AGENDA AND PROGRAMME
39th CONVENTION
11th to 14th May, 1965
at PORT ELIZABETH

YEARS

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JARE

THE ASSOCIATION OF MUNICIPAL ELECTRICITY
UNDERTAKINGS OF SOUTHERN AFRICA

DIE VERENIGING VAN MUNISIPALE
ELEKTRISITEITSONDERNEMINGS VAN SUIDELIKE AFRIKA

AGENDA EN PROGRAM
39ste KONVENSIE
11de tot 14de Mei, 1965
te PORT ELIZABETH

AGENDA AND PROGRAMME:

MONDAY, 10TH MAY, 1965:

9.30 a.m. - 4.30 p.m.	Meeting of Executive Council at Marine Hotel.
5.30 p.m. - 7.30 p.m.	Civic Welcome and Cocktail Party.

TUESDAY, 11TH MAY, 1965:

8.45 a.m.	Registration and Issue of Badges.
9.30 a.m.	Opening Prayer. Welcome to Port Elizabeth by His Worship the Mayor of Port Elizabeth. Official opening of the Convention by Dr. E. J. Marais, Principal of the University of Port Elizabeth. Ratification of actions of Executive Council. Induction of President. Venue of next Convention. Election of President-Elect.
10.30 a.m.	Refreshment Interval.
11.00 a.m.	Apologies and Greetings.
11.15 a.m.	Presentation (Past President's Medal and Certificate).
11.30 a.m.	Election of Executive Council.
11.45 a.m.	Presidential Address.
12.45 p.m.	Luncheon Adjournment.
2.30 p.m.	Paper : "Transmission and Distribution Line Equipment" by Mr. A.A. Middlecote, South African Bureau of Standards.
3.30 p.m.	Refreshment Interval.
4.00 p.m.	Discussion on Paper.
4.30 p.m.	Discussion on Curtailment of Conventions.
5.30 p.m.	Adjournment.
7.00 p.m.	Braaivleis/Sundowner Party at Uitenhage.

WEDNESDAY, 12TH MAY, 1965:

8.30 a.m.	Meeting of Executive Council at Conference Centre.
9.30 a.m.	Convention resumes. Communications from Council. Paper: "Transformer Noise and its Reduction in Situ" by Professor G. R. Bozzoli, Professor of Electrical Engineering, University of the Witwatersrand.
10.30 a.m.	Refreshment Interval.
11.00 a.m.	Discussion on Paper.
12.30 p.m.	Luncheon Adjournment.
2.30 p.m.	Visit to Industries.
8.15 p.m.	Members' Forum - Venue City Hall.
10.00 p.m.	Refreshments.

SAKELYS EN PROGRAM:

MAANDAG 10 MEI 1965:

9.39 vm. - 4.30 nm.	Vergadering van Uitvoerende Raad in die Marine Hotel.
5.30 nm. - 7.30 nm.	Burgerlike verwelkoming en skemerpartytjie.

DINSDAG 11 MEI 1965:

8.45 nm.	Registrasie en uitreiking van kentekens.
9.30 vm.	Openingsgebed. Verwelkoming in Port Elizabeth deur Sy Edele die Burgemeester van Port Elizabeth. Amptelike opening van die Konvensie deur Dr. E.J. Marais, Rektor van die Universiteit van Port Elizabeth. Bekragtiging van optrede van Uitvoerende Raad. Bevestiging van President. Vergaderplek van volgende Konvensie. Verkiesing van aanstaande president.
10.30 vm.	Pouse vir verversings.
11.00 vm.	Verskonings en groete.
11.15 vm.	Aanbieding van Medalje en Sertifikaat aan aftredende president.
11.30 vm.	Verkiesing van Uitvoerende Raad.
11.45 vm.	Presidentsrede.
12.45 nm.	Verdaging vir middagete.
2.30 nm.	Referaat: "Toerusting vir Transmissie en Distribusie lyne" deur Mnr. A.A. Middlecote, S.A.B.S.
3.30 nm.	Pouse vir verversings.
4.00 nm.	Bespreking van referaat.
4.30 nm.	Bespreking oor besnoeiing van konvensies.
5.30 nm.	Verdaging.
7.00 nm.	Braaivleis/skemerparty te Uitenhage.

WOENSDAG 12 MEI 1965:

8.30 vm.	Vergadering van Uitvoerende Raad by die konferensie lokaal.
9.30 vm.	Voortsetting van konvensie. Mededelings van die Uitvoerende Raad. Referaat : "Transformator geraas en die demping daarvan in posisie" deur Prof. G. R. Bozzoli, Professor van Elektrotegniese Ingenieurswese, Universiteit van Witwatersrand.
10.30 vm.	Pouse vir verversings.
11.00 vm.	Bespreking van referaat.
12.30 nm.	Verdaging vir middagete.
2.30 nm.	Besoek aan Nywerhede.
8.15 nm.	Lede Forum - Vergaderplek Stadsaal.
10.00 nm.	Verversings.

THURSDAY, 13TH MAY, 1965:

9.30 a.m.	Convention resumes. Annual Report of Secretaries. Appointment of Auditors. Amendments to Constitution of Association as proposed by Sub-Committee appointed by the Executive Council and annexed to this Agenda. Discussion on Reports of Sub-Committees and Representatives. Discussion on Papers.
10.30 a.m.	Refreshment Interval.
11.00 a.m.	Paper : "Some Notes on Tariffs" by Mr. W.H. Milton, Chief Commercial Engineer, Electricity Supply Commission.
12.30 p.m.	Luncheon Adjournment.
2.30 p.m.	Paper : "Maintenance of a Distribution System" by Mr. M.J. Chappel, Port Elizabeth Electricity Department.
3.30 p.m.	Refreshment Interval.
4.00 p.m.	Discussion on Papers.
5.00 p.m.	Adjournment.
7.00 p.m. for 7.45 p.m.	Banquet at Showground Hall. Commemoration of 50th Anniversary of Founding of Association.

FRIDAY, 14TH MAY, 1965:

9.30 a.m.	Convention Resumes. Communications from Council. Discussion of Papers and Reports. General.
10.30 a.m.	Refreshment Interval.
11.00 a.m.	Closing Session.
12.00 noon	Meeting of Executive Council at Marine Hotel.
Afternoon	Visits to local Power Stations, Distribution Load Centres and Factories can be arranged after adequate notice.

DONDERDAG 13 MEI 1965:

9.30 vm.	Voortsetting van konvensie. Jaarverslag van sekretarisse. Benoeming van ouditeurs. Wysigings aan grondwet van die Vereniging soos voorgestel deur die Sub-komitee deur die Uitvoerende Raad benoem en aan Sakelys aangeheg. Bespreking van verslae van Sub-Komitees en Verteenwoordigers. Bespreking van referate.
10.30 vm.	Pouse vir verversings.
11.00 vm.	Referaat:"Aantekeninge oor Tariewe" deur Mnr. W.H. Milton, Hoof Handelsingenieur, E.V.K.O.M.
12.30 nm.	Verdaging vir middagete.
2.30 nm.	Referaat: "Instandhouding van 'n benettingstelsel" deur Mnr. M.J. Chappel, Elektrisiteitsafdeling, Port Elizabeth.
3.30 nm.	Pouse vir verversings.
4.00 nm.	Bespreking van referate.
5.00 nm.	Verdaging.
7.00 nm. vir 7.45 nm.	Banketete in die saal, Tentoonstelling Gronde, ter viering van 50ste stigtingsverjaardag van die vereniging.

VRYDAG 14 MEI 1965:

9.30 vm.	Voortsetting van konvensie. Mededelings van die Uitvoerende Raad. Bespreking van referate en verslae. Algemeen.
10.30 vm.	Pouse vir verversings.
11.00 vm.	Afsluiting.
12.00 middag	Vergadering van Uitvoerende Raad by die Marine Hotel.
Namiddag	Besoeke aan plaaslike Kragsentrale, distribusie vragpunte of nywerhede kan gereël word indien vroegtydig aangevra.

LADIES PROGRAMME:

MONDAY, 10TH MAY, 1965:

5.30 p.m. - 7.30 p.m.	Civic Welcome and Cocktail Party.

TUESDAY, 11TH MAY, 1965:

8.45 a.m.	Assemble for Registration, Issue of Badges, Opening Prayer, welcome to Port Elizabeth and Official Opening of Convention.
10.30 a.m.	Refreshments.
11.00 a.m.	Apologies and Greetings.
11.15 a.m.	Presentation of Past President's Medal and Certificate.
11.45 a.m.	Presidential Address.
Afternoon	Visit to Factories or "Free".
7.00 p.m.	Braaivleis/Sundowner Party at Uitenhage.

WEDNESDAY, 12TH MAY, 1965:

9.15 a.m.	Bus trip around the Marine Drive and tea party with Mayoress.
Afternoon	Visit to Factories or "Free".

THURSDAY, 13TH MAY, 1965:

9.15 a.m.	Suburban bus trip visiting parks and places of interest.
Afternoon	Free.
Evening	Banquet at Showground Hall to commemorate 50th Anniversary of Founding of Association.

FRIDAY, 14TH MAY, 1965:

10.30 a.m.	Assemble for Refreshments and Closing of Convention.
Afternoon	Visits and Tours can be arranged for any who would like further outings, after adequate notice.

PROGRAM VIR DAMES:

MAANDAG 10 MEI 1965:

5.30 nm. - 7.30 nm.	Burgerlike ontvangs en skemerpartytjie.

DINSDAG 11 MEI 1965:

8.45 vm.	Sametrek vir registrasie, uitreiking van kentekens, openingsgebed, verwelkoming in Port Elizabeth en amptelike opening van konvensie.
10.30 vm.	Verversings.
11.00 vm.	Verskonings en groete.
11.15 vm.	Aanbieding van medalje en sertifikaat aan aftredende president.
11.45 vm.	Presidentsrede.
Namiddag	Besoek aan nywerhede of eie keuse.
7.00 nm.	Braaivleis/skemerparty te Uitenhage.

WOENSDAG 12 MEI 1965:

9.15 vm.	Bustoer langs die strandpad en teeparty met Burgemeestersvrou.
Namiddag	Besoek aan nywerhede of eie keuse.

DONDERDAG 13 MEI 1965:

9.15 vm.	Voorstedelike bustoer met besoeke aan parke en interessante plekke.
Namiddag	Eie keuse.
Aand	Banketete in die saal, tentoonstellingsgronde ter viering van 50ste stigtingsverjaardag van vereniging.

VRYDAG 14 MEI 1965:

10.30 vm.	Sametrek vir verversings en afsluiting van die konvensie.
Namiddag	Toere en besoeke vir diegene wie nog uitstappies verlang, kan gereël word mits vroegtydig aangevra word.

TRANSMISSION & DISTRIBUTION EQUIPMENT

by

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1. GENERAL

We live in a world of rapid technological development and enormous increase in technical knowledge, accompanied unfortunately by a serious lack of qualified personnel. Nowhere is this brought home more clearly than here in the Republic where the present rate of increase in industrial activity is about 20 per cent per annum - or put more clearly it is such that it will double itself every 3¾ years. Such development requires an influx of at least 15 per cent of new blood to any level of employment. In the case of electrical engineers the universities are turning out about 3.5 per cent increase per year. If this figure is added to the most optimistic estimate of that due to alternate entries to the profession, including immigration, one obtains a figure of 7 per cent - about half of the percentage actually required.

We are all aware that this problem is being faced by the universities in producing more engineers, by the technical colleges in producing more technicians, and by Industry in the utilization of the different categories of employees at their proper level and in the application of the latest technological developments to bring about increased productivity. However, it must be realized that there is no single solution to the problem - every avenue which can lead to increased production of engineers and also to an increase in the productivity of the individual must be explored.

It is the purpose of this paper to examine the best means of presenting the latest technological developments to the electrical engineer so that he may produce the best economic design with the maximum saving of man-hours on his own part. The field has been limited to distribution and transmission equipment, and as the writer is himself connected with standardization there is naturally a bias towards the part that standards play. But it must be emphasized that standards are not an expression of the individual. They represent the co-ordinated and balanced opinion of those concerned with research, development, design, operation, and maintenance and should be presented in such a form that when applied by the practising engineer they ensure that he is working to latest consolidated practice while being spared the almost impossible task of reading the large numbers of technical papers produced today. Just as the useful history book records only significant and important facts among many historical incidents so the standard records the essentials among the many technical developments. Standards record the successful products of research once they have passed through the stages of development, design, production and application. They also are influenced by the feed-back from the construction and maintenance engineer, and this aspect of a standard emphasizes the importance of the part that carefully kept records and statistics supplied by engineers play in standardization.

The value of controlled records of the actual performance of a commodity in assessing the worth of a standard for that commodity can perhaps be best illustrated by the example of electric lamps. The standard (which was framed on development and production and economics data) set a standard at 1000 hours for the life of such lamps when tested under laboratory conditions. A certain town electrical engineer, now retired but well-known to all of you for his interest in these matters, instituted a system of records reflecting the life of such lamps under operating conditions. His figures over a certain period compare well with those obtained under laboratory conditions for the same production period. Table I gives a comparison of the sets of figures. As laboratory tests are usually stopped at 1250 hours the correspondence is closer than appears at first glance.

