THE HONG KONG
INSTITUTION OF ENGINEERS
ELECTRICAL DIVISION

One day Symposium

Thursday, 19th November, 1987

Impact of Electrical Engineering on Hong Kong's Future Economy

at
Silver Ballroom
Sheraton Hotel
20 Nathan Road,
Kowloon, Hong Kong

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Symposium Programme

08.30 Registration and Coffee

09.00 Introduction: Symposium Chairman
— Mr. Simon S.O. Ho, BSc (Eng), MBA, FHKIE, CEng, FIEE, FIMarE, MIMechE, MCIBSE, ACIArb, MBIM
Welcomed by: Mr. A. D. Longmore, BSc (Eng), DipMS, FHKIE, CEng, FIEE, MBIM

09.05 Opening Address
— Dr. R.C.T. Ho, BSc., PhD, FHKIE, CEng, FICE, FIStructE, FIHT, MConsE (HK), JP President HKIE

1. Social Influence

09.10 The Structure and Further Development of Electrical Industries in Hong Kong
– Speaker: Prof. E.K.Y. Chen, Director, Centre of Asian Studies, HKU

09.30 Development of Local Electrical Installation Industries
– Speaker: Mr. K.C. Wong, Chairman, HK & Kln. Elect. Contractors' Association Ltd.

09.50 HKPC's Role in Hong Kong's Development of Electrical Industry
– Speaker: Mr. Graham C.H. Cheng, JP, Chairman, Hong Kong Productivity Council

10.10 Discussion

10.30 Coffee

2. Manufacturing Industries

10.50 Technology Transfer, Joint Venture – an Alternative Strategy for Hong Kong Electrical Manufacturers
– Speaker: Mr. Kevin C.P. Lo, Chairman, Gold Peak Industries (Holdings) Ltd.

11.10 Trends and Directions of CAD, CAM, CAE and CAT with particular reference to Electrical Engineering
– Speaker: Mr. Martin Sandfelder, Program Manager, Asia Pacific Group, IBM World Trade Corporation

11:30 Cable Manufacturing in Hong Kong
– Speaker: Mr. C.P. Yu, Deputy Manager, Keystone Electric Wire & Cable Co. Ltd.

11.50 Proposed Electrical Products (Safety) Regulations
– Speakers: Mr. S.K. She, SEME, EMSD, Mr. A.W.Y. Wong, EME, EMSD

12.10 Discussion

12.30 Lunch

3. Large Scale Projects

14.15 Role of Hong Kong Engineering Company in Construction of Turnkey EHV Substation in China
– Speaker: Mr. K.N. Hui, Project Manager, BBC Brown Boveri Ltd.

14.35 Competitive Coordinated Protection of LV Installation
– Speaker: Mr. J. Feenan, Technical Director, Fusegear Div. of GEC I.E. Ltd.

14.55 Use of Microprocessors in Solid State Relays for High Reliability of Power Supply
– Speaker: Mr. L. Matele, North-East Asia Regional Manager/ASEA Relays, ASEA

15.15 Coffee

15.30 Tunnel Lighting Design and Developments in Lamp Types
– Speaker: Mr. G.H.M. Giesbers, Sr. Lighting Design Engineer, Philips International B.V.

15.50 Development Plans for Kowloon Canton Railway Corporation
– Speaker: Mr. P. V. Quick, Managing Director, KCRC

16.10 Discussion

16.30 Summing up: Symposium Chairman
– Closing Address The Hon. H.K. Cheng, JP

Acknowledgement

The Electrical Division of the Hong Kong Institution of Engineers would like to express its sincere appreciation and gratitude to the following persons and organizations for their contribution to the symposium:

Speakers/Authors

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Dr. R. C. T. Ho
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Mr. K. C. Wong
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Mr. Kevin C. P. Lo
Mr. Martin Sandfelder
Mr. C. P. Yu
Mr. J. H. N. Chan
Mr. S. K. She
Mr. A. W. Y. Wong
Mr. K. N. Hui
Mr. J. Feenan
Mr. L. Matelle
Mr. G. H. M. Giesbers
Mr. P. V. Quick

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1. SOCIAL INFLUENCE

Paper No. 1

The Structure and Further Development of Hong Kong's Electrical Industry

Speaker: E.K.Y. Chen, Centre of Asian Studies, University of Hong Kong

THE STRUCTURE AND FURTHER DEVELOPMENT OF HONG KONG'S ELECTRICAL INDUSTRY

1. Hong Kong's electrical industry consists of 5 major groups of products under ISIC (International Standard Industrial Classification) at the 4-digit level, viz. (1) electrical industrial machinery and apparatus, 3831, which are mainly machinery specialized for particular industries mainly textiles and leather, pumps and compressors, fans and blowers, centrifuges, filtering and purifying apparatus; (2) electrical appliances and housewares, 3833, which are mainly electrical ceiling fans, grinders and juice extractors, hair dryers, curlers, irons; (3) dry batteries, 3836, including both conventional and micro-batteries; (4) Torch bulbs, electric bulbs and tubes, 3837; and (5) Miscellaneous electrical products, 3839, comprising wire and cable, lamps, lighting sets, insulators, switches, plugs and sockets, fuse, antenna. Electrical appliances and housewares have emerged as by far the most important sector, accounting for more than 50% of the industry's output. The relative shares of 3836, 3837 and 3839 have declined quite significantly.

2. The Hong Kong electrical industry experienced relatively rapid growth up to the period 1979 – 82 after which the industry has suffered from a decline. The industry's output (in terms of value added) accounted for 2.9% of total manufacturing in 1973, 4.8% in 1979, 5.4% in 1982, but only 3.5% in 1985. The industry was badly hit by the 1982–83 recession; unlikely the other industries, it has not recovered since then. The electrical industry has never been a key industry in Hong Kong. In 1985, it accounted for 6.0% Hong Kong's total domestic manufacturing exports and 3.3% of total manufacturing employment. There is also no evidence that the industry produces significant indirect linkage effects on other industries. Most of the industry's inputs (around 60%) are imported and most of its outputs (over 90% in the past few years) are exported. We would have expected that the industry supports the development of the local electronics industry. But this has not been the case.

Export/Sales in major manufacturing industries

Industries	export/sales (in %) 1978	1980	1982	1984	1985
Electrical	68.7	71.1	66.5	93.0	96.7
Textiles	22.2	26.1	25.1	26.6	24.2
Garmengs	96.1	95.0	98.2	97.9	99.0
Electronics	57.8	54.2	45.9	59.3	64.8

3. Productivity increase in Hong Kong's electrical industry is also insignificant. Labour productivity rose steadily up to 1982 but has slowed down in its growth since then. There has in fact been negative growth in capital productivity. implying that over capital-intensive technology might have been used or capital has been used ineffectively. Indeed, statistics show that the capital-labour (K/L) ratio in the electrical industry increased very rapidly in all sectors of the industry. In 1985, the electrical industry in fact had the highest capital-labour ratio among the major industries in Hong Kong.

K/L in major manufacturing industries, 1978 / 1985

HK'000

Industries	KL 1978	1985
Electrical	13.7	64.8
Textiles	25.6	26.3
Garments	6.9	56.9
Plastics	12.4	52.3
Electronics	9.5	53.9

In theory, a higher capital-labour ratio should bring about higher technological change and therefore higher growth in output. This does not seem to have been the case in the industry. While productivity seems to be lower in the electrical industry than in the other industries in Hong Kong, the wage level of the electrical industry is almost at par with the other major industries.

4. It would be of interest to examine whether Hong Kong enjoys a comparative advantage in the production of electrical products. On the basis of the RCA (Revealed Comparative Advantage) index shown in Table 5, we observe that only in the case of electrical appliances and housewares does Hong Kong enjoy a comparative advantage (RCA index > 1). Moreover, we note that the RCA index for such products increased over time. Thus, the future development of Hong Kong's electrical industry has to depend on the growth of the appliances sector. The lack of comparative advantage in the production of electrical products in Hong Kong is further illustrated by the fact that Hong Kong electrical firms have been investing abroad to reduce cost of production and foreign direct investment in Hong Kong's electrical industry is relatively small.

5. Summing up, the electrical industry of Hong Kong has suffered from a number of problems:

(1) The firms are small and in some sectors decrease in size over time, thus preventing them from enjoying economies of scale. But more recently, there are attempts of small firms to merge into bigger ones. This is most observable in the dry batteries sector which is now monopolised by large firms.
(2) Production is over capital-intensive or capital is used inefficiently and ineffectively.
(3) Productivity increase is slow. But wage level has to be competitive vis-a-vis other industries.
(4) The value added-sales ratio is low and a very high proportion of inputs are imported.
(5) Export markets are heavily concentrated in the United States. China is a great potential market and should be explored.
(6) The industry faces very severe competition from other Asian countries. Japan is of course is major producer of electrical products. Taiwan and Singapore also have a much greater comparative advantage than us. In terms of high quality products, we cannot of course match those produced in West Germany and other European countries.

6. To conclude, the electrical industry can play some role in Hong Kong's future industrial development if the industry moves along the following directions:
(1) Consolidation of the industry, resulting in larger firms enjoying economies of scale and more efficient use of capital.
(2) Diversification of export markets; developing-country markets should be especially explored.

(3) Increase of the industry's linkages with other local industries so that more local inputs are used and a greater proportion of output is for local sale.
(4) The comparative advantage of Hong Kong in the electrical industry lies in the appliances sector. More R & D in both process and product innovations should be undertaken so that higher quality and higher value added products are produced.
(5) Hong Kong firms should continue to make foreign direct investment for cost reduction or market expansion purposes. In some sectors of the industry, survival is possible only if part of the production processes is located elsewhere for the benefit of international division of labour.

Production Structure of the Electrical Industry, 1973-85

Sectors (ISIC)	Production in value-added (in %)									
	1973		1976		1979		1982		1985	
	(A)	(B)	(A)	(B)	(A)	(B)	(A)	(B)	(A)	(B)
(3831) Electrical industrial machinery and apparatus	22.7	0.7	26.3	0.6	30.1	1.5	22.6	1.2	28.5	1.0
(3833) Electrical appliances and housewares	30.7	0.9	35.8	0.8	40.9	2.0	54.4	3.0	50.7	1.7
(3836) Dry batteries	15.3	0.5	11.2	0.3	5.8	0.3	6.9	0.4	5.8	0.2
(3837) Torch bulbs, electric bulbs and tubes	8.4	0.2	7.5	0.2	4.7	0.2	3.3	0.2	4.2	0.1
(3839) Electric apparatus and Supplies, n.e.s.*	22.8	0.7	19.3	0.4	18.5	0.9	12.8	0.7	10.8	0.4
Electrical Industry	99.9	2.9	100.1	2.1	100.0	4.8	100.0	5.4	100.0	3.5

(A) relative share in the electrical industry
(B) relative share in the entire manufacturing sector

Source: Census and Statistics Department, Census of Industrial Production, various years.

*(3839) Wire and cable insulated, electric lamps, decorative lighting sets, insulators, switches, batteries, plugs and sockets, fuse cartridge, neon lights and T.V. antenna.

Growth in Production, 1973-85

Sectors	Average annual growth rates in production in terms of sales and value-added (in %)							
	1973-76		1976-79		1979-82		1982-85	
	(A) value-added	(B) Sales	(A) value-added	(B) Sales	(A) value-added	(B) Sales	(A) value-added	(B) Sales
(3831) Electrical industrial machinery and apparatus	30.2	27.3	50.2	61.2	7.5	13.3	8.2	6.2
(3833) Electrical appliances and housewares	30.9	34.5	50.5	52.9	30.4	43.4	-2.2	0.2
(3836) Dry batteries	12.4	13.5	15.3	18.1	26.2	59.6	-5.8	29.4
(3837) Torch bulbs, electric bulbs and tubes	19.6	18.2	23.2	54.2	4.3	6.0	9.9	3.5
(3939) Electric Apparatus and Supplies, n.e.s.	17.7	17.1	42.0	55.9	4.9	15.1	-5.6	-8.4
Electrical Industry	24.3	25.7	43.5	52.4	18.3	30.6	0.1	2.9

Source: Census and Statistics Department, Census of Industrial Production, various years.

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Measurement of Factor Productivity, 1973-85

Sectors	Factor Productivity									
	value-added/labour (HK$'000)					value-added/stock of fixed assets (HK$'000)				
	1973	1976	1979	1982	1985	1973	1976	1979	1982	1985
(3831) Electrical industrial machinery and apparatus	20.6	30.9	33.6	76.6	97.1	2.6	2.1	1.9	1.7	1.1
(3833) Electrical appliances and housewares	13.9	23.8	36.9	50.1	51.7	1.9	1.9	1.7	1.5	0.9
(3836) Dry batteries	13.0	17.7	21.3	39.7	55.1	1.8	2.1	1.2	1.2	0.7
(3837) Torch bulbs, electric bulbs and tubes	12.0	15.2	27.8	40.7	69.9	6.8	4.3	3.3	2.5	2.6
(3839) Electric apparatus and Supplies, n.e.s.	13.5	13.6	40.0	49.4	55.2	2.8	3.2	3.0	2.3	0.7
Electrical Industry	14.5	20.4	34.4	52.8	61.2	2.4	2.3	1.9	1.6	0.9

Source: Census and Statistics Department, Census of Industrial Production, various years.

Measurement of Factor Intensity, 1973-85

Sectors	Capital Intensity in terms of:									
	capital-labour ratio (HK'000)					value added-labour ratio (HK$'000)				
	1973	1976	1979	1982	1985	1973	1976	1979	1982	1985
(3831) Electrical industrial machinery and apparatus	7.8	14.9	17.4	45.9	84.5	20.6	30.9	33.6	76.6	97.1
(3833) Electrical appliances and housewares	7.2	12.3	22.2	32.9	56.3	13.9	23.8	36.9	50.1	51.7
(3836) Dry batteries	7.3	8.5	17.2	33.0	80.4	13.0	17.7	21.3	39.7	55.1
(3837) Torch bulbs, electric buibs and tubes	1.8	3.6	8.5	16.0	26.6	12.0	15.2	27.8	40.7	69.9
(3839) Electric apparatus and Supplies, n.e.s.	4.8	4.2	13.2	21.3	81.2	13.5	13.6	40.0	49.4	55.2
Electrical Industry	6.2	9.1	18.0	32.7	64.3	14.5	20.4	34.4	52.8	61.2

Source: Census and Statistics Department, Census of Industrial Production, various years.

The RCA of Electrical Industry, Hong Kong, Singapore, Korea, Japan, Thailand & Malaysia, 1970-85.

Country and SITC code / Year & RCA	1970	1975	1980	1985
Hong Kong				
772	0.24	0.32	0.49	0.55
773	0.38	0.56	0.62	0.58
775	2.13	2.85	3.25	3.54
778	0.51	0.55	0.79	0.66
Singapore				
772	1.41	1.77	2.70	5.0
773	1.26	1.48	1.82	2.46
775	1.23	1.68	2.00	2.20
778	1.67	1.63	1.57	1.29
South Korea				
772	0.66	0.47	0.31	0.18
773	0.39	0.77	1.03	0.65
775	0.45	0.50	0.75	1.46
778	1.03	0.66	0.50	0.49
Japan				
772	0.98	1.04	0.94	1.08
773	2.01	1.47	1.35	1.02
775	0.56	1.03	1.07	1.46
778	1.80	1.32	1.33	1.49
Thailand				
772	8.44	10.29	10.09	9.42
778			0.26	0.87
Malaysia				
772	0.62	1.46	0.62	0.85

RCA is Revealed Comparative Advantage which is measured by : $\frac{Xij / Xj}{Wi / W}$ where

Xij is the export of i by Country j; Xj is the total export of manufactures by country j; Wi is the world export of i; W is the world's total export of manufactures.

Source: (1) U.N., Yearbook of International Trade Statistics, vol. I & II, various years.
(2) Census and Statistics Department, Hong Kong Trade Statistics, various years.

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Export of Major Items by Major Markets, 1978-86

Items under SITC codes	Export market and market share									
	1978	(%)	1980	(%)	1982	(%)	1984	(%)	1986	(%)
Printed Circuits, electric (772201)	U.S.A.	58.8	U.S.A.	32.6	U.S.A.	44.3	U.S.A.	43.8	U.S.A.	39.2
	Singapore	8.2	Taiwan	15.8	Taiwan	29.4	Singapore	16.9	Singapore	16.8
	Taiwan	8.0	Malaysia	10.5	China	6.2	Taiwan	7.4	Taiwan	8.5
Ceiling fans, electric (775721)	Saudi Arabia	47.4	U.S.A.	71.3	U.S.A	78.9	U.S.A.	83.1	U.S.A.	78.9
	U.S.A.	11.2	Saudi Arabia	9.9	Saudi Arabia	7.2	Saudi Arabia	7.2	Australia	5.0
	Venezuela	5.3	Australia	5.5	Australia	4.4	Australia	2.8	Saudi Arabia	2.7
Electro-mechanical domestic food grinders and juice extractors (775730)	U.S.A	30.0	Australia	40.0	Australia	36.8	U.S.A	40.9	U.S.A.	79.8
	Iran	20.2	Iran	20.0	U.S.A.	21.1	Australia	33.8	Australia	6.9
	Saudi Arabia	14.0	Saudi Arabia	5.6	W. Germany	9.2	W. Germany	10.2	W. Germany	4.2
Domestic appliances, electro-mechanical, n.e.s. (775780)	U.S.A.	70.8	U.S.A.	47.1	U.S.A.	50.0	U.S.A.	61.5	U.S.A.	69.8
	Canada	5.6	W. Germany	13.2	U.K.	17.9	U.K.	9.0	U.K.	6.8
	W. Germany	4.0	Canada	9.9	Australia	9.5	W. Germany	5.9	W. Germany	6.0
Hair dryers, curlers and curling tong heaters (775830)	U.S.A.	77.6	U.S.A.	68.2	U.S.A.	65.4	U.S.A.	70.9	U.S.A.	56.7
	Canada	11.1	U.K.	6.9	Canada	7.7	Canada	7.0	Canada	14.2
	Australia	3.1	Canada	6.5	W. Germany	7.3	W. Germany	6.4	W. Germany	7.1

Source: Census and Statistics Department, Hong Kong Trade Statistics, various years.

Table 7

Number of persons engaged, 1973-85

Sectors	1973			1976			1979			1982			1985		
	no.	(A)	(B)	no.	(A)	(B)	no.	(A)	(B)	no.	(A)	(B)	no.	(A)	(B)
(3831) Electrical industrial machinery and apparatus	2096	16.1	131	3108	17.4	100	9802	30.9	46	5362	15.6	25	5360	18.0	17
(3833) Electric appliances and house-wares	4190	32.2	116	5480	30.6	45	12093	38.1	99	19751	57.3	94	17895	60.0	105
(3836) Dry batteries	2202	16.9	440	2315	12.9	386	2950	9.3	369	3183	9.2	168	1919	6.4	120
(3837) Torch bulbs, electric bulbs and tubes	1321	10.1	53	1790	10.0	18	1833	5.8	16	1422	4.1	10	1103	3.7	12
(3839) Electric Apparatus and supplies, n.e.s.	3212	24.7	68	5212	29.1	30	5066	16.0	28	4731	13.7	18	3555	11.9	14
Industry's Total Employment*	13021 (1.8)			17905 (2.2)			31744 (3.6)			34449 (3.7)			29832 (3.3)		

(A) as %.of the industry's total employment
(B) average number of employees per establishment

Source: (1) Census and Statistics Department, Census of Industrial Production, various years.
(2) Table VIII.

*Figures in parentheses are % share of electrical industry's employment in total manufacturing employment.

Vacancies in the Electrical Industry, 1973-85

	Sectors	1973			1976			1979			1982			1985		
		(A)	(B)	(C)	(A)	(B)	(C)	(A)	(B)	(C)	(A)	(B)	(C)	(A)	(B)	(C)
(3831)	Electrical industrial machinery & apparatus	5.2	108	12.8	1.4	42	6.3	1.4	138	13.3	7.2	385	20.4	1.5	79	15.2
(3833)	Electrical appliances and housewares	11.0	461	54.8	6.9	377	56.1	4.7	574	55.4	5.3	1056	56.1	1.6	294	56.4
(3936)	Dry batteries	2.3	51	6.1	2.2	52	7.7	6.0	178	17.2	10.3	327	17.4	4.2	80	15.4
(3837)	Torch bulbs, electric bulbs and tubes	13.3	176	20.9	8.7	155	23.1	5.1	94	9.1	7.2	102	5.4	6.0	66	12.7
(3839)	Electric Apparatus and supplies, n.e.s.	1.4	45	5.4	0.9	46	6.8	1.0	53	5.1	0.3	13	0.7	0.1	2	0.4
	Industry Total	6.5	842		3.8	672		3.3	1037		5.5	1883		1.7	521	

Source: Census and Statistics Department, Employment and Vacancies Statistics for the Industrial Sector, various years.

(A) vacancies reported as % of employment
(B) number of vacancies reported
(C) vacancies reported as % of all vancies in the electrical industry.

Wage and Salary by Major Sectors, 1973-85

Sectors		Wage and salary per head (including frindge benefits), with average annual increase in parenthesis									
		1973		1976		1979		1982		1985	
		HK$	%	HK$	%	HK$	%	HK$	%	HK$	%
(3831)	Electrical industrial machinery & apparatus	802	-	895	(3.7)	1567	(20.5)	2697	(19.8)	3233	(6.2)
(3833)	Electrical appliances and housewares	619	-	926	(14.4)	1350	(13.4)	2418	(21.4)	2886	(6.1)
(3836)	Dry batteries	725	-	798	(3.2)	1266	(16.6)	2197	(20.1)	3552	(17.3)
(3837)	Torch bulbs, electric bulbs and tubes	795	-	940	(5.7)	1533	(17.7)	2148	(11.9)	3100	(13.0)
(3839)	Electric apparatus and supplies, n.e.s.	726	-	711	(-0.7)	1737	(34.6)	2271	(9.3)	2687	(5.8)
	Industry average	733	-	854	(5.2)	1491	(20.4)	2346	(16.3)	3092	(9.6)

Source: (1) Census and Statistics Department, Report of Employment, Vacancies and Payroll Statistics, various years.
(2) Census and Statistics Department, Census of Industrial Production, various years.

Table 10

Wage and Salary of Major Industries, 1973-85

Industries	Wage and salary per head (including frindge benefits)									
	1973		1976		1979		1982		1985	
	HK$	A(%)	HK$	A(%)	HK$	A(%)	HK$	A(%)	HK$	A(%)
Electrical industry	733	-	854	5.22	1491	20.40	2346	16.29	3092	9.63
Garment manufacturing	861	-	1004	5.25	1664	18.32	2236	10.34	2832	8.19
Textiles manufacturing	804	-	938	5.27	1582	19.01	2435	15.44	3233	9.90
Plastics	772	-	900	5.24	1588	20.81	2438	15.35	3269	10.26
Electronics	751	-	873	5.14	1469	18.92	2543	20.05	3178	7.71

Source: Census and Statistics Department, Employment Statistics Section, Wage Statistics, various years.

A average annual percentage increase in wage and salary

— Notes & Questions —

Paper No. 2

Development of Local Electrical Installation Industries

Speaker: Mr. K. C. Wong, Chairman,
HK & Kln Elect. Contractors'
Association Ltd.

DEVELOPMENT OF LOCAL ELECTRICAL INSTALLATION INDUSTRIES

A. Introduction:

There are many ways to gauge the development of electrical installation industry in Hong Kong. But the simple method is to relate this to the housing and industrial developments which in turn closely indicates the progress in demand for electrical installations. Both housing and industrial developments in Hong Kong, often referred to as the "Hong Kong Economic Miracle" have attracted much attention for academics as well as professionals. Thus to chronicalise the development of Electrical Installation Industries against these gauges would not be too difficult a task. On the other hand to predict future developments would require some calculated guessing.

B. Historical Review:

B.1 The problem of housing has been with Hong Kong from the day Caption Elliot raised the Union Jack on the Island at Possession Point in 1841. There was already a steady stream of people making their way to Hong Kong from China for better fortune. The population of 7400 in 1841 rose to 988,000 by 1936. The only reversal of the trend was during the Japanese occupation when it dropped to 600,000 in 1945. However, in 1948 this has shot up to 1,800,000.

B.2 The earliest industry in Hong Kong was shipbuilding and repairs. Two sugar refineries were established in 1878–1882. A cement factory was transferred from Macau to Hong Kong in 1899. At that time, the electrical installation and maintenance was carried out by the directly employed workers.

B.3 In 1886, when the first electrical power generating station was built at Wanchai, the electricity generated initially was for street lighting and supplied to the people living at the

Peak. The offices at Central were also served. The electrical installation work was carried out by the workers employed by the power company.

As the demand increased the electrical network was extended. The increased workload had to be taken up by the skilled workers outflow from the shipyards and workers immigrated from China. They took up the job and acquired the knowledge of local supply rules from working experience. Many of them have little or no academic qualification nor formal training in electrical engineering.

Despite the lack of information, we believed that the limited number of electrical firms were of very small scale. Most of them used second hand, imported hand tools and simple measuring instruments (volt meters). We are not certain of the standard of these installations. However, we believe that the installations complied with the supply company's rules and regulations.

B.4 In 1947, it was estimated that there were about 95 firms related to electrical installation business comprising:–

Installation Contractors & Retailships and Importer & Wholesalers

All the wholesalers and importers were major setups (about 15%) and of European firms and the installation contractors & retailshops (about 85%) were almost run by Chinese in small establishments. The European trading firms were also doing installation projects such as complete installation of office buildings, factories, Government and Army's projects and high class residential houses. They purchased most of the materials from overseas and employed direct labour for the work. They also employed an English speaking Chinese clerical assistant to act as the middle man between the employer and the worker for the work control as well as to act as interpreter. The small firms were doing most of the work for the urban areas such as Chinese tenament buildings, restaurants, small factories and shops. Most of the small firms were of self-employ set up. They employed craft apprentices and casual semi-skilled labour as and when required. The standard of installation was based on the supply rules published by the supply companies. The Government had its own set of regulations which was based on IEE Regulations.

