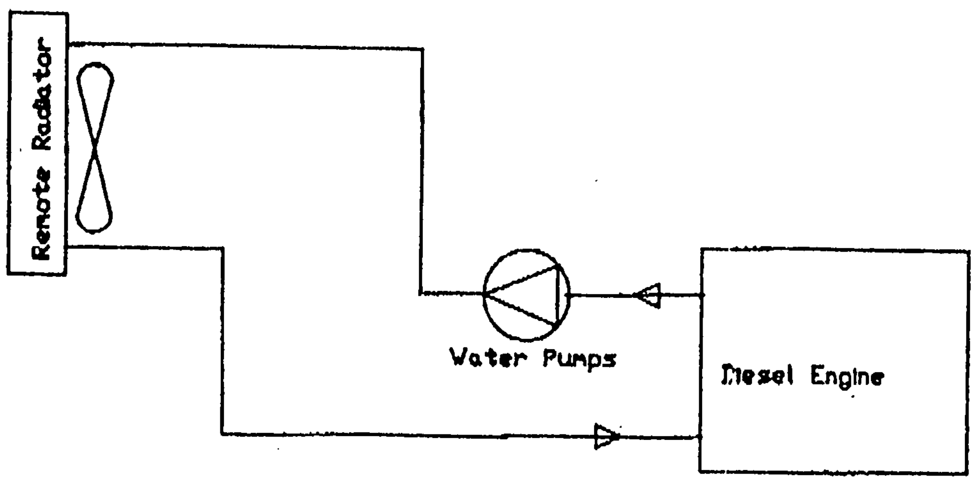


Fig. 4

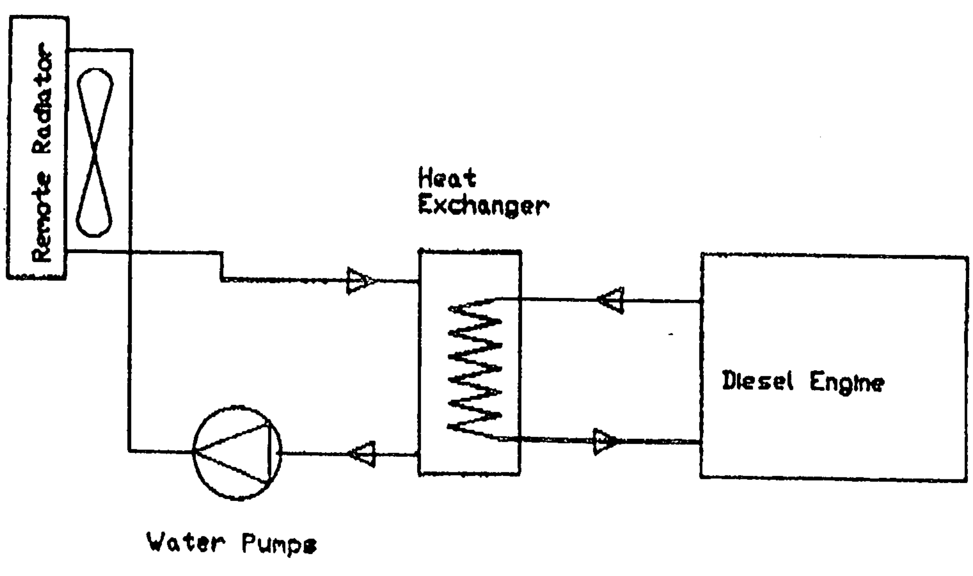


Fig. 5

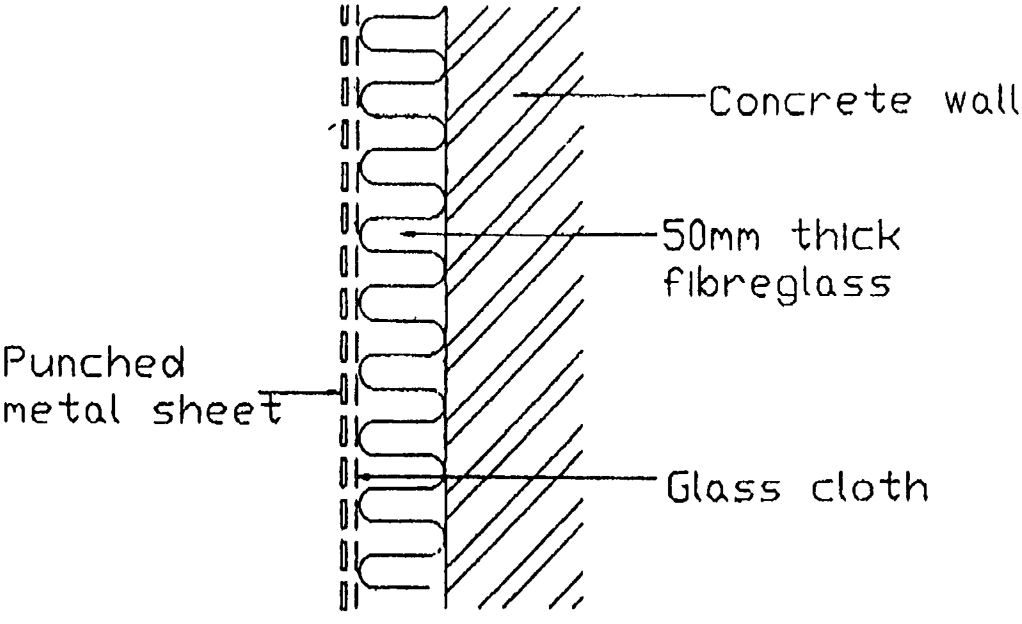

Concrete wall
50mm thick
fibreglass
Punched
metal sheet
Glass cloth

Fig. 6

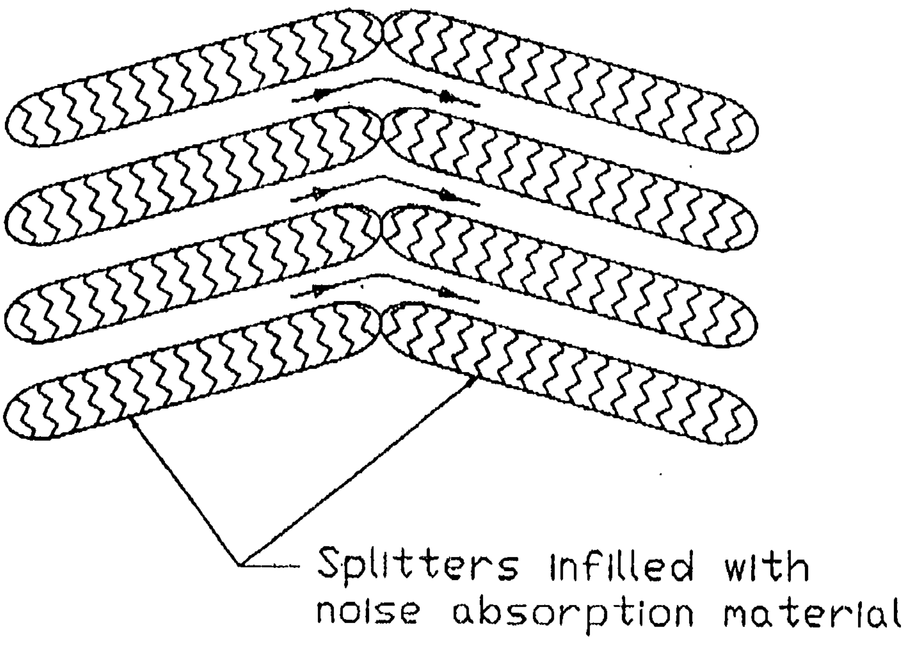