TABLE I

Wattage of lamps	Life under service conditions		Life under laboratory conditions	
	Number of lamps	Average life, hours	Number of lamps	Average life, hours
100	14 598	1 747	105	1 217
200	3 810	1 734	60	1 228
300	306	1 499	15	1 171
500	1 157	1 530	15	1 221

This example might appear almost too simple but has been selected because it shows clearly how well-kept records can provide good feed-back information for a standard. Such records are not only useful to the maintenance engineer; they can also be his contribution towards more successful and reliable standards for the community.

2. GENERAL HELP AVAILABLE FOR DESIGN OF DISTRIBUTION AND TRANSMISSION SYSTEMS

The particular field of distribution and transmission equipment has been selected as the subject of this paper because it is a clearly defined field and one where the practising engineer can be saved much labour by using information and facilities that are readily available. There are three main ways in which help can be given.

2.1 CODE OF PRACTICE.

Codes of practice are the foundation upon which any distribution or transmission system should be built. Basically such codes should draw attention to all Acts and Regulations which affect the system - the most important in the Republic being the Factories Act. They should also supply additional information on good practice and particularly on safety factors and basic factors such as wind load, which have to be borne in mind. They should also refer where possibie to standard specifications for material and equipment. Because of cross-reference to standard specifications and regulations, both of which must change with technological advance, it is essential for codes of practice to be dynamic and to keep pace with modern practice. The code of practice for overhead lines for conditions prevailing in South Africa is for this reason being revised by the South African Institute of Electrical Engineers. When complete it will be a valuable foundation for the design of any transmission or distribution system.

2.2 INSULATION CO-ORDINATION.

2.2.1 General.

In a country, with a high incidence of lightning, such as ours, most electric systems have to be designed to perform successfully under such conditions. There has been much test work and consequent development in this field, and the amount of technical literature is too large for the average engineer to read and sift to find a basis for any particular design on his part. In recent years there has been a tendency to consider this particular aspect under the heading 'Insulation Co-ordination'. It is possible that this aspect will be generally referred to in codes of practice, but pending such a decision and also because it is a subject with which many engineers are not familiar it is intended to discuss the subject in some detail.

Insulation co-ordination consists of the steps taken to prevent damage to electrical equipment due to over-voltages and to localize flashovers (when they cannot be economically prevented) to points where they will cause no damage. It is accomplished by establishing the necessary correlation between the insulation strength of electrical apparatus and the characteristics of the protective devices against over-voltages - as essentially characterized by an impulse withstand level and an impulse protection level respectively.

2.2.2 Overhead Lines.

The design of an overhead line is usually considered separately from that of any electrical equipment associated with it though it must be realized that the characteristics of the line have an important bearing on the equipment insulation and on the application and protective level provided by lightning arresters.

The choice of line insulation is determined largely by the degree of lightning immunity required, but considerations of the probability of contamination of the insulation are also important. At the very high voltages well designed lines are substantially lightning-proof but at the lower voltages, such as most practising engineers are concerned with, the necessary insulation to make the line lightning-proof is not economically justified. The main consideration in such cases is the selection of insulation to prevent power frequency line flashover under the worst weather and contamination conditions.

Properly located earth wires can intercept as much as 99.8 per cent of lightning strokes to a transmission line and much can be done by means of such wires to make a line immune to lightning. The angle of protection (i.e. the angle with respect to the vertical plane through the earth wire) required for earth wires to be effective is usually taken as 45°, but there is a strong school of thought that prefers 30°. The success of earth wires depends in turn on the tower or pole footing resistance. For instance, by computation a 66kV line with steel towers having a footing resistance of 100 ohms might have a flashover probability of 19 per 100 miles per year. If the footing resistance is reduced to 40 ohms, the probability will be reduced to 9 per 100 miles per year. It is interesting to note that if the insulation is increased by using wood structures the values given above would be reduced respectively to 9 and 3 per 100 miles per year - a point in favour of the use of wood.

Every electricity undertaking concerned with transmission and distribution of electricity in areas where lightning storms occur should keep accurate records to reflect outages of overhead lines due specifically to lightning. Such records are invaluable in the evaluation of different methods of making a line lightning-proof. For country-wide comparison of these figures it is necessary to have some measure of the occurrence of lightning in the different parts of a country. In the past lightning occurrence was given in terms of the number of thunderstorm days or hours. A better basis of comparison is the number of lightning strokes to earth. Lightning flash counters have therefore been developed and are in use in several countries. Authorities in the Republic are strongly urged to develop and work to counters of this type in the future.

2.2.3 Equipment Co-ordination.

The choice of equipment insulation depends on the magnitude of any surge voltage which the protective device, usually lightning arresters, allows to reach such equipment. This means that the protective device must be such that it is able to withstand any surge and, by discharging it to earth, to reduce its voltage peak to such a value that the equipment insulation can withstand without damage. It must be realized that the lower the value of the surge voltage allowed through, the higher the cost of the protective device. On the other hand, the higher the impulse withstand level of the equipment to be protected, the higher its cost. Insulation co-ordination seeks to find the most reliable and yet economic answer to this problem. It is a fine example of co-operative standardization.

While there are many national recommendations on insulation co-ordination, perhaps the most useful documents available at present are those issued by the International Electrotechnical Commission (IEC). These are based on international agreement by experts in the field, many decisions being made as a result of the work of study groups and discussions by experts at the International Conference on Large Electric Systems (CIGRE). These documents will be referred to as specific points are discussed.

(a) Basic impulse levels of equipment.

IEC Publication 71 'Recommendations for insulation co-ordination' has as its object the standardization of specification of the insulation of the various types of electrical equipment (such as transformers and switchgear) to be used in electrical installations. There are two series given: Series I, based on current practice of a group of European countries; and Series II, based on that of the USA and Canada. Thus for example Series I requires that for an installation having a highest system voltage of 12kV, equipment should have an impulse withstand level of 75kV. Our so-called 11kV system could be said to fall under this. On the other hand our 11kV might also be considered under the 15.5kV Series II class, which requires an impulse withstand level of 95kV. In fact the stronger opinion in this country, headed by the Electricity Supply Commission (ESCOM), favours the acceptance of the 95kV impulse level.
For all the standard ranges of system voltages used in the Republic it is essential that we establish a series of corresponding basic impulse levels, based on those given in the IEC publication and largely determined by the experience of the larger consumers such as ESCOM. This will result in rationalization of the manufacturing industry with consequent economic advantage to the consumer. It will also lead to simplification in the manufacture, supply, and specification of lightning arresters since arresters will be needed to protect to the relevant level apparatus of a standard impulse withstand level. This is a basic job which must be done soon.

(b) Impulse protection level of arresters.

Having established the basic impulse level for equipment, it is necessary to co-ordinate the performance of lightning arresters so that for equipment with a specific withstand level an arrester with a sufficiently low protective level may be selected. Here again in IEC Publication 99-1 and 99-2 'Recommendation for lightning arresters' protection levels for different ratings of arresters are given. It is worth noting that as a general rule the protective levels are 20-50 per cent lower than the probable withstand levels of the equipment they are intended to protect and are the maximum values. Individual makes might well give lower protective levels.

Perhaps at this stage a description of what determines the protective level of an arrester should be given.

When a surge reaches an arrester and causes it to operate, the peak value of the reduced surge that is allowed to continue along the line is determined by two factors:

1) The point on the voltage wave when the arrester gaps spark over, thus preventing any further increase in voltage;

2) the voltage drop across the arrester while it is discharging the surge current. This is equal in magnitude to the product of arrester impedance and the discharge current.

For the purpose of co-ordination the protective level is taken as the higher of these two values when tested under standard conditions, the standard impulse wave being used to determine voltage sparkover (1) and the nominal discharge current to determine the residual voltage (2).

It might perhaps be pointed out that the actual sparkover voltages and the residual voltages in practice are determined also by the characteristics of the transmission line. These characteristics determine the steepness of wavefront and the voltage peak of the surge voltage and the actual discharge current once the arrester is valved off.

(c) Correlation between equipment and protective devices.

Accurate correlation between the equipment and the protective devices on a complex system is the work of a specialist, but the IEC has produced a supplement to Publication 71 - Publication 71A which is the 'Application guide'. This publication gives the following simple rules that are of benefit to the average practising engineer:

The initial step is the determination of the ratio of the impulse withstand level to the impulse protective level. The precise value of this ratio can be determined only after calculation and test, the various parameters involved being taken into account. In the absence of a precise determination one should, in the case of an arrester placed as close as practicable to the equipment to be protected, aim at a ratio of the order of 1:4 in the lower voltage range. Of particular importance to the Republic is the correction necessary for altitude. In the case of external insulation of equipment the impulse withstand level decreases according to the density of air (1.25 per cent per 100 metres between 1000 and 3000 metres) while the protective level of air-light arresters is not influenced. Allowance must always be made for this.

(d) Protective zone.

The best protection for a particular piece of equipment is generally obtained by placing the protective device as close to it as practicable. If the arrester is positioned so that the time of propagation along the conductor between the arrester and the equipment to be protected is not negligible compared with the front duration of the impulse wave, the voltage at the equipment terminals will be higher than the protective level of the arrester. This increase in voltage depends on the distance between arrester and equipment; the characteristics of the line (which will tend to decrease the voltage); the capacitance of the equipment being protected (which will tend to increase the voltage); the total capacitance of the station apparatus; and the steepness of the incoming wave.

The protective zone of an arrester is therefore internationally defined as the length of conductor between arrester and equipment that corresponds to an increase in the voltage at the terminals of the equipment equal to the normal difference between the withstand and the protective levels. The length of the protective zone can be increased by -

1) any arrangement which reduces the steepness of the wavefront of the surge arriving at the station (extension of earthing or shielding wires; provision of localized capacitance; installation of cable; or where there are a large number of connected lines),

2) adoption of a lower protective level of arrester.

Methods for determining safe separation distances are under consideration in IEC Technical Committee 37, and the resulting recommendation will be a great help to the practising engineer. Discussions are also taking place in a study group of Committee 15 of CIGRE. Current discussions will be of value to the engineer who wishes at this stage to delve deeper into the subject. Meanwhile agreement on dispositions in important installations should be settled between the user and the lightning arrester manufacturer.

For simplification and easy reference the essentials of insulation co-ordination are given in Figure 1. Here it is shown how a surge which arises on an overhead line is modified in form by the characteristics of the line until it reaches a lightning arrester where it is reduced in magnitude to the protective level. The change in the value of this protective level from the arrester to the equipment to be protected is also given.

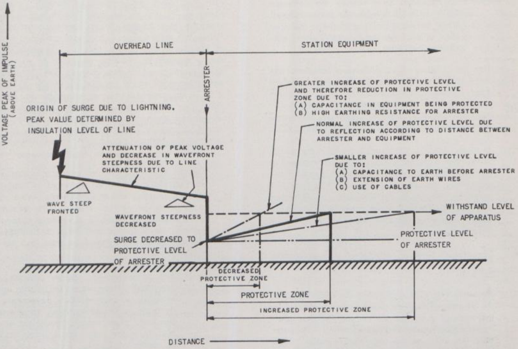

FIGURE. I DIAGRAMMATIC REPRESENTATION OF THE ELEMENTS OF INSULATION CO-ORDINATION

2.3 STANDARD SPECIFICATIONS.

The most general help given is in the form of standards for materials, components, apparatuses, and trade methods used on transmission and distribution systems. It is perhaps unfortunate that one of the engineers' greatest attributes, his individualism, makes him reluctant to use standards as freely as he should; he should however realize that standards are not arbitrary bureaucratic dictates but the result of the co-operative work of individualists like himself and exist to save him valuable time and to effect economies. Simple reference to a standard should be all that is necessary, but not to an individual standard which makes only cursory reference to a national standard. The remainder of this paper is devoted to an examination of how standardization can be of help when dealing with the components of a transmission or distribution system under the headings of Poles and Transmission Towers; Insulators and Line Hardware; Lightning Arresters; Transformers; and Switchgear.

3. POLES AND TRANSMISSION TOWERS

Basically the design of poles and towers for transmission and distribution lines is a matter of general engineering design. In the case of large towers for the extra high voltage systems there is economically no doubt a good case for individual design, but there is possibly a strong case for the production of standardized poles and structures for the simpler lower voltage lines. However, such standardization is still a job for the future.

At present standards exist which are of great value in the design and specification of poles and transmission towers. We are all familiar with the standards available for the steel and non-ferrous metals and alloys used in their construction but perhaps less aware of the help available regarding anti-corrosion measures, timbers, and concrete poles.

3.1 PROTECTION OF TOWERS AGAINST CORROSION.

The most effective method of protecting steel against corrosion is to apply a comparatively thick layer of zinc over the entire surface. This layer is usually applied by dipping the cleaned and pickled components into a bath of molten zinc, leaving them there for a short period (usually a minute or two), and then withdrawing them slowly. The thickness of the zinc layer which remains on the steel is dependent on various factors, which are only partially under control. The layer is tightly adherent and actually consists of a zinc-iron alloy layer next to the steel base, the composition changing to almost pure zinc on the outside. The zinc protects by sacrificial action, that is to say that in a corrosive atmosphere the zinc, and not the steel, is attacked, so that the zinc slowly corrodes away. The zinc coating is capable of protecting bare areas, and areas where the coating may have been damaged.