B.5 The business for the small firms was based on buyer's faith in the electrical contractors and suppliers. The electrical contractors and suppliers were normally situated within the district and a personal relationship existed between him and the buyer. Their business depended on personal acquiantance because of the geographical compactness of urban areas. The work was carried out by the proprietors and their employees (craft apprentices). The mateials were supplied by prominent European firms. For large establishments like shipyards, they directly employed workers (trained by the shipyard) and obtained materials from overseas suppliers. They employed European trainers (Foreman I/C of the Electrical Section) from overseas. The business was considered as an in-house business within their organization. The business for the European firm was more or less the same as the small firms. In addition, they were prequalified by the Government & Army for the works.

B.6 There was no organized training among the industry except the Apprentice Training in Government and shipyards. The craft apprentices in the small firms were expected to acquire their skill by watching and trying out along with other skilled workers. After a certain number of years of services, the apprentice, at the discretion of the employer, became a skilled craftsman.

C. "One Person" Small Firms:

C.1 Since there was no planned housing provisions for the immigrants. the living conditions soon became more congested. In addition, the damages to property during the Japanese invasion and occupation had made the problem of housing even more difficult. The housing problem became even worse as a consequence of the establishment of the Peoples Republic of China in 1949 which motivated more refugees to seek shelter in the territory. While most people arrived were destitute, many of them brought their capital and technical skills which established employment in Hong Kong. The population in 1950 was 2,100,000. The houses were occupied to their capacity and people again overflowed into the streets. Cottages and wooden huts were erected virtually overnight, on the urban periphery, on the roofs of buildings and in sheltered coastal embayments and on boats.

C.2 The electrical installation industry grew rapidly as a result of the increase of squatters. Powered hand tools (Drills) and gesting instruments (Multi-meters) were more frequently used. More craftsmen (both skilled and semi-skilled) were employed for the work. The industry had grown in quantity for small firms because some craftsmen became 'self-employed' as small firm owners.

C.3 During these years, the availability of electricity supply like other public services were limited. Most of the rural areas, particularly the isolated villages did not have electricity supply. It was estimated that over 25% of the squatters within the urban area did not have electricity supply. Most of the housing had only few lighting points with only 2A/5A sockets for desk fans and radios. The use of electric iron was considered as luxury for many people in those days.

C.4 The Korean War and the resultant embargo on trade with PRC drastically reduced the amount of commerce and made people invest more in the local manufacturing industries, producing cotton piece-goods for export.

The growth of local manufacturing industries led to the business growth of the major electrical firms and the European organizations because the construction of factories required greater engineering backup, more finance and manpower commitment. To meet the growth, the major electrical firms had to employ more workers. In some cases, they sub-contracted (labour only) out to small firms for work which their direct work force cannot cope with.

C.5 Despite the inadequacy of statistical data for analysis, information from senior members in the electrical industry revealed that most of the electrical installation firms were traditionally of "One Person" businesses and sole proprietorship organisations and some were not even licenced. Those "self-employed" setups did not require much capital and high technology. They were, however, profitable because less overheads were needed. They continued to provide much needed service for the people within the urban and squatter areas.

C.6 Those "One Person" firm owners were required to personally monitor and control the qualitative work standard, the quantitative work done, the job cost, the period of time (scheduling) and compliance to Government's statutory regulations. In addition, they had to take care of material stocks, tools & equipment. They had to give instructions to their employees and maintain the harmony with-in their organisations.

Those "one person" small firm owners normally selected their business locations in densely populated areas. They made use of all available spaces such as pavements, staircases, backyards as their workshops. Their business depended on personal contacts. Jobs were carried out by the owners themselves and daily paid workers were employed as and when necessary. The materials were supplied by a small number of Chinese wholesale suppliers. For larger establishments and European firms, their business remain unchanged as the demand for better accommodation and commercial buildings was not so great.

Most of the business linkages were based on buyer's faith and the personal relationship between the contractor and the buyer.

C.7 The average wage range for the employees were:

Skilled Craftsman	– \$5 – \$7
Semi-skilled Craftsman	– \$3 – \$4
Unskilled Craftsman	– \$2 – \$3
Apprentice Craftsman	– *

* Pocket money of about \$5 per month would be given to the apprentice. However, meals and lodging were provided. In some cases, the apprentice had to do housekeeping work in the workshops.

D. **Ignition:**

D.1 In December 1953 as a consequence of a disastrous fire in a squatter settlement at Shek Kip Mei which, overnight made over 55,000 people homeless. The Government thus initiated an emergency programme to build resettlement accommodation with the object of clearing land occupied by squatters. The programme was quickly put into operation by 1957 and 120,000 persons were accommodated. Housing Authority was formed in 1954 and low cost housing estates were built.

D.2 Despite the combined efforts of the Government and the private developers to alleviate the housing shortage, the housing problem was still in critical proportions. The population had increased to 3,100,000 in 1961.

Consequently in 1961, a Government low-cost housing scheme was introduced for the provision of accommodation upon application for households living in overcrowded and substandard conditions. At the same time, there was an unpredictable wave of private residential development. Thus, within only ten years, the urban area of Hong Kong underwent a transformation as a result of which multi-storey buildings of up to twenty storeys and more became the dominant characteristics of the city.

D.3 In view of the establishment of Government's housing policy, the pattern of the business for electrical installation industry changed. The business for the "self-employed" setups and one person small firms maintined a steady growth rate as the demand from the small families in urban areas and squatters increased. The business for large firms had grown significantly as the Government low cost housing increased since the job nature require more capital, more manpower and greater scale of engineering management. Works of some large firms were carried out by directly employed workers and supervised by a "Foreman". For works sub-contracted out to small firms, a "foreman" would also be employed for work co-ordination and supervision of the sub-contractor. Most of the materials purchased were imported from overseas by the major firms.

D.4 Previously, the "Foreman" was the key-man who would affect the profitability of a project. Therefore, he was selected in addition to his practical experience and technical skill, upon the personal faith of the employer. With the change in the scale of projects a new form of foreman (technical supervisor) was now required to have some knowledge of contract management besides practical trade skill. Although planning and decision making may be done by the technical supervisors or management, the actual implementation of works entirely depended upon the foremen. Also, the technical supervisors and foremen perform their duties solely depended on the owners' directive from time to time.

D.5 In the 1950s, there was drastic increase in housing construction. Electrical Installation industry reacted quickly to the new situation. Difficulties in employing skilled craftsmen, led to the introduction of mechanisation (conduit cutting and bending machines). The sub-contractors employed by large firms become medium firms in some cases. If they have sufficient capital some technical supervisors and foremen became the sub-contractors to the major firms.

D.6 It was estimated that there were about 236 electrical installation contractors including some operating without business registration. The average wage range (1955) for daily paid electricians was:

Skilled	– $8 – $12
Semi-skilled	– $6 – $8
Unskilled	– $4 – $6.5
Apprentice	– $1 – $2 (meals provided by owner)

D.7 The electrical installation industry consisted four major categories: installation contractors, manufacturers, wholesalers & importers and retailshops.

Over 50% of these firms were installation contractors who employed over 75% of the workforce and command over 60% of the business. Only 1% or less of the firms were wholesalers and employed about ½% of the workforce. Almost the rest were either importer or retailshop owners who employed 25% of workforce and account for about 40% of the business. In some cases, they would also carry out minor installation works.

D.8 Manufacturing of simple fluorescent lighting battens, fuse distribution board and LV cubicle switchboards with components imported from European countries were common practice. At the same time, manufacturing of electrical accessories also commenced. There were 34 electrical manufacturing firms employing 3,400 workers at that time. Those manufacturer were of small scale and sole proprietorships and produced simple products like sockets, lighting switches, and bell transformers. They had no financial backup from banks and had only minimum quality control on their products.

D.9 In the 1960's with the improvement of public transport by the use of double-decker buses and diesel electric locomotives the population extended to the new towns. Also more farmers changed from rice growing to rearing of poultry and pigs. To cope with the increased demand for electricity, the power company extended their electricity supply to the isolated villages. This meant that the development in the electrical installation industry in the NT grew more rapidly than in the urban areas. The expansion of these services was mostly from the self-employed small firms only. The business linkage was of personal contacts.

D.10 In 1961, the installation of Sek Pik water scheme was a landmark in electrical installation industry since comprehensive and complicated design including HV, LV and instrumentation were involved.

E. Diversification:

E.1 Whilst there was pressing need to modernize the old resettlement estates and to provide temporary housing, the waves of illegal immigrants continued to surge from China. The standard of public housing estates was also up-graded to much more comprehensive design and self-contained communites.

E.2 There were continued demand for private housing although the level of requirement fluctuated from time to time. For example, in 1967, this was adversely affected by the several industrial disputes deliberately and politically exploited and caused some disruption to the ordinary life of Hong Kong. Whereas in recent years, there are large scale developments of comprehensively designed housing estates which incorporate a wide range of commercial and community facilities, for example, Fairview Park, Hon Lock Yuen, Chi Fu Fa Yuen and Tai Koo Shing.

E.3 During the decade of rapid growth, there was a complete change of the business pattern for electrical installation industry for both small and large firms.

More and more sub-contractors for the large companies became medium firms and registered with the Government as specialist contractors. More employees of large firms became the owners of the small firms. In other words, the electrical installation companies grew both in size and number. There were 1250 firms dealing with electrical installation works including those non-registered firms with a workforce of 9000. The average wage range for daily paid electricians was:

Skilled	–	\$10 – \$30
Semi-skilled	–	\$6 – \$15
Unskilled	–	\$5 – \$10
Apprentice	–	\$3 – \$5

E.4 The extension of electrical installation industry due to the growth of the housing construction, local manufacturing industries and export tradings, lead to the creation of organizations quite different from the tranditional pattern of "One Person" small family business. This produced a corresponding need to develop managerial skill above "EXECUTION" level. The huge amount of financial involvement and the complex nature of the work forced the sole proprietors to acquire, in addition to his engineering experience, some managerial and office administration skills. As a result of these changes, Engineers with some managerial experience were promoted to managers whilst the owners concentrated in business administration. A stratum of senior management was thus created in the European firms. The same also applied to the importers as well.

E.5 Although heavily dependant upon internal trade, electrical installation industry could not insulate itself from the effects of world-wide inflation and financial turbulance prevalent during 1974. Most of the installation equipment and material were imported from overseas. The industry experienced a difficult time of sky-rocketing prices for copper and plastic materials e.g. cables. The electrical installation industry was forced to improve the quality of work and to diversify in other fields in response demands of the markets and competition from newly established firms.

In addition, specialised manufacturers of MCB D/B, contemporary lighting fittings and switchboards continued to consolidate their position in the electrical installation industry. Capital investment in modern manufacturing equipment were made, even though there were setbacks from the decline in private sector building construction. Cables for house wiring, type-tested switchboards, busbar risers, MCB D/G etc. were manufactured locally to reduce costs for the electrical installation industry.

F. Specialization:

F.1 Housing in Hong Kong continued to be a commitment for the Government as well as a major concern for the private investors. The policy of better homes and more pleasant landscaped surrounding with all sorts of facilities increases the demand for higher standard of electrical installation work in domestic housings.

Increased building density, more cost effective building construction methods and higher demand for comfort conditions in lighting and air conditioning are the key parameters of the modern commercial building design.

F.2 Owing to the ever-appreciation of foreign currencies in particular the Japanese Yen, and the end of cheap labour in Hong Kong, the electrical installation industry is forced to use more local manufactured items and cheaper products from other countries such as from Mainland China & Korea to reduce their project costing.

F.3 Building automation, advanced telecommunication system, data processing and computer equipment are common requirements in "Commercial Buildings" in making them "Smart Buildings". All these equipment depend on a reliable and better quality electrical supply system which includes UPS and standby generators. In this respect, equipment selection, cost-effective consideration and equipment application plus special installation methods create demand for professional engineers, technicians and specialised skilled craftsman as well as specialised tools, testing and measuring instruments.

F.4 With regard to the shortage of skilled labour, the current practice adopted by the electrical installation industry is to sub-contract all labour intensive work to their sub-contractors. In most cases, both installation materials such as cables, conduit etc. are also sub-contracted together with labour for the complete installation. These sub-contractors in turn further sub-sub-contract the work (labour only) to their casually employed workers. In some cases, both labour and a minor accessories are also sub-sub-contracted out. Therefore, the supply of labour is relinguished to these sub-contractors and the casually employed workers who are paid on actual daily workdone. It, in fact, motivates the workers to work harder. It is not uncommon that they work at least 12 hours daily (i.e. approx. 50% over and above normal working time). In the long run, this may lower the quality of work. In order to improve their earning, workers also utilize high productivity and automatic powered tools and organize themselves in small self-employed groups for the work. At present, we estimate that there are at least 3 to 4 specialised labour contractors of this kind per site for work such as conduit forming, cable laying, installation of electrical fittings and accessories etc. In this case, the foreman and the sole proprietor of the labour sub-contractor represent the administrative cadre. Sometimes the white collared technical supervisors are also included in this class.

F.5 It is estimated that there are about 3500 electrical installation contractors and materials suppliers some of which are without company registration. The total number of workers is around 26,000. The average wage range for daily paid electricians are:

Skilled	–	\$180 – \$250
Semi-skilled	–	\$150 – \$200
Unskilled	–	\$100 – \$150
Apprentice	–	\$ 50 – \$ 75

Over 75% of these firms are installation contractors, who employ over 80% of the workforce. Only 2% or less of the firms are wholesalers and they employ about 5% of the workforce. The rest are either importers or retailer which employ 15% of the workforce.

F.6 In other developing countries, the mode and level of the construction industry are largely determined by the influence exerted by and the strong support of their own Governments. Because of the laisez-fair system in Hong Kong, the electrical installation industry is left on its own when business demand is low. It diversifies its operations; it moves to the China market; it reduces its workforce and operation and it cuts cost through more productive machineries.

F.7 Electrical installation industry like other construction industries has had many problems over the past years – the effect of the property slump of 1981, the Government's budget deficit and the political uncertainty on the future of Hong Kong. However, the electrical installation industry stood up to these challenges despite the atmosphere of increased competition from overseas contractors and suppliers in a territory that has a committed policy of free enterprise.

In order not to be smothered by the "Dumping" prices of overseas contractors simply join forces with local property developers to secure business. Others work as sub-contractors to the overseas contractors.

F.8 Nowadays, management of the local electrical installation companies could be grouped to three levels:—

Top management:	in all cases, the major share holder decides on the company policy and controls all financial and personnel matters. He even controls selection and purchasing of major items for projects.
Middle management:	usually engineers and supervisors employed to run the project. They are only authorised to decide on minor items for projects. They directly supervise labour and work progress.
Lower management:	usually foreman and gangers employed to handle the day to day work of projects.

G. China Trade:

G.1 The open door economic policy adopted by China since 1979 has given rise to increased economic interchange between Hong Kong and Mainland. This has a significant impact on the electrical installation industry.

G.2 There has been substantial growth in entrepot trade in Hong Kong. China is its largest re-export market for heavy power equipment such as MV and LV switchbear, transformers, generators and cables. In 1986, more than 15% of the locally manufactured cubicle LV switchboard were expoted to Mainald (30% increase compared with 1985 production). Besides sales of actual equipment, various forms of invisible trade such as consultancy and services in the electrical installation industry also increased.

G.3 The investments in Mainland from both Hong Kong and overseas have been concentrated initially on hotels and tourist-related facilities. They are mostly in the form of joint ventures with China enterprises. In order to secure work in these projects, lots of medium sized firms of the electrical installation industry work closely with or are even taken over by the large investment groups who actively participate in the property construction in Mainland China. Thus their growth is in size but not in number.

Their involvement includes design, provision of equipment and supervision.

G.4 Apart from the building services involvement, the trading group of electrical installation industry has also participated heavily in the re-exports to Mainland of heavy power generation and transmission equipment including generators, HV switchgears, transformers etc. Very often this type of business is negotiated between China and the overseas manufacturers with Hong Kong companies acting as the "middle man".

G.5 Because of the cultural affinity between the Chinese in Hong Kong and Mainland, it is easier for Hong Kong people to set up the initial business contact with the Mainland Chinese than foreigners. Thus, lots of foreign engineering organizations establish offices in Hong Kong and they employ local technical people from the electrical installation industry for the China trade. Such employment will initially concentrate on the setting up of business contacts with Chinese enterprises and act as "translators".

G.6 Meantime, electrical installation contractors and materials suppliers owned by China enterprises have also increased their activities in Hong Kong and diversified from trading to installation contracts. The local supply of managerial and technical talent would certainly provide on-site training to their project management & technical teams. However, the situation may change in future when the coastal cities and the special economic zones will provide similar environment. We foresee that as the economy of China improves the market for the electrical installation industry will grow in an even faster pace. These China enterprises will become more involved in these newly developed markets and gradually withdraw from Hong Kong to concentrate more on the hinderland. As a result there will be less competition.

H. Impact of '1997':

H.1 The signing of the joint declaration on the future of Hong Kong by Chinese and British Governments in December 1984 brought about some dimensions of change which Hong Kong has never experienced before. The main concern of the public is the difference in the systems of Government existing in China and that promised for the future special Administrative Region. There is a risk that it could not be implemented with ease. In order to reduce the risk of losing their wealth and freedom some owners of electrical installation companies revised their business plans. Some have transferred part of their capital overseas. Other have withheld their business strategic planning lke re-investment and business expansion.

H.2 In some cases, the senior staff of major establishments have been invited to become partners because the owners have migrated. Others promoted their senior technical staff to act as managers to run the projects during their absence.

H.3 With fewer active companies, there is less competition. This provides golden opportunities for the owners who have no intention to move out from Hong Kong.

H.4 In the last couple of years, the uncertainly in our future has gradually subsided. Capital has returned. Property construction has regained momentum. These attracted many ex-Hong Kong people to return.

I. Training:

I.1 In 1965, the Government approved an Industrial Training Advisory Committee comprising representatives from industry, labour and other organizations such as Hong Kong Electrical Contractors' Association and the education establishments. On its advice, six associated advisory committees were formed including engineering and building construction industries.

I.2 The Vocational Training Council was set up in 1982. Under the Council are 19 training boards which included one for the electrical industry. The attached table shows the relevant figures for the electrical installation industry which embraces:

a) manufacturing of electrical installation products, such as MCB distribution board and lighting fittings;
b) contracting work in electrical, lift and escalator, HVAC and fire services (electrical side only);

Broadly speaking, the electrical installation industry employs approximately one quarter of the total workforce indicated in the table.

The Government, through the Construction Industry Training Authority, started to train electrical workers in the mid 70's and subsequently expanded to a second centre in Kwai Chung. There are 100 electrical trainees each year.

I.3 In the 1970's, there were 5 technical institutes offering various courses for craft and technician trades in the electrical installation industry. This has now been expanded to a total of eight technical institutes with more than double the number of places offered for such training.

I.4 The Government-financed Electrical Industry Training Centre was established in Hong Kong in 1985. The annual output is 120 full-time apprentices. It also provides upgrading courses for more than 1,000 existing electricians.

I.5 The Hong Kong Polytechnic and the University of Hong Kong have increased substantially the intake of students for the electrical engineering discipline. This provides a steady output of youngsters to be developed into engineers or technicians.

I.6 Summing up, in the last 10 years, the Hong Kong Government has spared no effort in fostering the training of relevant personnel in the electrical industry. Thus even if higher demand of quality is required, it can be met by a sufficient pool of skilled personnel.

I.7 In 1961, the Technical College provided full time and part time courses in electrical engineering leading to Diplomas and Certificates. No courses were offered for electrical installation work.

I.8 The Industrial Employment (holidays with pay and sickness allowances) Ordinance 1961 is designed further to improve the condition of workers in Hong Kong. This leads to requirement for greater number of workers on site for normal working hours to offset the additional cost for overtime working on holidays.

I.9 In 1973, Hong Kong Training Council succeeded the Industrial Training Advisory Committee. Provisional Construction Industry Training Authority was appointed to train electrical craftsman for construction sites.

J. Electrical Contractors' Associaiton (ECA):

J.1 ECA, a non-profit making organization established in 1964, aimed to promote the quality and productivity of the electrical installation industry in Hong Kong. The Association comprised of 8 members only. It was financed by an annual membership subscription. All the 8 founder members were Government registered specialist contractors and most of them were European firms.

J.2 In order to strengthen its voice in the discussion with Government, the ECA was re-organised in 1976 and accepted all Government registered specialist contractors (all group I, II & III) as members.

J.3 In1978, ECA amalgamated with Hong Kong & Kowloon Electrical Contractors Association to increase its efficiency in certain areas of its work. Now, ECA has over 500 members.

J.4 The major role of the ECA is to establish a dialogue with the Government. The first issue brought out was on the Conditions of Contract. ECA also endeavoured to conduct contract management courses for the improvement of the quality of the site supervisors.

J.5 The ECA organised group visits to Korea, Taiwan, Mainland, Singapore & Malaysia to exchange installation administration knowledge.

J.6 The ECA produces regular newsletters and journals mianly for circulation to members in order to keep the members informed of up-to-date trade information and the development of installation regulations. Seminars and exhibitions were also organized.

J.7 In addition, ECA sponsored for Construction Industry Training Centres for the training of electricians on construction sites. Scholarship were also granted to HKP students in High Diploma studies.

J.8 For upgrading the technical skill, training courses for IEE Regulations were also conducted with external speakers from professional establishment such as EMSD, FSD, Labour Department, consulting engineers and visiting professionals from U.K.

J.9 ECA has established regular communication link with others contractors' associations, electrical manufacturers' association and engineering professional institutes in more than 17 countries for the exchange of trade informations.

K. Conclusion:

K.1 The success of Hong Kong's economy has been attributed to many industries. One of them, obviously, is the Electrical Installation Industry which has undoubtedly been perfecting itself through the search of advanced techniques and efficiency improvements.

K.2 We have seen the gradual decrease in the number of "self-employed" businesses in synchronisum with the large squatter sites. However, the coming proposed revision of Electricity Ordinance may lead to another generation of the "self-employed" organizations which have demonstrated their effectiveness in the development of the Electrical Installation Industry.

K.3 Hong Kong in the coming years has an important part to play in bridging the social and economic disparities between the China and foreign countries. We believe the Electrical Installation Industry will continue to have sustained growth in the China Trade – not only in the form of re-export into China, but rather of assisting in the distillation of Chinese products for their high qualities to show the World.

— Notes & Questions —

Paper No. 3

HKPC's Role in Hong Kong's Development of Electrical Industry

Speaker: Mr. Graham C. H. Cheng, JP,
Chairman, Hong Kong Productivity Council

HKPC'S ROLE IN HONG KONG'S DEVELOPMENT OF ELECTRICAL INDUSTRY

Hong Kong Productivity Council

The Hong Kong Productivity Council, a statutory organization established in 1967, is responsible for promoting the increased productivity of industry in Hong Kong. The Council comprises a Chairman and 20 members, all appointed by the Governor, representing management, labour, academic and professional interests as well as government departments closely associated with productivity matters. It is financed by an annual government subvention and by fees earned from its services.

The Council offers a wide range of consultancy services covering industrial technologies, feasibility studies, production management, personnel recruitment, market research, EDP and environmental control. HKPC conducts some 500 training courses a year ranging from various technologies, computer training to management and supervisory skills. In addition to organizing industrial exhibitions and overseas study missions, HKPC also offers a technical information service.

The role and functions of HKPC have undergone substantial changes since its formative years. It has evolved from a training and consultancy organization into a major organizational focus for providing industry support services with the implementation of the recommendations of the Advisory Committee on Diversification. The revised HKPC Ordinance in August 1985 provides for the enlargement of the powers and functions of the Council to meet the changing industrial development needs of Hong Kong with greater flexibility and effectiveness.

To develop and apply technologies identified to be necessary for Hong Kong's industrial development, HKPC was requested by the Government to implement the "Unified Approach" in technology transfer for industry. The implementation plan entails HKPC's capability enhancement in the expansion of relevant technical branches to provide an integrated industrial automation support service, and the improvement of precision tooling capability.

Our Objectives

At the enterprise level, we provide an integrated range of training, consultancy, technical and laboratory based services in areas critical to the development of industry.

At the industry level, we aim to identify innovative development opportunities and to undertake development work designed to serve multiple users' requirements.

At the Government level, HKPC undertakes major techno-economic studies and advises the Government on major factors affecting the productivity of industry in Hong Kong.

In addition, HKPC undertakes to consult with, coordinate and assist the activities of persons or organizations, either in Hong Kong or elsewhere, engaged in the study, development or dissemination of programmes, methods or techniques for productivity enhancement, as well as to conduct productivity related assignments both within and outside Hong Kong.

Our Resources

HKPC has a total staff establishment of about 300. Its team of professional consultants possess export knowledge and substantial practical experience in engineering, science, economics, business administration, electronic data processing and metallurgy.

An important strength of HKPC is its ability to dynamically mix and blend skills for a large variety of industry support activities. Inter-divisional expertise and resources are deployed and integrated in handling client assignments and in productivity improvement systems developed for industry. HKPC's consultants assist clients to identify management and technical problems, formulate cost-effective recommendations and implement solutions. To help you improve your technology level and production efficiency, or solve your technical and managerial problems, HKPC's consultancy strength is reinforced by well-equipped and up-to-date facilities. These include electronic data processing facilities, a microprocessor laboratory, a CAD/CAM centre, an industrial chemistry laboratory, a metal finishing laboratory, a heat treatment unit, a die-casting unit, an environmental control laboratory, a technical reference library, an on-line information retrieval service and twelve classrooms.

To keep up-to-date with technological developments and the introduction of new techniques, HKPC maintains effective liaison and cooperation with local and international organizations which provide training opportunities, technical information and expert services to the industrial needs of Hong Kong.

HKPC is linked to international organizations such as the Asian Productivity Organization (APO), the Asian Network for Industrial Information and Extension (Technonet Asia), and the United Nations Development Programme (UNDP).

Contact HKPC

Before a consultancy project is undertaken, HKPC staff will carry out a preliminary investigation to determine the objectives and scope of the project; recommend action to be taken; estimate the time required to complete the project; and indicate the cost.

There is no commitment up to this stage on the part of the client. Upon acceptance of HKPC's proposal by the client, we will then proceed with the project according to the terms of reference. Client confidentiality will be maintained at all times by HKPC.