Splitters infilled with
noise absorption material

Fig. 7

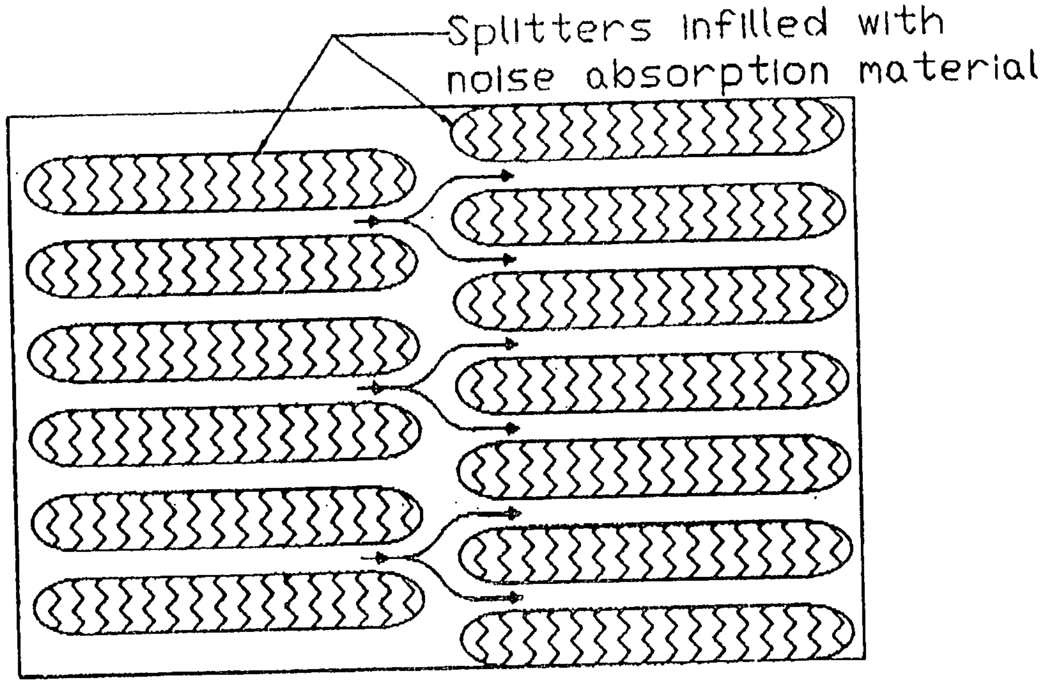


Fig. 8

A DIESEL GENSET INSTALLATION SHOWING TYPICAL NOISE CONTROL MEASURES

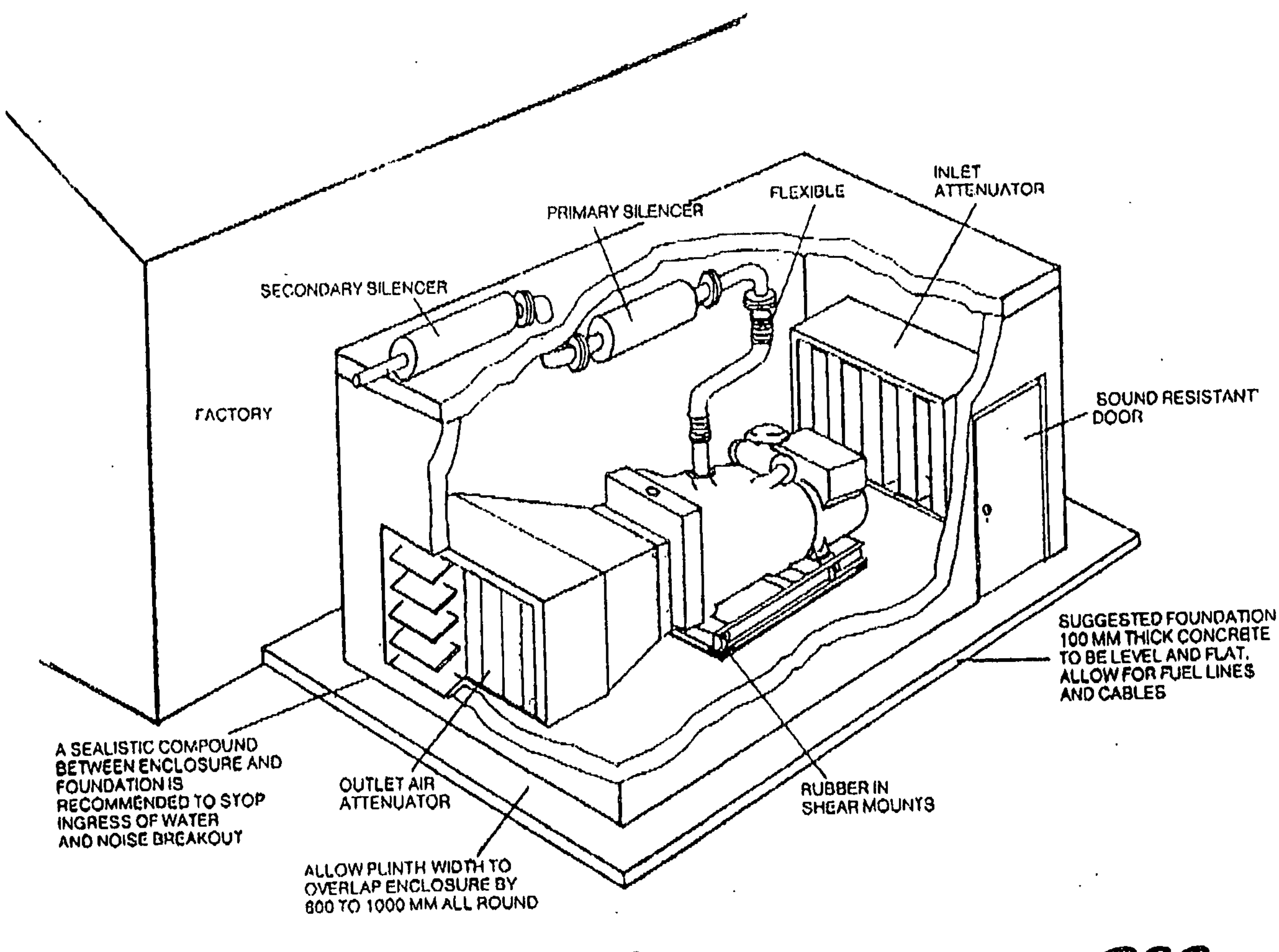


Fig. 9

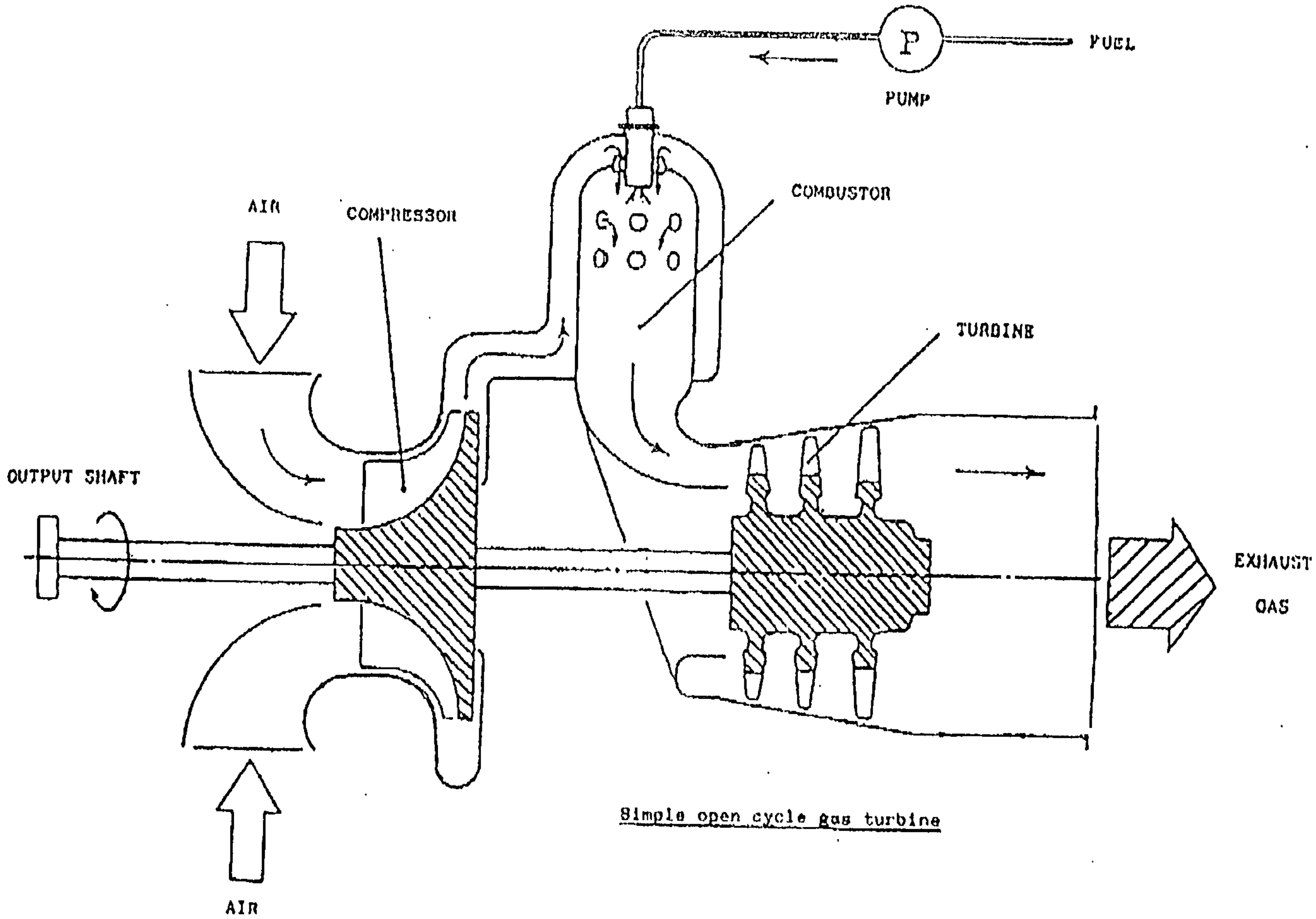


Fig. 10