For permanent outdoor structures a zinc layer at least 0.0035 inch thick is regarded as essential. This represents 2 oz of zinc for each square foot of surface. Under inland conditions steel having such a layer of zinc on it will last 20 years or more without any sign of rust.

At the coast a slightly thicker layer of zinc, at least 0.0040 inch is used, and a life of at least 15 years without any sign of rust may be expected.

Some years ago Escom realized that unless they erected transmission lines in such a way that they would stand for at least 20 years without any maintenance at all they would reach a state where most of their manpower would be devoted to maintenance and replacement. Escom thus approached the Bureau of Standards to co-operate with them in preparing a private specification for the quality of galvanizing on steel used for transmission lines. This resulted in their specification M1/1-2 against which all orders for galvanizing are placed. Arrangements were also made to have all consignments of galvanized commodities or components inspected by the Bureau to ensure that they did in fact comply with the requirements of the specification - a most important follow up. The result of this co-operation is encouraging. Something like 30,000 tons of galvanized steel have already been inspected and the standard of galvanizing in this country has been raised to a very high level indeed.

The Escom specification was so successful that various other organizations have asked and obtained permission to use it.

The South African Bureau of Standards is at present preparing a national standard based on the experience of Escom and when available this document will be a valuable aid to sound specification.

It must be noted that transmission towers which are to be galvanized should be designed in such a way as to facilitate sound galvanizing. Cavities which could entrap acid during pickling and air during galvanizing should be avoided or adequately vented and provision should be made for draining. Welds should be continuous and should seal all edges between overlapping or contacting surfaces so as to prevent the formation of crevices into which acid could seep and initiate corrosion after galvanizing or into which the liquid zinc could not easily penetrate. In addition, the dimensions of built-up welded units should not exceed the available working dimensions of the galvanizing baths available, and should be kept as small as possible.

Zinc may also be applied by spraying on site and this process can be very successful if the surface of the steel is well cleaned and prepared and a suitable thickness of zinc is applied. Zinc-rich paints may also be used to apply zinc to steel, but the resulting resistance to corrosion will not compare with that of hot-dip galvanizing.

Smaller articles such as bolts, nuts, and miscellaneous hardware may have zinc applied to them by a process known as sherardizing. This process gives an even layer of zinc, and has other advantages also. The zinc layer however is thinner than that obtained by hot-dip galvanizing.

The full value of a sound specification for galvanizing cannot be obtained unless it is followed up by a comprehensive consignment inspection to ensure compliance with the specification.

With regard to such inspection the most important part is visual inspection. The coating must be free from lumps, thin patches, ungalvanized areas, acid and black spots, flux, etc., and must be adherent, smooth and continuous.

The thickness is usually checked by use of simple non-destructive thickness gauges.

Small articles such as bolts, nuts, and miscellaneous hardware are subjected to a copper sulphate dipping test (the "Preece" test). It must be noted that it is not practicable to get a thick layer of zinc on bolts, nuts, etc., and one must be satisfied with 1 to $1\frac{1}{4}$ oz per sq. foot. For inspection of the smaller channels, beams, etc., items should be sampled statistically and the sample inspected; but larger sections should be subjected to 100 per cent inspection.

3.2 PAINTING OF TRANSMISSION LINE EQUIPMENT.

It is usual practice to protect steel or galvanized steel transmission line equipment against corrosion by the application of suitable paints. Although galvanizing of steel is in itself a protection of steel the life of the galvanized steel can be further extended by painting after erection. The zinc layer now protects both ways - it in itself prevents corrosion of the steel and in so doing prolongs the life of the paint film which corrosion of steel would normally lift. The final life of the zinc-paint system is thus far in excess of the combined lives of its two components. For instance, if under certain conditions a paint system would last two years and a zinc layer 15, then paint over zinc would have a life in excess of 15 + 2 years and probably close on 25 years. Even if no further paint is ever applied, the initial layer will extend the life of the structure for a considerable number of years.

In practice the painting of transmission line equipment may include transmission towers, poles, and cross-members, and transformers and switchgear in sub-stations.

To obtain the maximum life from paints and the best protection of steel it is of paramount importance that the steel should be properly prepared for painting. SABS 064-1960 'Code of practice for the preparation of steel surfaces for painting' gives precise instructions and is a complete guide to the engineer for the preparation and painting of steel surfaces for virtually all types of conditions normally encountered in the Republic.

The code refers to various paint specifications of the South African Bureau of Standards. Amongst these specifications engineers will find an adequate number of types of primers and finishing paint to choose from. All will give the desired protection.

These specifications and the code of practice are up to date representing accepted and tried methods of corrosion prevention, and there is no need for experimentation with 'miracle' paints. It is important for the engineer to realize that proper maintenance is a logical sequence to proper protection and as important to attaining an economical life from equipment as is the thorough preparation of surfaces and the use of quality paints and paint systems.

The following paint and primer specifications are available:

SABS 312	Red lead base primers for structural steel
SABS 436	Water-resistant aluminium finishing paint
SABS 630	Decorative high gloss enamel paints with a non-aqueous solvent base for interior and exterior use (2 grades)
SABS 631	Decorative oil gloss paint with a non-aqueous solvent base for interior and exterior use
SABS 679	Zinc chromate primers for steel
SABS 682	Finishing paint, aluminium type
SABS 684	Structural steel paint
SABS 723	Wash primer (metal etch primer).

3.3 WOOD POLES.

There is an increasing tendency to use wood poles for the construction of transmission or distribution lines mainly because of their relatively low cost and the facility they offer for climbing. They also improve the performance of a line under lightning conditions - most desirable property, the value of which is not always appreciated.

The most important requirement for wood poles is adequate strength to maintain the overhead lines under all operating conditions for a long period. While good appearance is desirable, this requirement should not be allowed to neutralize the fundamental advantage of the wood pole, namely its relatively low cost. When prohibited and permitted defects in poles are being considered, it must be borne in mind that unnecessary rejections will result in an unnecessary increase in cost.

Because of this inter-relationship of cost and requirements, the case of wood poles provides one of the best examples of the help provided by a national standard. In the Republic the two specifications SABS 753 'Wooden power transmission poles and cross-arms' and SABS 754 'Wooden telephone and general purpose electric light poles' give the requirements for a satisfactory product as determined by research workers of the Forestry Department and by timber technologists and practising engineers, bearing in mind the availability of wood in the Republic. All engineers are urged to work strictly to these specifications in order to use the natural resources of our country to the best advantage. In this connection the following points should be seriously considered:

(a) Availability of wood poles.

As indicated in SABS 753, Eucalyptus paniculata is the only local species of timber classed as AA. This species is grown only in the Transvaal and Zululand. Pinus canariensis and certain other eucalypts form the major supply of Class A poles. Eucalyptus saligna which is the main source of Class B poles is by far the easiest pole to obtain (277,848 acres of Eucalyptus saligna as compared with 14,734 acres of Pinus canariensis and 55,618 acres of eucalypts of Classes AA and A are given in 'Investigation of the Forest and Timber Industry of South Africa, 1960'). For this reason it is advised that wherever possible serious consideration should be given to specifying not only poles of Classes AA or A but also Class B poles of a larger diameter which will be in the same strength class as poles of Classes AA or A. (Equivalent diameters are given in SABS 753).

(b) Moisture content.

Most of the recognized pole producing timber species have non-durable heartwood. During the preservation process only the sapwood is freely penetrated. The heartwood is penetrated only a certain distance along the grain. If well impregnated sapwood, through further drying, is broken by the development of surface or end checks (known as post-impregnation splitting) the heartwood will be vulnerable to destructive agencies.

Research has shown that if the correct moisture content is ensured before impregnation, post-impregnation splitting will not occur. The correct value is ensured by measuring the average moisture content of a drilling from the outside to the centre and this value must be 25 per cent or below.

(c) Sapwood.

Since the sapwood is freely penetrated and therefore forms the main protective sheath, it is important that a pole should have a minimum radial width of half inch of sapwood. Care must be taken during impregnation and in handling treated poles to ensure that mechanical damage of the sapwood does not occur.

(d) Retention.

A good service life can be ensured only if a minimum weight of preservative is retained in the pole. A pole might appear to be thoroughly impregnated but might still be attacked in service if the weight of preservative retained is below a certain value. The SABS specifications require a retention of at least 5.5 lb/cub. ft. for hardwoods up to and including 5 inch diameter and 8.0 lb/cub. ft. for softwoods. The respective figures for diameter over 5 inch are 5.0 and 7.0. These figures are based on years of research by the Forest Research Institute at Pretoria West.

(e) Spiral grain.

Much work has been done in the ASTM Pole Research Program regarding the strength of poles containing spiral grain. The results have indicated that spirality does not seriously affect the strength of a pole. It does, however, affect the degree of twisting of the tops of the poles under varying weather conditions. Accentuated twist, as can be realized, will cause changes in the sag of the conductors. It is therefore important to limit spirality, and the limits established in the South African specification have been based on the work of P.M.D. Krogh of the Forest Research Institute, Pretoria.

(f) Crook and sweep.

Crook and sweep, like spiral grain, are not important as regards the strength of the pole. They are, important, however, in that they affect appearance and ease of construction. Although it is appreciated that most end-users prefer to have a pole as straight as possible, it has been found that a good compromise between what the tree can normally be expected to yield and what the end-user prefers is to allow crook and sweep to be 0.20 L inch, where L is the maximum deviation from the natural straight between two points (measured in feet) that are in line and on the inner surface of the curve. In poles, L is measured from a point not less than 4 ft. 6 in. above the butt-end of a pole. (The value for cross-arms is 0.15 L and for telephone poles 0.10 L.)

(g) Knots and knot holes.

The recommendations for the number and maximum size of knots considered permissible by the technical committee responsible for the preparation of the two SABS specifications were also based on observations made at the Forest Research Institute, Pretoria, during the breakage tests on full sized poles.

It must be pointed out that the visual grading of knots and the assessment of knots and their influence on strength must be regarded at best as inadequate; it is for this reason that before any species in the Republic is placed in a strength category exhaustive tests on the full size poles from many localities are carried out. In the case of poles approved by the SABS, these are normally graded by Bureau inspectors before being tested and some correlation between actual strength and defects such as knots is attained during the grading.

(h) Insulation value.

As already pointed out. wood poles have the additional advantage of increasing the impulse flashover value of a given line and therefore considerably reduce the probability of lightning outages. This is because breakdown has to take place through the air over the insulators and then through the wood structure. Thoroughly dry wood has an impulse flashover voltage closely approaching that of a rod gap of the same dimension (i.e. about 100 kV per ft.), but the actual value depends upon the condition of the wood and in the case of overhead line design the value appropriate to wet conditions should be taken.

Much work has been done in the United States of America as regards the surge strength of wood, and the following recommendations, given in the American Institute of Electrical Engineers (AIEE) Committee Report in 1956, are a valuable basis for design:

1) While not strictly a function of length or number of insulation units, the impulse insulation which wet wood can add to porcelain insulators will be from 20 to 100 kV per ft., depending upon the condition and arrangement of the wood.

2) Until more complete data are obtained, a value of 30 kV per ft. is suggested for the design of high voltage lines.

The SABS is doing test work to establish more reliable figures for South African wood and hopes to make comprehensive figures available soon. Tests done to date have indicated a figure of 125 kV per ft. for dry canary pine poles and 90 kV per ft. for wet canary pine poles. Other figures are 114 for wet saligna.

These figures would appear to indicate that for the present a figure of 30 kV per ft. could be used at present with confidence.

it is interesting to note that good service records kept by practising engineers in South Africa bear out these points. In the Annual Report of the Cape Northern Undertaking of Escom for 1963 the following interesting figures regarding outages on 132 transmission lines are recorded:

On $138\frac{1}{2}$ miles of 132 kV line of lattice steel construction from Grootkop to Kimberley there were 15.9 faults per 100 miles during 1963. On the 151.44 miles of 132 kV line on wooden structures from Kimberley to Sishen the incidence of faults was less than 1 per 100 miles during 1963.

These figures compare fairly well with general comparative figures given in a paper by Wagner, Witzke, Beck, and Teague (in the AIEE Transactions, December 1952) of 14 faults per 100 miles for steel structures and 4.2 faults per 100 miles for wood structures on 138 kV lines with footing resistances of 100 ohms.

The figures given in the Escom report are equally significant for other lines. On comparative 66 kV lines the fault incident was 19.9 per 100 miles per annum for a stretch of 166 miles of mixed steel, concrete, and wooden structures while the value was only 3.6 per 100 miles per annum for a stretch of 55.8 miles of line on wooden structures.

It must be stressed, however, that the insulation value of wood holds only when considering impulse breakdown. Wet wood has no insulation value when subjected to 50 cycle voltage. In fact the insulation provided by the porcelain insulators must be sufficient to ensure that the power frequency leakage current does not burn the wood at the point of attachment.

It is also necessary to protect wood pole lines in lightning areas by an earth wire, since otherwise direct strokes to any of the poles might seriously damage them. This does involve positioning of the phase conductors with reference to the down wire from the overhead earth wire to the physical earth, so as not to reduce the insulation provided by the wood.