HKPC: Structure & Scope of Services

Council

Executive Committee

Central Administration

- Council & Executive Committee Secretariat
- Hong Kong Government Liaison
- International Cooperation
- Public Relations, Publicity & Publications
- Industry Liaison
- Accounting & Management
- Project Control
- Personnel Administration
- Audio Visual Support

CORE ACTIVITIES

Training

- Technology Courses
- Management & Supervisory Courses
- Computer Courses
- In-plant Training Programmes
- Seminars, Conferences, Study Missions & Exhibitions

Management & Industrial Consultancy

- General Management
- Production Management
- Personnel Management
- Marketing Services
- Project Management
- Administrative Services

Computer Services

- Technical Evaluation
- Systems Analysis Consultancy
- Application Software Development
- Bureau Facilities

Technical Information

- On-line Information Search
- Information Packaging
- Technical Library
- Information Networking
- Technical Bulletins

INDUSTRY SUPPORT ACTIVITIES

Metals Development

- e Treatment &
- strial
- istry
- reatment
- ion Machining
- sting
- y Control &
- rance

Electronics Services

- Feasibility Study
- Project Design & Development
- Process Control
- Product Evaluation & Testing
- Quality Control & Assurance

Industrial Automation

- Time-sharing Bureau Services
- Hands-on Training
- Feasibility Studies on CAD/CAM Operations
- Advisory & Consultancy Services
- Software Evaluation & Modification
- CAD/CAM Interfaces
- CNC Programming
- PCB Design

Engineering Services

- Automation Projects
- Manufacturing Process Improvements
- Systems Evaluation
- Equipment Design and Manufacture

Environmental Management

- Systems Evaluation
- Pollution Analyses
- Waste Control & Recycling
- Energy Conservation

— Notes & Questions —

2. MANUFACTURING INDUSTRIES

Paper No. 4

Technology Transfer, Joint Venture – an Alternative Strategy for Hong Kong Electrical Manufacturers

Speaker: Mr. Kevin C. P. Lo, Chairman
Gold Peak Industries (Holdings) Ltd.

TECHNOLOGY TRANSFER, JOINT VENTURE – AN ALTERNATIVE STRATEGY FOR HONG KONG ELECTRICAL MANUFACTURERS

Let me begin with a quotation from the findings of a recent survey conducted by the Hongkong Japan Business Cooperation Committee. Hong Kong's products, to the Japanese exporters, are "generally perceived to be weak in durability, innovation, packaging, finishing, safety, standardisation and market appeal". The only good thing about Hong Kong products is that they are "comparatively cheap".

These criticial remarks are applicable to some of the products of Hong Kong's electrical manufacturing industry.

Now, let us take a look at the industry. With the exception of a few companies, most manufacturers are still involved in assembly intensive business. The industry in general does not place much emphasis on product and technology innovation. Rather, it depends mainly on overseas export orders for low value-added products.

You may ask why hasn't the industry moved up market into higher-end, quality products with better profit margins?

One reason is the low level of manufacturing technology used by most of the industry. Most of the manufacturers are not practising some of the more modern manufacturing techniques such as Total Q.C., Zero Inventory or Just In Time etc.

Another reason is the state of our supporting industries, such as plastic moulding and metal work, that provide the necessary components for the manufacturer. Many of them are small operations incapable of providing the necessary technical know-how and the financial resources to develop and produce high quality components required by manufacturers who wish to upgrade their product.

One way of getting around this problem is by vertical integration. That is, the manufacturer develops and produces his own high quality components. With the exception of a few, most manufacturers do not have the necessary financial and technical capability to expand into vertical integration.

Another obstacle against manufacturers moving up market concerns the overall lack of experienced manufacturing engineering talents. In terms of job challenge and prospect, there seems to be little incentive for well-qualified electrical engineers to join the manufacturing sector and make a career out of it. This problem is further aggravated by competition from the service sector which – as many of you here know – tends to offer more sophisticated and interesting assignments than in manufacturing. Job opportunities are abundant in engineering consultancy, high-tech marketing, utilities companies or the public sector, etc. Hence it is not surprising that Hong Kong's electrical industry generally lacks the competitive edge.

Yet another obstacle against manufacturers moving up market is the nature of Hong Kong's domestic market. It is well-known that for countries such as Japan, their strong performance in export markets is partly a result of the existence of a sizeable domestic market making investments in product development viable and attractive. Indeed, products are often sold at a premium price in the domestic market to allow competitive pricing for exports.

In contrast, Hong Kong's domestic market is small and dominated by imported products. Not much of the investments in product development can be amortized locally.

The obstacles I have just outlined are not insurmountable. One possible means of getting around these obstacles is for the local manufacturer to set up joint ventures with overseas technology/marketing partners.

Now, allow me to tell you about my personal experience with setting up joint ventures.

A few years back, one of the companies I am associated with decided to go into the manufacturing of electrical wiring accessories for the higher-end markets. Hong Kong's small domestic market for such products was then dominated by imports mainly from the U.K. It would be very costly and time-consuming to develop products in-house from scratch. Hence, instead of investing heavily into our own product development and marketing from zero base, we decided to enter into a joint venture agreement with a technology/marketing partner. The advantages of this arrangement are:

Firstly, quick transfer of design and manufacturing know-how;

Secondly, ready access to experienced engineering talents and advanced manufacturing techniques;

Thirdly, availability of testing facilities and expedience in meeting international standards in terms of both quality and safety requirements;

And last but not the least, good will for products and access to established markets.

Today, this joint venture is the only local electrical wiring accessories manufacturer that has successfully captured a significant share of the local higher-end market, selling to hotels, office buildings and government housing projects against many overseas competitors. These products have also penetrated many overseas markets that demand stringent safety standards and quality.

Before I close, allow me to make a few more observations. The first is about education and manpower. In recent years, a lot of attention and resources have been spent on training engineers in high technology. We are now planning a Third University devoted to science and technology. However, as I have pointed out earlier, one of the basic problems with Hong Kong's manufacturing industry is its low level of manufacturing technology. We need more engineering talents in this area to ensure that we can turn out products of higher standard and quality in order to move up market.

Also, as mentioned before, most of the manufacturing and supporting industries are small scale operations, without the means to gain access to or use advanced manufacturing technology. Perhaps what we need is some form of government-funded support to serve our small manufacturers and component vendors, similar to what the Hong Kong Productivity Council is doing but in much bigger and more aggressive scale.

My second observation concerns another aspect of the government's functions. Government standards on safety and radio frequency interference suppression, tend to be so lax in Hong Kong that the market is often flooded with low quality electrical products from Hong Kong and now China. Thus many better quality products have been effectively driven out of the market. A case of Gresham's law: the bad drives out the good. This state of affair, apart from discouraging investment into higher quality products, means that the population in general are not quality or safety conscious.

Yet having a quality culture is one of the reason why countries such as Japan have been able to produce competitively-priced quality products. Introducing more stringent government control on standards could be a step towards nourishing such a quality culture for Hong Kong.

My final observation is a more encouraging one. It seems that now is the best time to set up joint ventures with overseas partners. In the past, Japanese manufacturers were often reluctant to transfer technology overseas. However, the rising value of the Yen has now made many manufacturing operations financially unviable in Japan. In order to survive, Japanese manufacturers are now being compelled to move their operations overseas, particularly to the

Asian-Pacific countries. Now is the time for the industry to look for new opportunities and I hope that my paper would provide some food for thought in this direction.

— Notes & Questions —

Paper No. 5

Trends and Directions of CAD, CAM, CAE, and CAT with Particular Reference To Electrical Engineering.

Speaker: Martin E. Sandfelder, Program Manager IBM Asia Pacific Corpoation, Hong Kong

TRENDS AND DIRECTORS OF CAD, CAM, CAE, AND CAT WITH PARTICULAR REFERENCE TO ELECTRICAL ENGINEERING

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(Slide 1)

Good afternoon. I want to thank you for providing me the opportunity to speak to you on the subject of CAD/CAM directions with an emphasis on the field of electrical engineering. I started my career in IBM as an electrical engineer – actually a solid state circuit designer. For a while, I was convinced that the way to build an oscillator was to design a solid state amplifier. I remember spending a lot of time stabilizing solid state amplifiers. But, today I want to talk about CAD/CAM.

First of all, why do we care about this subject? There are many reasons. Lets look at just a few.

Committed Cost Versus Spent Cost
(Slide 2)

Consider the costs of a project. The horizontal axis represents time and tasks, while the vertical axis represents project dollars. Decisions made very early in a design commit you to costs which will be spent later in the project. The earlier you can identify design problems and correct them the sooner you can avoid committing the costs associated with these problems and thereby lower the total project cost.

Another reason is that we all live in a time of very rapid change. You are under pressure from change in many areas.

Environment of Change
(Slide 3)

Competition, technological innovation such as D.C. versus A.C. transmission systems, and higher efficiency generating plants are two examples. When the recent and exciting developments in super-conductivity are applied to your industry you will see even more dramatic changes.

While this is happening you are under constant pressure to keep costs down and maintain the quality of your products.

Quality Versus Cost
(Slide 4)

How can CAC/CAM/CAE help you do this? Before we answer this question we better define what we mean by these initials.

Terminology Overlap
(Slide 5)

Unfortunately, it is becoming more and more difficult to separate these terms. Sometimes we use the term engineering graphics for CAD/CAM systems, while CAE refers to computer aided engineering and includes modeling, simulation and analysis.

CAD/CAM usually means computer aided or assisted design. CAD has become much more than just drafting, while CAM usually means computer aided or assisted manufacturing and includes some form of numerical control machines.

Lets take a closer look at some of the characteristics of a typical CAD/CAM system and the trends in these areas.

Conceptualize, Design, Detail, Analysize, Simulate
(Slide 6)

Conceptualize refers to the ability to "sketch" ideas on the CAD system resulting in a preliminary design concept. The trend here is towards 3-D like systems which allow you to visualize a particular structure. Then the CAD system can drop off the 2-D views for detailing. An obstacle here in southeast Asia is a shortage of designers who think in 3-D. Most of us were trained in a flat 2-D world. A reasonable compromise being used today is to sketch in 2-D views with the system storing the relationships between the views, this is sometimes described as 2½-D design. And simply letting the CAD system generate the isomertic views. Or if you prefer you can design using a 3-D solids technique and then let the system generate all the 2-D views for you.

Detailing refers to such activities as dimensioning, in all its complexities, material specification and all the information required to build the particular component or assembly.

Analysis includes a wide range of functions, one example is the determination of mass properties. You could use a CAE system to compute weights, surface areas, volumes, centers of gravity, and the mass moments. For complex shapes made of more than one material this is extremely useful and many times essential. Solids modeling is usually required to perform this function for maximum accuracy and is available to do this.

Simulation almost always requires additional programs which link to your CAD system. For example, you might design a structure, then create a finite element mesh, apply some loads on various points in your model and then pass your loaded model to an analysis program that performs the finite element analysis and allows you to display the deformed part as shown in these slides.

Part with Finite Element Mesh
(Slide 7)

Here is a part that shows a finite element mesh. We pass this part model with loads to an analysis program such as MSC-Nastran. Next we can view the deformed part.

Deformed Part
(Slide 8)

Sometimes you may just want to look at the stress contours as shown in this slide.

Stress Contours
(Slide 9)

Sometimes you may just want to look at a piece of the part as shown in this slide.

End View of Stressed Part
(Slide 10)

And sometimes you may want to take a slice through the part and examine stress contours in more detail as shown in this slide.

Stress Sections
(Slide 11)

It is a lot easier doing this kind of analysis on a system in your office than having to observe wind loading effects on a transmission tower in the New Territories during a signal 8 or 10 typhoon. Now, if you happen to be designing a part made of plastic you can visualize mold-flow before you build the part.

Here is an example of a computer simulation of the flow of molten plastic in mold.

Plastic Mold Flow Slide
(Slide 12)

This is a simulation of temperature contours in the mold and you can easily see areas of low temperature in blue where the plastic would not fill the mold properly.

In this next slide we display pressure contours which could be used to make sure the mold will survive the molding process.

Plastic Mold Flow Slide
(Slide 13)

Use Same Slide As Slide 6
(Slide 14)

Manufacture usually refers to the data required to actually build the parts and in many cases this refers to numerical control information. The trend here is to do tool path generation and analysis directly on the CAD/CAM system and produce cutter path data. This data is sent to a post processor which prepares the N/C machine specific data. The trend here is for generalized post processors that can generate N/C data for many different machines.

In addition, we might use extraction programs to prepare bills of materials for input to other functions such as pricing, costing and procurement departments.

Finally, test and inspect refers to systems that can accept the CAD data and automatically inspect a part using an automated coordinate measuring system.

If we now look at this sequence of activities we can see how CAD/CAM can help reduce cost.

Experience in many different industries shows project costs decreasing from 30% to up to as much as 60% as shown in the slide.

CAD/CAM/CAE Cost Reduction Slide
(Slide 15)

These cost reductions results from lower costs in detailing, using simulation to reduce the need for protyping, lower costs for scrap and rework and a reduction in the number of engineering changes. In addition, there can be savings from projects being completed on time and with a higher level of quality.

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(Slide 16)

A key concept in CAD/CAM is that of a model. This means a collection of data contained in the CAD system database that contains all the information required by the processes I have described. Notice, and this is important, a drawing is only an output of the process. The drawing as we now know it becomes less important in the design process.

In fact there are now examples of "paperless design systems" in Southeast Asia. Conceptually, people require drawings while CAD/CAM/CAE systems only require and use models.

Now that we have a general understanding of CAD/CAM/CAE systems lets take a look at an application of CAD/CAM closer to your interests.

In electrical design you have a requirement for many different kinds of design details. I want to show you some examples of design components that you may recognize. The first is a simple wiring diagram.

Wiring Diagram
(Slide 17)

Once you have this wiring data in a CAD/CAM database the system can generate from – to lists for you automatically.

This next slide illustrates schematic capture.

Schematic Capture
(Slide 18)

With this kind of data in your design database it is very easy for the system to produce signal lists.

Ladder diagrams are very common in electrical design and have been in use for over 40 years in the design of electrical systems. Here is an example of a ladder diagram.

Ladder Diagram
(Slide 19)

Once you have a ladder diagram in the system it is easy to extract information from the ladder diagram as we will see in a moment.

This is an example of another much more complicated ladder diagram that has been built out of a library of common symbols that you would create based on a particular electro-mechanical design.

Complex Ladder Diagram
(Slide 20)

I said that once you have built a ladder diagram in the system you can extract useful information from the database. Here is a report that was extracted that is a cross reference between coils and contacts and shows which coils and contacts are being used on different rungs of the ladder.

Ladder Cross Reference Report
(Slide 21)

And finally here is a display of standard symbols that you would use in building your ladder diagrams.

Another common drawing is a process and instrumentation drawing or a P & ID drawing. Here is an example of

P & ID Drawing
(Slide 22)

Once you have this P & ID information in the system it is easy to extract from – to lists, bills of materials, and equipment lists.

Blank Slide
(Slide 23)

Next I want to use an example of a control pedestal to show how a CAD/CAM system can be used with a concept called hierarchical drawings. A hierarchy is essentially a series of nested circuits spread out over a number of models.

Here we have an example of a black box which happens to be a control pedestal.

Control Pedestal Black Box
(Slide 24)

By moving down the hierarchy we can see what is inside the control pedestial.

Inside of Control Pedestal
(Slide 25)

And by moving further down the hierarchy we can see what is inside the instrumentation panel.

Instrumentation Panel
(Slide 26)

Typical CAD/CAM systems such as I am showing here can traverse as many as 99 layers within a hierarchy which should be enough for most applications.

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(Slide 27)

One term that you will hear used in CAD/CAM systems is "ease of use" which refers to the ease with which you can accomplish productive work. While there are as many approachs to ease of use as there are CAD/CAM systems, I wanted to show you two techniques that represent a high degree of ease of use.

Both techniques use the concept of a user library of parts and in this case I have used electrical components.

Parts Library With Icons
(Slide 28)

Notice along the right edge of this slide the symbols for various parts in your design database. The full details of these parts are known to the system, dimensions, characteristics, and any other information that you stored when you put these parts in the library. Now to execute a design all you do is pick up the part by moving a cursor to the icon and then moving the part out onto the drawing surface. Notice, I said drawing surface when I really should have said model surface.

Another ease of use feature would be the ability to query the design database and say show me a drawing of all wiring components with their symbols, and the next slide shows just what you would expect to see.

Electro-Mechanical Components
(Slide 29)

And of course if you used any of these components you would not have to redraw them, you literally just pick them up out of the design database and use them.

Blank Slide
(Slide 30)

Conclusion:

The direction in our industry today is towards highly intelligent workstations providing the ability to perform as much as 80% of your work directly on the intelligent workstation. At the same time the cost of these systems continues to fall. We will still need access to additional CPU resources for highly compute bound tasks such as logic circuit simulation and multiple level circuit routing, and for file management.

If you accept the trends I have discussed you may agree we can now meet in Victoria Park with all of our T-squares and drafting boards and dispose of them.

Thank you.

M. E. Sandfelder
IBM World Trade Asia Corporation

— Notes & Questions —

Paper No. 6

Cable Manufacturing in Hong Kong

Speaker: Mr. C. P. Yu, Deputy Manager,
Keystone Electric Wire & Cable
Co. Ltd.

CABLE MANUFACTURING IN HONG KONG KONG

Background

The Hong Kong electric wire and cable industry was first activated in the 60's. It started with PVC insulated wire. Then, people adopted the use of rubber insulated wire and were not ready to accept new material. This hesitation lasted for almost five years. During the transition period, conductors insulated by this type of material were required to be tin plated. In conjunction with the rapid development of the construction industry in the early 70's, five major cable factories were established. Their manufacturing technology were mainly introduced from Taiwan. Now, we have more than forty manufacturers in this field. Products include:

– wire for electronic industry.
– appliance wire.
– co-axial cable, shield wire.
– control cable.
– telecommunication cable and cord.
– flexible cable.
– low voltage power cable.

Raw Materials

With the recovering of world economy, the incoming material cost has increased by almost 25 percent this year in general. Starting from the beginning of the second quarter, with the rise at the London Metal Exchange, copper price in the Hong Kong market has increased drastically. Hong Kong does not have any natural resource of raw materials for the cable industry. Manufacturers have to relied on import. Consequently, if the economy in suppling countries are good, instead of exporting, they will reduce their supply to the Asian market. Their demand are usually large enough to generate shortage of raw material supply in the local market.

Copper is the most common metal used to conduct electricity. Aluminium is another well-accepted and satisfactory material. However, it needs care in installation by experienced electricans, and only justified if significant cost savings result from its use. Roughly speaking, for equivalent power loading, aluminium wire size need to be 40 percent large than that of the copper wire.

With the growing of petroleum chemical industry, more polymers have been developed to suit different electrical wire insulating and jacketing purpose. Figure 1 lists the polymeric materials for insulation and jacketing of electric wire and cable.

Figure 1: Cable Insulation and Jacketing Materials.

1. Natural and synthetic rubber
2. Silicone rubber
3. Ethylene-propylene-rubber
4. Ethylene-vinyl-acetate
5. Chloroprene-rubber
6. Chloro-sulfonic polythene
7. Polyvinylchloride
8. Polythene
9. Polyamide
10. Polytetrafluorethylene
11. Tetrafluorethylene-hexafluor propylene
12. Ethylene-tetrafluorethylene

13. Polyamide foil
14. Polypropylene
15. Polyvinylidefluoride
16. Polyurethane
17. Polytheneterephthalate
18. Polythene, cross-linked

The most common materials used to-day arepolyvinylchloride (PVC), Polythene (PE) and cross-linked polythene (XLPE). PVC is a compound of PVC resin, plasticizers, lubricants, fillers, and pigments. They are mixed in accordance with specific formulations in order to obtain the required properties. It is relatively cheap, easy to process and hardly combustible. PVD cables are easy to install. It also has some drawbacks such as softening at higher temperature, low temperature brittleness, generation of hydrochloride in case of fire and electric properties are only sufficient for low voltage cables.

PE consists of carbon and hydrogen atoms only which is an unpolar material. It has been used by European and other nations as an insulating material for medium and high voltage cable for many years. It has some disadvantages. Since it is thermo-plastic material, the binding force between the individual macromolecules will disappear at high temperature. Molecules are able to move freely, thus the material melt. It is combustible, sensitive to wate and electrical partial discharges.

XLPE is a thermo-elastic material. Once it is cured, the individual macromolecules are chemically linked. Therefore, it has very good dimensional stability even at high temperature. It also has excellent electrical properties.

Manufacturing Process

The basic outline of production flow is shown in figure 2. Process starts with purchased raw materials such as copper, aluminium and PVC compound. Going down the drawing process, finer wire size is obtained and then annealed to regain its properties. During drawing, copper wire is reshaped to the predesigned size by cold drawing through several diamond dies. The long life of diamond ensures the dimensional accuracy of the finished wire. Work hardening on the copper wire greatly reduces the ductility and affects the conductivity. Therefore, annealing is required immediately to regain the characteristics of copper. Nowadays, most cable manufacturers are equipped with on-line continuous resistance type annealer. This greatly reduces the processing time and eliminates the generation of oxidized wire which is usually created by misuse of conventional type vacuum furnace. At this stage, an elongation test is done to check the softness of the annealed wire. Depending upon the amount of cold work, wire without annealing tends to break during the latter processes and will generate more unnecessary machine downtime and material wastage.

These annealed wires are then used as single conductors or are stranded together to become less rigid for forming the basic shape of laid conductors which are designed to accommodated specific power loading.

The conductor is then put through the extrusion process which encloses the conductor with insulation. Keystone currently manufacturers PVC compound with operating temperature ranging between 60 to 105 degree Celsius. Because PVC can only sustain a very short thermal history, plasticizer and stabilizer are introduced for this purpose. This PVC is then loaded onto the hopper of the extruder and pushed through a preheated cylinder by a special screw. At the end of this cylinder is the extruder cross-head, it directs the molten material to flow uniformly across the circumference of the extruder die and onto the wire.

For safety purpose, spark tester is installed on the extrusion line to ensure that the finished insulated wire does not even have a pin hole.

Modern manufacturer uses helium/neon laser to monitor the diameter of the insulated wire. This non-contact measurement inspects 100 percent the outcoming wire with accuracy. Measurement error due to compression or distortion caused by contact measurement is eliminated. This instrument can also be equipped with close-loop control system which controls the speed of the wire being pulling through the extruder thus ensuring dimensional accuracy of the wire and also reduces the material cost by tightening the tolerance that is needed by the operator.

Prior tothis, the concentricity of the conductor in the wire has to be ascertained. This can be achieved by using a vacuum pump sucking at the inlet of a tubular die. The mechanical property of the polymer is also improved. When the running conductor passes through the centre of the tubular die where molten material is being pushed out of the extruder, the wire stretches the material, and forces the molecular chain to lay parallel to the axis of the wire. Thus, better tensile stress of the polymer is achieved.

For multi-cord cable, several insulated cores are laid or stranded together, and going through the extrusion process again to form a protective layer on insulated cores. This outer layer is called the sheath or jacket of a cable. After the cable is completely fiinished, cable is ready for quality inspection. During installation, cable is being bent, twisted and pulled. In operation, the environmental condition can also be critical. Thus, testing on polymer is a major concern. Tests will be on elongation, tensile stress, percent properties retained after aging, percent deformation at predetermined temperature and period, dielectric strength and insulation resistance of cable. Then the cable is put to storage and ready for despatch.

Problem of Local Cable Manufacturer

Since land cost is very high in Hong Kong, few local cable makers can afford large factory space. From time to time, they have to be very conscious in utilitizing such limited space. On the contrary, machines bought aboard usually take up a lot of space. The limitation of factory space and the desire to be more flexible in operation capacity resulting most machines are converted to suit the local manufacturing environment. This conversion usually not only reduces production output of the machine but also creates operational difficulties.

In addition, we have other limitations which restrict the local enterprises to develop into the production of larger and higher voltage cables. Most industrial buildings in Hong Kong are not designed to adopt heavy machineries. For large size cable, manufacturing process requires the use of some heavy production machineries which weight more than 30 metric tons, more than 40 meters in length and need 6 meters of headroom. It is clear that such manufacturing industry cannot be easily accommodated within a multi-storey industrial building because of excessive vibration during operation, insufficient floor laoding, storey height and construction of deep concrete machine plinths.

The recent recovery of the world economy and the favorable exchange rate have benefited and stimulated the export market. With the rising standard of living and shortage of manpower, industry is paying higher wage to pull in the labour force. As compared to 1984's figure, to-day's labor wage has raised by 45 percent. However, the younger generation has a tendency of preferring the white collar rather than blue collar. Although cable manufacturing is not a labour intensive industry, it is a heavy labour job. Thus, more cable manufacturers are taking the advantage of production facilities in China so as to stay competitive. The political uncertainty is another factor that holds the local companies to look into the possibility of long-term investments.

Substandard cables are in the market. Price war is only feasible in the short run, and can be a benefit to the local market. In the long run, operation loss is inevitable. Therefore, this is not a good strategy. Normally, when the price goes below their profitable margin, manufacturers will cut the quality or size in order to be survive. Non-ethical and harmful effect to the public is a serious problem and should be discouraged. Govvernment restriction on safety standard will be a help.

Prospect of Local Manufacturer

Among all the electric wires, the equipment wire and the less cable for less than 1 KV are the most commonly used ones. It passes electricity to all sort of equipments for control and other purposes. Figure 3 has illustrated the ratio of each type of wire over the entire range of imported cable in 1986.

Supply of cables for domestic usage rely mostly on import. Companies from overseas scramble to gain a foothold to open their own retail outlet. Figure 4 has shown the proportion of imported countries of electric cables in 1986.

With the rising standards of living, electrical appliances become widely used. For this reason, different types of wire are developed to suit for different purpose. Not taking into the account of local produced cables, more than 670 million dollar worths of cable were imported last year. Figure 5 has shown an increasing trend based on the imported value of past five years.

The local cable manufacturers are providing very good services such as short delivery notice, running short production for some special cables, and keep good quantity of wide range of stocks, bearing in mind of the costly space in Hong Kong. Some people do not have confidence on the quality of local cables. The basic technology in manufacturing low voltage cables have not been changed for decades. Only processing materials and speed are being improved continuously.

In this aspect, the industry should receive support from all sides, particularly our government, in conformity with its policy to promote local industries that can improve local trade balance. At the same time, the local manufacturers must try to up-grade their manufacturing and quality control facilities, thus improve the quality of their products and output efficiency.