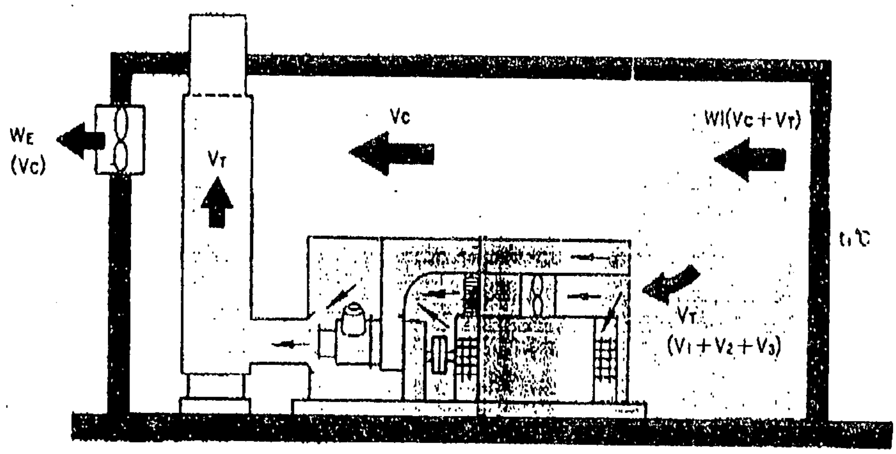


Fig. 11

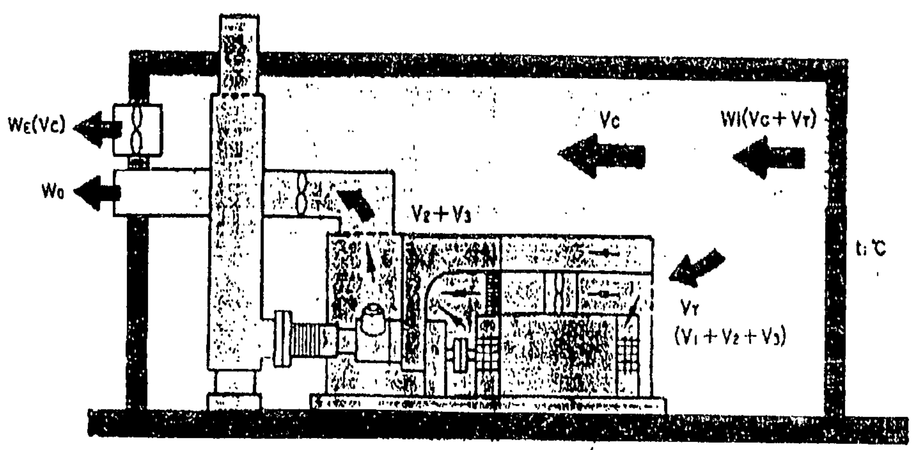


Fig. 12

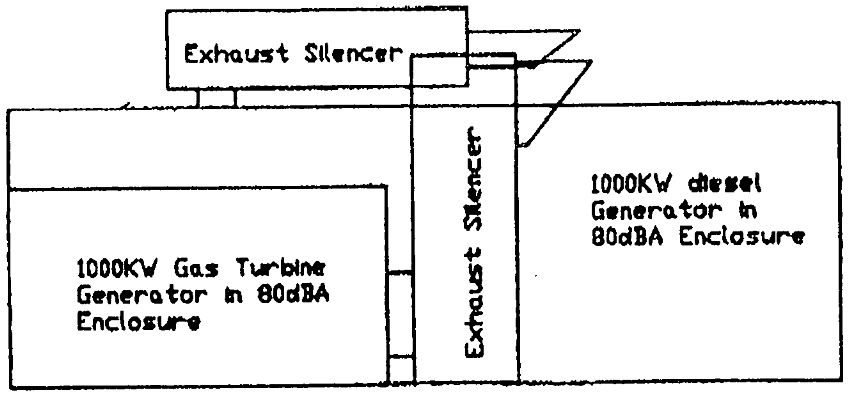

Exhaust Silencer
Exhaust Silencer
1000KW diesel Generator in 80dBA Enclosure
1000KW Gas Turbine Generator in 80dBA Enclosure