The probability of running rural high tension overhead supplies with one phase earthed and run on the top of the poles so as to fulfil the dual function of "earth wire" as well as "phase wire" has many advantages. This practice is not favoured mainly because of the fact that earth leakage protection cannot be supplied. On the other hand it has economical advantages on wood pole lines in making such a line lightning proof.

4. INSULATORS AND LINE HARDWARE

The South African specification SABS 177-1963 'High voltage porcelain and toughened glass insulators' gives all the essential requirements to ensure a satisfactory insulator for normal duty. The designer of a line who uses this specification has only to select a suitable value for the minimum dry impulse flashover, the minimum wet power frequency flashover, and the minimum failing load from the relevant cables in the specification. The minimum failing load is a natural follow-up of the mechanical design of the line. The normal values for dry impulse and wet power frequency flashover for a line of given rated voltage are given in an Appendix to the specification but departures from these values will have to be made if conditions are in any way abnormal.

For example :

(a) Increase in altitude will require a correspondingly higher value for both the dry impulse and wet power frequency

(b) A decision to raise the immunity against lightning by raising the insulation level of the line would require a higher impulse flashover value to be assigned to the insulator.

(c) Abnormal pollution or fog conditions might require specification of a higher wet power frequency flashover value.

4.1 ESSENTIAL REQUIREMENTS OF THE SPECIFICATION.

While SABS 177-1963 covers all the essential requirements for a satisfactory insulator, SABS 178 'Dimensions of standard insulators and fittings for overhead power lines', which is in the course of preparation, will do much to improve maintenance and extension by ensuring interchangeability of insulators with particular reference to ball and socket and tongue and clevis details. It may be mentioned that the IEC recommendations regarding such details, which it is hoped will be finalized this year, will be followed in the Republic.

There are, however, three points not completely covered at present in our specifications but which will soon be finalized. These refer to pollution requirements, front of wave impulse testing, and anti-corrosion measures.

4.2 POLLUTION OF INSULATORS AND HARDWARE.

At present the wet power frequency flashover value is the only available standard criterion for performance of an insulator under polluted or foggy atmospheres. It is unfortunately not a very reliable criterion and much work is being done to establish better criteria and test methods. However, until these have been established and accepted we can only rely on the wet flashover value.

There are actually two different conditions which are classified as polluted atmospheres. The first is that due to an industrial atmosphere or socalled smog conditions. The second is that due to ocean salt spray. It can immediately be appreciated that to develop a single test method to assess the performance under both conditions will be a very difficult task. At present the only successful method is that of practical service exposure testing. Overseas such tests are done at special exposure points such as Croydon in England, Reeklinghausen in Germany, and Mons in France. Unfortunately tests based strictly on service take a long time.

Much work is being done to develop suitable artificial tests of which there are two main types. The first requires the deposition of an artificial industrial dust (often a mixture of kieselguhr, kaolin, and salts) on the insulator followed by measurement of the flashover voltage when such a coating is moistened either by formation of a dew when the insulator is suddenly cooled in a humid atmosphere or is operated in an artificial fog. This test tends to simulate industrial pollution conditions.

The second test is based on the performance of the insulator under a salt spray of varying salinity. The test tends to simulate coastal pollution but many consider that it will be of value for assessing performance under industrial pollution conditions as well.

The actual mechanism of flashover due to pollution is interesting and is the basis for a rational approach to testing. Leakage current across an insulator is always present, but the value depends on the surface conditions. Usually the basic level is about 5 milliamps. However, there are frequent surges of 50 - 150 milliamps randomly dispersed along this base. It has been indicated by some authorities that flashover is imminent if these surges exceed 100 milliamps. These surge characteristics result from non-uniformity and instability of surface films; for example, drying of a contaminated surface of an insulator at a certain point will suddenly cause that area to become a high resistance area and consequently a major portion of the applied voltage will appear across the area. This can cause sparking and an arc may develop which will spread to the terminals of the insulator, finally causing a flashover.

The question of pollution is not as important in the Republic as it is overseas since it is only in limited areas in the Reef complex where anything like a mild industrial atmosphere exists and on the coast, particularly at the Cape where ocean salt spray conditions exist. For this reason one can go on using the wet flashover, inadequate as it is, until a better test method has been developed. In addition information based on practical exposure tests or even a comparative assessment of measured creepage distances can be used. Creepage distance assessment is in fact used by many authorities, but it must be realized that other features, such as changes in contour, also have an effect. The test methods being developed overseas are being watched and will be used as soon as finality has been reached. From our point of view a salt spray test based on that being developed by the Central Electricity Research Laboratory in England is the most promising, since coastal pollution is our greater problem. In fact it is hoped that with the present approach to the smog problem in the Republic we shall never have to deal with a severe industrial pollution problem. The Bureau of Standards has started work on the salt spray test and should be able to help in this regard.

From the point of view of maintenance heavy rainfall is the best protection against pollution of insulators. Failing a heavy rainfall, frequent cleaning of insulators with a water spray has obvious advantages.

A design which leads to uniform cleaning of an insulator has advantages. Prevailing rains might clean only one side of an insulator leaving the other to build up a polluted surface. The careful design of the shed countour and spiral grooved insulators as developed i

contour and spiral grooved insulators as developed in Europe has advantages in this respect. A further approach to the problem of pollution is the use of silicone coatings. These reduce the currents flowing over a moist contaminated surface. The use of semi-conducting glazes to reduce radio interference also has a beneficial effect on operation in polluted atmospheres but much has still to be done to develop a glaze which does not corrode electrolytically.

4.3 STEEP FRONTED WAVES.

It is most important that an insulator when subjected to the most severe impulse overvoltages in service should always flashover before being punctured. This fundamentally requires a certain relationship between minimum thickness of insulation and the creepage distance.

Current specifications have approached this problem by including a puncture voltage test. This requires that the power frequency voltage which can puncture an insulator when immersed in oil shall be at least 1.3 times the flashover voltage. It is unfortunate that insulators are still punctured in service, despite this test, with the result that attention has been focused on the need for a more reliable test. At the same time the problem of service failures should not be exaggerated since these occur only under extraordinarily severe conditions.

One reason for the tendency to puncture in service is the fact that the steepness of the wavefronts of surges due to direct lightning strikes to a line are much higher than was thought to be the case when the 1/50 microsecond wave was accepted as the standard wave for impulse testing.

Consequently one approach has been to develop a steep fronted wave impulse test, which however requires a specially designed impulse generator and measuring techniques of an extremely high standard. Initial investigations required that such wave fronts should be of the order of 7000 kV per microsecond as compared with the range 500 to 1000 kV per microsecond which occur when using the standard impulse wave.

More recently the approach has been to subject an insulator to an impulse test while immersed in oil or pressurized gas so as to prevent surface flashover. In this manner a single shot puncture voltage versus time characteristic can be obtained and when this is correlated with the air flashover versus time characteristic it can be established whether puncture can take place. Most national committees of the IEC are working on tests of this nature and it is hoped that the IEC meeting in Tokyo in 1965 may indicate exactly what test will be internationally accepted. This will undoubtedly be the method adopted in the Republic.

There is however a more simple and direct approach to this problem which does not require the possession of a special impulse generator or special measuring techniques. It has been established by test that an insulator will not puncture if the ratio between the dry arcing distance and the minimum thickness of insulation is not greater than 5. Analysis of the design of an insulator to ensure that this ratio requirement is satisfied coupled with control tests to prove the quality of the porcelain or glass insulation can do much to ensure that an insulator will not puncture in service.

It was to a large extent consideration of this problem which lead to the development in Europe of the "langstab" or "long rod" insulator. This consists essentially of a long cylinder of ceramic provided with the usual series of "sheds" and this design results in such a low ratio between the dry arcing distance and the minimum thickness of insulation that the insulator may be considered unpuncturable.

Other advantages which such insulators have over the conventional disc type insulator are:

1) They offer less horizontal flat surfaces upon which pollution can settle than is

the case with the conventional disc insulator;

2) the design especially if helical sheds are used, can result in a completely self-cleansing insulator;

3) the voltage distribution across the insulator is better than is the case with disc insulators where the alternations of insulation and metalware result in unequal voltages across each disc;

4) corrosion troubles are reduced because there is less metalware.

On the other hand disc insulators still retain the following advantages:

1) They will not drop the line should the ceramic or glass shatter;

2) There is better standardization possible. By using a limited number of standard discs, the different values of power frequency flashover or impulse flashover required by the design of the overhead line can be obtained by varying the number of discs used.

3) Replacement of insulators, usually only one disc, is easier.

It will be interesting to see what the trend will be in the Republic during the next few years. To ensure that this trend will be in the best interests of the Republic engineers are urged to give serious consideration to the problem when viewing the merits and demerits of each type of insulator.

4.4 CORROSION OF HARDWARE.

The corrosion of insulator and associated hardware is a problem of particular importance in certain areas, notably those that fall under the definition of polluted atmospheres, whether industrial or coastal. In general, wrought iron and steel components are protected by means of galvanizing and much of what has been said in connection with galvanizing of steel structures holds here as well. In the case of insulators particular care must be taken since corrosion can in many cases (for example corrosion of the pin) cause the insulator ceramic to crack. The specification, however, covers all these aspects and any insulator which complies with it will give satisfactory service.

Corrosion of insulator hardware is often accelerated because of leakage currents and because of the ozone formed as the air breaks down at certain places. Design can often mitigate this.

The most important point regarding insulator hardware, however, is the selection of the correct material. Aluminium in contact with copper can corrode because of electrolytic action. When moisture is caught up in a blanket of dust or contamination surrounding the junction of these two metals, it forms an electrolyte with the salts in such a blanket. The two metals in contact themselves become electrodes and the metal which is anodic (in this case aluminium) becomes corroded. For this reason aluminium is never used in contact with copper.

This same argument holds for many dissimilar metals in contact with each other and used in a situation which can lead to electrolytic corrosion. Perhaps few of us realize that there is a virtual 'standard' to help ensure that we can steer clear of such trouble. Here I refer to the Electrochemical series. The more detailed series can be interpreted only by an expert taking into account all the conditions, but the simple one given in Table II can give the average practising engineer some indication of what dissimilar metals can be used under corrosive conditions; for example, if a fitting to clamp to an aluminium conductor is required a metal close to aluminium and preferably anodic (and therefore the one likely to be attacked) should be selected. It may be seen from the Electrochemical series that galvanized iron fittings or cadmium plated fittings should be satisfactory. Thus if copper has to be in contact with aluminium it may be used if the copper is successfully cadmium plated.

In addition to the Electrochemical series the Admiralty and Ministry of Supply Inter-service Metallurgical Research Council has produced a publication Corrosion and its prevention at bimetallic contacts issued by Her Majesty's Stationery Office, which is an extremely useful guide in the selection of dissimilar metals required to operate in contact.

Apart from corrosion due to bimetallic contact it is generally accepted that iron, steel, magnesium alloys, and unclad aluminium-copper alloys should not be exposed unless suitably protected. Finally, any alloy which is prone to stress corrosion should not be used on overhead lines. Certain brasses and bronzes are subject to such corrosion when manufactured in such a way that stresses are left in the component. When subjected to certain atmospheres such components might suddenly fracture because of what is known as stress corrosion.

5. LIGHTNING ARRESTERS

Much has already been said about the selection of suitable lightning arresters from the point of view of insulation co-ordination but there is more to lightning protection than specifying a suitable impulse protective level.

At present there is a national specification SABS 171 'Low voltage lightning arresters' available for easy reference. It is hoped that work will soon be begun on a specification for high voltage lightning arresters. This specification will undoubtedly be framed largely around the IEC recommendations as given in Publication 99 'Recommendations for lightning arresters'. Pending the issue of SABS specifications, engineers are urged to use this IEC recommendation as the basis of specifications. Unless an arrester is ordered to a sound specification and is correctly rated and installed, it is a waste of money to install it, since it will not give any real protection. In fact one could go further and say that unless the manufacturer can produce adequate data regarding tests on his product, or that an inspection is carried out to ensure compliance, or that the product is virtually underwritten because it bears a standardization mark, one will not be able to look upon such arresters as giving reliable protection.

The standardization mark is probably the most reliable assurance since it represents a continuous control on the characteristics of the arrester, but this facility will only be available for high voltage arresters when the national specification is available.

5.1 ESSENTIAL REQUIREMENTS.

The most important requirements to be covered by a specification are:

(a) Dry and wet withstand voltages.

These are similar to the requirements for insulators and are intended to ensure that the arrester itself will not break down in service.

(b) Power frequency sparkover voltage.

This is required to give a minimum value since it is not desirable that the arrester should operate on transient power frequency overvoltages and cause unnecessary outages.

(c) Impulse sparkover test and the residual voltage test.

These two tests ensure that the arrester will give a certain maximum protective level to the equipment it is required to protect.

(d) Operating duty test.

This test simulates the service operation of an arrester, by subjecting the arrester to 20 successive impulses or so-called artificial lightning surges, while the arrester is connected to a power frequency supply capable of providing the necessary power follow through current. After such a test the characteristics of (c) shall not have changed by more than 10 per cent, nor shall it have failed. This test is essential since in practice an arrester might successfully operate on a few occasions and then blow up or, worse still, the gaps incorporated might change to such an extent that the protective level of the arrester might become higher than the withstand level of the apparatus it is required to protect.