Applying for international standard recognition will be a benefit, which puts us in a strong position of saying our quality standard are equivalent to the level of those well developed countries. However, this is a very costly process. Most countries will protect their own interest. Our cost for acquiring overseas recognitions are usually much higher than their domestic users. This makes us less competitive. If government accredits a testing laboratory with international recognition in this field, it will be beneficial to the local industry.

Conclusion

The outlook of the cable industry remains promising. With the blooming construction industry and the rising electronic industry, demand for electric wire and cable will upsurge in the 90's. If the labour cost remains stable or greater degree of automation is employed in this industry, we will continue to be competitive in the world market.

Reference

"Hong Kong Trade Statistics", Census & Statistics Department Gerhard Wanser, Langenhagen "The Development of Power Cable in Europe – Part II, "Wire" volume 36 (1987) 7, P287–289.

FIGURE 2 : MATERIAL FLOW OF A TYPICAL CABLE MANUFACTURING FACTORY

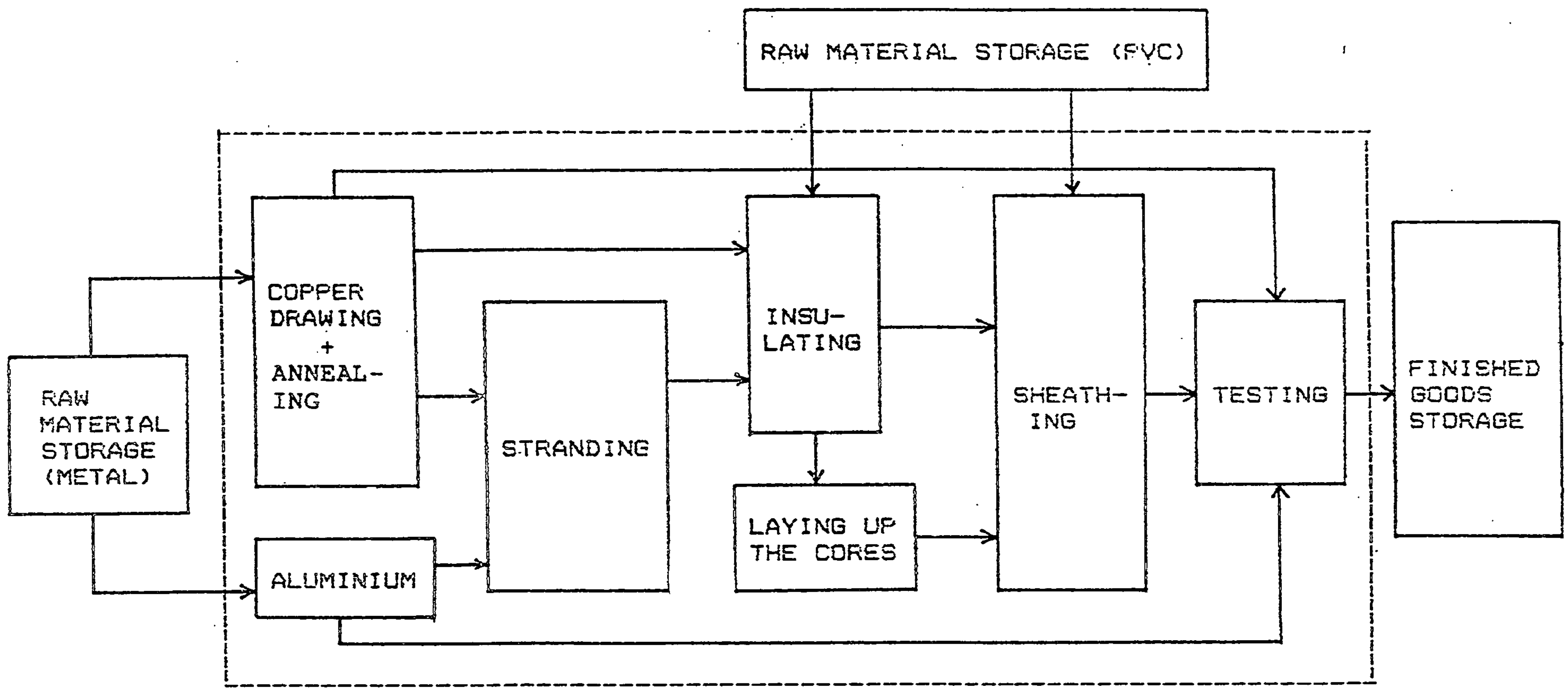


FIGURE 3 : PROPORTION OF TYPES OF IMPORTED CABLE IN 1986

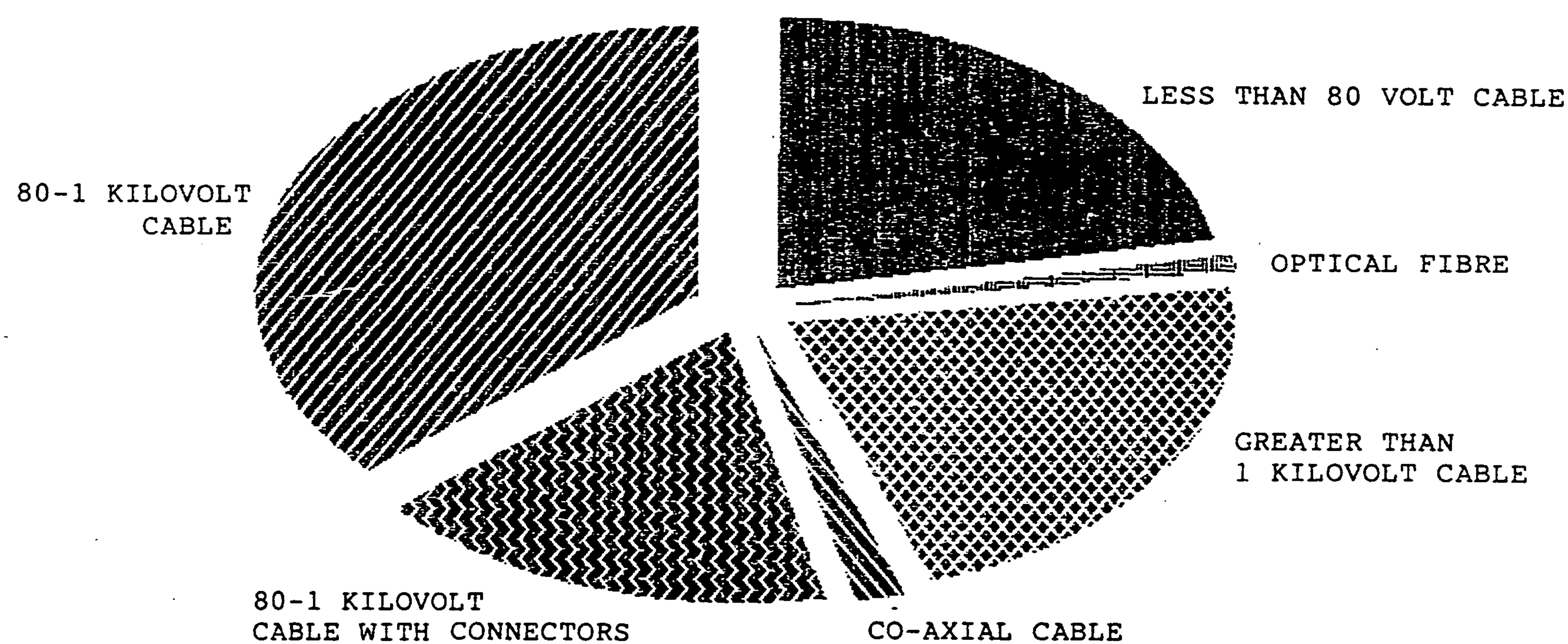


FIGURE 4 : PROPORTION OF IMPORTED CABLE IN 1986 BY COUNTRY

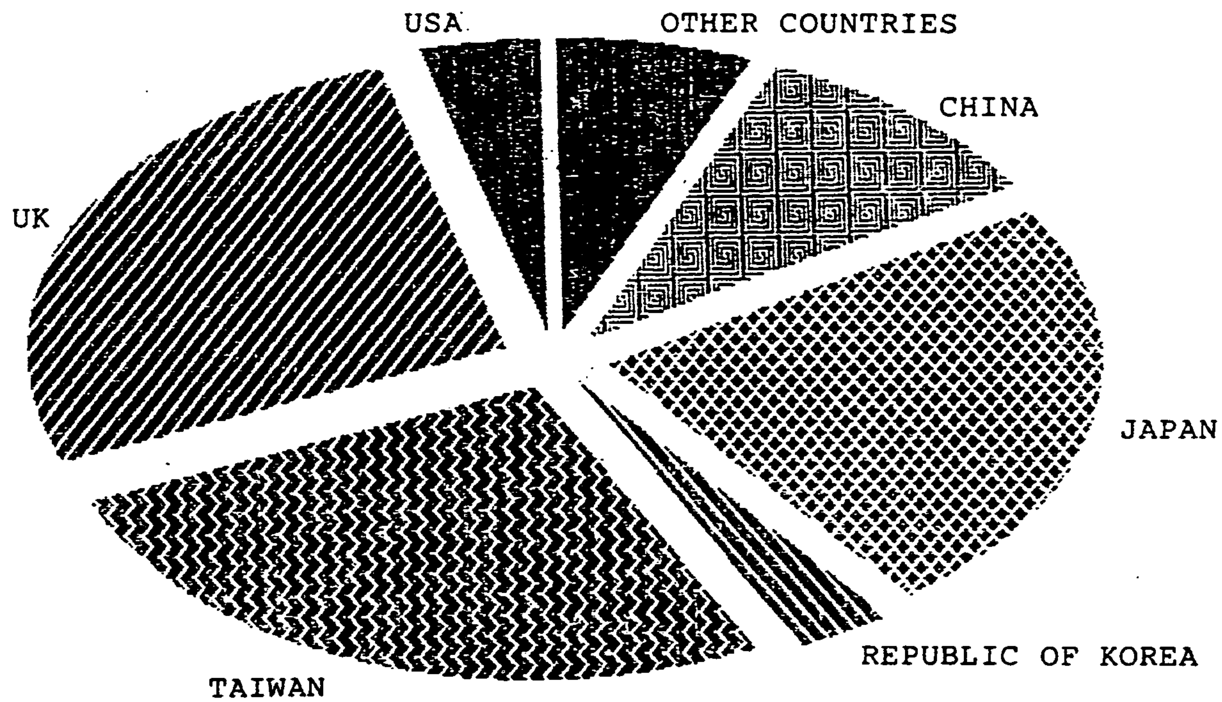
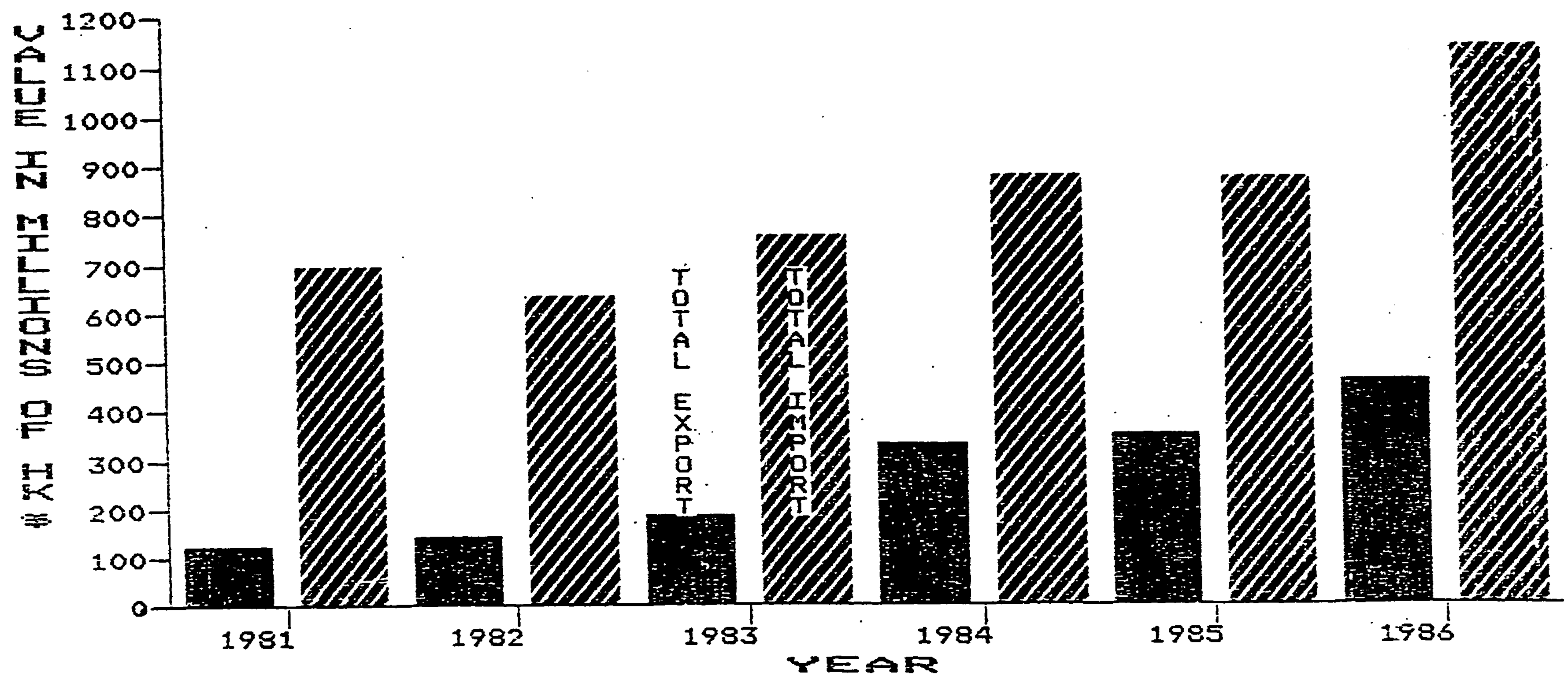


FIGURE 5 : VALUE OF EXPORTED VS IMPORTED CABLE



— Notes & Questions —

Paper No. 7

Proposed Electrical Products (Safety) Regulations

Speakers: Mr. S.K. She, MSc, MHKIE, CEng, MIEE, E&M Engineer, EMSD
Mr. W.Y. Wong, MSc, MHKIE, CEng, MIEE, MIERE, E&M Engineer, EMSD

PROPOSED ELECTRICAL PRODUCTS (SAFETY) REGULATIONS

Introduction

You may recall that in a symposium on 'Management and Implementation of Electrical Safety in Hong Kong' organized by the Hong Kong Institution of Engineers three years ago, a paper was presented describing the general structure and principles of the new Electricity Bill which was under consideration by the Government.

As mentioned in that paper, the Governor-in-Council will be empowered under the new Electricity Bill to make regulations governing the safe use and supply of electricity. One of the proposed Regulations is the Electrical Products (Safety) Regulations (the Regulations) which will specify the safety requirements for electrical products for sale, hire and use in Hong Kong.

The principles of the Regulations have been circulated twice to the concerned parties for comments since 1984. Drafting instructions for the Regulations which incorporate valid comments from the concerned parties will shortly be circulated for consultation.

Now, I would like to give more details of the Regulations including their proposed contents and their likely impact on Hong Kong's future economy.

Principal objective

The principal objective of the Regulations is to enhance public safety in the use of electrical products. To achieve this objective, the Regulations will specify:

(a) the safety requirements for electrical appliances and specific requirements for certain types of electrical products. Electrical products which do not meet the safety requirements of the Regulations will be prohibited under the new Electricity Ordinance for sale, hire or use;

(b) the responsibilities and duties of the concerned parties (namely the manufacturer, testing organisation, purchaser-seller, consumer and the Director).

The main points of Regulations are described below.

Application

The Regulations will apply to electrical products which are:

(a) imported or locally manufactured;

(b) for local sale, hire or use; and

(c) designed or suitable for domestic use.

The Regulations only apply to electrical products for domestic use because electrical products for commercial or industrial use may be very specialized that the safety requirements stipulated in the Regulations cannot be wholly applied.

Safety Requirements for electrical products

(1) The general safety requirements will apply to the design and construction of electrical

appliances at low voltage. The general safety requirements are intended to ensure, under normal use, their user's safety from –

(a) electrical shock due to direct contact;

(b) risk of fire or explosion due to over-heating;

(c) personal injury due to loosened parts or overheated surfaces which are to be touched in using the electrical appliances;

(d) danger due to improper use on account of lacking proper information; and

(e) danger due to hazardous materials used in electrical appliances.

(2) Specific requirements will apply to the design and construction of certain types of electrical products to be prescribed in the Regulations. An example of specific requirement is that in the case of a plug, specific dimensional requirements are necessary to ensure proper matching and interchangeability. Initially, prescribed electrical products will include –

(a) plugs,

(b) adaptors,

(c) lamp holders,

(d) starter holders for fluorescent tubes, and

(e) flexible cords.

Additional prescribed products such as unvented storage-type electric water heaters and microwave ovens will be introduced progressively as and when required.

(3) Both general safety requirements and specific requirements will be adopted from internationally accepted requirements; i.e. the International Electrotechnical Commission (IEC) standards and the British Standards (BS). Where an electrical appliance (e.g. a microwave oven) is prescribed under the Regulations, the specific requirements for the appliance should either be additional to or should supersede part of the general safety requirements.

Responsibilities and duties of various parties involved in electrical products

Under the Regulations, the following responsibilities and duties of various parties involved in the manufacturing and sale of electrical products will be imposed.

(1) The Manufacturer

A manufacturer will be required to design and construct his electrical products in compliance with the requirements stipulated in the Regulations. It is the responsibility of the manufacturer to provide a certificate of compliance to his client. In the issuance of such a certificate, the manufacturer is assuming full responsibility for compliance with these Regulations. Alternatively the manufacturer may employ a recognized testing organization to carry out the certification on his behalf.

(2) The Purchaser – seller

It is the responsibility of a purchaser-seller (importer, wholesaler, or retailer) to ensure that the electrical products he purchases are covered by valid certificates of compliance which are either issued by the manufacturer or by a recognized testing organization. In cases where the manufacturer cannot provide a certificate of compliance, the purchaser-seller may employ a recognized testing organization to issue him with such a certificate.

The purchaser – seller is obliged to provide information to the Director regarding the origin of his electrical products.

(3) The Consumer

It is the responsibility of the consumer to keep himself informed, via the Government gazette together with press release, of the electrical products which have been prohibited by the Director. It is also the consumer's responsibility, for his own personal safety to refrain from using an electrical product which has been prohibited by the Director. But the user will not be prosecuted if the electrical product does not comply with the requirements unless he knowingly allows it to be used (i.e. after a notice has been served to him).

(4) The Testing Organisation

It is the responsibility of the testing organization to ensure that the certificates issued by him are valid.

(5) The Director

The Director of Electrical & Mechanical Services (the Director) shall administer these Regulations and publish a list of the recognized testing organizations as well as prohibited electrical products in the gazette.

Implementation

It is intended to enact the Regulations after the enactment of the Electricity Bill. Following the enactment of the Regulations, the Director shall:

(a) publish Guidance Notes giving technical guidelines, specifications and testing methods on how the requirements of the Regulations can be met. Please note that the Guidance Notes are not part of the statutory requirements. They are capable of being updated by the Director as and when necessary, without having to amend the Ordinance or its Regulations;

(b) invite applications from both local and overseas testing organizations who wish their certificates of compliance to be recognized by the Director;

(c) gazette a list of recognized testing organizations 6 months before the Regulations come into opration to enable manufacturers to employ recognized testing organizations to test and issue certificates of compliance for their electrical products.

The Regulations will come into operation 12 months after enactment. This serves as a grace period to enable the manufacturers, importers, purchaser-sellers to acquaint with and conform to the safety requirements and to give them time to dispose of existing stocks.

After the above 12-months grace period, should there be any additional electrical products to be included as prescribed electrical products under the Regulations, there will only be a 6-month grace period from the date of promulgation of the additional prescribed electrical products.

Impact of the Regulations on Hong Kong's future economy

Lastly, I would like to talk about the likely impact of the Regulations on Hong Kong's future economy which is the theme of this Symposium. As mentioned earlier, the Regulations are still in the preliminary drafting stage. Assessment of the economic impact of the Regulations will be made after the draft Regulations have been circulated for consultation. However, as the concerned parties involved in the manufacturing and sale of the electrical products have been fully consulted since 1984, the economic impact of the Regulations on them and hence on Hong Kong's future economy will be minimal. Meanwhile, the slight impact on the concerned parties is envisaged as follows:

(1) The Manufacturer

Both local or overseas manufacturers are required to ensure that their electrical products comply with the Regulations. As mentioned earlier, they have to issue certificates of compliance for their electrical products or employ a testing organization to do so. As the safety requirements of the Regulations will not be more stringent than international standards, there will be very little economic impact on the manufacturers who are already manufacturing their electrical products to international standards. For those manufacturers who are not, they may need to upgrade their manufacturing facilities. As local manufacturers are very adaptable to changes, no problems are expected for them to upgrade their facilities. On the other hand, if a manufacturer's electrical products do not meet the Regulations and are prohibited by the Director, he will suffer loss of sale and other consequential losses. If a manufacturer issues certificates of compliance for his electrical products which are subsequently prohibited, the Director may refuse to recognize any future certificates issued by the manufacturer. In such event, the manufacturer needs to employ a testing organization to certify his electrical products in compliance with the Regulations.

(2) The Purchaser-seller

A purchaser-seller is required to ensure that his electrical products are covered by certificates of compliance. However, irrespective of whether his electrical products are covered by certificates of compliance or not, his electrical products may be prohibited for sale should they be found not complying with the Regulations. Hence, he may also suffer loss of sale. Of course, he may safeguard himself against such loss by commercial arrangement that in such incident, the loss will be borne by the manufacturer concerned.

(3) The Testing Organisation

There will be an increase in demand for testing of electrical products by recognised testing organizations. Should a recognized testing organization have certified electrical products which are subsequently found not complying with the Regulations, the Director may remove its name from the list of recognized testing organizations.

(4) The Consumer

Consumers will be protected by the Regulations and they will enjoy safer and better electrical products.

— Notes & Questions —

3. LARGE SCALE PROJECTS

Paper No. 8

Rôle of Hong Kong Engineering Company in Construction of Turnkey EHV Substation in China

Speaker: Mr. K.N. Hui, Project Manager,
BBC Brown Boveri Ltd.

ROLE OF HONG KONG ENGINEERING COMPANY IN CONSTRUCTION OF TURNKEY EHV SUBSTATION IN CHINA

1. Introduction

Guangdong Province as one of the fastest developing provinces in China plans to add 1,000 MW power supply to their electricity supply network in 1987 to alleviate severe power shortage. To achieve this ambitious plan, Guangdong General Power Company (GGPC) launched a large transmission and distribution project in 1985 which called for installation of the first 500KV overhead line and 500KV Substation in Guangdong. In March 86, a contract was signed by GGPC with BBC Brown Boveri Company for Supply for the first 500/220KV GIS Substation in Guangdong by end Sept. 87.

2. Substation

The Substation site is located in a hilly area about 8 km from Jiangmen city, Guangdong. Extensive site formation work was undertaken by GGPC to acquire a levelled area of 250m x300m. The size of site is dimensioned for 8x500KV overrhead lines and 14x220KV overhead lines in ultimate stage. In the first stage, only 1x500KV line and 5x220KV lines are installed.

The 500/220KV Substation is planned to be constructed in various stages to cope with the development of supply network and to reduce capital investment in early stage. Indoor GIS layout was adopted because of:–

a) Land cost – civil work cost, land compensation

b) Shorter installation time

c) ease of maintenance.

One-and-half breaker scheme is chosen for 500KV switchgear to ensure safe and reliable distribution of energy from Sha Jiao 'B' Power Plant. In present stage, only 1 diameter (3 breakers) is installed. A temporary bypass busbar is used to connect busbar I & II to form a mesh. The temporary busbar which will be removed in future extension, is also used to realise the busbar protection scheme.

3x250MVA single phase auto-transformers are installed which step down the voltage from 500KV to 220KV (secondary) and 15.7KV (tertiary). The secondary side of main transformer is connected to 220KV GIS via 200 KV overhead line routed across outdoor yard of static var compensator.

Double busbar configuration is chosen for 220KV switchgear. It is planned that 1 of these busbars will be divided into 3 sections. Each section will be fed by one 750MVA transformer. As there is only 1 750MVA transformer, the busbar is not sectioned in present stage. But dismantling unit is provided in the busbar to allow installation of bus sectioner in future without shutdown of complete switchgear. In addition, the switchgear is designed to allow future extension in both directions without services interruption.

The tertiary side of main transformer is connected to static var compensator (SVC) by an insulated bus duct rated at 6000A. The voltage of tertiary winding (15.7 KV) is optimised according to the requirement of SVC system, for instance, reactive power, and thyristor valve data. The SVC is used to regulate the 220 KV system voltage and to improve system stability. The SVC system consists of 3 parts, namely, thrysitor controlled reactor (TCR), Breaker Switched Capacitor (BSC) and Fixed Capacitor (FC). The reactive power generated or absorbed by SVC is continuously regulated between 120MVA (capacitive) and 120 MVA (reactive) by controlling the TCR current and status of BSC.

The fixed capactior bank which is rated at 50MVA, is tuned to absorb the harmonic current produced by TCR. The breaker switched capacitor which is rated at 70MVA will be switched by a vaccum circuit breaker in case capactive power requirement exceeds 50 MVA. The thyristor controlled reactor (TCR) which is rated at 170MVA, is used to adjust the total reactive power output of SVC by controlling the firing time of thyristor valve.

3 AC auxiliary supplies are available to secure continuous operation of the substation. Main supply is obtained from tertiary winding of main transformer by 1x1000KVA 15.7/0.4KV auxiliary transformer. A back up auxiliary transformer (10000KVA 10.5/ 0.4KV) is fed from an existing 10.5KV overhead line in vicinity of the substation. A 250 KW diesel generator is installed for supplying essential load of the substation. These 3 auxiliary supplies are terminated into a main AC distribution board where automatic change-over device is installed to ensure continuous AC supply and no two supply sources will be connected in paralled at any time.

2 sets of 110 V DC batteries are installed for control and protection equipment.