Fig. 13

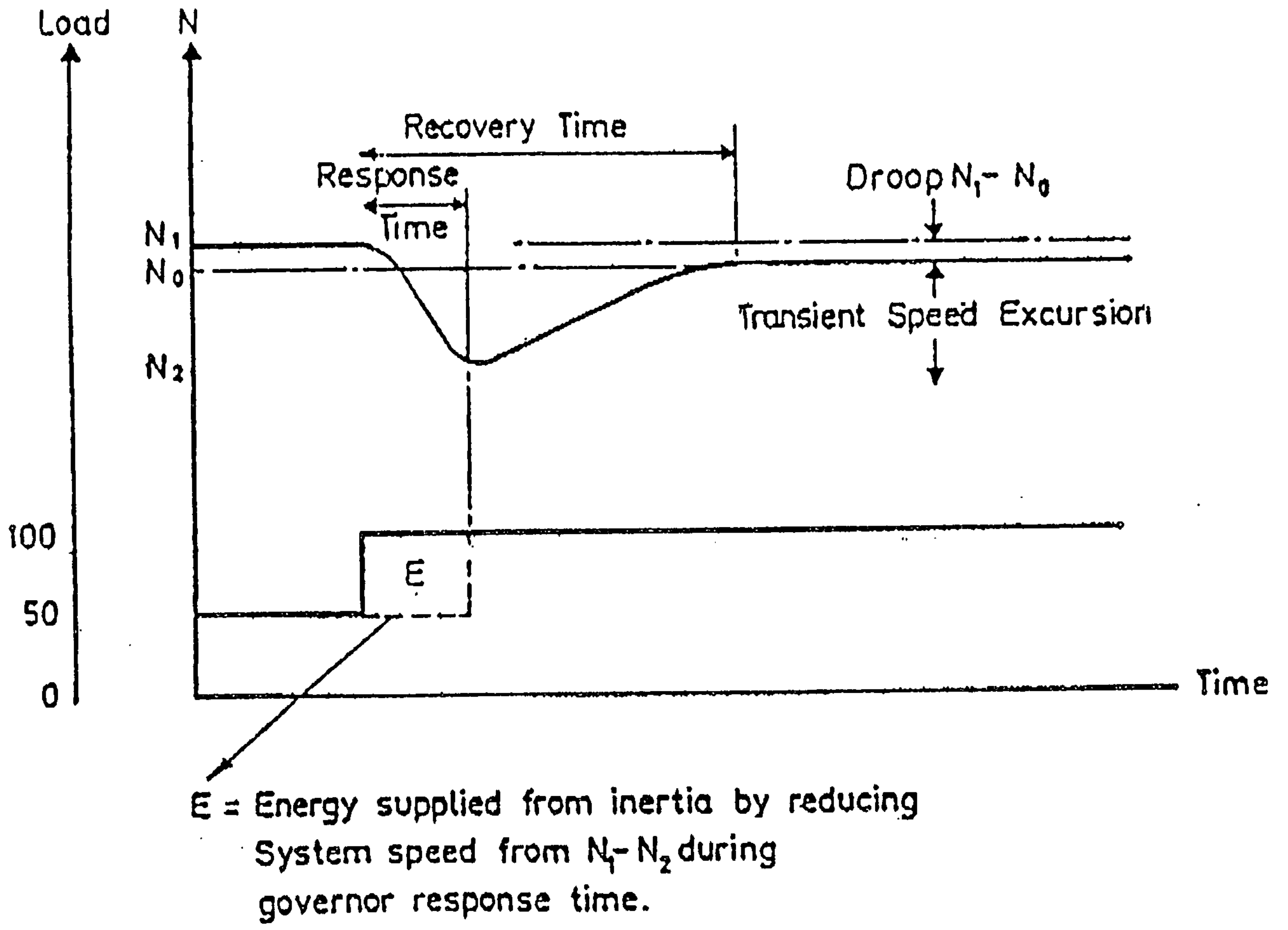
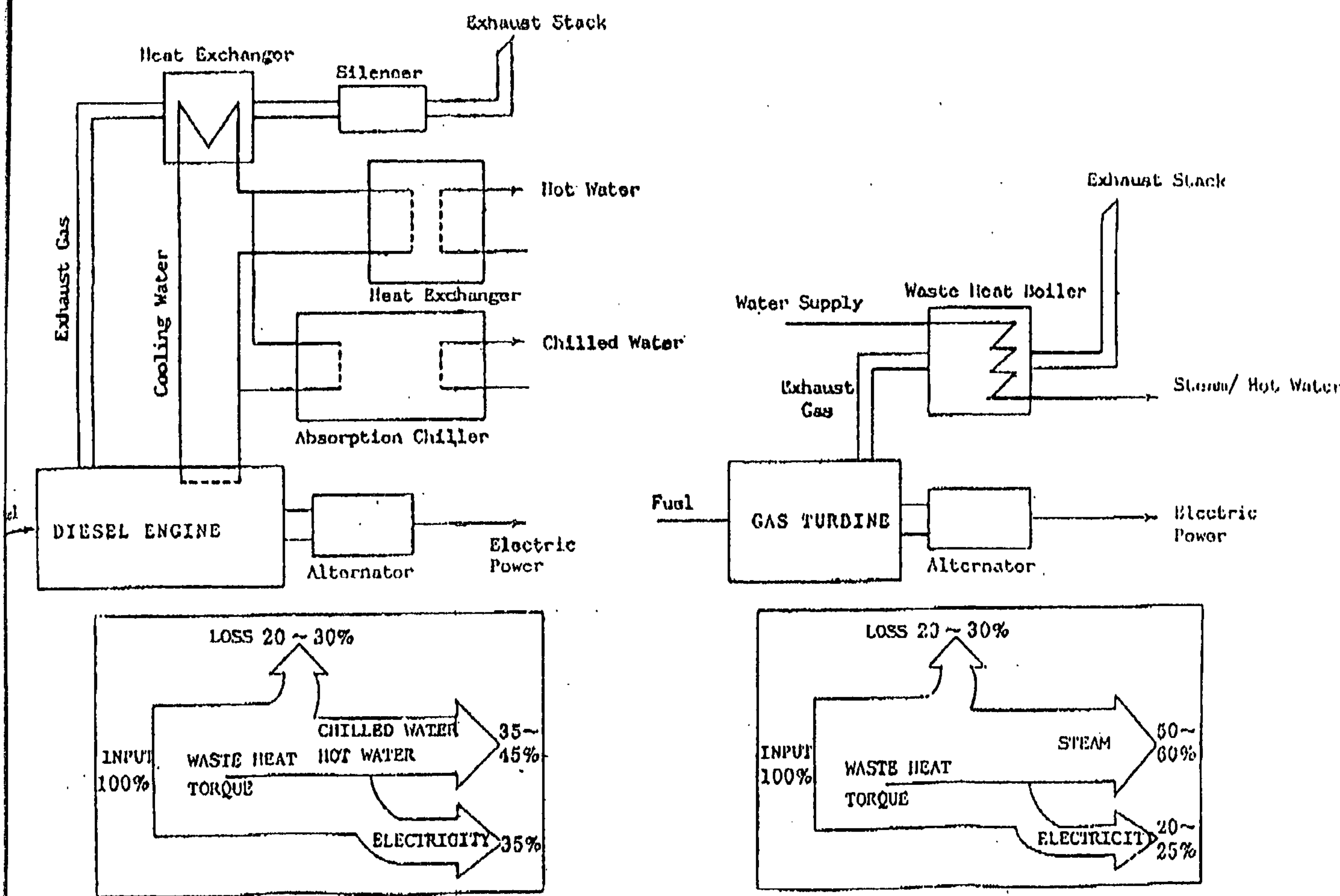

Load
N
Recovery Time
Response
Time
Droop $N_1 - N_0$
N_1
N_0
N_2
Transient Speed Excursion
100
50
0
E
Time
E = Energy supplied from inertia by reducing System speed from $N_1 - N_2$ during governor response time.

Fig. 14



CO-GENERATION SYSTEM OF DIESEL AND GAS TURBINE

Fig. 15

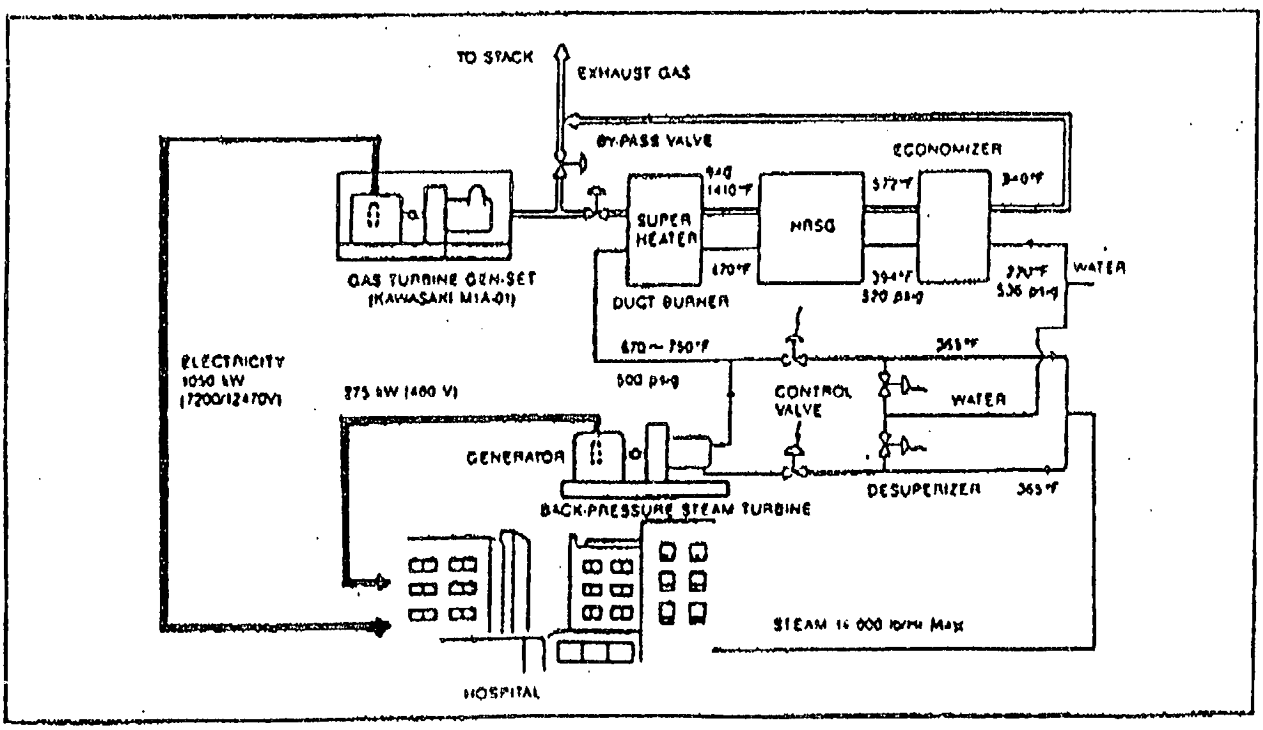


Fig. 16

4. Human Resources

Paper No. 8

To Prepare for the Challenge

– Speaker: Mr. Leonard C.P. Lee,
VP, PBA & Lead Electrical
Engineer, FMCA, San Francisco

TO PREPARE FOR THE CHALLENGE

The purpose of this paper is to identify areas which members of the electrical engineering profession in Hong Kong should pay special attention to and should take steps to equip oneself in order to face the challenge of the nineties.