Other requirements (such as those for finish, workmanship, and materials like ceramics) are similar to those specified for most quality engineering products.

5.2 RATINGS OF ARRESTERS.

Arresters are rated for the normal voltage applied across them. However, in practice this voltage must be the maximum which can be applied to an arrester under normal or abnormal conditions of operation, including fault conditions, if damage to the arrester is to be avoided. Generally one considers this as the voltage produced between unfaulted phases and earth as a result of system earth faults. This in turn depends on the earthing of the supply system. Usually three systems are considered:

(a) Effectively earthed neutral system.

A system in which the coefficient of earthing does not exceed 80 per cent. The arrester should have a voltage rating of at least 80 per cent of the system phase-to-phase voltage.

(b) Non-effectively earthed neutral system.

A system in which neutrals are earthed through resistances or reactances such that the coefficient of earthing can exceed 80 per cent. This includes systems where neutrals are earthed through ground fault neutralizer coils. The arrester voltage rating should equal the highest phase-to-phase system voltage.

(c) Isolated neutral system.

The arrester voltage rating should be equal to or greater than the phase-to-phase system voltage.

IEC Publication 99 gives a very good table for selection of the correct rating. Under these rules, for example, a 9 kV rated arrester might be used on a 12 kV effectively earthed neutral system; a 12 kV rated arrester on a non-effectively earthed neutral 12 kV system; and a 13.6 kV rated arrester on an isolated neutral 12 kV system.

Once the correct rating of the arrester has been determined the corresponding protective level may be obtained for the purpose of insulation co-ordination. In specifications these are usually maximum values but in special cases, unusually low protective levels have to be specified by the purchaser. This might be necessitated by -

1) high prevailing earth resistances,

2) excessive separation between arrester and equipment,

3) low apparatus withstand level.

Finally any unusual system or service conditions should be brought to the attention of the supplier. The most obvious example is altitude. As previously mentioned, the impulse withstand of equipment, if determined by flashover, will decrease with increase in altitude. Arresters with sealed gaps will not change their characteristics with altitude but those with unsealed gaps will and these points must be considered when an arrester for operation at altitude is specified.

6. SWITCHGEAR

There is no South African standard for switchgear, but BSS 162-1961 'Electric power switchgear and associated apparatus' is available. In addition there are many IEC publications, the most important from the operating engineers' point of view being

Publication 56-4	Chapter III	Rules for strength of insulation
	Chapter IV	Rules for selection of circuit breakers for service
	Chapter V	Rules for the erection and maintenance of circuit breakers in service
Publication 129	Alternating current isolators	

Chapter IV gives an extremely good summary of the important features which have to be selected and clearly defined - preferably from a list of standards such as for rated voltage, rated current, and rated breaking capacities. Corrections for altitude and local atmospheric and climatic conditions are also given, and finally all information which should be given with an inquiry or order is listed.

When all the IEC recommendations have been completed there is no doubt that these will form the framework of South African national specifications.

6.1 IMPULSE WITHSTAND LEVELS.

There is little trouble regarding the specification of rupturing capacity, and the international standard ratings are generally accepted. These are 50, 100, 150, 250, 350, 500, 750, and 1000 MVA. It is however in regard to impulse withstand levels for equipment used on 12 kV systems where some difference of opinion exists in the Republic. One group, led by ESCOM, favours acceptance of 95 kV as the South African standard whereas the other favours that given in Series I of the IEC, viz. 75 kV. It is my opinion that the 95 kV is the better value for South African conditions for the following reasons:

(a) The experience and well-controlled records of service performance of ESCOM must be heeded.

(b) The cost involved in improving the level from 75 to 95 is not high. In most cases it requires only increase in external flashover distances, often of benefit to the whole design.

(c) The earthing difficulties in many parts of the Republic, especially on the Reef, sometimes result in such a high value of earth resistance that a greater margin than normal is required between the arrester protective level and the switchgear withstand level. It is, on the whole, more economical to raise the withstand level of switchgear than to use an arrester with abnormally low protective levels.

(d) Most installations in the Republic are at an altitude of over 4000 feet. This results in a decrease in the withstand level from the value at normal conditions. Thus if a rated value of 95 kV is accepted the value at an altitude of 5500 feet will still be 87 kV.

6.2 MAINTENANCE.

Valuable help is given in CP 1008-1961 'Maintenance of electrical switchgear' and Chapter V of IEC Publication 'Rules for the erection and maintenance of circuit breakers in service'.

7. TRANSFORMERS

Probably everyone is aware of the help available in regard to specification of transformers from both the British Standards Institute (BSI) and the IEC. It is hoped that the South African standard will soon be completed and since it will probably include standardization of losses as well as fittings for pole-mounted transformers it should be of great help.

There are two points worth mentioning:

7.1 IMPULSE WITHSTAND LEVEL.

In cases where lightning is encountered impulse withstand levels as given in IEC recommendations should be adhered to. Here again there is difference of opinion on the 12 kV system as to whether the level should be 75 kV or 95 kV.

Perhaps in this case the argument in favour of the 95 kV standard is not as strong as in the case of circuit breakers since it is much more costly to raise the insulation level of transformers from 75 kV to 95 kV. On the other hand the relatively high capacitance of a transformer will result in a greater increase of any impulse voltage which reaches the transformer terminals. This increase, which is due to reflection may be as much as 20 per cent higher than that which occurs at the terminals of equipment having a low capacitance. It would therefore appear reasonable to prefer 95 kV as the standard and to use the 75 kV value only when there is absolute certainty as regards the reliability of arrester performance.

7.2 CHOPPED WAVES.

In most cases it is recommended that a transformer should be tested with use of a chopped wave. A transformer designed to withstand only the full-wave test is vulnerable to an unknown extent to waves chopped in the vicinity of the transformer because higher internal stresses between turns and coils may be developed than under full-wave conditions. All flashovers in a station result in chopped surges and if these are liable to occur in service to a dangerous degree it is advisable to ensure adequate strength of the transformer by including a chopped wave test in the specification. It should be noted that horn gaps are particularly easy sources of chopped waves and this is the reason why they are viewed unfavourably by many.

Where an engineer has designed a station layout such that flashovers are unlikely and good arrester protection is also provided, it might be quite reasonable not to call for a chopped wave test. For this reason the South African standard specification will provide for either a standard impulse wave withstand test or for both the standard and chopped impulse wave test.

It is also hoped that the chopped wave test method will include an improved means of fault detection. Current methods rely on the application of a full wave test after the chopped wave test to detect whether the transformer insulation has failed. After testing many transformers, officers of the SABS feel that detection of faults during the chopped wave test will be far more reliable; consequently they are developing a suitable means of fault detection.

7.3 PAINTING OF TRANSFORMERS.

What colour to paint a transformer is a small point of controversy which might well be cleared up. Practice in Europe has been to paint transformers a dark grey. Apart from the ease with which paint of this colour can be kept allegedly clean in the oily conditions which usually prevail, a dark colour radiates heat losses readily and therefore helps to keep the temperature rise down. This is quite in order in Europe where there is not a great deal of sunshine but here in the Republic conditions are somewhat different. The large amount of solar radiation makes it possible that heat absorbed from the sun by the dark colour may be greater than the heat radiated, since a good radiating surface is usually also a good heat absorber. Silver and other light glossy paints have been used in the Republic because they reflect the radiant energy although there is a consequent drop in the heat radiated from the transformer as well.

Dr. Einhorn of Cape Town University has suggested the use of a selective white paint, i.e. one which radiates well in the longer wavelengths (such as those required to radiate the transformer losses) but which absorbs little in the shorter wavelengths which constitute solar radiation. Further work in this direction may well prove fruitful in discovering a more suitable colour to paint transformers.

8. CONCLUSION

It is hoped that this short discussion of standards that are available to ease the burden of those engineers concerned with the design and maintenance of distribution and transmission systems will fulfil a useful purpose. At the same time it is also hoped that it will indicate to engineers the value to their engineering fellowships of keeping clear and accurate records of service operation and of feeding back such information to standards authorities who will be able to co-ordinate these results with those of research, development, and production to produce dynamic up-to-date standards.

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TABLE II

THE ELECTROCHEMICAL SERIES

Anodic End
Magnesium and its alloys (-1.55 v)
Aluminium (-1.33 v)
Manganese
Zinc (-0.76 v)
Chromium (-0.56 v)
Cadmium (-0.40 v)
Iron (Fe^{++}) (-0.44 v)
Galvanized Steel
Galvanized Wrought Iron
Aluminium Alloys (e.g. Al-356, Al-245, Al-133, Al-195)
Mild Steel
Copper Steel
S.A.E. 4140
S.A.E. 3140
Wrought Iron
Cast Iron
Chromium Steel
50-50 Lead Tin Solder
Chrome-Nickel Steels
Lead (-0.12 v)
Tin
Muntz Metal (60 per cent Cu, 40 per cent Zn)
Manganese Bronze (66.5 per cent Cu, 19 per cent Zn, 6 per cent Al, 4 per cent Mn)
Naval Brass (add. of $\frac{3}{4}$ per cent Sn to Muntz Metal)
Nickel (Active)
Yellow Brass
Admiralty Brass
Aluminium Bronze
Red Brass
Copper
Bronze
Nickel (Passive)
Monel (70 per cent Ni, 30 per cent Cu)
18 per cent Cr - 8 per cent Ni Steel, Types 302, 303, 304, 321, 347 (Passive)
Mercury (+0.85 v)
Silver (+0.80 v)
Gold
Platinum
Cathodic End.

TOERUSTING VIR DIE OORBRING EN VERSPREIDING VAN ELEKTRIESE KRAG

1. ALGEMEEN.

Die doel van hierdie referaat is om die aandag van die ingenieur, belas met die oorbring en verspreiding van elektriese krag, daarop te vestig dat hy, deur oordeelkundig gebruik te maak van standaarde, sy lewe baie kan vergemaklik. Die verskillende standaarde, ten opsigte van die verskillende komponente van so 'n stelsel, wat beskikbaar is en die mate van hulp wat hulle bied, word in oënskou geneem.

Standaarde is nie 'n produk of produkte van 'n enkele persoon nie. Hulle verteenwoordig die gekonsolideerde, oorwoë menings van almal wat met die navorsing, ontwikkeling, ontwerp, werking en instandhouding van die betrokke artikel gemoeid was of is. Daarom is die hou van behoorlike rekords so belangrik omdat dit die vernaamste bron is waarvandaan inligting teruggevoer kan word.

Standaarde kan in twee breë groepe verdeel word, nl. Gebruikskodes en Standaardspesifikasies. Gebruikskodes gee leiding en rigting. Dit sê mens wat jy moet doen, hoe jy dit moet doen en wat jy moet gebruik. Dit is die fondament waarop enige distribusiestelsel gebou moet word. Een van die vernaamste funksies van so 'n kode is om die aandag te vestig op alle wette en regulasies wat in ag geneem moet word by die ontwerp en bou van so 'n stelsel; die belangrikste een in Suid-Afrika is die Fabriekswet. 'n Goeie voorbeeld van so 'n kode is die „Gebruikskode vir Bogrondse Leidings vir Toestande eie aan Suid-Afrika" wat tans deur die Suid-Afrikaanse Instituut van Elektrotegniese Ingenieurs hersien word en by voltooiing waardevolle hulp by die ontwerp van 'n distribusiestelsel sal verleen.

Standaardspesifikasies daarenteen lê die gehaltevereistes vir die toerusting en materiaal wat gebruik word, neer. Soos reeds gesê, verteenwoordig dit die gesamentlike pogings van verskeie persone, gewoonlik deskundiges op hulle gebied en dit is daargestel om hom, die ingenieur, kosbare tyd en geld te bespaar.

2. KOÖRDINERING VAN ISOLERING.

In gebiede waar donderstorms, met die daarmee gepaardgaande blitsontladings, gereeld en dikwels voorkom - soos in Suid-Afrika - moet elektriese stelsels so ontwerp word dat hulle nog bevredigend onder sulke omstandighede sal werk. Baie navorsing is op hierdie gebied gedoen en in onlangse jare word hierdie aspek gewoonlik onder die benaming „koördinering van isolering" behandel. Dit behels hoofsaaklik die voorsorgmaatreëls wat geneem word om beskadiging van elektriese toerusting te voorkom en, waar oorslag nie op ekonomiese gronde voorkom kan word nie, sulke oorslae te beperk tot punte waar geen skade aangerig kan word nie. Dit word gedoen deur die isoleringsterkte van die elektriese apparaat te koördineer met die kenmerke van die beskermingsmeganisme. Die basiese maatstawe is respektiewelik die stootspanningsbestandheidsvlak en die stootspanningsbeskermingsvlak.

Die kenmerke van die bogrondse lyn beïnvloed natuurlik die beskerming tot 'n groot mate. In die geval van goedontwerpte kraglyne vir baie hoë spannings is die isoleringspeil gewoonlik so dat die lynbestand is teen blitsontladings. In die geval van lyne vir laer spannings, soos dié waarmee ingenieurs gewoonlik te doen het, bepaal die ekonomiese aspek gewoonlik die peil van isolering en word laasgenoemde so gekies dat geen oorslag by kragfrekwensie onder die slegste weersomstandighede en toestande van besoedeling sal voorkom nie.