3. Contract set-up

The contract can be divided into 2 packages, equipment supply and project management for local construction and erection work. The supply portion which is similar to a usual supply contract including design, engineering, manufacturing, test and CIF delivery of all electromechamical equipment of the substation, and civil work design as well. The project management portion is to provide project management services to GGPC for execution of local civil construction contracts and erection contract.

The local contracts are signed by GGPC and local contractors. BBC is to delegate competent engineers to manage the local contracts on behalf of GGPC. The task of the project management for civil work and erection work are

1) Determine, evaluate and carry out on behalf of GGPC required steps necessary to quarantee proper execution of local contracts.

2) Draft and prepare tenders for civil & erection works on behalf of GGPC.

3) Evaluate tenders received by GGPC and negotiate with local contractors jointly with GGPC and advise GGPC regarding the selection of local contractor(s).

4) Draw up formal contracts to be concluded between GGPC and local contractor for execution of local works.

5) Coordinate the tasks to be carried out by the local contractors, GGPC and BBC.

6) Obtain review and administer the local contractor's construction programme.

7) Control and certify the payment applications submitted by local contractors to GGPC.

8) Prepare complete monthly progress reports (quality, supply, comparison with schedule etc.)

9) Set up the methods and inspection procedure to assure the fulfillment of the technical requirements and to assure the fulfillment of the quality and safety requirements.

10) Control the site organisation and the management methods of the local contractors.

The contract is different from a usual turnkey contract in such a way that the main contractor (BBC) does not employ their own sub-contractor for civil and erection works. The construction & erection contractors are paid directly by GGPC upon payment recommendation made by the main contractor. The "Main" contractor (BBC) does not take the overall responsibility for the completion of project. The Major different from a turnkey contract is that the buyer has to take an active role in monitoring the performance of their local contractor. If it is reported that the local contractors do not carry out the work according to the requirements or advice given by the Project Managmeent, buyer will take action to rectify the failure of their contractors. The advantage of this kind of contract set up for the buyer is that they could save some foreign currency by employing local contractor directly and still could have the seller to take care of the progress and quality of work performed by their contractor. On the other hand, the risk of the seller involved in the local construction & erection works are reduced because the seller is not binded financially for the workmanship of local contractors and progress of work.

4. Role of Hong Kong Engineering Companies in the Project

Due to this complicated contract set-up and language problem that may be encountered during project execution. It was decided to sublet following works to Hong Kong engineering companies.

– complete civil work design

– design, engineering, supply and commissioning of complete fire fighting system.

– project management for civil construction work

– project management for erection work

4.1 Civil work

The complete civil work design is done by HK civil engineering company who also provides the project management services for local construction work. The Hong Kong company has following advantage in execution of the work:

a) Drawings are prepared in Chinese and English which help the local civil contractor to prepare their work more efficiently.

b) All site engineers are from HK who can readily get familiar with the Chinese construction method and civil work material available in China. It makes quality and progress control more effective.

c) Direct communication between local contractor, the end-users and GGPC made the coordinate work more efficient. Correspondence from local contractor and GGPC are all in Chinese which can be handled by Hong Kong engineer without translation.

4.2 Fire fighting system

The fire fighting system installed in the substation including an automatic water spraying system for main transformer and fire detection system for main control building. The supplier of the system is responsible for design, engineering, FOB supply, supervision of erection and conmmissioning of the equipment. All of these equipment supplied are provided with Chinese lables and instructions. This is essential for safety operation and for obtaining the necessary approval from Fire Protection Authority.

4.3 Project Management for Erection Work

Due to poor communication facilities and complicated custom clearance procedures in China, the time required for custom clearance and transportation to site can be as long as the shipping time from Europe. For this reason, besides the tasks mentioned in item 3 above it is also an important task for the project management to monitor closely the clearance and transportation work to reduce as much waiting time as possible.

To ease the communication problem and hence to achieve an efficient handling of the erection contract, the management and administration works are undertaken by Hong Kong company. In addition, Hong Kong engineers are employed to assist the European engineers delegated by the supplier for erection supervision and commissioning of various equipment. General substation engineering work, for instance, substation auxiliary equipment, cabling and earthing is handled by Hong Kong engineers.

5 Summary

The work carried out by Hong Kong companies is only a small portion of the complete project. But they are the center of information flow between foreign company and Chinese partners. The companies do play a key role in bringing satisfactory result to both the foreign supplier and Chinese buyer. Because of good knowledge in western technology and the bilingual skill (Chinese – English), Hong Kong engineering company is the good partner of foreign company who wants to develop their product in China.

— Notes & Questions —

Paper No. 9

Competitive Coordinated Protection of LV Installation

Speaker: Mr. J. Feenan, Technical Director, Fusegear Div. of GEC I.E. Ltd.

COMPETITIVE COORDINATED PROTECTIONOF LV INSTALLATION

Co-ordinated system protection in low voltage electrical installations is implicit in the regulations issued by the International Electrotechnical Commission (IEC) and the Institution of Electrical Engineers (IEE).

Chapter 4.3 of the 15th Edition of the IEE Wiring Regulations, Protection Against Over-current, gives specific requirements for the overload and short circuit protection of the cables used in an electrical installation. This chapter describes the requirements for (a) A single device providing both overload and short circuit protection and (b) when such protection is provided by two devices in series.

What the regulations do not specify in detail, is the additional requirement of co-ordination between two overcurrent protective devices in series, which is essential for the correct design of the circuit. The only relevant clauses which refer to this aspect are 434–4 wich discusses the requirements for protecting an overcurrent device of a lower breaking capacity with another of the necessary breaking capacity, and clause 435–1 which describes the requirements for the co-ordination of a device providing overload protection only, and another providing short circuit protection. These two clauses read as follows:

434–4 The breaking capacity rating shall be not less than the prospective short circuit current at the point at which the device is installed, except where the following paragraph applies.

A lower breaking capacity is permitted if another protective device having the necessary breaking capacity is installed on the supply side. In that case the characteristics of the devices shall be co-ordinated so that the energy let-through of these two devices does not exceed that which can be withstood without damage by the device on the load side and the conductors protected by these devices.

Other characteristics may need to be taken into account, such as dynamic stresses and arcing energy, for the device on the load side.

NOTE – Details of the characteristics needing co-ordination should be obtained from the manufacturers of the devices concerned. Co-ordination with regard to their operating times is of importance.

435–1 The characteristics of devices for overload protection and those for short circuit protection shall be co-ordinated so that the energy let-through by the short circuit protective device does not exceed that which can be withstood without damage by the overload protective device.

NOTE – For circuits incorporating motor starters, Regulations 435–1 does not preclude the type of co-ordination described in BS4941.

The task of ensuring that such devices are properly co-ordinated rests with the IEC Product Committees and consideration is being given to clarification of what is quite an obscure situation.

The most popular combination of devices to which clause 434–4 refers, is the MCB backed-up by another short circuit protective device. The typical combination covered by clause 435–1 is a motor starter, backed-up by a short circuit protective device.

Low Voltage HRC Fuses

The most effective and economic means of providing back-up protection to both the MCB and the motor starter is the HRC fuse, and a recent revision of IEC269 'Low Voltage Fuses', reflects the very significant achievements which have been reached in the international standardisation of the electrical characteristics of low voltage fuses. This will shortly be issued as a revision of BS88.

Although the specification contains a number of additional requirements compared to the earlier edition, the most significant inclusions are standardised time current gates, and time current zones for all fuses claiming compliance with this new standard. (See Fig. 1 and Table 1).

Fuses to BS88: 1975, already comply with these new requirements, but fuses to other dimensional systems such as DIN, will require modification to their time-current characteristics in order to achieve compliance. The request for standardised time-current zones came from the IEC Wiring Regulations Committee, TC64. One of the main objectives was improved discrimination between major and minor fuses whatever their dimensional system. This has now been achieved.

Another important agreement, concerns the pre-arcing I^2t limits at 10 milliseconds. The new fuse specification now includes min and max limits of pre-arcing I^2t at 10 milliseconds, for all general purpose fuses complying with the specification, (Fig. 2) and this is useful information for manufacturers of contactors and MCB's, for the purpose of discrimination and back-up protection. These I^2t limits are an important first step, but it is already obvious, that with the trend towards compact dimensions in all of the devices mentioned earlier, there is a need for closer limits than those presently agreed.

The GEC 'T' range of fuses has been designed to have time-current characteristics which combine superior motor starting capability within the standardised time current zones, with the lowest pre-arching I^2t (and total I^2t) within the specified limits (Fig. 3) in anticipation of a continuing trend in compactness of associated equipment.

Back-up Protection of MCB's

The advent of current limiting MCB's has increased the breaking capacity achieveable by them, but at the same time has increased the problem of back-up protection on fault currents above their brreaking capacity. The low I^2t let through of these MCB's permits better discrimination with up stream fuses, economy in cable sizes etc, compared with the American zero point type, but makes the selection of a fuse for correct back-up protection on fault levels above the breaking capacity of the MCB more critical, because the I^2t withstand of the current limiting MCB is relatively low (approximately 100,000 amps^2 seconds).

This can militate against the maximum thermal utilisation of an MCB board because the total load current of the MCB board, when situated in the installation at a fault level above the breaking capacity of the MCB, is dictated by the size of the incoming fuse providing back-up protection. The GEC/Vynckier MCB has a breaking capacity of 16kA to the requirements of BS3871 and the combination of this performance with the low I^2t let through of the GEC T range fuses, enables correctly co-ordinated back-up protection of these MCB'S with a 200 amp fuse on fault currents up to 50kA at voltages up to 415V AC. This permits the full thermal utilisation of the associated MCB board which has 200 amp busbars, on any installation where the fault level is as high as 50kA. Correct co-ordination between an HRC fuse and an MCB requires a thorough test series at both the maximum fault level of the combination and in the take-over region between the MCB and the fuse. The fuse/MCB co-ordination test requirements are not yet agreed in IEC but the same rules as for the fuse and MCCB combination must apply. This means that the take-over point of the fuse from the MCB must be at a current not exceeding the maximum braking current of the MCB. Therefore the higher the braking current of the MCB the larger the rating of back-up fuse. Similarly, the lower the pre-arcing and total I^2t of the associated fuse, the larger the fuse can be. The combination of the high breaking capacity of the GEC/Vynckier MCB and the low I^2t of the T range fuses, has enabled a successful test series to be completed, at both the take-over current and at 50kA, at 415V 3PH on the range of

GEC/Vynckier MCB's protected by 200 amp T type fuses.

An interesting aspect of back-up protection of current limiting MCB's arises from the inherent impedance of the MCB solenoid coils. Whereas for the GEC/Vynckier 63 amp MCB, the impedance is 1.32 milliohms, that of the 6 amp MCB is 69.7 milliohms. Table 2, shows what effect this has on the actual test current, in test circuits having prospective currents from 16 kA up to 50kA. Thus the 6 amp MCB can interrupt all actual fault currents on prospective currents up to 50kA leaving the 200 amp fuse intact, ie, there is no take-over current. The actual current and power factor are limited to values within the breaking capacity of the MCB contacts.

At the other extreme, the 200 amp fuse operated when the 63 amp fuse was tested at its take-over current, and at 50kA.

Figure 4, which relates the let through I^2t to actual test currents, rather than prospective test currents clearly illustrates this effect.

Fuse/Motor Starter Combinations.

The need for satisfactory co-ordination between starter and back-up device has always been recognised in relevant legislation and regulations.

Rule 435–1 of the 15th Edition, outlines the co-ordination required between the overload relay of the starter and the back-up device. What is not immediately evident however, is the fact that in the majority of motor circuit installations the overload relay on the starter is also providing overload protection to the cable which is usually sized to the full load current of the motor. The back-up device is therefore only providing short circuit protection to the cable as well as short circuit protection to the starter.

IEC292–1, Motor Startes, (BS4941) describes the requirements for three types of co-ordination:

Type a

Any kind of damage may occur within the starter provided its enclosure remains intact.

Type b

The overload relay trip characteristics may be altered permanently, but no other damage is permissible.

Type c

No damage is allowed.

For Types b and c, light welding of the contacts is acceptable provided that the welds can be easily broken.

It follows from consideration of rule 435–1, that where the cable between the starter and the motor is sized on the basis of the full load current of the motor, type 'c' co-ordination permits compliance with the regulation. It is the only one which prevents the overload relay from being damaged under any short circuit fault condition, thus allowing it to continue to provide overload protection to the cable as well as to the motor.

It is also interesting to note that the recent revised IEC439–1 (BS5486–1: 1986), 'Low Voltage Switchgear and Controlgear Assemblies', is more specific than hitherto about the need for co-ordination.

Clause 7.6.1 states that co-ordination of components, for example co-ordination of motor starters with short circuit protective devices, shall comply with the relevant IEC standards.

Figure 5 shows diagramatically the test requirements for proving type 'c' co-ordination. The conditions which must be met are onerous. The HRC fuse is undoubtedly the best device for providing such protection, particuarly for contactors with low I^2t withstand, because no device with moving parts can match its breaking speed. To establish whether the conditions are met, it is necessary to conduct tests, (see Fig. 5), in the region of the take-over current (the current at cross over Ic) of the fuse/relay combination. The combination is tested at both 0.75 Ic and 1.5Ic, at 110% rated voltage, and 0.35 PF. At the lower current the contactor opens before the fuse operates, because of the action of its overload relays. At the higher current the fuses operate before the contactor opens. (In this case it is possible that one fuse will blow before the others, reducing the fault current in the other two phases to 87% of their original value, causing the overload relays to open the circuit in those phases. This is allowed). In IEC 292–1 (BS4941) these duties are called test currents 'p'. After these tests the fuse contactor combination is subjected to a test current 'q', without any of the motor starter components being replaced or refurbished. (The only corrective action allowed is the separation of any slightly welded contacts and resetting of the overload relay.

Test current 'q' is usually 50kA at 415V, although certain specialised applications may require a higher fault level. One breaking operation is performed with the starter closed prior to the test, and this is followed by two breaking operations in which the fuses operate after the contactor is closed onto the short circuit. The motor starter must then be subjected to dielectric tests and verification of making and breaking capacities in accordance with IEC292–1 (BS4941), whth no refurbishment of the contactor of renewal of parts.

When all of these tests have been completed, time current tests must be made on the overload relay, to demonstrate that it remains true to its characteristics. This last test is of great importance, because only if the overload relay remains undamaged will the combination continue to give overload protection to the associated cables.

Selecting a fuse with the correct time-current characteristic is vital if the full capability of the motor starter is to be realised. The protecting fuse must be able to withstand the inrush current of the largest motor the starter can control for the appropriate starting time, (10 seconds is a generous value for most motors), but at a test current of 50kA, (in most applications) the fuse must limit the let-through I^2t and peak current to within the withstand capabiliity of the starter. The consistency and accuracy of the characteristics of the HRC fuse over this range of currents, cannot be matched by other protective devices, making the fuse the preferred device for providing type 'c' co-ordination to IEC motor starters. There is no record of certified test evidence of type 'c' co-ordination, with a circuit breaker protecting IEC starters, at a fault level of 50kA. The time-current characteristics of the GEC 'T' range fuselinks, (see Fig. 3), optimise the two conflicting requirements of (a) good motor starting capability of 10 seconds, and (b) low values of cut off and I^2t at high prospective currents.

The demand for independently certified type 'c' co-ordination is growing, as users appreciate that with the increaisng safety legislation being introduced in many countries, documentary proof of compliance with the installation rules is essential.

The fuse used in the certification tests is a vital part of the co-ordinated package, and users need to specify the same fuse as used in the test in order to ensure that the certified co-ordination is maintained in service.

At present, few manufacturers of IEC starters give details of the withstand capabilities of their contactors and more importantly, their overload relays. Because of this the IEC fuse and contactor committees have begun to look at the problem with the object of establishing internationally acceptable guide-lines, but it will take some considerable time before this is achieved. In the meantime, users should use the fuse of the same make used in the certification tests. In North America most controlgear manufacturers, recognising the obvvious economic benefits, have begun to manufacturer IEC starters to replace the bulkier NEMA types which are currently popular. Awareness of the need to review methods of back-up protection as a result of this is growing, particularly in Canada. The United States National Electric Code recognises that in motor circuits the overload relay also provides protection for the associated cable, and although this has not been a problem with the more robust NEMA starters, there is recognition that more attention will need to be paid to the correct protection of motor starters utilising IEC starters, the demand for which is growing.

It will be interesting to watch the US where 70% of motor starter circuits are at present protected by circuit breakers.

Discrimination

One of the objectives of the revision of IEC269, was the achievement of improved discrimination between major and minor fuses. The standardised time current zones and pre-arcing I^2t limits now agreed, results in a discrimination ratio between major and minor fuses of 1.6 : 1 based upon pre-arcing I^2t at 10 milli seconds. The popular view is that in practice, many circuit conditions are such that arcing I^2t can be ignored. This may be true for final circuits of domestic and commercial installations, but it is wrong to ignore arcing I^2t altogether particularly where high fault currents and inductive circuits exist. A more practical viewpoint is to consider the worst conditions which can be encountered between major and minor fuses in a 3 phase circuit.

Under such conditions a ratio of 1.6 : 1 can be achieved with GEC 'T' ranges fuses on 415V circuits on fault currents up to 50kA. This degree of discrimination is not achieveable with other protective devices. In fact, if one considers combinations of MCB's and MCCB's, the range of currents on which discrimination between major and minor devices is achieved is limited to those currents which equate to the instantanteous tripping current of the major device.

This has lead to the introduction of the term 'cascading' to cover those situations where both devices trip. This condition is at best a nuisance, and at worst can cause considerable down time and loss of production.

Future Trends

The technical achievements which have been reached in the revision of IEC269, in the international standardisation of the electrical characteristics of low voltage fuses, and the vital role which the fuse plays in co-ordinated system protection, has led to the development of compact and competitive packages of fuses and fusegear. This is exemplified by the pending issue of BS88 Part 6 'Compact Fuses for use in 240V/415V Industrial and Commercial Applications'. Fuselinks, fuseholders and fuse switches are now available in ratings up to 125 amps, having dimensions which achieve a volumetric reduction of approximately 50% when compared with fuses to BS88 Part 2, whilst providing all of the unique protective capabilities of the HRC fuse described above. (Figs 7 & 8) The time current characteristics of this range comply with the standardised gates of IEC269, and the power losses are lower than for fuses to BS88 Part 2. This range of equipment is increasing in popularity in many parts of the world, as more users are appreciating the need for co-ordinated system protection whilst looking for economy. The essential role the fuse plays in the modern protective scheme, coupled with the substantial dimensional and economic benefits of compact fusegear justifies the claim that it provides the most competitive co-ordinated system protection available on the market.

I_n (A)	I_5 sec. max (A)	I_{10} sec. min. (A)	$I_{0.1}$ sec. min. (A)	$I_{0.1}$ sec. max. (A)
16	66	33	85	150
50	250	122	353	614
100	580	290	818	1450
200	1250	610	1910	3417
400	2840	1420	4504	8057
800	7000	3060	10620	19000

Table 1. Gates for gG fuses (IEC 269-1)

Prospective Values		**Actual Values**			
No MCB in circuit		With 6 A MCB* inserted		With 63 A MCB† inserted	
Current kA	P.F.	Current kA	P.F.	Current kA	P.F.
50	0.2	3.43	0.99	43.6	0.41
30	0.2	3.38	0.99	27.8	0.33
16	0.3	3.2	0.98	15.26	0.37
48	0.35	2.4	0.87	4.7	0.37

* For 6 A MCB : R = 0.0694Ω X = 0.0012Ω
† For 63 A MCB : R = 0.0013Ω X = 0.0003Ω

Table 2. GEC current limiting MCBs. Effect of MCB impedance on fault conditions.

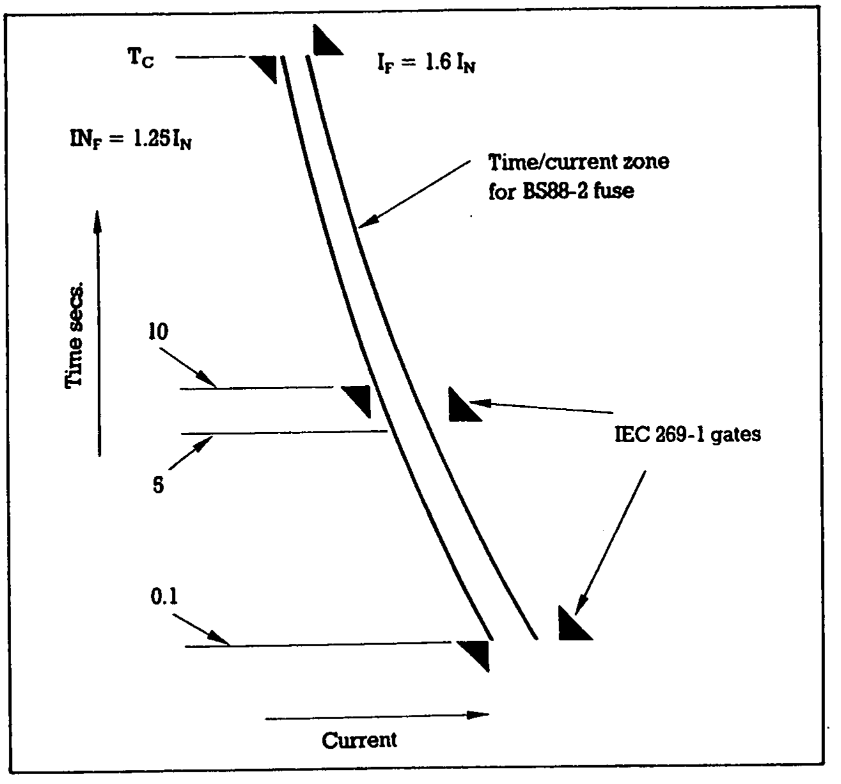


Fig. 1. Standardised time/current zones.

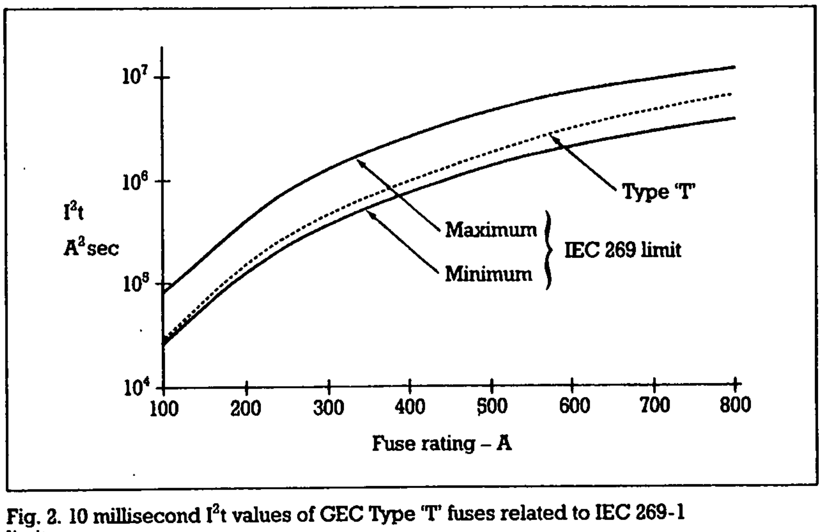


Fig. 2. 10 millisecond I^2t values of GEC Type 'T' fuses related to IEC 269-1 limits

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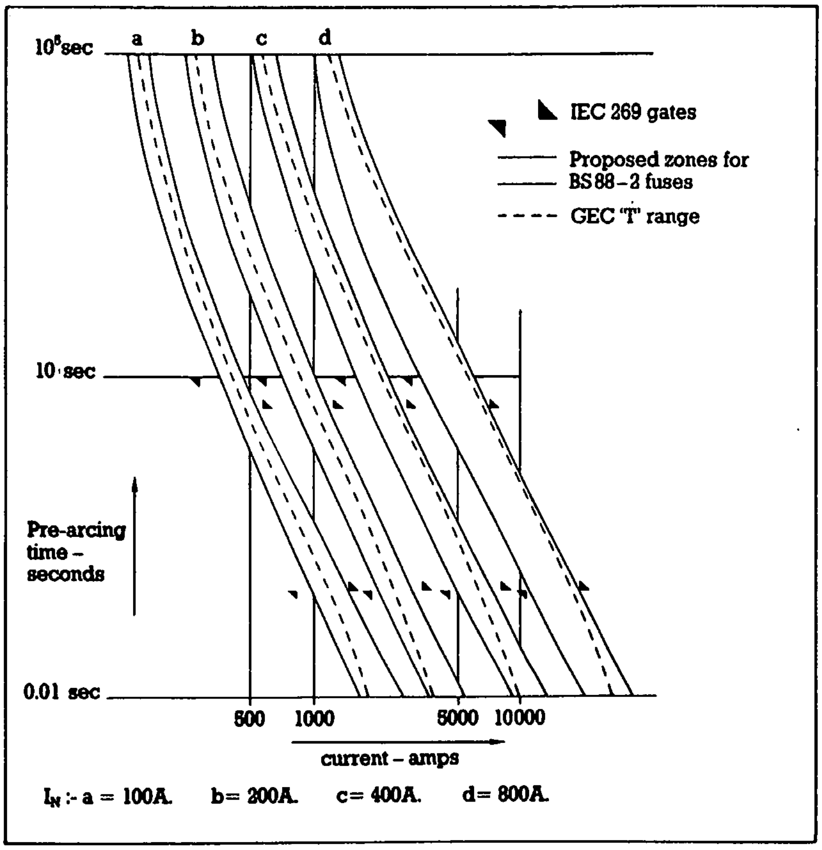

Fig. 3.

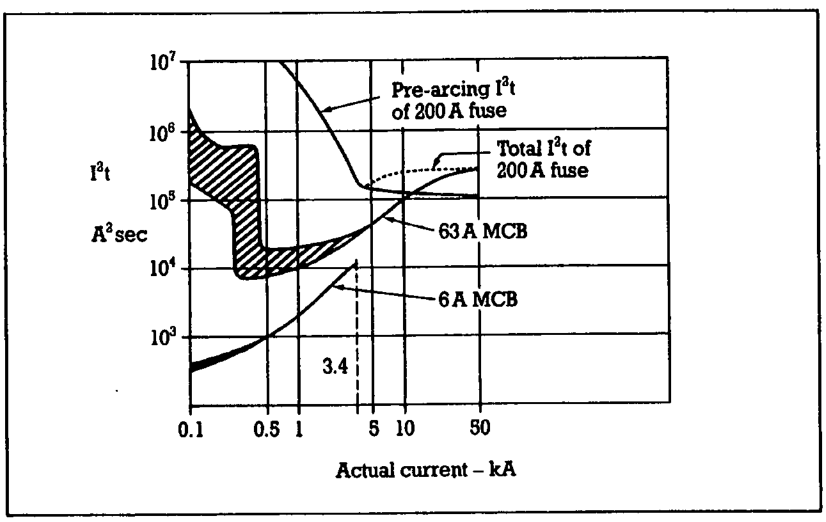

Fig. 4. Coordination of GEC Type 'T' fuses and current limiting MCBs at fault currents up to 50kA.