Having spent almost fifteen years after my graduation from the University of Hong Kong practising as an electrical engineer involved mainly in local projects, I have the opportunity to be involved in working on international projects for the past five to six years. Especially for the last two years, I have been working in the United States where the engineering environment is quite different from that which we are all familiar with in Hong Kong. I have thus become more aware of those areas which an electrical engineer in Hong Kong will generally find himself inadequate in an international environment. My presentation will try to identify some of these areas and to suggest ways which we can be better prepared. In view of the political situation in Hong Kong, we must prepare ourselves and be better equipped for the changes and challenges ahead; irrespective of whether it is because of changes in the engineering environment here or because we decide to continue our profession elsewhere.

Perhaps I should start by saying that in general the exposure an electrical engineer has in Hong Kong is one which is difficult to find anywhere else. The fast pace of work and the technological exposure we have are really second to none. The products we are using have always been one of the most, if not the most, advanced in the industry. We can rarely find anywhere in the world where we can have access to the wide range of products from so many different countries of origin. As a result we could become familiar with products of different national standards or codes. This kind of exposure should have made an electrical engineer more versatile and give him the proper frame of mind to appreciate, identify and solve engineering problems; however in spite of such background, there are areas which we should improve upon.

(i) The need to specialise

One of the areas which an electrical engineer in Hong Kong needs to do is to identify a field of electrical engineering in which he can develop and where he can call himself an expert. Electrical engineering in itself contains a very wide range of fields and in Hong Kong, but it is often very difficult to become too specialised in any one particular field. To take some of the topics we have covered in this symposium for example, how many tunnels will we be building in Hong Kong in the nineties? I think we will be very lucky to have one each year. How many bank buildings will we be building? The new Hong Kong Bank building was completed a few years ago, the new Bank of China building is completed this year, the new Chartered Bank building is under construction. Will we have any more new bank buildings in Hong Kong in the nineties? How many Convention Centers will Hong Kong be building and how many new development plans will the two Power Companies be having in the nineties? I think the answer is obvious. As a consequence, electrical engineers in Hong Kong are forced to diversify in order to survive. I don't think we can afford to only become a specialist in only one particular field of electrical engineering because the opportunities in Hong Kong are in a way limited. Thus we tend to become 'Jack of all trades and master of none'. To use an old Chinese saying, 'we have many knives but none of them is sharp'.

In the international environment an area of expertise is very important. If 'we only have one knife which is sharp' it will be good enough. Eventhough there may not be tunnels, bank buildings, convention centers in one country or city, there are always many such projects in the whole world. Thus if we have done five to ten tunnels, or bank buildings or convention centers, it is obvious that we will be able to sell our service in that particular field much more easily. Just as we sometimes ask experts to come to Hong Kong to tackle special engineering problems, we need to have a field of expertise in order to sell ourselves in the international environment. If we want to face the challenge of the nineties and to have our eyes not only on the opportunities in Hong Kong but also in the international environment, it becomes important as we build our experience that we should identify an area in which we have special knowledge and be able to call ourselves an expert. Since the opportunity in Hong Kong is such that it is difficult for all engineers to become an expert in one particular type of project such as tunnels, bank buildings or convention centers, they need to look for areas which are common to all projects such as lighting, control, relay protection, or even emergency back up systems to build up expertise.

(ii) The need to be aware of details.

One thing I have found out practising electrical engineering in the States is the depth of details an electrical engineer is expected is get into. In Hong Kong, because of competition, we are forced into a very fast pace and often tend to be less concerned with details. We are more concerned with the fact that 'it works' and have less concerned as to 'how and why it works'. It is of course normal when an engineer specifies or approves something, he is expected to be aware of every detail of the things he specifies or approves. However my experience tells me that the depth of details expected of an electrical engineer in Hong Kong is in general much less than expected in the rest of the world.

The concern of details in places other than Hong Kong may be partly due to the legal problems associated with professional liability of the Engineer and partly due to International Contractor who normally submits a tender with a low price and when he is awarded the contract siezes every opportunity to claim for extras. Let me quote you an example, I think it is not uncommon to find minor discrepancies in the specification and drawings and it is normal to cover this by stating that should the Contractor finds discrepency in the specification and drawings he should clarify it with the Engineer before the submission of his tender or else the Engineer's decision shall be final. A small discrepancy had resulted in a request from the Contractor for a variation order which was rejected on the grounds that clarifications should have been made before tender submission. However in spite of what seems to be obvious to us, there were suggestions that had the Contractor persisted with his claim and the case ended up in the hands of the lawyers. It might be better for the Consultant, from a financial point of view, to settle the case out of court with the Contractor. It would save him on the expensive legal costs involved and furthermore, if the court ruled in favour of the Contractor, the Client would not be required to pay for the variation order; as the Consultant would then become professionally liable and would be expected to bear the responsibilities. Using that example engineers are expected to check every detail in all the documents and drawings that go through their hand and to know not only exactly how things work but also what every little word means. Therefore eventhough we are working at a fast pace, we should learn to be more careful and pay more attention to details.

(iii) The need to know the basics

In Hong Kong we sometimes rely too much on Codes and Standards to specify what we want without a thorough knowledge of what exactly these Codes and Standards really mean. This can lead to problems when we try to practise in an international environment where Standards and Codes are different to what we are used to. Let me quote two examples.

When we want to specify equipment enclosures we normally specify IP23 to B.S. 5490 for rain proof and IP65 to B.S. 5490 for water proof protection. In the States instead of talking of boxes having a degree of protection to IP we talk about equipment being in NEMA boxes. A NEMA3 and NEMA3R box are both defined as rain proof boxes. But do we know the differences between an IP23 box, an IP65 box, a NEMA3 box and a NEMA3R box to determine which is suitable for the purpose we required. NEMA states that a NEMA3 box is equivalent to an IP54 enclosure and a NEMA3R box is equivalent to an IP14 box but without knowing the test requirments do we understand why this is the case.

Another example is electric starters. The IEC standard which we normally use has its origin in Europe with historical experience of relatively short supply and high cost of raw material. In the interest of conserving materials, designers considered the average application and used no more material than required. This resulted in smaller sized devices per horsepower rating than the NEMA standard which is used in North America where material were plentiful and relatively inexpensive. The market demands a very high level of performance throughout a wide range of motor applications and as a result, a very high standard was written to eliminate as much human error in application as possible. Very rarely did the specifier have to know any more than the horsepower and voltage of the motor to select the proper sized devices. Thus if a NEMA sized starter is specified how do we know whether a starter to the IEC standard would be applicable and that the system is still safe and reliable.

These examples tell us that it is not enough to base our engineering and /or specification on a particular set of codes and standards when we are in an international environment. More often not we cannot simply detail in our specification equipment to a certain B.S. or IEC standard because if we do so, when equipment of other standards are offered, we would have difficulty in deciding whether what the offer is indeed what we need without comparing the two standards in detail. Instead we should specify clearly at least the important parameters of the equipment we want. Such action normally requires a full understaning of the basics.

(iv) Improvement of Communication Skills

The last thing I think we should be aware is try to improve our communication skills. I was told recently 'never assume you think he thinks he knows what you know'. The ability to communicate your ideas to others are important. Most of us are brought up and educated in Hong Kong. We thus have common cultural and social backgrounds. Furthermore in our day to day operations, we can often use Chinese, our mother tongue, to communicate and, thus, it makes us easier to understand each other. However when we operate in an international environment we may not be familiar with the cultures and customs of the people we are working with. Their mother tongue may be French, German or Japaness; and even if they speak English, their slangs and common word usages may be different. In order to be effective in our communication there are a few things we need to do. Firstly, we should definitely try to improve our English which is the most commonly used international bussiness language. Secondly, we should be short and precise in our communications. However, we should never assume anything as what is obvious to you may not be obvious to someone else and sometimes it pays to be a little 'long winded' to make sure the other party knows what you want. This applies not only in our conversation but also to our presentation in our specification and drawings.