Gronddrade wat wyslik geplaas is, kan tot 99.8 persent van blitsontladings na 'n kraglyn onderskep. Hulle doeltreffendheid word egter grootliks beïnvloed deur die weerstand van die voet van die mas of toring.

Die beskermingsmeganisme, algemeen bekend as 'n stuwingsafleier, moet die stuwing kan weerstaan, dit na aarde aflei en die topwaarde van die spanning verminder tot 'n waarde waarteen die isolering van die apparaat bestand is. Hoe laer die waarde van die spanning wat deurgelaat word, hoe duurder die stuwingsafleier; hoe hoër die stootspanningsbestandheidsvlak van die apparaat wat beskerm moet word, hoe duurder dit kos. Die oplossing is dus 'n kompromie.

Van die dokumente wat beskikbaar is tot hulp vir die ingenieur, is die van dié Internasionale Elektrotegniese Kommissie (I.E.K.) miskien die waardevolste. Hierdie dokumente is die uitvloeisel van die werk van die deskundiges op internasionale gebied en kan met die grootste vrymoedigheid nagevolg word. Kortliks kan hierdie dokumente soos volg saamgevat word:

(a) Basiese stootspanningsvlakte vir toerusting - I.E.K. - publikasie 71, „Recommendations for Insulation Co-ordination".

Standaardiseer die isolering vir gebruik in verskeie tipes elektriese toerusting, bv. transformators en skakeltuig. Twee reekse word gedek nl. reeks I, gebaseer op gebruik in Europa en reeks II, gebaseer op gebruik in die V.S.A. en Kanada. Reeks I vereis 'n stootspanningsbestandheidsvlak van 75 kV vir 'n stelselspanning van 12 kV en reeks II 'n stootspanningsbestandheidsvlak van 95 kV vir 'n stelselspanning van 15.5 kV. EVKOM gee voorkeur daaraan dat ons plaaslike 11 kV stelsels onder die reeks II geplaas word.

(b) Stootspanningsbeskermingsvlak van Afleiers - I.E.K. - publikasie 99-1 en 99-2, „Recommendation for Lightning Arresters". Die beskermingsvlakke vir afleiers van verskillende kenwaardes word gegee.

(c) Verband tussen toerusting en beskermingsmeganisme - I.E.K. - publikasie 71A, „Application Guide" wat 'n toevoeging tot publikasie 71 is. Om die akkurate verband tussen die toerusting en die beskermingsmeganismes in 'n komplekse verspreidingstelsel te bepaal, is die werk van 'n deskundige. In hierdie publikasie word eenvoudige reëls gegee wat die gewone ingenieur kan navolg om hom te help om 'n beskermingstelsel te beplan.

(d) Beskermingsgebied. Die beste beskerming word verkry deur die stuwingsafleier so na as moontlik aan die apparaat, wat beskerm moet word, te plaas. Metodes om veilige afstande te bepaal, word tans deur die I.E.K. tegniese komitee nr. 37 behandel. Dieselfde onderwerp word ook deur 'n studiegroep van komitee 15 van CIGRE behandel. In die tussentyd sou dit raadsaam wees om in die geval van belangrike installasies die plasing van die afleier met die vervaardiger te bespreek.

3. STANDAARDSPESIFIKASIES.

Die hierbogenoemde publikasies kan almal onder die hoof „Gebruikskodes" ingedeel word. Die res van die referaat word gewy aan standaardspesifikasies wat tot hulp van die ingenieur kan wees.

3.1 TRANSMISSIEPALE EN -TORINGS.

Die ontwerp van metaalpale en torings is 'n kwessie van algemene ingenieursontwerp en ingenieurs is oor die algemeen bekend met die spesifikasies wat die eienskappe van die materiale wat in hulle konstruksie gebruik word, dek. Hulle is miskien nie so bekend met die voorskrifte vir beskerming teen korrosie nie.

Die beste beskerming vir staal is galvanisering. As gevolg van die leiding wat EVKOM in hierdie verband geneem het, is 'n privaatspesifikasie vir die galvanisering van staal 'n paar jaar gelede opgestel. Dit staan bekend as EVKOM-spesifikasie M1/1-2. Hierdie spesifikasie het die standaard van galvanisering in Suid-Afrika op 'n baie hoë peil geplaas en was so suksesvolg dat verskeie ander organisasies met EVKO

in Suid-Afrika op 'n baie hoë peil geplaas en was so suksesvol dat verskeie ander organisasies met EVKOM se toestemming gebruik gemaak het daarvan. Die SABS is tans besig om 'n Nasionale spesifikasie, gebaseer op hierdie een, op te stel.

Die beskerming wat galvanisering bied, kan natuurlik nog verder verhoog word deur 'n verflaag boor die sink aan te bring. In hierdie verband kan die volgende SABS-spesifikasies genoem word:

SABS 312	Standaarspesifikasie vir Grondver
SABS 312	Standaardspesifikasie vir Grondverf met 'n meniebasis vir boustaal.
SABS 436	Standaardspesifikasie vir Waterbestande Aluminiumdekverf.
SABS 630	Standaardspesifikasie vir Hoëglansemaljesierverf met 'n nie-waterige oplosmiddel as basis.
SABS 631	Standaardspesifikasie vir Olieglansierverf met 'n nie-waterige oplosmiddel as basis.
SABS 679	Standaardspesifikasie vir Sinkchromaatgrondverf vir staal.
SABS 682	Standaardspesifikasie vir Aluminiumdekverf.
SABS 684	Standaardspesifikasie vir Boustaalverf.
SABS 723	Standaardspesifikasie vir Etsgrondverf.

'n Uiters belangrike vereiste vir goeie resultate is natuurlik die voorbereiding van die oppervlak wat geverf moet word. In hierdie verband kan verwys word na SABS 064. Gebruikskode vir voorbereiding van Staalvlakke vir Verfwerk, waarin die ingenieur volledige aanwysings sal vind vir die voorbereiding van staaloppervlakke wat geverf moet word, vir feitlik alle toestande wat in die Republiek aangetref word.

Houtpale word almeer en meer gebruik omrede hulle betreklike lae koste, klimbaarheid en, belangrikste van almal, verbeterde werkverrigting in donderstorms. Hier is daar twee spesifikasies waarna daar verwys kan word, nl.:

SABS 753, Houtpale vir Kragoorbrengingsleidings en dwarsarms.

SABS 754, Houttelefoon- en algemene elektriese-kragpale.

Hierdie spesifikasies verteenwoordig jarelange navorsing deur die Departement van Bosbou, houttegnoloë en ingenieurs, met inagneming van die natuurlike houtreserwes van die land. Dit is belangrik dat ingenieurs streng ooreenkomstig die aanbevelings van hierdie spesifikasies werk om sodoende die land se natuurlike bronne ten beste te benut.

Soos reeds gemeld, het houtpale die voordeel dat hulle die stootspanningsoorslagwaarde van 'n gegewe kraglyn verhoog. Daar is heelwat werk in hierdie verband in die V.S.A. gedoen, en nuttige informasie word in die „American Institute of Electrical Engineers (AIEE) Committee Report, 1956", gegee. Vir die huidige word daar aanbeveel dat 'n syfer van 30 kV per voetlengte vir Suid-Afrikaanse houtpale gebruik word.

Daar moet egter op gelet word dat hierdie isoleringswaarde van hout slegs geldig is wanneer stootspanningsweerstand oorweeg word - nat hout het geen isoleringswaarde by spannings met kragfrekwensie nie. Direkte blitsontladings kan houtpale ook ernstig beskadig en daarom moet die pale deur aardingsdrade beskerm word.

3.2 ISOLATORS EN LYNMETAALWARE.

In die Suid-Afrikaanse spesifikasie SABS 177, Hoogspanningsisolatore van Porselein of Glas, word al die vereistes vir 'n goeie isolator vir normale gebruik gevind. Daar moet egter onthou word dat die waardes aangegee vir droë stootspanning en nat oorslag by kragfrekwensie vir 'n kraglyn van gegewe kenspanning, aangepas moet word vir:

(a) hoogte,

(b) verhoging van blitsbestandheid van lyn, en

(c) abnormale besoedeling of mistoestande.

Aanvullend tot SABS 177 is SABS 178, Afmetings van Standaardisolatore en Toebehore vir Bogrondse Kraglyne, wat tans opgestel word. Aanbevelings van die I.E.K. word in hierdie spesifikasie nagevolg en daar word gehoop dat dit baie sal meehelp om verwisselbaarheid d.m.v. standaardisasie te bewerkstellig. Dit sal weer op sy beurt help om instandhouding te vergemaklik.

Een van die probleme waarmee 'n mens te kampe kry is die besoedeling van die isolatore en metaalware. Hierdie besoedeling kan van tweërlei aard wees: as gevolg van rookmis in nywerheidsgebiede en as gevolg van soutneerslag by die kus. Daar is tans net een manier om vas te stel hoe suksesvol 'n isolator onder sulke omstandighede sal werk en dit is die nat-oorslagtoets by kragfrekwensie. Hierdie toets is nie baie bevredigend nie en in verskeie wêrelddele word navorsing gedoen om 'n meer betroubare toets te ontwerp. Dit is duidelik dat daar prakties probleme is - dit is nie so maklik om een toets te kry wat beide vorms van besoedelings kan dek nie. Dit is te hope dat ons in Suid-Afrika nooit sulke probleme met rookmis sal ondervind soos die ouer nywerheidslande nie en dat ons probleem hoofsaaklik tot dié van soutneerslag beperk sal bly. Daarom konsentreer die SABS op 'n soutmistoets wat tans deur die „Central Electricity Research Laboratory" in Engeland ontwikkel word.

Nog 'n probleem is dat die golffront van 'n direkte blitsontlading op 'n lyn baie steiler is as wat oorspronklik vermoed is en dat die standaarddeurslagtoets onder olie dus nie 'n betroubare aanduiding gee van die moontlikheid van deurslag in die praktyk nie. Nuwe toetstegnieke word ondersoek en dit is moontlik dat meer inligting beskikbaar sal wees na die jaarvergadering van die I.E.K. in Oktober vanjaar.

Die fatsoen van die isolator en verhouding van droë oorslagafstande tot minimum dikte van isolering speel natuurlik ook 'n belangrike rol en gee aanleiding tot nuwe ontwerpe soos die „langstab" (langstaaf) en heliksvorm van Europa.

'n Belangrike faktor i.v.m. metaalware is korrosie. Nie alleen kan korrosie bv. die pen van 'n penisolator beskadig nie, dit kan ook tot gevolg hê dat die isolator self beskadig word. Hier moet 'n mens veral die keuse van materiaal in gedagte hou. 'n Mens moet veral versigtig wees wanneer verskillende metale saam gebruik word. So moet koper bv. nooit saam met aluminium of magnesium gebruik word nie. In hierdie verband kan genoem word dat die elektrochemiese reeks vir mens tot groot hulp kan wees. Die Britse Admiraliteit, in samewerking met die „Ministry of Supply Inter-service metallurgical Research Council" het 'n publikasie, genaamd „Corrosion and its prevention at bimetallic contacts" die lig laat sien. Hierdie publikasie is 'n baie nuttige handleiding.

In die algemeen word aanvaar dat yster, staal, magnesiumlegerings en nie-geplateerde legerings van aluminium en koper nie blootgestel moet word tensy dit behoorlik beskerm is nie.

3.2 BLITSAFLEIERS.

Blitsafleiers, of stuwingsafleiers soos party ingenieurs verkies om hulle te noem, is alreeds gemeld in die bespreking van die koördinering van isolering. Hierdie is egter maar een aspek van die toepassing van blitsafleiers. Tensy die korrekte afleier vir die besondere geval, gemaak volgens 'n betroubare spesifikasie, korrek geïnstalleer word, word geen beskerming aangebied nie en is dit geld in die water gooi.

In hierdie geval is die beste oplossing 'n afleier wat onderskryf word deur 'n standaardeliggaam. Tans is dit wel die geval in Suid-Afrika, wat betref laespanningsblitsafleiers. Die betrokke spesifikasie is SABS 171. Wat afleiers vir hoë spanning betref, word daar aanbeveel dat vir die huidige die I.E.K. publikasie nr. 99, „Recommendations for Lightning Arresters" nagevolg word. Die Suid-Afrikaanse spesifikasie sal op hierdie een gebaseer word.

Die kenspanning wat deur die fabrikant aan 'n afleier toegesê word, is die maksimum spanning, insluitende foutspannings, waaraan dit in die praktyk onderwerp mag word as beskadiging van die afleier vermy moet word. Hierdie spanning word weer op sy beurt beïnvloed deur die aarding van die stelsel. Publikasie 99 gee 'n nuttige tabel om mens te help om die regte kenwaardes te kies.

Indien die stelsel self ongewoon is, of die werkstoestande van die normale afwyk, moet die aandag van die leweransier daarop gevestig word. 'n Voorbeeld hiervan is hoogte bo seespieël. Afleiers met verseëlde vonkgapings sal nie hierdeur beïnvloed word nie, maar afleiers waarvan die vonkgapings nie verseël is nie, wel.