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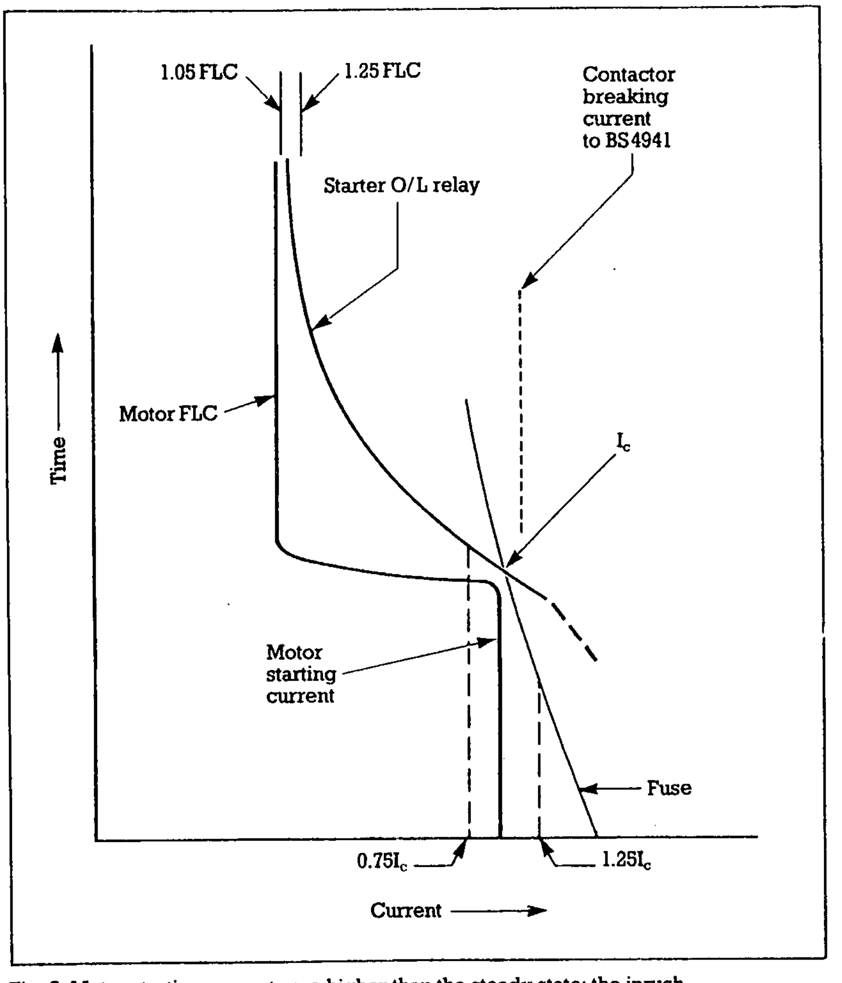

Fig. 5. Motor starting currents are higher than the steady state: the inrush lasts for up to 10s, but must be tolerated by the protective circuit.

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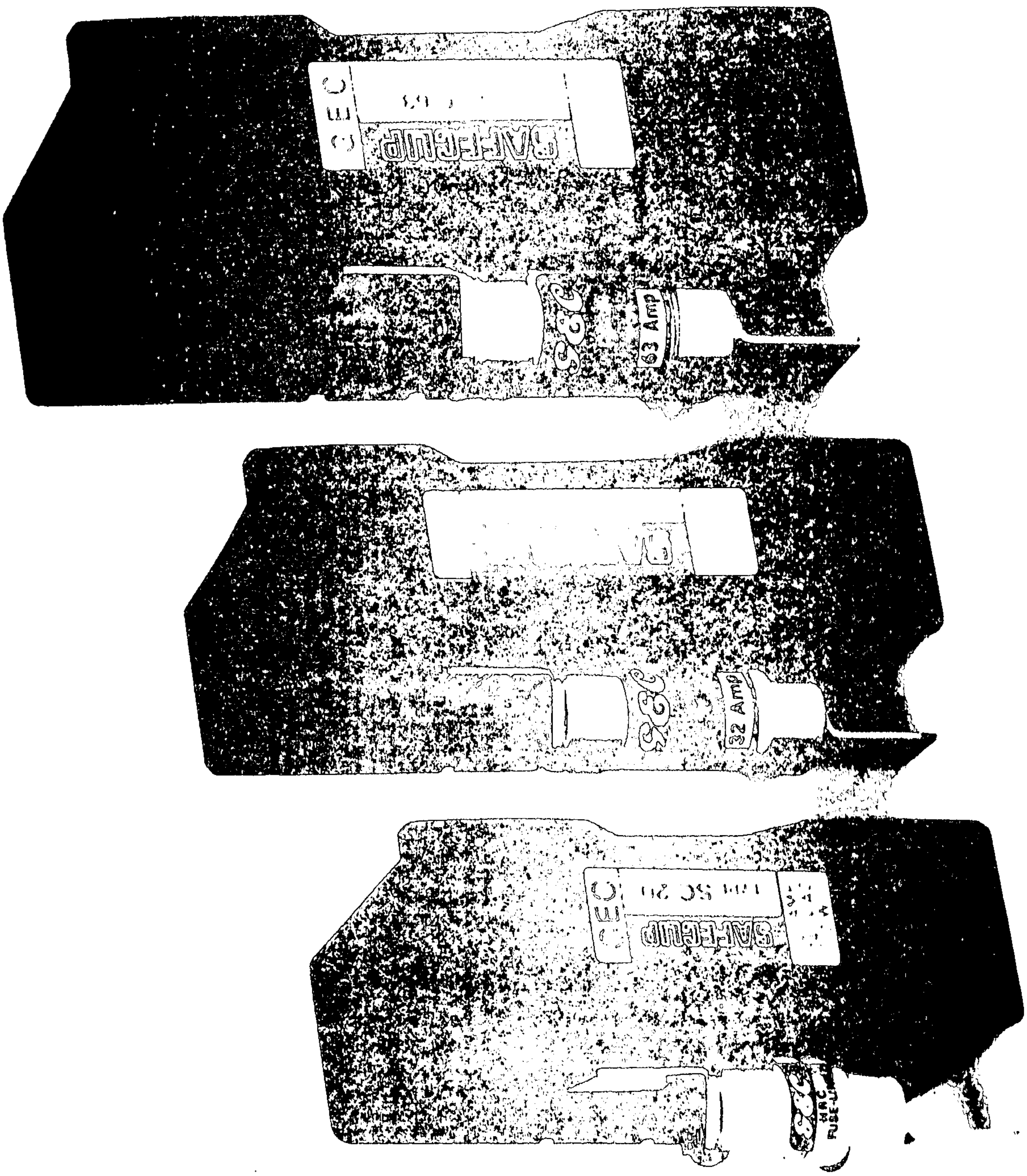
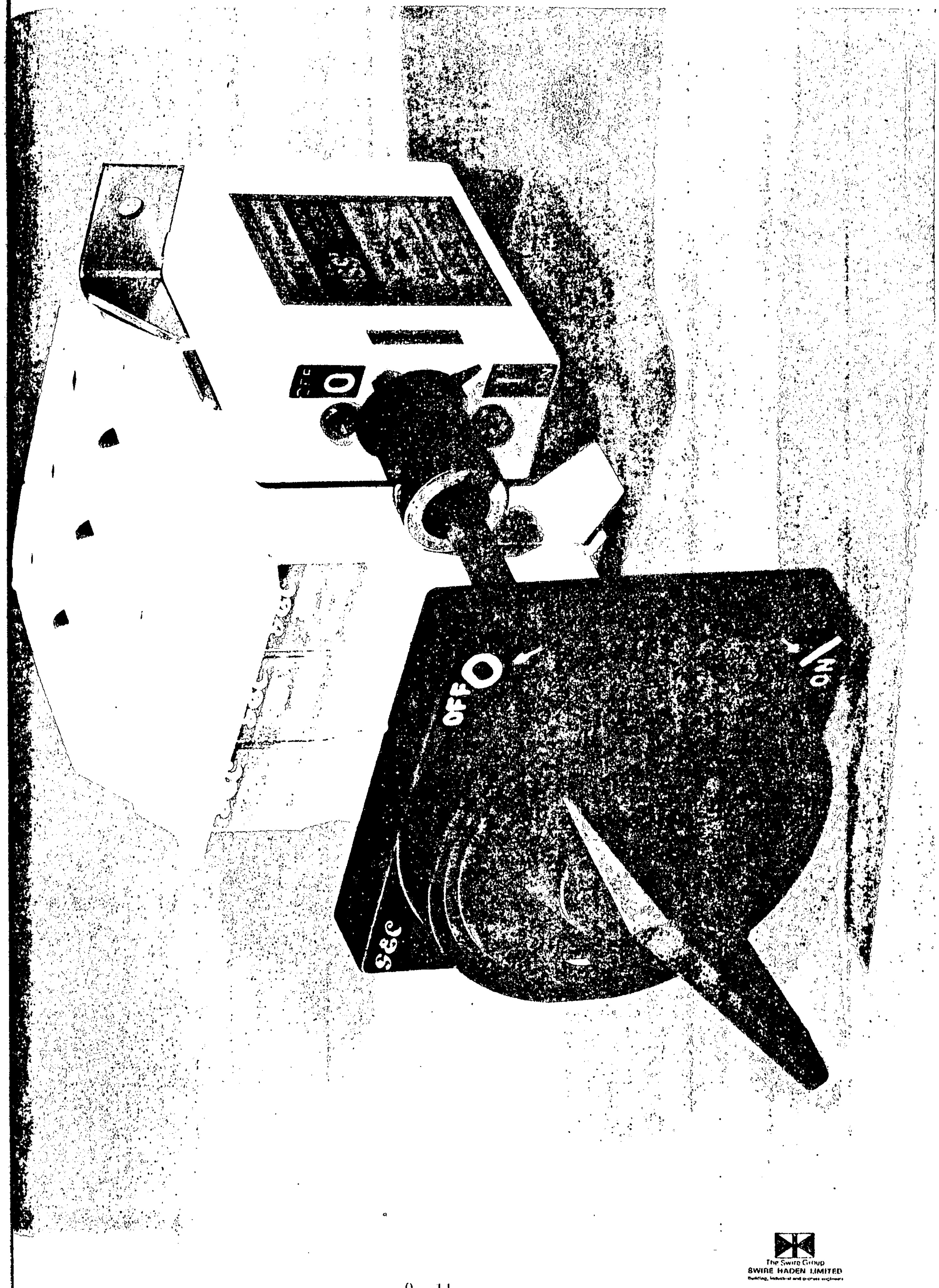

63 Amp
32 Amp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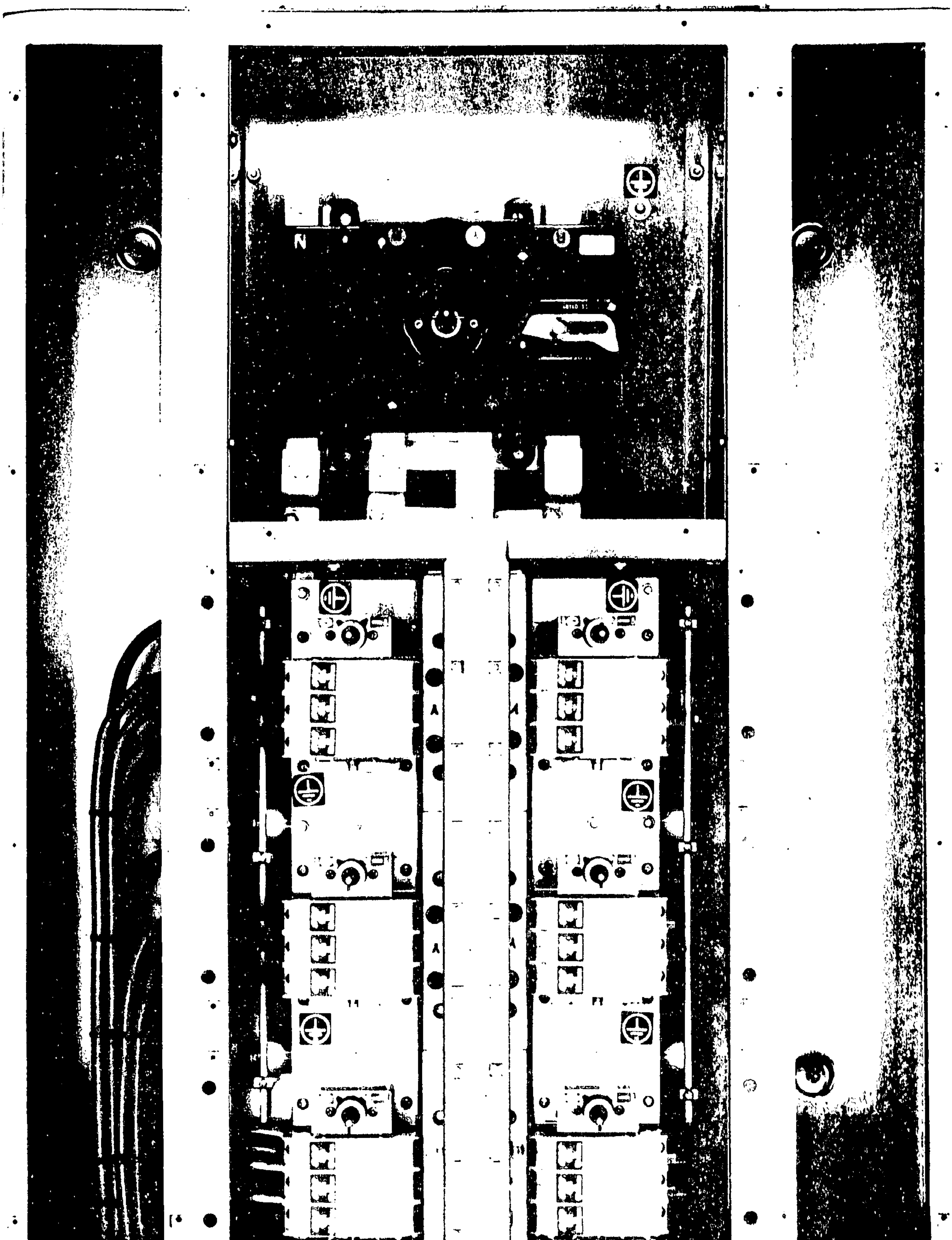

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Building, industrial and process engineers

— Notes & Questions —

Paper No. 10

The Use of Microprocessors In Solid State Relays For Higher Reliability of Power Supply

Speaker: Liladhar Matele, Regional Manager, North-East Asia, ASEA RELAYS

THE USE OF MICROPROCESSORS IN SOLID STATE RELAYS FOR HIGHER RELIABILITY OF POWER SUPPLY

1. Introduction

During the last 15 years, static relays have to a great degree replaced the electro mechanical relays in power system protection. These relays have mainly been based on analogue measuring techniques. Microprocessor based relays using digital measuring technique are commercially available today and several utilities already have these relays in operation.

In this paper the advantages and disadvantages of microprocessor based digital relays compared to conventional analogue measuring static relays are discussed with respect to the basic requirement of protective relays.

The principal design of five microprocessor based relays are presented; a distance relays for HV-lines, a distance relay for EHV-lines, a fault locator, a multifunction feeder protection and a multifunction motor/generator protection. The conclusion is that a microprocessor based digital measuring technique should be used only when true benefits are achieved and when the same or better reliability can be obtained, compared to conventional static relays.

For the manufacturer the introduction of digital relays requires new advanced tools for R & D and quality control, such as programming tools, emulation stations and network simulators.

For the user, the introduction of micro processor based relays gives new possibilities. Simplified selection, application, testing and maintenance may result in new routine giving both a higher reliability and a more interesting job as a protection engineer.

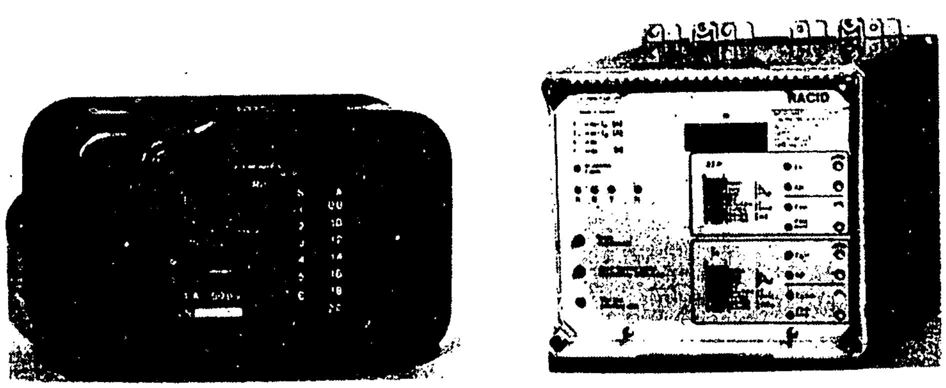

Figure 1 Single phase time overcurrent relay from 1918
Three phase and ground multifunction relay from 1985.

2. Basic requirements on protective relays

Reliable protective relays are essential for power system reliability. They should operate reliably whenever a fault occurs. Based on heavily distorted information, the relay should decide within a few miliseconds if an important transmission line or transformer should be disconnected or not.

Utilizing power equipment closer to its limits of operation and the use of non-linear equipment in the power system calls for protective relays which are faster, more accurate and with better selectivity, which can correctly discriminate between normal and abnormal operation as well as internal and external faults.

Electromechanical protective relays have traditionally been considered as "black-boxes" filled with springs, screws and gear wheels. They have been regarded as complicated devices requiring careful maintenance and were understood only by a few dedicated specialists. Today these relays represent a high cost for maintenance.

Even when the "black-boxes" have been replaced by static relays, it is still true that protective relaying is a very specialized part of power system engineering. There is a need for relays which are easier to select, set and test, relays with a flexible and universal design, a good man/machine communication and little maintenance. A relay which is user friendly and which can make the work for the protection engineer easier and more interesting will be desired.

Finally the introduction of SCADA systems where several stations are remotely controlled from a master station has called for data transmission from the protective relays. Here we have the typical "technology trap" since new technology give us the possibility of collecting a lot of information independent of whether we need it or not.

Too much information as well as too little information can also often be a problem for the operation personnel. Information should be simple to understand even during stress situations. Here there is need for local storage of base information and remote transmission of more "intelligent" processed information.

As a summary, the basic requirements on protective relays can be divided into two groups.

From the power system point of view:

* Speed – Operate and reset time

* Accuracy – Sensitivity and selectivity

* Reliability – Security and dependability

* Flexibility – Selecton and application

From the operation and maintenance point of view:

* User friendly at installation – Mounting and setting

* User friendly for maintenance – Testing and trouble shooting

* User friendly operation – Local and remote information

3. Comparison between analogue and digital measuring techniques

The introduction of static relays made it possible to improve the performance of the protection system giving faster and more reliable fault clearing even for heavily distorted signals.

Furthermore, static relays require less space, less maintenance and impose less burden on CT's and VT's compared to electromechanical relays.

The question now is can microprocessor based relays further improve the cost/performance ratio of the protection system compared to conventional static relays.

Such a comparison has to be built on an evaluation of how the basic requirements are fulfilled for a specific application.

The operation of a protective relay can be divided into four functional blocks.

1. Analogue signal conditioning, i.e. filtering

2. Measuring algorithm, i.e. fault/load discrimination

3. Logic, i.e. tripping criterias

4. Man/machine communication, i.e. setting and signalling

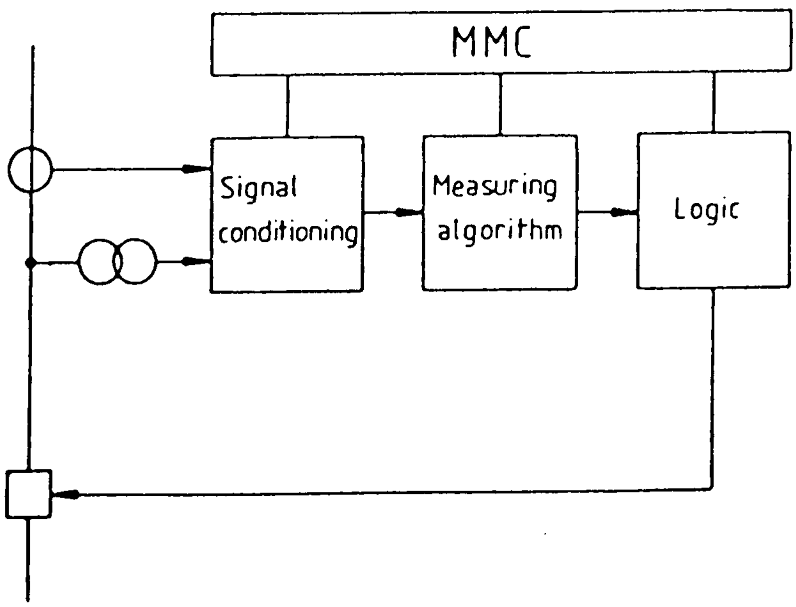

Figure 2 Functional blocks of a protective relay

The introduction of static relays has given improvements of all these four blocks. New advanced filtertechnique and new measuring algorithms made it possible to design relays with better performance for less cost. Programmable logic, lightemitting diodes and thumbwheels have improved the flexibility and man machine communication.

From the power system point of view static analogue measuring techniques still offer and will for many years to come offer equal or superior performance compared to digital measuring techniques in certain areas. One exception is when accuracy is favoured over speed. Here digital measuring algorithms can give better performance.

Digital filtering can also offer some improvement, because it can be designed for higher Q-values.

From the operation and maintenance point of view, the use of microprocessors can give several benefits.

- One universal version can be programmed for various measuring algorithms, logic and functions which are field selectable.

- Load and fault data such as load current, fault current, fault location and type of fault can be obtained.

- Continous selfsupervision can be included without any need for additional components or wiring.

4. Where to use microprocessor based relays?

4.1 Bus & Breaker failure protection

Bus faults normally result in heavy fault current. A short operating time of less than half a cycle is therefore often required from the bus differential relay.
This is to limit damages, ensure correct operation even during fast saturation of the current transformers and for stability reasons.

For a simple current measurement during heavy fault conditions the analogue technique is still preferable for several reasons – ultra high-speed, simplicity, reliability and cost as well as long proven experience.

This is especially true for busdifferential and breaker failure relays. In both cases high speed operation and maximum reliability is more important than accuracy. The objective of the protection is to determine whether there is a bus fault or not and if there is a breaker failure or not. A false trip is in many applications as bad as a failure to trip with maximum security and dependability.

A bus and breaker failure relay should operate correctly if the CT saturates. Since bus and breaker failure relays often are added to an existing substation the capability of using CT's with different ratios as well as the ability to handle the burden of other relays in the same secondary is important.

The moderately high impedance percentage stabilized principle for a bus differential relay was developed in the 1960ies. The relay operates for an internal fault condition within 1–2 ms and initiates tripping of circuit breakers in about 7 ms. It operates correctly during CT saturation and is insensitive to remanence, fault current levels and X/R-ratios. Furthermore it can be connected to CT's of various ratios and does not require a dedicated secondary.

For breaker failure protection, maximum reliability is also of concern, which means a fast and reliable current measurement has to be ensured even during CT-saturation. Also here the analogue technique can provide a good solution. In a breaker failure relay the current can be measured in 4 ma with a reset time of less than 12 ms. In combination with an impulse storing circuit this also ensures correct operation during CT-saturation as shown in figure 4.

The conclusion is that for current measuring relays such as bus differential and breaker failure relays the use of digital measuring technique does not give any significant advantages.

The main benefits of digital relays; accuracy, load and fault data availability and selfsupervision does not improve the performance of the bus and breaker failure relays described above. The operating principle used gives the required sensitivity and selectivity without any need for improved accuracy.

There is no real need for load and fault data since that can be obtained elsewhere.

The non-complex, phase by phase design, with few components gives in itself a reliable system which is easy to apply, set and test. Consequently there is no need for selfsupervision of the relay itself. On the contrary, adding components for selfsupervision will increase the probability for false trips.

Furthermore for the bus differential relay both the external current curcuits and trip circuits can easily be supervised.

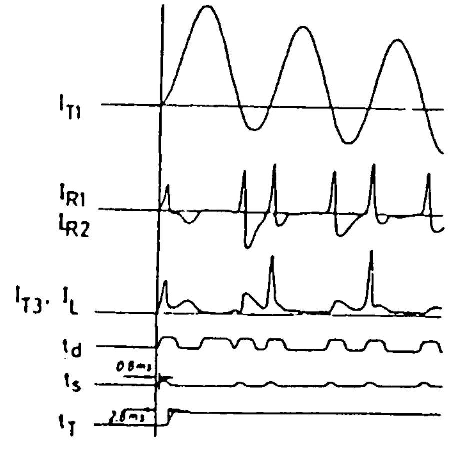

Figure 3 RADSS-bus differential relay during test. Internal fault of 24 kA (62 kA peak). Supervisory and differential relays (t_S) operated in 0.8 ms. Tripping relay (t_T) was energized in 2.8 ms.