I hope this short presentation has given all of us something to think about so that as the electrical engineering profession faces the challenge of the nineties we can be fully equipped and prepared.

Paper No. 9

'Reverse Flow' to fill the Gap in Electrical Engineering

– Speaker: Mr. W.H. Wong,
Director, BMP Mechanical &
Electrical Ltd.

'REVERSE FLOW' TO FILL THE GAP IN ELECTRICAL ENGINEERING

1. The Gap

"Asia's millenium has come," said a lot of economists.

Located at the centre of Asia and equipped with the latest and most advance infrastructure of communication, transportation, banking and finance facilities, Hong Kong will play an important role in this era of Asia.

It is estimated that Hong Kong is going to spend in the next decade over HK$100 billions on infrastructure, including airports, roads, rail extensions, tunnels, land reclamation, communication systems, urban redevelopments etc. Together with the already booming properties developments and the increasing popularity of foreign manufacturing industries to establish their production lines in Hong Kong, the demand of service of electrical engineers keeps on rising.

A HK$2.1 billion 1200MW pumped storage hydroelectric project is being planned at Conghua in Guangdong province of P.R.C. and will have major technical and financial involvement of Hong Kong companies. 1992 will see the commissioning of the Daya Bay nuclear station.

All these activities direct to the conclusion that the post-1997 uncertainties do not have any impact on the economic growth of Hong Kong.

On the other hand, all these commitments and show of confidence have not stopped electrical engineers from emigrating and the numbers leaving Hong Kong in the last two to three years show a dramatic growing trend.

In fact, the brain drain problem has becoming more and more alarming and fears are growing that it will hamper Hong Kong's electrical industries.

Speaking of 'brain drain', this term originated in the fifties when hundreds of top British geniuses flew over to America. There are therefore people who argue that there is no such thing in Hong Kong. They are of the opinion that Hong Kong people simply manufacture, buy, sell or finance and rely on foreign medical breakthroughs, foreign new inventions, foreign advances in computers, foreign technology and foreign machinery etc. Nothing is invented and there is little, if at all, R & D in Hong Kong. The recent jump in the migrants does not therefore create any brain drain in the territory. This argument does seem to have a few valid points though it is debatable.

In view of this, perhaps the term 'brain drain' should be avoided when discussing the recent loss of many local experienced electrical engineers for the lure of foreign passports. The fact that a lot of engineering companies are currently hard hit by the difficulty of recruiting or retaining experienced electrical engineers is however undeniable.

Hong Kong is one of the most education intensive places on earth and its engineering degree awarding tertiary institutions are continuously expanding to produce more and more engineering graduates each year. However, unlike an artist whose success does not necessarily depend on his or her years of working but rather more so on the talent, an engineer does need time to expose himself or herself to all the required perspectives and to gather experience in responsible involvement of engineering works to qualify as an experienced engineer.

A controlled training scheme does help to expedite the learning period for a graduate to become a qualified engineer. Nevertheless it is obvious that the pace is still not fast enough to replace the loss of experienced brains. There is definitely a 'gap' in the electrical engineering field caused by the mass emigration and this 'gap' is further widened by the present Hong Kong economic boom.

2. The Reverse Flow

There have always been people emigrating from Hong Kong to other countries.

Most people who left in the past, (or to be a little bit more specific, before 1983 when jitters over the transfer of sovereignty to China in 1997 suddenly became an 'in-topic') were genuine migrants. They left to reside in other countries for their own reasons – desire to live overseas, join with other family members or relatives, seek for better career and exposure etc. These people rarely return to work or live in Hong Kong again.

The sharp increase in the number of emigration cases in the last few years however does not mean the increase of the number of Hong Kong people wanting to live or work abroad. In the contrary, most of these recent leavers in fact like to stay. Their departures are mainly due to their distrust of PRC's guarantee of the continuation of Hong Kong's social, economic, legal and other systems for 50 years after 1997. The results of a survey of professionals in 1989 when asked if emigrants intended to return to Hong Kong after securing a second passport were as follows:–

Definitely yes	8%
Probably yes	30%
Undecided	26%
Probably no	28%
Definitely no	8%

The Secretary's Notes in May 1989 Journal of the HKIE addressed the fact that there had been a down turn trend of losses of members to overseas and the year 1988/89 was the lowest since 1984.

There is no statistical figure showing the number of people returning to work and live in Hong Kong after having gained citizenship elsewhere. The estimated rate is a maximum of 25%. Apparently, while there is a continuous growth in the number of people leaving, there is on the other hand a trend of reverse flow of people back to Hong Kong.

3. To Fill the Gap

Hong Kong Government predicted that the exodus of the people in the territory will increase by 30 per cent next year. It is further estimated that the number will level out in the next two to three years at between 50,000 and 60,000 a year. In other words, in the 90's, a total of over half a million of Hong Kong Chinese will emigrate.

A survey done in 1988 revealed that most of the emigrants (77%) are between the age of 26 and 39 and the professional and technical occupational categories amount to 28%.

The constituents of emigrants in the 90's probably will not deviate much from the survey figure. The number of electrical engineers lost in Hong Kong in the next ten years will therefore be phenomenal.

Using some assumed date as below.

- 4 persons in each family leaving
- out of the 28% professional/technical emigrants, 10% is to be engineers
- out of all the engineers leaving, 20% is to be electrical engineers

The result is that there will be over 75 electrical engineers lost each year in the next decade.

It may be said that the rate of loss can be compensated in majority by the rate of expansion of tertiary education. However, the real problem is not the sum but rather that over 50% of those who depart would have 10 years or more of working experience. They cannot be simply replaced by higher yield of engineering graduates now or in the near future.

To fill this gap, one solution is the traditional approach of importing more foreign engineers. This arrangement is not new and had been commonly adopted by the industry. In the past, expatriate engineers were brought to work here mainly because of the general inadequacy of trained and experienced engineers and the lack of latest knowhow in Hong Kong. Over the last twenty years or so, the number of local electrical engineers has increased substantially. Thanks to the never-ending expansion of the engineering education bodies and HKIE Committees' effort in promoting formal training schemes. Despite the increased demand of electrical engineers to cope with the growth of Hong Kong, the number of expatriate engineers had in fact decreased.

Foreign engineers however do have problems and frustration in working here. They are:–

- difficulties in communication
- unfamiliarity of local codes, regulations and practice (in particular those who are not from U.K.)
- difference in cultural background and as a result creation of more conflicts
- unaccustomed to the local lifestyle and living environment

Very otten, an engineer from overseas needs 6 months to one year to adjust himself staying here, Some, though relatively minor, in fact cannot adapt to the change and leave.

On the subject of local codes and regulations, the electrical engineering practice in Hong Kong has always been to follow very closely the U.K. systems with very minor adjustments to suit local conditions. Recently, the voice of setting up standards and codes of practice for Hong Kong becomes louder and louder as the simple adoption of British Standards will no longer be adequate to keep pace with the growth of Hong Kong, to match standards required for the Single European Act in 1992 and for the need of more coherence with China as it gets closer to 1997.

This does not only mirror the heavier workload for electrical engineers in the coming years but also reinforces the need of engineers with in-depth knowledge of the local situation. The obvious solution to ease this crisis is to encourage more emigrants to come back to work. The greater is the number of returnees, the faster is the gap filled.

4. Realities-Working Overseas

The estimated rate of reverse flow of 25% is far from satisfactory as far as filling the gap is concerned. But why bother to return after having gone through the trouble of moving.

Let's look at some realities of living and working as an electrical engineer in the host countries of emigration.

— Loss of Career Connections:

Electrical engineers with ten years or so of experience would have established a lot of contacts in the home country. The contacts include fellow colleagues, professionals of related fields, clients and others. With these contacts, one is put in such a position that would make one's day-to-day works much smoother and more successful.

In a new place, all these contacts would have lost. It may be possible to build up similar career connections in the same way as in Hong Kong but it would mean another ten years, if not longer, to achieve the same status, if ever achievable. The greatest hurdle is however not the time, but the age gap.

It would be so much easier to deal with a senior executive if he had been an acquaintance or had worked to others before, when he was still a college-leaver or a trainee. The best contacts one can have are those with whom he had jointly fought the uphill battle in their career path.

To try to repeat this process is not impossible so long as one can make 'friends' with people from a completely different cultural background and ten years younger.