3.4 SKAKELTUIG.

Daar is geen Suid-Afrikaanse Spesifikasie vir skakeltuig nie, maar wel 'n Britse een, B.S.S.162-1961, „Electric Power Switchgear and Associated Apparatus" en heelwat I.E.K. publikasies, waarvan die belangrikste die volgende is:

Publikasie 56-4	Hoofstuk III -	Rules for strength of insulation
	Hoofstuk IV -	Rules for selection of circuit-breakers for service
	Hoofstuk V -	Rules for the erection and maintenance of circuit-breakers in service.

Publikasie 129, Alternating current isolators.

Soos reeds vroeër gemeld, is daar een aspek wat skakeltuig raak en waaroor nog nie tot 'n finale besluit gekom is nie en dit is die stootspanningsbestandheidspeil vir toerusting vir gebruik in 12 kV-stelsels. Een groep, met EVKOM aan die voorpunt, gee voorkeur aan 95 kV en 'n ander groep aan 75 kV.

Om verskeie redes word daar gevoel dat 95 kV die geskikste peil is vir Suid-Afrikaanse toestande.

Wat instandhouding betref, kan gemeld word dat waardevolle hulp beskikbaar is in Cp 1008-1961, „Maintenance of electrical switchgear" en Hoofstuk V van I.E.K.-Publikasie „Rules for the erection and maintenance of circuit breakers in service".

3.5 TRANSFORMATORS.

Alle ingenieurs sal seker bekend wees met die Britse en I.E.K. spesifikasies vir transformators. Daar word gehoop dat die Suid-Afrikaanse spesifikasie binnekort voltooi sal word. Dit is miskien wenslik om twee punte te noem: eerstens, waar blitsontladings voorkom, moet die stootspanningsbestandheidspeile wat in die I.E.K.-aanbevelings aangegee word, nagevolg word, tweedens, dit is wenslik dat die transformator met 'n gekapte golf getoets word aangesien die meeste oorslae in 'n krag- of substasie aanleiding gee tot gekapte stuwings. Horinggapings is bv. 'n besondere vrugbare bron van gekapte golwe.

'n Laaste puntjie wat betref die kleur wat transformators geverf moet word; vir Suid-Afrikaanse toestande beveel Dr. Einhorn van die Kaapse Universiteit aan dat 'n selektiewe wit verf gebruik moet word, dit wil sê een wat goed uitstraal in die langer golflengtes (om van transformatorverliese ontslae te raak) en wat min absorbeer in die kort golflengtes (nie hitte van die son opneem nie).

4. AFSLUITING.

Daar word vertrou dat hierdie kort bespreking van Standaarde wat beskikbaar is vir die distribusie-ingenieur, 'n nuttige doel sal dien. Daar word ook gehoop dat dit sal dien as aansporing vir ingenieurs om behoorlike rekords te hou en die inligting aldus verkry, terug te voer na standaardeliggame om hulle in staat te stel om nog beter spesifikasies op te stel.

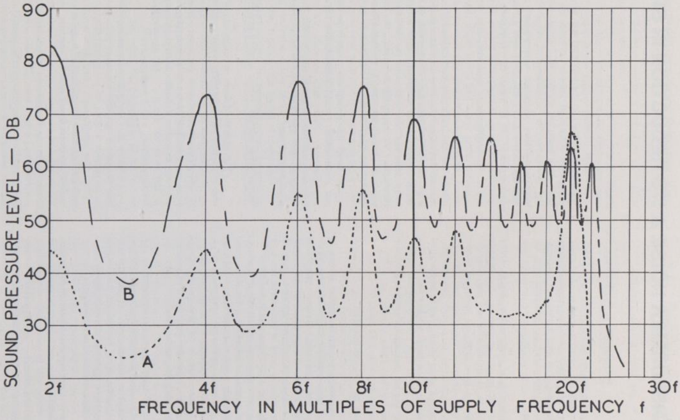


FIG I. TRANSFORMER NOISE SPECTRA

TRANSFORMER NOISE & ITS REDUCTION IN SITU

by

PROFESSOR G. R. BOZZOLI, D.Sc. (Eng.), M.I.E.E., M.(S.A.)I.E.E.

Much attention has in recent years been focussed upon noise and its effect upon people. Generally the noise is generated by mechanisms or moving machinery of some kind, but it is well known that even static transformers in large sizes can generate very intense noise fields.

It is interesting to observe how design limits which were once set by the properties of materials have now come to be established by our physiological reactions. Materials have improved vastly in recent years, particularly magnetic materials and the very high flux densities prevalent in present day designs, coupled with the large units which need to be installed in densely populated areas have emphasized the fact that materials subjected to high alternating flux densities are liable to vibrate mechanically and so generate audible noise.

CAUSES OF NOISE IN TRANSFORMERS.

Although the magneto-strictive effect is one of the main causes of transformer noise, there are others like vibrations at core gaps and joints, vibrations caused by interaction between core and coils and vibrations of the coil conductors carrying current, each of which may be enhanced by parts or structures resonant at twice the supply frequency or its even harmonics.(1)(6) The magnetostrictive expansion and contraction of the magnetic material under the influence of the alternating flux density is a highly non-linear function of the flux density, so that the noise generated is anything but a sinusoidal tone. In this respect, the magnitude of the magnetostrictive effect may be of lesser importance than its non-linearity, since the harmonics are likely to be more audible than the fundamental.

Joints become noisy because at a joint there are over-lapping laminations where the flux is divided between the parallel iron and air paths. The division of flux varies during the cycle because of the varying iron permeability. Here again the effect is highly non-linear leading to the generation of harmonics.

In all cases, since the movement of the material (iron, lamination, coil, etc.) depends upon the flux density squared, there will be two cycles of movement for each cycle of flux change, which means that the lowest noise frequency will be twice the supply frequency.

Fig. 1 shows typical noise spectra of two large transformers, of which A could be described as quiet except for a resonant peak at 10 times the fundamental, and B could be described as noisy, but not showing any particular resonances. These noise levels would have been measured with a sound level meter together with a set of filters to sort out the frequency components. It is clear that important noise frequencies lie in the range from 2 f to 20 f, or 100 c.p.s. to 1,000 c.p.s. approximately.

These noise levels will have been measured outside the tank, at a standard distance from the transformer and under standard conditions of measurement, e.g. at 100% excitation voltage with no load on the transformer. The noise will have been propagated away from the core and coils via the solid and liquid insulation, the clamping structure, the tank, cooling tubes or heat exchangers, to the atmosphere and to the foundations upon which the transformer is mounted.

Up to this point, the problem is one of design and construction, and responsibility rests upon the manufacturer. From here onwards, the noise reduction becomes the responsibility of the power supply authority, and the first question to be considered in a physiological one.

SUBJECTIVE SOUND - THE AUDIBILITY OF NOISE.

The effects of noise on people can be considered under two headings. Firstly noise can be so intense as to cause pain to the listener and ultimately partial or complete, temporary or permanent loss of hearing. It is most unlikely that any transformer noise will fall into this category since the level required is in excess of 100 db at 100 c.p.s., a far greater figure than so far experienced with transformers.(2)

Secondly, the noise can cause annoyance, and this is a far more difficult reaction to assess. There is at present a scale of annoyance ranging from a unit called "no complaints" through a number of values such as "sporadic complaints", "frequent complaints", up to a maximum figure called "vigorous legal action". These units of annoyance have been related to decibel levels at various frequencies, and the results of various environmental effects have also been taken into account. For example, a noise of continuous pitch (such as transformer noise) is known to be more annoying than one having no particular characteristic frequencies; an impulsive noise is more annoying than a continuous one; a particular noise is less annoying if the environment is noisy, so that suburban dwellers are more critical of a noise than town dwellers.

Added to this is the fact that the human ear cannot hear low frequency sounds very well, particularly when they are not very intense. In fact, a sound of 100 cycles per second requires to be about 30 db more intense than one of 1,000 cycles per second in order that both shall be just audible. By combining this effect with the known or suspected relation between annoyance and sound level, a set of noise criteria has been established and is in fairly wide use in the U.S.A. Using these criteria, it is possible to allot a particular NC curve to a particular area for purposes of determining what noise levels are likely to be annoying. For example, the recommended curve for homes (sleeping areas) in NC-30. This should be reduced to NC-25 when the home is in a very quiet suburban district, but may be increased to 40 when the home is near some light industry. For the latter curve, NC-40, the permitted level at 100 c.p.s. would be 55 db, at 500 c.p.s. it would be 49 db, and at 1,000 c.p.s. it would be 42 db. The corresponding figures for the NC-25 would be 43, 35 and 29 db.[(4).(5)]. A modified form of these criteria has now been proposed for international acceptance and this country is likely to accept the proposals in the first instance in their present form.

The position today is therefore that for a given locality, the recommended NC curve can be ascertained, and knowing the noise output of the transformer to be installed in that locality, the degree of sound reduction in situ required at each frequency can be determined.

TRANSFORMER NOISE CONTROL.

Once the noise has been generated by a transformer, the only method of controlling it is to pay attention to its propagation. There are four basic principles involved.

1. Anti-vibration mountings, to prevent the vibration which gives rise to noise from being propagated through the structure of a building.

2. Complete enclosure of the transformer in a more or less sound proof enclosure.

3. Erection of sound.

3. Erection of sound-barrier walls to deflect sound away from a particular direction.

4. Interposing distance between the source of sound and the listener.

Combinations of these are, of course, possible.

ANTI-VIBRATION MOUNTINGS.

The amplitude of vibration required to generate a noise of the order of 60 db above the threshold of audibility is about 5 millionths of an inch at 100 cycles/sec, and this would be the order of movement to be expected in the case of a transformer. At 120 db this rises to 5 thousandths of an inch.

The vibration of the transformer must be prevented from reaching the structure.

(a) by installing the transformer on solid ground,

(b) by using a large foundation block resting on resilient mountings,

(c) by leaving an airgap between the foundation block and the surrounding structure to a depth of several feet.

Where resilient mountings are used, it is very important to ensure that their effectiveness is not short circuited by solid connections such as pipes, cables, earthstraps and the like.[(7)] Any solid links of this kind must be made flexible and "floppy" by the inclusion of rubber bellows or flexible conductor.

The reduction of noise by resilient mounting was strikingly demonstrated by Churcher and King[(8)] who measured a reduction in sound level from 56 db to 52 db when resilient supports had been fitted. Since the db is a unit derived from the logarithm of a power ratio, it is readily calculated that the noise power had been reduced from 40 micro-microwatts per sq. cm to 16 micro-microwatts per sq. cm. This means that well over half the noise power was being transmitted through the base. This experiment also demonstrates how important it is to tackle both the vibration and the noise propagation simultaneously. For example, removing the transmission via the mounting reduced the noise level from 56 to 52 db. Removing the acoustic noise propagation entirely and leaving the mounting vibration unaffected would have reduced the noise power by the 16 micro-microwatts per sq. cm. only, i.e. leaving 24 micro-microwatts per sq. cm., which corresponds to a noise level of 53.8 db.

If, however, the resilient mounting had been fitted and the acoustic propagation been reduced to say, one tenth of its original value, the resulting noise level would have been 1.6 micro-microwatts, which corresponds to 42 db - a very worthwhile reduction.

The resilient material must be springy and cork is of little value in this respect. A rubbery material like neoprene can reduce the vibration by 25 to 30 db, and steel springs by about 50 db(9). The neoprene supports generally consist of ribbed sheets arranged with ribs on successive sheets at right angles and built up to a sandwich of the required thickness. The loading can be of the order of 50 lbs per inch and a transformer weighing over 250 tons could be supported on a pair of such sandwiches 8 feet long by 6 inches wide(10).

NOISE REDUCTION BY ENCLOSURE.

This involves the erection of a completely closed structure around the transformer, designed to provide the requisite sound attenuation at the frequencies required. The principles of sound attenuation by enclosure are straightforward, in the sense that the degree of attenuation introduced by a wall is a direct function of the density of the material of construction. However, it is not sufficient to consider only the material of the structure. When a source is generating continuous sound within an enclosure, the sound level inside rises exponentially to a final steady value in much the same way as the current in an inductive circuit does. This final steady value is reached when the rate of supply of sound energy equals the rate at which sound energy is absorbed. Unless steps are taken to provide sound absorption within the structure, the internal level can rise to a very high value, thereby greatly increasing the difficulty of the job of attenuation.

To express this in figures, an open transformer may give rise to a noise of 100 microwatts. In the open air at a distance of 10 feet, the noise level would be 53 db and this is to be reduced to 40 db by means of a closed room, measuring 15 feet by 15 feet by 12 feet high. If the structure is erected and no steps are taken to provide for sound absorption, the noise level inside will rise to a value of 79 db. If the walls and ceiling were covered with material having an absorption coefficient of 0.5, the noise level would only rise to 69 db. So in the first case the structure would have had to provide 39 db of insulation, calling for a $4\frac{1}{2}$ inch brick wall. In the second case, 29 db could have been provided by a medium weight partition. The decision could have been made on an economic basis, or on a basis of total dead weight. Fig. 2(a) and (b) illustrate the point.