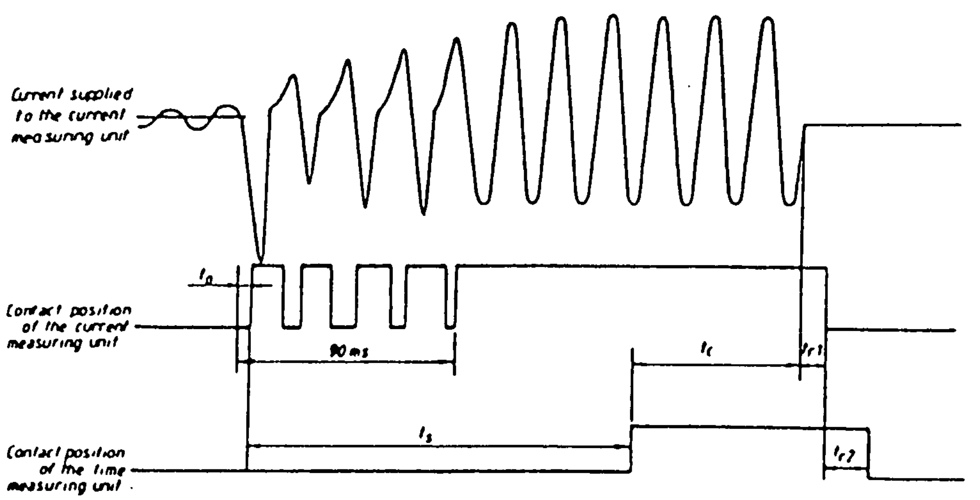

Figure 4 Example of a diagram for operation of breaker failure relay RAICA with saturated current transformers. Correct time measurement is obtained with impulse storing circuit.

4.2 Transmission line protection

For transmission line protection an accurate directional measurement as well as an accurate fault/load discrimination is essential to ensure correct operation.

Line protection usually includes a large number of functions which have to be coordinated and adapted for various applications.

Since line faults are the most common type of fault there is a need for maximum reliability. Finally, there is a need to obtain accurate fault information so a persistent fault can be and/or the performance of the protection system can be checked.

With the introduction of the quadrilateral impedance characteristic for distance relays in the sixties and the directional wave measuring principle in the seventies two major steps towards improved line protection schemes were taken. Both these innovations were based on advanced filtering techniques and analogue measuring technique.

The quadrilateral characteristic as well as the directional wave measurement made it possible to detect phase and ground faults even for heavily loaded tnrasmission lines, independent of length.

Operational experience has been excellent with static distance relay systems with quadrilaterial characteristics. The conclusion is that the microprocessor technique in it self will not significantly improve the performance of transmission line protection from the power system point of view.

The existing measuring algorithms based on directonal wave and quadrilateral characteristic give the speed, sensivity and selectivity required in most applications.

There are however three areas where the microprocessor technique can give significant improvements for line protection schemes.

1. Increasing the flexibility by designing one universal and field programmable version for several different relay schemes.

2. Increasing the reliability and decreasing the maintenance with continuous self-monitoring.

3. Give accurate information about fault type, fault location, fault and load currents/ voltages, time for the fault.

Microprocessors are today used in distance relays both for measuring and logic.

Traditionally distance relays have been divided into switched relays and non-switched relays where switched relays can be said to be a European practice and non-switched relays a U.S. practice for HV transmission lines. Today many U.S. utilities have accepted and are using switched static distance relays. For EHV lines non-switched relays are used world wide.

Electromechanical distance relays were originally used to detect phase to phase faults due to the circular characteristic. Ground faults had to be detected by zero sequence current measuring relays.

One principle was based on two measuring elements per zone, one for two phase faults and one for three phase faults. The other principle was three elements for phase to phase measurement. If several zones were required, zone switching or multiplication of the number of elements combined with timers was the solution. Separate starting relays were sometimes included.

When distance relays were used for phase to ground measurement, three additional elements per zone had to be included for a non-switched distance relay. Figure 5 shows the principal function of such a hybrid. Each zone will for a phase and ground distance relay normally include 5–6 measuring elements and the starting function 4–6 measuring elements. This configuration requires a logic for coordination.

Figure 6 shows the principle function of a switched relay. Phase switching should today be renamed to sequential measurement since no switching is actually done in a static relay, but rather a selection of measuring quantities.

The starting relays will here determine which phases the measuring element shall measure. The two measurements are done in sequence. This method provides a non-complex and reliable solution for most phase and ground distance relay applications.

The main advantage for a non-switched scheme over a sequential measuring scheme is shorter operating time. This is why non-switched schemes are used for HV and EHV systems but switched schemes for MV and HV systems.

The reliability and internal redundance of a switched scheme compared to a non-switched scheme is often discussed. This is however more a question of the structuring and quality of the functions within the relay. This is an essential aspect when applying microprocessors.

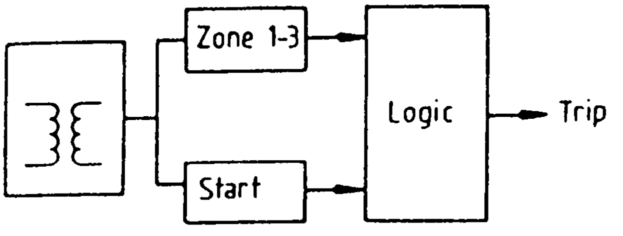

Figure 5 Hybrid with starting relay, without phase switching, with or without zone switching.

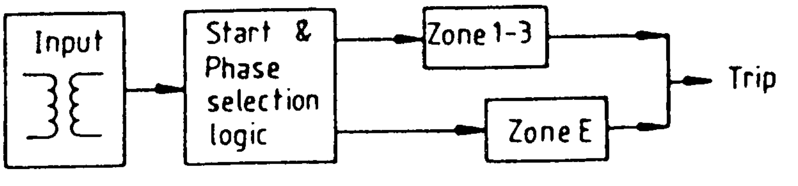

Figure 6 Sequential measurement with phase switching, with or without zone switching.

In both figures 5 and 6 it is shown that the logic is a common function. If that fails the protection fails.

The same is valid for the starting relays. Furthermore for a zone-switched relay the function is dependent on one set of measuring elements, which thus requires less testing and maintenance.

To improve the reliability of a switched relay using starting relays, the microprocessor technique could be used. One solution is to have one micro-processor continuously monitoring the impedance in each phase. The measurement can be done very accurately and furthermore each microprocessor can be continuously supervised. If the measuring zones are duplicated so two redundant zones can measure simultaneously the reliability is further increased. This is shown in figure 6 where one element provides zone 1–3 and another element zone E.

By this the switched distance relay has improved its performance so it can replace non switched relay for many applications. Due to its simplicity, little maintenance, and lower cost it is an interesting alternative for most HV applications.

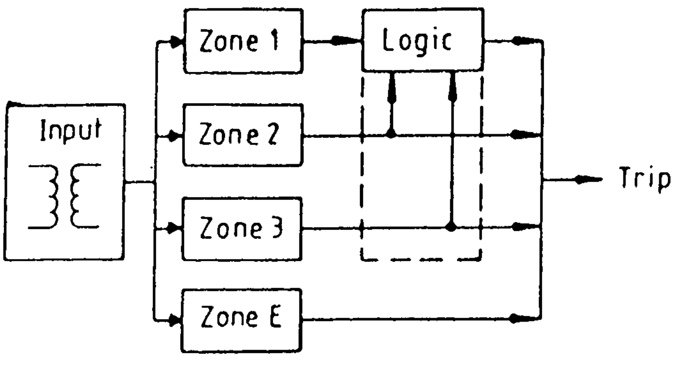

Figure 7 Parallel measurement Fullscheme distance relay without zone or phase switching

Figure 7 shows a solution when microprocessor technique is used to give maximum reliability. The measurement in each zone is done in parallel by one microprocessor per zone. The logic needed to avoid overreach in zone one is using criterias from the other zones. No separate starting relays are required.

The logic functions are provided by a separate microprocessor. In that function timers and communication logic are included. If this processor fails, zone 2 and zone 3 can still provide back-up function. Zone E is independent and can be used either underreaching or overreaching. Each microprocessor is continuously monitoring itself.

Another important feature in this solution is that also the current and voltage input circuit can be supervised and for example detect an open circuit in a current transformer.

As a summary can be said that figure 7 shows a fullscheme distance relay with 1-4 independent zones. The relay supervises itself and its input circuits. Finally it can also function if one or two microprocessors fails.

As earlier mentioned microprocessor technique can provide a more accurate measurement. This can be used in fault locators for transmission lines. The difference between a distance relay and a fault locator is that the distance relay only has to compare the impedance with a preset value but a fault locator actually has to determine the impedance.

By using a new algorithm which can compensate for both laod current, remote infeed, fault resistance and frequency variations it is possible to measure the distance to fault a within ± 1% or ± 1 km accuracy.

4.3 Feeder protection

Phase and ground over current relays are the most common type of protection used today for radial feeders. Depending on system conditions and coordination requirements with other equipment various types of time-current characteristics are used; definite time, normal inverse, very inverse and extremely inverse. Often there is also a need for a separate instantaneous high set function as well as a separate start function.

Static phase and ground over current relays have been used for many years.

Here the performance of conventional static relays has proven to be very good but the microprocessor technique can further improve the performance.

The areas where microprocessors can improve the performance are:

1. Increasing the flexibility by one universal and field programmable relay capable of providing a number of different characteristics.

2. Increasing the reliability and decreasing the maintenance with continuous self supervision.

3. Give accurate information about fault type, fault current and load current.

With the possibility to display load current per phase on the display, continuous monitoring of internal circuits and auxiliary voltage supply together with a built-in trip circuit test it is possible to check the relay within one minute including input and output circuits.

This provides a comprehensive functional test of the relay and the need for a complete secondary injection test is therefore reduced.

4.4 Generator and motor protection

For small and medium sized motors and small generators a typical protection consits of overload, short circuit, ground fault and unbalance protection. Long starting time and repeated start protection may also be required for large motors.

Static generator and motor protection schemes have been used for more than 15 years.

Generally the performance is excellent but there are areas where micro-processors can give improvements.

Accuracy is especially important for an overload protection. Existing relays often have an inaccuracy in the current measurement which can be 5–10%. As an example if an overload protection has an inaccuracy of ± 2% instead of ± 10% the maximum load can be increased from 64% to 92% of rated thermal capacity since the thermal losses is a function of I^2.

Some other advantages with microprocessors can be summarized as follows:

1. Increasing the flexibility by one multifunction and field programmable relay.

2. Increasing the reliability and decreasing the maintenance with continuous self supervision.

3. Display accurate load and fault data such as current, thermal content, phase unbalance, starting time and starting current.

By integrating several functions a good cost/performance ratio can be obtained.

Also for large generators a multifunction relay could be used as a back-up to the primary system.

A built-in display, self supervision and trip circuit test can also here give a relay which can be functionally tested within one minute. The display of various load data gives a tool to simplify the setting procedure as well as to study the behaviour of the motor.

5. Brief description of five mocroprocessor based relays

5.1 New range of microprocessor based relays

A new range of microprocessor based relays is described briefly here below as examples of the new technique.

RAZOA-universal phase and ground distance relay for permissive and blocking schemes, 1–4 directonal zones suitable for MV and HV lines and cables.

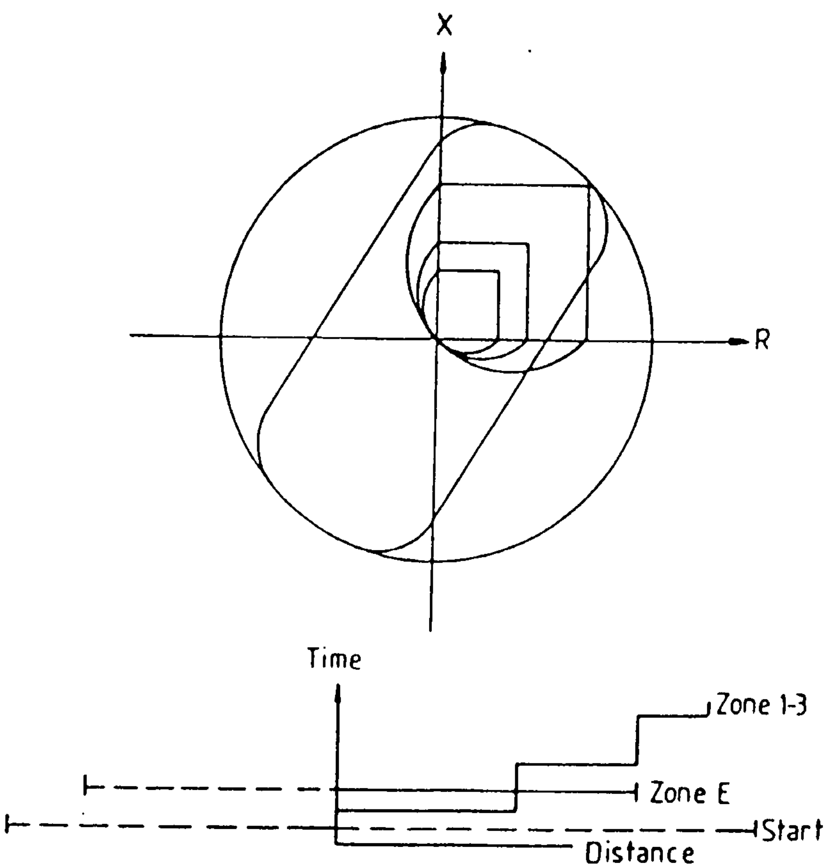

Figure 8 RAZOA microprocessor based distance relay for MV and HV lines.

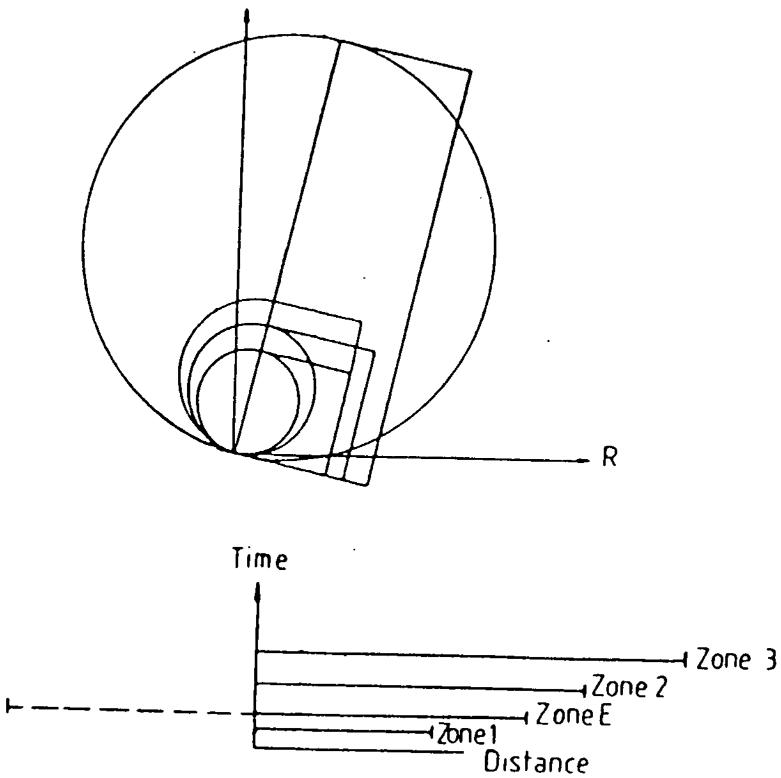

Figure 9 REZ 1 microprocessorbased distance relay for HV and EHV lines.

REZ 1-unversal phase and ground distance relay for permissive and blocking schemes, 1–4 directional zones suitable for HV and EHV lines and cables.

RANZA-fault locator which can display locally or remotely information about faulted phase, fault location, fault current and voltage, prefault current and voltage, time at fault, RANZA can be used as a stand alone unit or be combined with RAZDA and REZ 1.

RACID-universal phase and ground overcurrent relay for lines and cables. Instantaneous, time delayed and start function is included. Time delayed function is programmable for definite time, normal inverse, very inverse and extremely inverse. RACID can display information about faulted phase, fault current and load current.

RAMDE-multifunction relay for motors and small generators. RAMDE includes overload protection with accuracy cloass 2%, short circuit, ground fault, unbalance, long starting time, stall and repeated start protecton. RAMDE can display information about laod current, thermal content, phase unbalance, accumulated start time, latest start time and latest start current.

Up to now more than 500 microprocessor based transmission line terminals and over 2000 microprocessor based feeder and motor protections have been delivered. The operational experience has been good. The improvements in accuracy has been verified in field tests and during normal operation. The number of component failures reported has been extremely low.

5.2 Principal functions

Figure 10 shows a block diagram of a microprocessor based relay.

From the input transformers the analogue signal is normally further processed before the actual A/D conversion. Since the number of parallel inputs to a microprocessor is limited a multiplexer has to be used which scans the various signals measured.

The microprocessor includes the measuring algorithm and/or logic functions. The microprocessor also controls the A/D converter and MUX which in some designs can be an integrated part of the microprocessor.

A separate "watchdog" self monitoring function provides supervison of the internal circuits and the microprocessor.

The man/machine communication consits of a display and/or diodes together with dipswitches, thumbwheels and/or potentiometers.

As shown in figure 11 analogue signal conditioning is used in several relays. For the current measurement in RACID analogue bandpass filtering ac/dc conversion and lowpass filtering will give a signal proportional to fault or load current. The A/D conversion has a cycle time of 8 ms. By this method ± 5% accuracy, > 95% resetting ratio and < 5% transient overreach is obtained.

For the overload protection in RAMDE RMS-measurement is used. The reason is that for a motor it is important to include harmonics in the measurement in order to give a correct value of the thermal content. The accuracy class obtained is 2% which is actual measuring accuracy (not setting accuracy).

For both RACID and RAMDE the analogue signal conditioning gives equal or even better performance compared to if digital filtering technique had been used.

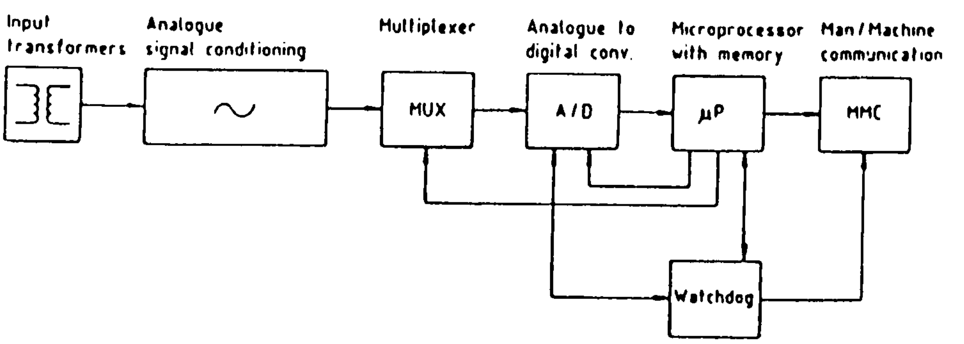

Figure 10 Block diagram of micro processor based protective relay.

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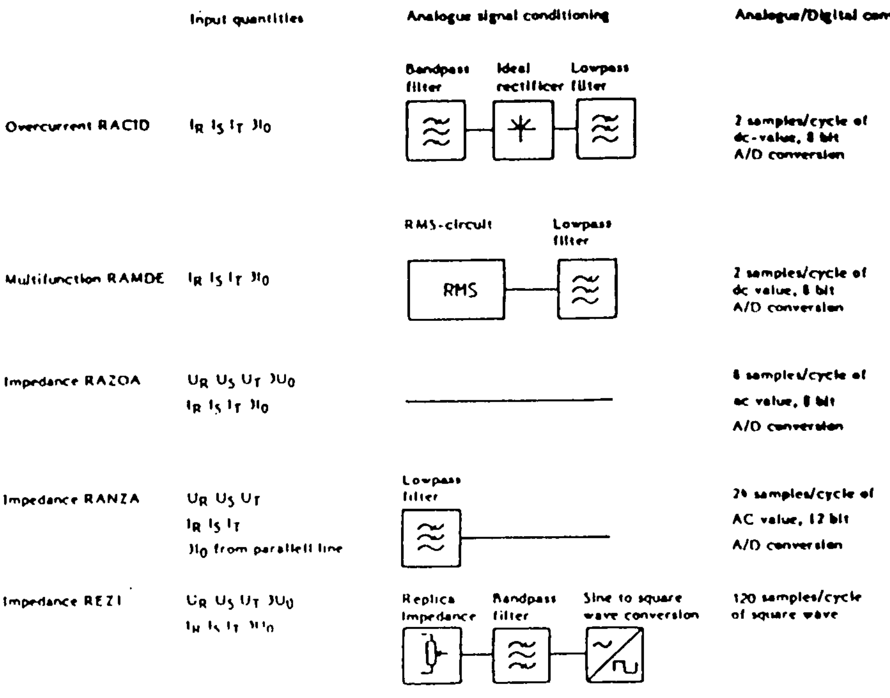

Figure 11 Analogue signal processing

In RAZOA and RANZA digital filtering is used. For RAZOA 8 samples per cycle and for RANZA 24 samples per cycle is used in the A/D conversion. The difference is due to the fact that RAZOA has an undirectional underimpedance measurement but RANZA measures the distance to the fault.

For digital impedance measurement used in distance relays orr fault locators digital filtering in combination with a high sampling rate should be used.

The reason is that the input quantities very often can be heavily distorted and the distance measurement requires an accurate measurement of the fundamental frequency.

Analogue filtering with a narrow bandwidth can during an ageing process slightly change its frequency response. This is especially a problem if current and voltage signals are filtered separately. Furthermore a variation of the system frequency will influence the measurement. Digital impedance measurement based on amplitude or phase comparison of voltages and current will thereby not be accurate enough, because even a small change in the filter response will result in a significant measuring error. A digital filter can here give an accurate measurement of the fundamental frequency without any ageing problems.

To obtain both accuracy, reliability and speed the sampling rate for undirectional measurement should not be less than 8 samples per period and for the directional distance measurement not less than 16 samples per period. For high accuracy, like in the fault locator, 24 samples per cycle has to be used.

1

	Measuring quantities	Number/Type of microprocessor	Digital signal conditioning
Overcurrent RACID	Rectified $I_R, I_S, I_T, 3I_0$	One 8 bit	Amplitude/time comparison Memory for load and fault data
Multifunction RAMDE	RMS $I_R, I_S, I_T, 3I_0$	One 8 bit	Amplitude/time comparison Continuous integration Memory for load and fault data
Impedance RAZOA	U_R, I_R U_S, I_S U_T, I_T	Three 8 bit, One per phase	Digital filtering Amplitude comparison Phase selection
Impedance RANZA	$U_R, U_S, U_T, 3U_0$ $I_R, I_S, I_T, 3I_0$ $3I_0$ from parallell line	One 8 bit External memory	Digital filtering Amplitude comparison Phase selection Calculation of distance to fault Memory for load and data
Impedance REZ1	20 square waves per zone	Four 8 bit, One per zone and one for logic External memory	Phase sequence comparison Time comparison Logic

Figure 12 Digital signal processing

REZ 1 utilizes the well proven method of replica impedance, bandpass filtering of compensated quantities and phase comparison of square waves. 120 samples per cycle, i.e. 6 per ms are taken from the square wave.

The disadvantage of analogue filtering does not affect the phase comparison measuring technique used in the REZ 1 distance relay due to the filtering of compensated quantities.

The high sampling rate is needed to obtain the accuracy together with highspeed measuring.

Figure 12 shows the digital singal processing. Eight bit microprocessors are generally used even if the A/D conversion can be 12 bit. In RACID and RAMDE an amplitude and time comparison is made. To improve the dependability the trip condition is checked 2–4 times before allowing a trip. For the overload protection the result of a continuous integration of the load is memorized.

In RAZOA and RANZA digital filtering, amplitude comparison and phase selection is made. In RAZOA the fundamental frequency is filtered out.

In RANZA a special algorithm for calculating the distance to the fault is included. Prefault and fault voltages and currents are stored and processed. The memory can store 9 cycles of information.

In REZ 1 phase sequence comparison, time comparison and logic is included. One microprocessor per zone is used together with a separate microprocessor for overall logic.

This structure allows the relay to operate even if one or two microprocessors would fail. The main benefit of microprocessor technology in REZ 1 is however the self monitoring function which also includes the current and voltage inputs. For failures within the relay the display will show the faulted part which then rapidly can be replaced.

6. Development of microprocessor based relays

Reliability is the key word for protective relays. With the use of software instead of hardware, new measures have to be taken by the manufacturers to guarantee high quality also for the software. Continuous testing during the development as well as of the final product has to be made.

Digital technology requires quite a different method of design than analogue electronics. Modern development tools are a necessary investment if one is to be successful in the difficult "art of relay protection". Computers and terminals have largely replaced drawing boards and logic and software analysers have supplemented oscilloscopes.

Conceptual studies are performed via simulation systems, which model the dynamic behaviour of a power network in connection with different disturbances. The Electromagnetic Transient Program (EMTP), developed by Bonneville Power in the United States, is one example of such a well-proven aid. This has become something of a standard in the relay protective field and is also used by many utilities. In addition, interactive simulation and signal analysis programs are used like SIMMON and IDPAC, developed at Lund Institute of Technology, Sweden.

Developing relay protection also demands extensive know-how of the characteristics of a power system during normal and abnormal conditions, as well as knowledge of how different fault sources influence the measuring signals to be processed in the protection relays. EMTP, for example, is used for conceptual studies, but today's digital simultation aids are inadequate when it comes to development tests and the simulation of customer systems. It is above all impossible to perform simulations in real time in view of the very large number of parameters occurring in a power network such as type of fault, fault location, fault resistance and fault initiation. It normally takes 10 hours to perform with a VAX 11/780 computer an EMTP simulation for a parameter study, where the fault location and switching angle are varied, involving 100 cases.

Therefore a powerful analgoue power system simulator is needed to assess and test the best solution for each particular application. The simulator has to simulate most types of power systems with generators, transmission lines, circuit breakers, surge arresters, instrument transformers, etc.

— Notes & Questions —

Paper No. 11

Tunnel Lighting Design and Developments in Lamp Types

Speaker: Mr. G.H.M. Giesbers, Sr. Lighting Design Engineer, Philips International B.V.

TUNNEL LIGHTING DESIGN AND DEVELOPMENTS IN LIGHTING COMPONENTS

Synopsis

Basic research and national and international recommendations combined with practical experience are the background for tunnel lighting design. Efficient traffic handling and overall management are the objectives. This report will focus on present-day and future lighting system designs. For the basic, or interior lighting, fluorescent versus low and high-pressure sodium systems will be evaluated. It will be shown how the developments in lighting components, intended for large-scale production, can be of benefit to tunnel lighting.

Tunnels

There are various possible reasons for building tunnels to handle the continuously growing volume of road traffic:

- To link areas separated by mountains;
- To carry traffic in hilly or built-up areas where surface roads would be either impossible or uneconomical, bearing in mind the large curves needed to handle high speeds;
- To shorten distances in areas where there are many rivers, when bridges high enough to allow the passage of river traffic would be more expensive;
- For reasons of conservation in rural areas and areas of natural beauty.