Dream-home No Longer Cheap:

One of the main talkabout of living overseas is the big house with lots of spaces and with price only half of a flat in Hong Kong. Unfortunately, only the former part is true now.

With the influx of thousands of migrants to popular places like Toronto, Sydney, Melbourne, Vancouver etc, in the last few years, properties prices in these places had skyrocketted to more than double. Late comers now would find that they have to bite the bullet to stay close to the city or to drive over 30km each way each day to work.

And the Banks charge much higher interest and do not finance so much as their counterparts do in Hong Kong.

Not a lot of people can earn enough to repay a high mortgage sum anyway.

Engineers Become Maids:

Those with young children would have to convince their wives to stay home to do the houseworks. Maids are rarely heard of. Not that they are not available but they cost more than cars.

Some people find out a loop-hole which is to apply for bringing in a Filipina maid to look after a pregnant wife. But they have to make sure that their wives are always pregnant to keep the maid and to make sure that the maid does not marry a local to secure a passport for herself.

Very often, emigrants become returnees because their wives want to stay as career woman in Hong Kong or else the engineers become maids abroad.

Job Dissatisfaction:

Hong Kong has become one of the most densely developed cities in the world and giant projects keep burgeoning to quickly dwarf newly completed ones. Engineers in Hong Kong have much opportunity in getting job satisfaction out of working on and very often heading the team for these projects.

New projects overseas are often much smaller in scale and/or in number. Being new comers, most Hong Kong electrical engineers would not act as the principals of major projects anyway.

A lot of emigrants would find that they are under utilised and feel frustrated of not having the opportunity to demonstrate their ability.

- High Income Tax and 'Higher' Cost of Living:

  Most people are aware of the high income tax in the host countries before they go but only to find that their take-home pay is less than half of what they used to receive in Hong Kong and they can hardly save anything (saving money seems to be a gifted slogan to Chinese) after paying the food, utilities bills, petrol etc.

  The cost of living is not really high in Hong Kong terms but is relatively high when considering the nett earning. Cars, in particular the maintenance and repair, are very costly and can easily take away 25% of the after-tax income. Public transport is more expensive and one has to be very patient with the slow service.

  Insurance premiums (house, house content, medical, dental, life, car, loss of income–you name it) are really high. One can avoid some of them but not all.

  Public schools are free but if one is used to sending the children to reputable/famous schools (they also exist in these places), the fees for two are equal to another 25% of the take-home salary.

- Lifestyle and Entertainment:

  Needless to say, these are completely different.

  To quite a great number, in particular the sporty ones, these are not necessarily problems.

  Still, there are some who find that life overseas is boring.

  Old friends and relatives, if any in the same country, are still one phone-call away but they may need to drive a long way to meet. Meeting places are no longer in restaurants like Hong Kong (dining-outs are expensive) and are usually at home or in the parks. (Wives have to prepare the food or engineers become cooks). Most weekends, people are busy in doing garden work or upkeep of the house (labourers can be two times more expensive that engineers) so gatherings are much less frequent and friends and relatives are not as many.

The above items are not necessarily exhaustive and not necessarily applicable to all (at least, 75% of the migrants can tolerate so far). They do represent the soul-searching feeling of quite a few.

5. **Mending The Broken Bridge-Pros and Cons**

Most emigrants would feel agonized in deciding what to do after they have secured their second passports. It is hard to determine in reaching this cross-road whether to stay settling in the new home country to continue the climb back up or to mend the broken bridge leading their way back to Hong Kong. Those with children studying would find it even harder to select the alternatives between bringing the whole faimily back or leaving the family behind.

The plus of returning includes:

- Better Opportunities and Promotion Prospects:

  With the current economic climate, there is no difficulty for a returned emigrant to find a job in Hong Kong. Employers in fact are becoming more interested in employing returnees because they are comparatively more stable than existing ones. It is not uncommon now to find some people always declaring that they will definitely not emigrate, suddenly hand in their resignation to move to other countries.

Returnees can immediately and efficiently produce as they already have all the local experience and connections. A few years of experience to the western countries' engineering practice also enhance their lateral thinking in tackling engineering problems.

Opportunities and prospects for returning emigrants have therefore not been lessened due to their short-term departure and in some cases have been better.

- Kids to Learn Chinese:

  A lot of emigrants (in fact a lot of overseas Chinese also) want to nurture their children's links with Chinese culture. By returning, young children can make use of this opportunity to have Hong Kong schooling in order to learn how to read and write (and for some to speak) Chinese.

  It will be very hard to teach the children to learn their native language in foreign countries.

- Monetary Rewards:

  High salary, low tax and relatively low costs for 'luxury' items such as maids, taxis, restaurants, fashioned apparels, new audio-visual products, etc. make the trouble of coming back worthwhile.

- Renew Cherished Ties:

  A few years of separation would make the family re-union more memorable.

  Meeting old friends in exchange of experience of working overseas and for missing eye-witness of changes in Hong Kong while away can be enlightening.

The penalties of coming back are:

- Uncertainties of Hong Kong's Prosperity:

  No doubt, Hong Kong's economy can be very fragile. It responses too closely and sensitively with the political climate of China.

  While Hong Kong is now more prosperous than ever, things can turn sour very quickly. The June event in Beijing had drained nearly 20% of the properties values down the tube in one week. No one can predict how long the booming situation will last.

  Returnees do have this concern in their decision making although the worries of these uncertainties are shared by all Hong Kong people.

- Missing Opportunities:

  Most electrical engineers have to start all over again in their career development when emigrating overseas. Working through the qualifying period of citizenship may have brought them one-third, if not half, the way up.

  To eventually leave Hong Kong again will mean the climb back up in the host countries even much harder.

  One of the criteria in making the decision to return is therefore how long they think they can work in Hong Kong in the working conditions they like. Based on this, they can evaluate if the rewards of coming back can compensate the opportunity lost.

- Education for Children:

  A recent survey of returnees when asked if they intend to leave Hong Kong again before 1997 had the following results.

Definitely yes	25%
Probably yes	32%
Undecided	31%
Probably no	10%
Definitely no	2%

  Hence, while some prefer to have their children learning Chinese in Hong Kong, a lot want their children to receive education similar to their destinations so that they can carry on their studies abroad.

  The common headache faced by most of those who return is where to settle their children when they come back.

- Separation from Family:

  Those who decide to leave their families abroad and return only by themselves would as a matter of course suffer the difficulties of separation from the family.

6. **Actions to Attract More Returning Brains**

Positive action should be done to invite electrical engineers to come back. These include:

- Advertising Overseas:

  While people abroad may be aware of the crisis in Hong Kong, most still want to play safe by ensuring permanent employment before packing-up to return. Employers should therefore advertise overseas to attract more engineers.

- Establishing Appropriate Education Facilities:

  More schools with system, curriculum and setting planned for enabling students to continue studies overseas should be built to resolve education problems of returnees' children.

- Continue to Grow and Advance:

  Hong Kong needs to continue grow and to advance the sophistication and technology in manufacturing and industrial products to stay competitive. In turn, this would provide more job satisfaction and challenge for experienced engineers to offer their knowhow.

7. **Synopsis**

- Economy of Hong Kong keeps on booming. More electrical engineers would be required.
- The electrical industry of Hong Kong is having a 'gap' in resources. This is created mainly by the increasing outflow of engineers for lure of citizenship elsewhere.
- The 'gap' is best filled by the reverse flow of emigrated engineers.

Paper No. 10

Human Resources in the 90's

– Speaker: Mr. Peter Barrett
Managing Director,
Organisation System Ltd.

HUMAN RESOURCES IN THE 90's

Anyone hoping to predict the human resource situation in Hong Kong in the 90's must surely be paid much higher than a 'Fong Shui' man who advises on disposition of our offices, homes and our lives. It is for this reason that I am not going to attempt to forecast exactly what would happen but outline some trends that I think may emerge in Hong Kong and in general management in the decade ahead.

As Alvin Tofler said in his book The Third Wave "Humanity faces a quantum leap forward. It faces the deepest social upheaval and creative restructuring of all time." He went on to predict that the third wave brings with it a genuine and new way of life based on diversified, renewable energy resources, on methods of production that make most factory's assembly lines obsolete, on new non-nuclear families, and drastically changed schools and corporations of the future. I would like to examine some of Tofler forecasts and to adjust these for Hong Kong's condition.

TOFLER'S VIEWS	HONG KONG ADAPTATION
Slow economic growth	Decelerating economic growth
High unemployment	High employment with high labour turnover
A revolution of communication technology	The most advanced communication technology in Asia
A total new office context	Decentralized, nuclear offices
New ways of doing work	More effective use of scarce labour resources
World wide energy reallocation	Daya Bay
Change expectation of younger managers, less concerned with success and money	More democracy and freedom of expression, more concerned with security for the future outside Hong Kong
Responsibility of leader to society	Realization that managers should contribute to the development of Hong Kong over the long term

TOFLER'S VIEWS	HONG KONG ADAPTATION
Increase the impact of multinationals	Reallocation of multinationals away from Hong Kong
Changing power in society	A new sovereign power in 1997

WHAT IS HAPPENING IN ORGANIZATIONS IN HONG KONG

1. **Organizations are becoming more differentiated and complex.**

    * A need to manage different specialists.

    * Inability to talk to each other, computer specialists, design engineers, etc.

* Need to integrate this variety.

* This poses career development challenges.

2. **Subunits are becoming more interdependent.**

   * With shorter production cycles, manufacturing is more reliant upon proper delivery of raw materials at the right time.

   * Design engineering must build in good service capability.

   * Products must be such that they are marketable to the consumer with distinct products advantages.

3. **Organization climate is more collaborative and co-operative.**

   * Competition between departments will be destructive and will let competition in.

   * Managers will have to pay more attention to team work.

   * Chairmanship skills and temporary teams will be established.

4. **Organizations will be more dependent on natural communication.**

   * More information flow between specialists.

   * Information should be available to all in the form needed.

   * Development of digital information delivery in both text, voice and image forms at the desk.

   * Temporary project teams and task forces will manage the rapid escalation of problems and issues.

5. **Power will be based upon more information than upon formal position and will be more decentralized**

   * General Managers will not be able to handle all data. Therefore they must delegate.

   * Managers must have more skills to obtain, analyse and disseminate information.

   * More skill and finesse needed in controlling the decision making process which relies upon more people to provide the information to reach a satisfactory conclusion.

6. **Challenges**

   * How to allocate the time of specialists against a range of tasks.

   * How to run teams for effective performance.

   * How to motivate and retain effective managers within the organization.

HUMAN RESOURCES ISSUES IN THE 90's

I believe the following issues will face top management in the next few years and they had better prepare for these challenges now.

New ways of motivating staff to stay and to return to Hong Kong when they have their insurance policy.

Improved selection skills not to find the best person for the job but to establish the minimum acceptable standard for reasonable performance.

With new information needs, all managers require to have key-board skills.

Increased delegation to offices which will become decentralized not only in the new towns but in Western, in East Wan Chai and Causeway Bay as a consequence of limited space high rent in Central business district.

Due to rapid departure of middle management, general managers have the task of creatively restructuring their organization and using flexible job evaluation techniques to rearrange their salary structures.

Management must find rapid ways of training staff to undertake these revised jobs. This will require the use of specialist external trainers, distance learning technology and computer based training.

With more democracy within the society, we need to more democracy at the place of work and thus increase the need for joint consultation with staff and may even involve development of trade union negotiations.

Because of this, management will have to communicate more to account for its actions and to advise of staff changes in advance so that staff understand the rapidly changing environment in which they work. Thus leadership skills will predominate and leadership training will be necessary and leadership performance will need to be rewarded.

Management will require to be more involved with the community to respond to the obligation that business has, to help the development of Hong Kong as an ongoing concern. Issues like the environment, pollution, political development will all lead to the need for companies to adopt more proactive public relations policies.

Middle class professionals will begin to dabble in politics and may need to be given time off for community work.

Because of the rapid change and decentralization into smaller subunits, there will be a need for more general managers and thus managers will need to be trained earlier and be appointed to general management positions as soon as possible. The skills they will need to be trained in will include developing teams; running meetings, managing in a more democratic environment and understanding better the use and abuse of power.

Middle managers will need to have stronger supervisory skills. They must be able to handle more work pressure in the slimmed down organization of which they will become a part and thus they must handle themselves and the stresses upon them more effectively. More attention must be paid to the relationship and balance between working life, home life, exercise and leisure. Thus working hours may need to have to be reduced to enable people to spend more time maintaining this balance to equip them to deal with more effective hours at the office.

Hong Kong is becoming human, feelings and emotions may have more of a place at work than hitherto. You must therefore be prepared to maintain some sense of humanity at the place of work and deal with your staff as people and not as a unit of labour. This will require more time, more sympathy and more skill.

Companies must engage in more rapid management development and should be prepared to allow managers t spend more time in training programmes and in self-development. Training can best be carried out by a skilled manager coaching his subordinates and delegating more. This will mean we must have less of the autocratic management style and a better understanding of coaching skills.

However, with the increased ambiguity and uncertainty, there will still be conflict and managers must know how to handle uncertainty.

There will also be increasingly rapid changes of organization and organization development skills will become increasingly important so that there will be more skills in analysis of the changing demand upon companies and how organizations should be successfully reoriented to meet the challenges.

The changing values of our staff will mean frequent reassessment of our management style and we must become more familiar with the opportunity options open to us in terms of how we behave as managers.

The perspective of management will change. What is the point of a 5-year plan in a company which cannot forecast its staff five years ahead or cannot forecast the skills it will possess five years ahead or even the government regulations which may control it. Thus there will be a tendency towards more short-termism and to managing businesses on a year-by-year basis than longer term planning. Contingency planning may become a skill of 90's.

In order to retain and reward our staff, their pay must be related to performance and perhaps even to their stability. We may need to have more retention type, fringe benefits, a stronger social relationship with our staff and much more honest communication in our relations with them.

Because local professionals will emigrate, expatriates from Asia and elsewhere will replace them and Hong Kong will become a much more international place. There will be a move towards short term contracts, towards managing cultural diversity and adopting a global focus in our attempt at recruitment. I eventually suggest that global executive search will be the service upon which Hong Kong may have to depend for its continuity.

Because of the increased cost of managers, there may be a move towards the use of temporary consultants to deal with particular problems rather than wholesale employment of specialists on a permanent basis. Thus a number of individuals will increasingly become freelance consultants and more companies will be willing to engage consultants and although their fees may be high, such fees will only be incurred when there is a major problem to handle and where the cost of those fees will be less than having a full time employee. There will be tendency therefore for subcontracting of work and subcontracting of dealing with some of the major problems by specialists.

Despite all of these, staff must be imbued with the sense of quality and customer service because we will still have to compete with overseas competitors who are not faced with the political pressures and economic changes that Hong Kong will face.

The changing nature of work will also require some adaptation. There will be more understanding in a family about the responsibility of the breadwinner because the breadwinner will have a fax machine in his home. He will have phone mail delivered to him at home and he may even work at home from time to time. Alternatively, the family may have to relay messages to him received at home when he is at work.

In general, Hong Kong may becoming a more caring place. It may care more for the lives of individuals who stay here, more for the way in which the environment interacts with them and more for the values such as quality of life and acceptance that one's working day should be a pleasant experience rather than a stressful one. Because of the political strains, managers in Hong Kong will become increasingly concerned with long term security and companies will need to adapt their human resource policies to reflect that concern. They will be more open to respond to the legitimate family aspirations of their staff, to accommodate the plans of their employees within their own business plans. This will call for a review of reward and benefit programmes towards providing better long term security. Provident funds will be seen as an increasingly valuable method of enabling staff assisted by the company to build up that capital lump sum which will be available to them when they leave the company to go overseas. There will be more frequent manpower and succession planning and as a consequence, an increase frequency of training to ensure the development of staff to their maximum in the shortest possible time.

Improbed career counselling skill will be required for senior managers as well as better judgement of potential, perhaps using assessment centres, to identify the high fliers for rapid development. Performance appraisal will become more realistic so that employees to be able to take action to remedy their weaknesses or to develop their potential.

In conclusion, it is clear that the companies will need to spend much more money on their human resource function, be it training, recruitment or staff relations. They will need to have more sophisticated managers to handle an international group of staff with the wide variety of aspirations in an increasingly temporary society. More money will need to be spent both on effective training programmes or developing new reward systems and upon receipt of high class consultancy advice.

In all, there is little time to adapt to this escalating pressure upon Hong Kong managers and they do well to begin to address some of these issues now.

— Notes & Questions —