But whatever the reason for building a tunnel, the aim is always to allow the road traffic network to be developed in a safe and economic way.

The majority of tunnels can be divided into two groups according to their manner of construction, namely bored and open-trench. These normally have between 2 and 4 traffic lanes, each some 3.7 metres wide, with a 1-metre-wide pavement on each side. The clearance height is normally 5 metres (see Fig. 1).

In view of the investment involved of between US$10 and 25 million per kilometre of tunnel (compared with US$7.5 to 15 million per kilometre for a bridge and US$2.5 to 5 million per kilometre for a highway), high operating requirements will be imposed. In order to give an idea of the amount of traffic that can be carried by a two-lane one-way tunnel, the relation between realistic capacity and traffic speed is given in Fig. 2.

The theoretical design capacity, based on the traffic speed in the local road network, can increase by a factor of 1.5 during peak hours to reach saturation point, there then being far more private vehicles than lorries. The consequences of breakdowns and accidents, especially during these periods, must therefore be avoided as far as possible or serious disruption to the traffic flow will result. Traffic control and monitoring equipment plays an important role here, as do the lighting and ventilation installations. The investment for these provisions accounts for between 5 and 30 per cent of the total investment.

Lighting

Vehicles approaching an unlighted tunnel entrance by day have a tendency to slow down. One of the reasons for this is the so-called black-hole effect (Fig. 3), whereby the driver is unable to distinguish a possible obstacle within the tunnel entrance because he is visually adapted to the high daylight level.

The results of the basic research into this phenomenon are published in CIE Publication No. 61 (1985). Fig. 4 gives the minimum background luminance in the tunnel entrance needed to detect an obstacle in the tunnel from a certain distance, as a function of the daylight adaptation level. Because this adaptation luminance begins to decrease just before the tunnel entrance, at the so-called transition point, the length of the zone over which this entrance luminance must be present is about equal to the safe stopping distance. This zone is called the threshold zone. Whether or not a motorist is already partially adapted is a point for research and discussion. As soon as the transition point is passed, a motorist will begin to adjust to the changed lighting conditions. This adjustment process takes time.

In CIE Publication No. 26 (TC–4.6) 1973 we find Fig. 5, which illustrates this process for the part of the tunnel known as the transition zone. The length of the transition zone is determined by the time spent there, and thus by the speed of the vehicle passing through it. For a sufficiently long tunnel, a minimum lighting level is eventually reached. The current minimum level of 3 to 20 cd/m^2 has been more closely defined in the new CIE Publication No. 26 Draft 6 as lying between 1 and 15 cd/m^2, and is again dependent on traffic density and speed. The zone over which this level is employed is called the interior zone. The next zone, the exit zone where one-way traffic is concerned, can call for a higher lighting level for the following reasons:

- to make small vehicles following behind large lorries visible when the daylight at the tunnel exit is glaringly bright;
- to make following vehicles visible in the rear-view mirror of a vehicle leaving the tunnel;
- so that the exit can be used as entrance in the case of emergency, maintenance, etc.

At the onset of darkness, drivers will be adapted to the road lighting level employed in the vicinity of the tunnel. This means that the lighting level throughout the tunnel can be set at the same level, or possibly somewhat higher to compensate for spacial limitations.

In addition to visibility and adaptation, the so-called flicker effect produced by the lighting plays a role. The combination of driving speed and luminaire spacing in the direction of travel can, after a time, give rise to troublesome light flicker if the variation in the amount of light entering the eyes is too great. Fig. 6 gives the luminaire spacings to be avoided at certain speeds and over certain distances.

Design Guidelines

- International Recommendations for Tunnel Lighting (shortly to be revised) of the Commission International de L'Eclairage (CIE) Publication No. 26 (TC–4.6) 1973 and New Draft No. 6
- Permanent International Association of Road Congresses (PIARC)
- National recommendations
- Contract conditions and contract interfaces

- Authority's or consultant's recommendations

- Expertise of a world-wide lighting company with its own 'Lighting Design and Engineering Centre' and 'International Architects and Consultancy Offices'

The techniques used to predict lighting performance are the same as those employed in indoor lighting; that is to say, the direct and indirect lumen-flux methods, isolux diagrams, and conversion factors to translate lighting levels into luminance levels. The point-by-point luminance calculations making use of standard road-surface reflectance tables, familiar in road lighting, and the luminance yield diagrams are also employed. However, the fact that in interior lighting only diffusely reflected light rather than the specular component is generally considered, may lead to differences in the luminance values obtained.

A Local Example

The lighting in the entrance zone of a tunnel can be shown schematically as in Fig. 7. The top half of the figure shows sections through the tunnel while the lower half shows the corresponding lighting levels in the various zones.

The following points should be noted:

- Whereas the lighting level in the threshold zone is constant, that in the transition zone gradually decreases throughout the zone in a number of steps. The lighting in the interior zone is again constant. The brightness of the walls serves both to reveal possible obstacles on the road and as a means of increasing the apparent size of the tunnel.

- Matching the entrance lighting to the adaptation needs of the motorist is achieved by switching lighting units in and out in response to a light adaptation meter at the tunnel entrance measuring the strength of the daylight. A second meter in the threshold zone monitors and controls the switching of the luminaires, making allowance where necessary for the effects of luminaire soiling and lamp depreciation. The number of steps is fixed by the maximum acceptable light reduction ratio of between 1:3 and 1:5 and the energy saving requirements. In those tunnels with relatively low lighting levels and the minimum number of lamps, each of high wattage, it is possible to use 50 per cent dimming ballasts or semi-continuous (e.g. 20–100 per cent) dimming.

- The use of tubular high-pressure sodium and fluorescent lamps having a high lumen output per watt will present no problems with regard to, say, the proper colour rendition of traffic signs.

- Twenty per cent of the continuous fluorescent lighting also serves as emergency lighting.

Developments in Lighting Components

- for the basic or interior lighting in tunnels

The low-pressure sodium lamps introduced in 1932 were used in the Scheulde tunnel in Belgium one year later in place of the originally planned incandescent lamps. This gave an energy saving of 80 per cent. This energy saving and the lamp's low brightness are the main reasons why these lamps are still used today for both entrance and interior zone lighting. The high-pressure mercury lamp came on the market at about the same time, but since 1968 its role in tunnel lighting has been taken over by the high-pressure sodium lamp.

The inexpensive general purpose fluorescent tube introduced in the 1930s won a place for itself for use in the interior zones of tunnels. Continuous lighting provided by single or multiple fluorescent lamp luminaires facilitates the provision of the desired daytime lighting level, with in addition good luminance uniformity, excellent visual guidance and negligible glare. The luminaires are relatively simple and the TL lamp features instant restart after an interruption to the mains supply. A continuous improvement in its light output per watt has strengthened its position. Whereas in 1970 the light output of a tubular flourescent lamp (including ballast losses) was 70 lm/W, this has now been increased to 95 lm/W for the newest 50 W high-frequency version (TLD-HF), which is operated on an electronic ballast.

In order to match the night-time lighting levels to the reduced traffic flow so as to save energy, selected TL lamps are switched off, or else dimmable TLM lamps are employed. In the latter case, a number of lamps are connected to a central dimming circuit (or Dim-Rack). The mass-produced electronic high-frequency ballast introduced in 1984 is now available in a dimmable version in which the central dimming circuit is no longer necessary. Since the main lighting in a tunnel is on virtually continuously (at least 8760 hours per year), it follows that these easily integrated, energy-saving lighting components will pay for themselves in a very short time.

Because of the large number of units involved, the continuous rows of TL luminaires are relatively expensive. Ever since their introduction, therefore, the low-pressure sodium and high-pressure mercury lamps were looked to as possibly cheaper alternative. In the entrance zone, for example, one or more continuous lines of these lamps are normally employed. And in the interior zone one or two broken lines would serve, with the maximum luminaire spacing being determined by the luminance and luminance uniformity required and the degree of glare considered acceptable. The choice was between monochromatic sodium light or the 50 per cent less efficient mercury lamp with its better colour rendering. When, in 1968, the high-pressure sodium lamp with its much-improved colour rendering and an efficiacy of 110 lm/W was introduced (and later, in 1975, the 100 W and 150 W versions in particular), the lighting in the interior zone underwent an interesting development (Fig. 8).

By employing the HPS lamp in mass-produced road lighting optics, their installation efficiency, expressed in terms of road-surface luminance per watt, approaches that of a conventional LPS installation. This is because in 'conventional' (transverse) installations an additional lighting component plays a role, namely the optical system determining how the light is distributed in the different directions.

For the lighting in the interior zone, one can distinguish between two types of light distribution (Fig. 9).

A. Transverse light distribution

Here the light is radiated mainly at right angles to the axis of the tunnel, the most familiar example being the continuous TL line. This optical system is very suitable for linear sources such as TL and LPS.

Advantages:

- visual guidance by light line formed by end-to-end or closely-spaced luminaires
- minimum glare
- good light between vehicles, even with high traffic densities
- simple night-time and emergency switching
- simple optics

Disadvantages:
- many luminaires
- greater luminaire spacing gives uneven luminances
- less suited for use with point sources, such as HPS tubular lamps
- more chance of flicker effect

B. Longitudinal light distribution

Here the light is radiated more or less parallel to the tunnel axis. This optical system is very suited for use with point light sources such as the HPS tubular lamp, but also with linear lamps such as LPS.

Advantages:
- luminance efficiency up to twice that of type A with the same lamp, depending on the road surface
- larger luminaire spacing, and thus fewer luminaires

Disadvantages:
- the results are less easy to predict
- unsuitable luminaires or too much tilt can cause glare
- vehicles screen off the light more, which means that this lighting is more suitable for low traffic densities, possibly with higher speeds
- uneven wall lighting
- switching is only possible with double-lamp luminaires or dimming ballast luminaires

With the longitudinal light distribution the reflectance properties of the road surface are used to increase the installation efficiency, just as is done in road lighting. However, this calls for a sound knowledge of road surfaces. The PIARC/CIE Publication No. 66 (1984) furnishes the necessary information on this point.

Lighting Design and Overall Tunnel Management

Starting with the initial planning, decisions are often unwittingly made that could influence the operating costs of the lighting installation. Take, for example, the influence of traffic speed or toll gates and the use of daylight louvres. And then there is the influence that the geographical orientation of the tunnel entrance has on light adaptation, the preference being for darker materials outside the tunnels entrance and light walls within. A light-coloured concrete road surface can, for example, give an improvement of more than 200 per cent in the efficiency of the lighting installation compared with that obtainable with dark asphalt. The lighting level needed at the tunnel entrance is often determined by the accepted practice locally and by the local economy, and to a lesser extent by the criteria mentioned above. The new CIE Publication No. 26, Draft 6, distinguishes between the effectiveness of light distributions, especially those employed in the entrance zone.

This CIE publication also suggests that measurements of the anticipated daylight adaptation situation for traffic approaching the tunnel entrance should first be made over a long period before actually designing the lighting installation. This can yield information from which the maximum desirable entrance level and the most economical switching levels can be determined. With regard to safety, a seldom employed but nevertheless economical alternative where there is too much daylight or not enough artificial light at the tunnel entrance, is to lower the permitted traffic speed. Subsequent measurements can serve to bring about an improvement in the switching arrangement and in the maintenance program, as for instance, relamping.

If, during the planning stage, due account is taken of what has been said above about tunnel lighting design, the result will almost inevitably be a simpler and cheaper tunnel management program.

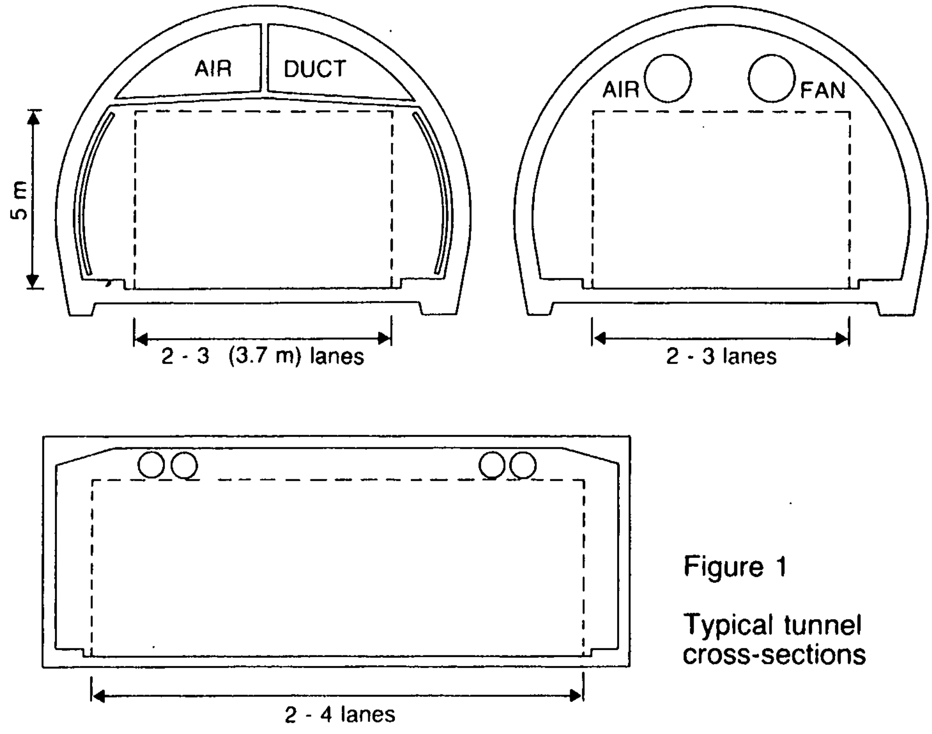

Figure 1

Typical tunnel cross-sections

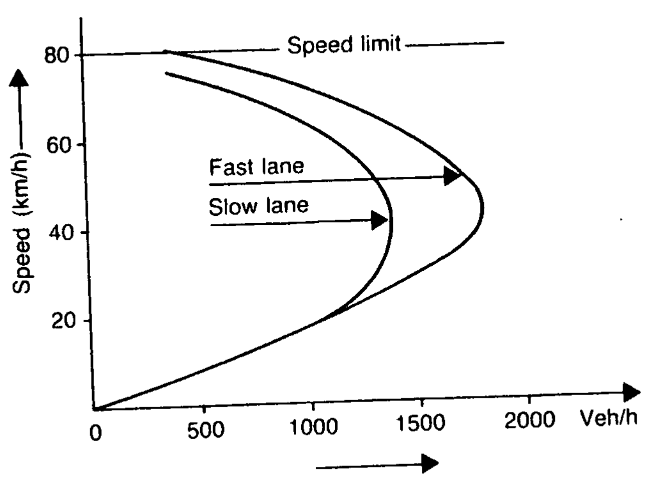

Figure 2 Car capacity per lane veh/h.

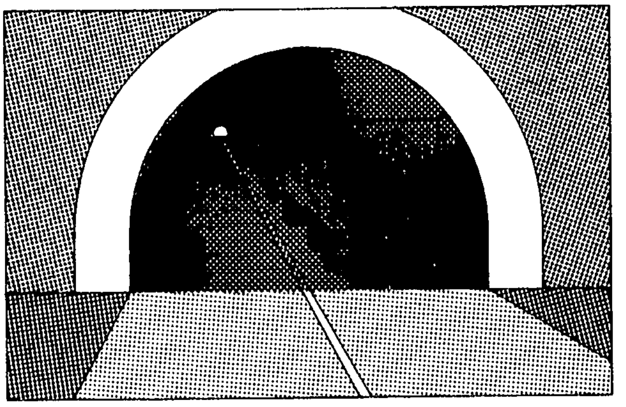

Figure 3 The blackhole of an inadequately lit tunnel

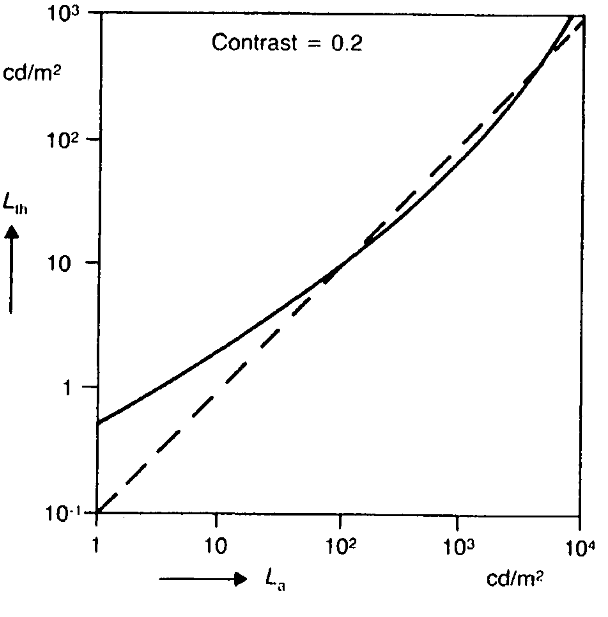

Figure 4 The luminance L_{th} needed in the threshold zone, as a function of the outside adaptation luminance L_a.

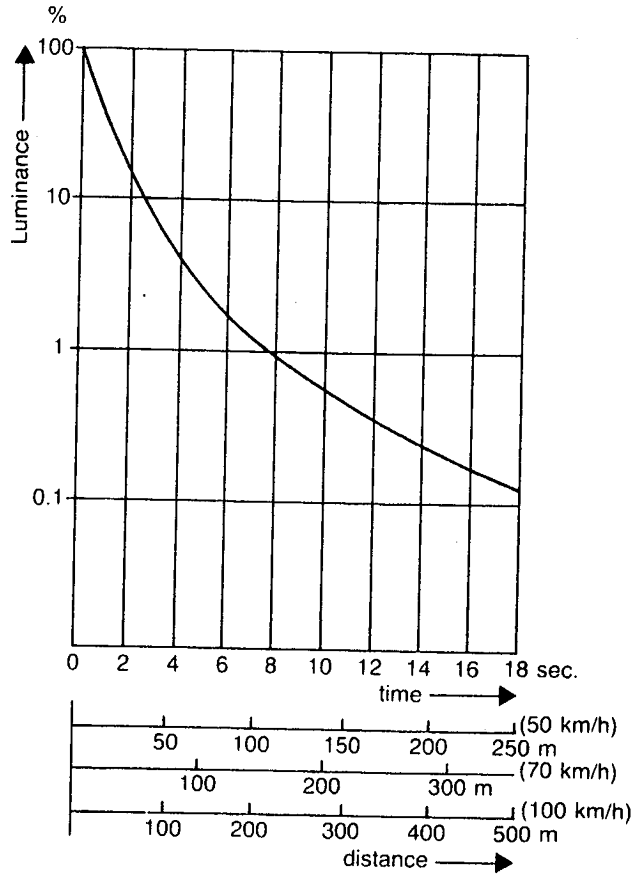

Figure 5
Luminance reduction curve of the transition zone.
Source: CIE 1973.

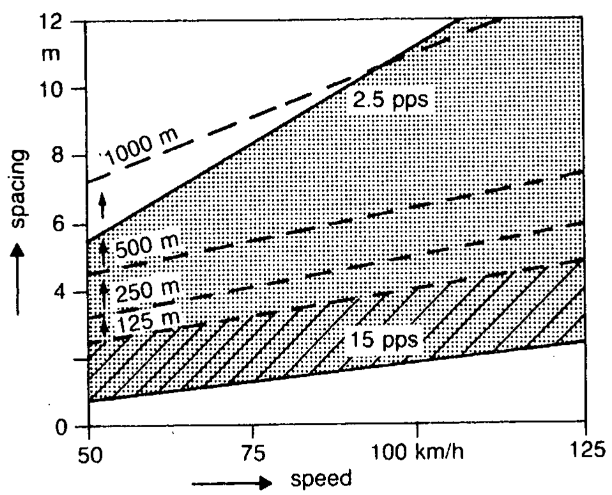

Figure 6 Forbidden luminaire spacing (shaded area) as a function of driver speed needed to avoid disturbing flicker in a tunnel (CIE).
And the effect of the length on it.
(Walthert; broken line)

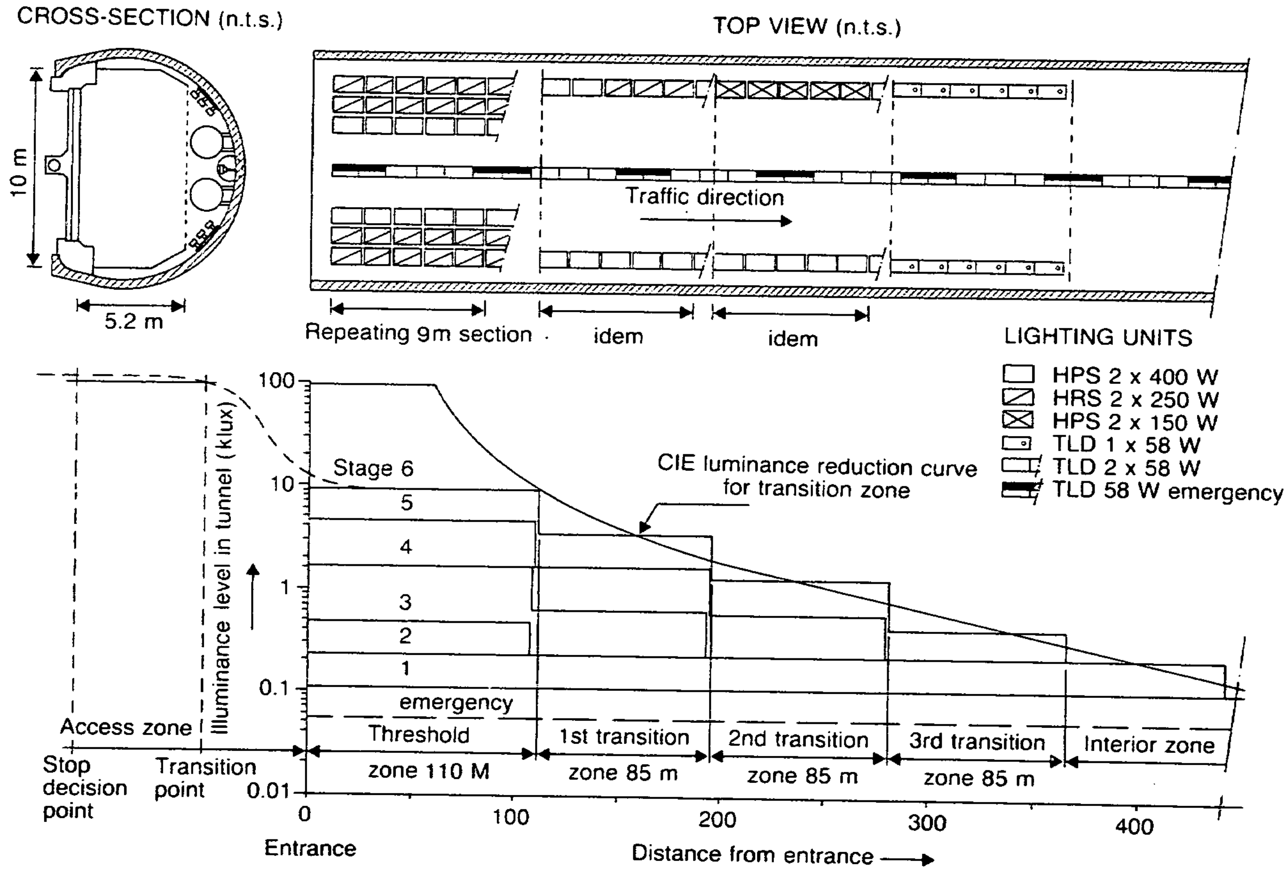

Figure 7 Tunnel lighting layout and illuminance levels

Lighting	Past	Present	Future
			More electronic gear
Basic	(1970)	(1983)	
	TL 70 lm/W	TLD-HF	100 lm/W
+	TLM 67 lm/W	TLD-HF 95 lm/W	
	+Dim-Rack	+Dim-Gear	
Interior zone			
	LPS 35/90W 115 lm/W	LPS 35/90W	
		(1984) LPS(E) 26/66W Hybrid 135 lm/W	180 lm/W
		(1985) HPS-T 100/150W	100 lm/W
Entrance zone	LPS 35/180W 140 lm/W	LPS 35/180W Hybrid Autoleak	200 lm/W
	(1968) HPS-T 250/400W	HPS-T 250/400W (50% or Dim-Rack)	130 lm/W (Cont. dimming)
	Daylight	Screened and	Regulated

Codes:
TL = tubular fluorescent lamp
LPS = low-pressure sodium lamp
HPS = high-pressure sodium lamp

Fig. 8 Lamps and gear used in tunnel lighting

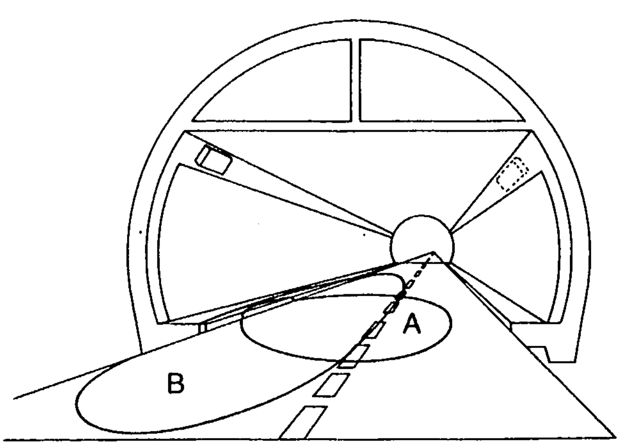

Figure 9 ISO lux curves for a type A and B light distribution

Paper No. 12

Development Plans for Kowloon Canton Railway Corporation

Speaker: Mr. P. V. Quick, Managing Director, KCRC

DEVELOPMENT PLANS FOR KCRC

1. **Introduction**

2. **History and Progress To Date**

   – KCRC Electrification

   – LRT Project

3. **Current Plans**

   – LRT Extensions (Regional)

   – LRT Extensions (Urban Link)

   – KCRC Expansion

4. **A Look to the Future**

   – Long-Term Developments

   – Ma On Shan Light Rail

   – Tate's Cairn Rail Tunnel

5. **Summary**