This effect can become particularly serious in a room having parallel walls, or parallel floor and ceiling, when one of the room dimensions equals an exact half wavelength or its multiple at one of the frequencies being generated. This means an integral multiple of 5.66 feet at 100 c.p.s., and in such a case, a resonant standing wave is set up and very much higher noise levels still would be reached. In addition to making walls non-parallel if possible, absorption at low frequencies must be introduced by fitting one of the many available acoustical materials to the walls and ceiling.

Care must be taken to distinguish between absorption and attenuation. The former is provided by light porous materials, while the latter is provided by a dense wall or partition. There is a vast difference in the order of the effect required in the two cases. A good absorbent has an absorption coefficient of 0.8, which means that after reflection the energy leaving the absorbent is 0.2 of the incident energy, a reduction of 5 to 1 which corresponds to 7 db.

A good attenuator needs to provide an attenuation of 30 db or more, which means a reduction of 1,000 to 1, and this can only be provided by a massive rigid structure. Clearly, absorbents and attenuators work best in combination, as for example, a heavy wall with absorbent lining on the side where the sound is generated. The attenuation, or transmission loss, of a single rigid wall of brick weighing about 40 lbs per square foot of surface is about 46 db at frequencies of several hundred cycles per second. The transmission loss increases by 4.3 db for each doubling of weight per square foot. For a limb wall of mass M lbs per sq. foot, the attenuation of a frequency f cycles per second is approximately (20 log Mf-30) db(11).

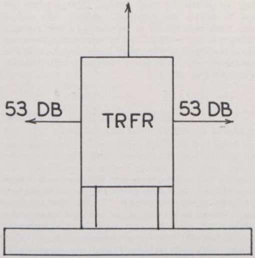
Control of transformer noise has its own particular problems, since both the absorption of acoustic materials and the attenuation provided by walls, becomes less at lower frequencies, and transformer noise is predominently at low frequencies. When high attenuation has to be provided, it may be uneconomic to attempt to achieve it by increasing the weight of the wall. A 9" wall for example will only increase the attenuation from 46 db to 50 db. On the other hand, high insulation can be achieved by constructing a double wall, each wall consisting of $4\frac{1}{2}$" brick. If the two walls are completely isolated from one another, the total attenuation in db is practically twice that for one wall - or 90 db.

EXAMPLES OF ENCLOSING STRUCTURES.

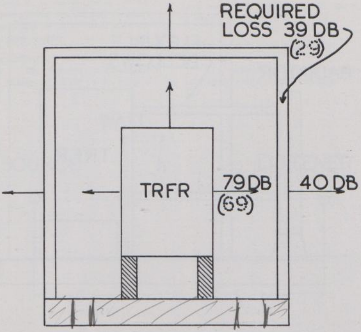
These can be of two types, either a large transformer chamber or a close fitting specially built structure. In the former case it is likely that a transformer chamber was required in any case so that an indoor installation was envisaged. It is also likely that all sources of noise would be included in the chamber - transformer, cooling heat exchanger, fans etc. It then becomes a matter of ensuring by design that the required number of db of attenuation have been introduced by the structure. It must be borne in mind that holes, cracks and crevices act in parallel with the walls and any sound leaking through vitiates the effect of the wall. As an example,[8] a wall giving an attenuation of 40 db will have a sound energy density on one side that is 10, 000 times that on the other. If now a number of holes are made in the wall representing 1% of the wall area, this will allow 1/100 of the incident sound through, and this will increase the average energy density on the outer side by 100 times. The attenuation is now the ratio 10, 000 to 100, or only 20 db. This illustrates the importance of sealing all openings adequately.

FIG 2.

EFFECT OF ENCLOSURE



(a) TRANSFORMER ALONE



(b) TR. IN REVERBERANT ENCLOSURE

A number of close fitting structures have been fitted successfully. The problem in most cases has been to provide the requisite cooling. The method lends itself particularly to transformers with separate cooling radiators which can be left outside the close fitting structure. The pipes connecting radiators to transformer tank may need to be acoustically isolated, as indicated in fig. 3.

In one example[12] a close fitting box was constructed of 10 A.W.G. steel plate to which a 1/16 inch lead sheet had been stuck with epoxy resin compound. This box was freestanding and isolated from the transformer, with a few inches clearance on all sides. Between the box and the transformer tank a 2 inch Fibreglass curtain was mounted, clear of both tank and box, to provide internal absorption. Before the radiators were connected up, the noise reduction was 22 db. With the radiators connected up, the transmission loss was reduced to 17 db. It would probably have proved possible to restore the loss to 22 db by fitting vibration isolating bellows in the pipe connections. In a second example[11], the enclosure took the form of a substantial steel box enclosing the transformer alone, and constructed of double sheets of steel plate with a layer of viscous adhesive between. The inside surface was unlined on the grounds that the spacing between the transformer tank and the box (about 1 ft. 6 ins) was much less than a half wavelength either at 100 c.p.s. or at 200 c.p.s. The bushing adaptors and oil pipes connecting the transformer to the radiator and to the conservator tank were brought through so as to clear the hole in the enclosure, and the gap sealed with neoprene rubber. The attenuation achieved was 24 db.

In a third example[10] a 180 mVA 275 kV transformer was provided with a very substantial enclosure measuring 30 feet by 25 feet, and using the same steel sandwich construction described above. The radiators were connected up via flexible bellows, and great care was taken to seal up the spaces around other pipe work passing through the enclosure. The attenuation achieved was 30 db, but leakage past the bushings and vent pipes reduced this to 25 db.

If the noise problem is anticipated before installation, it is possible to obtain a completely pre-assembled sound enclosure.[13] The obvious advantage here is that the transformer itself can be designed to fit readily into a simple rectangular enclosure. Units of 10 mVA have been so treated, giving noise attenua-

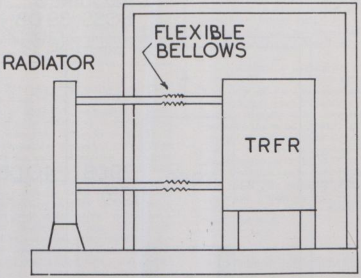


FIG 3. EXTERNAL RADIATOR

tions of 14 db without absorbant lining and 20 db with lining.

NOISE REDUCTION BY SOUND BARRIER.

Since sound is basically propagated like light, in straight lines, it would be expected that a barrier would cast an acoustic shadow. In this way a transformer noise could be deflected away from the area in which it is troublesome, without having to build costly closed structures with all the attendant difficulties of arranging for the cooling. A shadow is, in fact cast, but because low frequency sound wavelengths are so long, they become comparable with the height of any economically feasible barrier, and the shadow is very blurred indeed Nevertheless the attenuation provided by a barrier can be calculated.[14] In terms of fig. 4 the attenuation between source and listener due to the wall alone depends in rather a complicated manner upon the quantity $\frac{a+b}{ab}$. It turns out that the wall is least effective when a and b are equal, and increases in effectiveness when either source or listener are close to the wall, and the other a long distance off. The attenuation also falls off very markedly as the frequency becomes lower. Table I gives a few figures for comparison.

The effective height h, is the height of the top of the wall above the line joining source and listener. Barrier walls are consequently of little value when the listener is in a tall building nearby.

Despite these disabilities, barrier walls have been used successfully. The barrier is frequently constructed in a "U" shape to assist in forming a sharper shadow at the ends of the wall. This has the effect of permitting the sound level to build up between the two ends of the "U" and between the tank and the walls in much the same way as it would in an enclosure. The effect can, of course be minimised by acoustic absorption on the inside of the walls, but since absorbent materials are mostly soft and cannot withstand the weather effectively, this treatment is not easy. Model tests have been described[15] in which the calculated attenuation figures are confirmed.

TABLE I

Dimensions in feet

Effective wall height-h	a	b	db attenuation at		
			100 c.p.s.	200c.p.s.	400 c.p.s.
10	30	30	14	17	19.6
	20	40	14.7	17.4	20.5
	10	50	16.5	19.2	22.5
20	30	30	19.7	22.7	25.7
	20	40	20.3	23.5	26.3
	10	50	22.4	25.2	28.6

Many variations in the barrier wall patterns have been tried. A successful one with a partial roof is shown in fig. 5.[15]

SOUND FIELD CANCELLATION.

A possible method of reducing the sound level at a point would be to propagate to that point, another

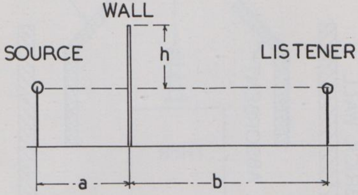


FIG 4

sound field of the same frequency, and waveform but of opposite phase. This has been attempted[15] with some success, using loudspeakers with amplitude and phase control of the 120, 240 and 360 c.p.s. noise components on a 60 cycle per second system. Using an array of four loudspeakers, cancellations of up to 30 db were obtained in certain directions, 20 db over fairly wide angles and 6 db over long radial distances over an angle of 35 degrees. Whether such a system has ever been installed permanently is not known.

THE DISTANCE LAW.

The simplest, but not necessarily the cheapest method of bringing about sound attenuation is to make use of the inverse square law of attenuation with distance. As a result of this effect, a propagated sound emanating from a point source diminishes by 6 db every time the distance is doùbled. Thus if the sound level is 84 db at a distance of 10 feet, it will be 78 db at 20 feet, 72 db at 40 feet and 66 db at 80 feet. Provided enough open ground can be provided, at a reasonable cost, this is undoubtedly the simplest method of control.

PLANNING FOR LOW NOISE.

Before a transformer of any appreciable size is installed, a survey should be made of the area, of the nature of the buildings - heavy industrial, light industrial, residential, urban, suburban - and of the likely changes in the nature of the surrounding properties. For each type of environment the desirable noise level should be ascertained and the noise output of the transformers also determined. Appropriate measures for reducing the noise to the desired level can then be planned for in advance. It must be remembered that transformer noise is of little account during the day when traffic is running and the ordinary noises of living are around - but in the dead of night when the other noises have died down, its the "hum" that does it.

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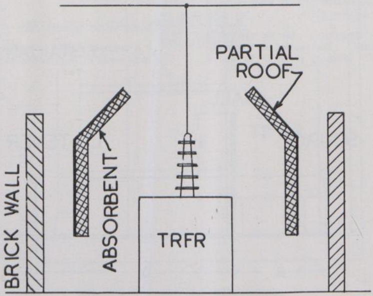

FIG. 5 BARRIER ARRANGEMENT

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MAINTENANCE OF A DISTRIBUTION SYSTEM

by

M. J. W. CHAPPEL.

The engineer in charge of a Municipal Electricity Undertaking generally has in his care a considerable variety of equipment and the maintenance procedures which he applies have to be developed to suit the particular conditions under which his Undertaking operates.

It is evident that the task would be simplified if it were possible to standardise on the makes and types of equipment which are installed as is sometimes done in commercial undertakings. Standardisation, besides simplifying installation and maintenance procedures, would reduce the quantities of spare parts which are purchased and which accumulate and have to be kept in stock. Fortunately, distribution equipment is generally robust and the quantity of normal spares carried for any particular make of equipment is usually small; however, where, for example in the case of switchgear, there are at least ten different makes of equipment, each make coming in several different models or sizes, it is necessary in the aggregate to carry a fair quantity of spare equipment.

However, the procedures which have to be followed, where equipment is bought for a municipal undertaking, are laid down by statute, the object of which is to enable every supplier of such equipment to have the opportunity of securing orders. The effect of such legislation and the way in which it is applied tends to prevent standardisation because the Engineer's specification must of necessity be based on duty and performance and as such allows a fairly wide variety of tenders; on adjudication there is considerable pressure for acceptance of the cheapest tender and it is generally only under exceptional circumstances that an order is placed for any but the lowest offer. The net effect, therefore, is a necessity to hold in stock a comparatively large variety of spares such as contacts, current transformers, bus bar sections, porcelains and bushings, contactor coils, etc., and the maintenance staff must contend with variations in size, detail, fixing centres, etc.

This paper discusses some of the maintenance procedures adopted in the Port Elizabeth undertaking; no claim is made that these procedures are the only, or even the best, but they have been evolved over a period of time and in the main have been reasonably successful.

The Port Elizabeth Electricity Undertaking has a maximum demand of approximately 140 MW. The distribution system operates with a 66kV main transmission system and a 22kV primary distribution, feeding into an extensive 6.6kV reticulation from which the majority of low voltage supplies are obtained. Sub-stations are of both the indoor and outdoor types and vary in size according to requirements, the larger and more important having pilot and telephone circuits connecting them to the main control centres. All 66kV switchgear is of the outdoor type; the 22kV system has both indoor and outdoor circuit breakers while, with the exception of rural pole mounted reclosers, all 6.6kV circuit breakers are of the indoor variety.

TRANSFORMERS.

The maximum size of transformers in use is 40 MVA and generally all those of 5 MVA and above are fitted with on load tap changing equipment.

A considerable range of smaller transformers is in use and a number of these go back to the earlier days of the undertaking. Generally speaking a transformer requires only a small amount of maintenance and even this can be neglected for a prolonged period, but in the end the effects of such neglect are felt. In Port Elizabeth at one period a few years after the end of the Second World War a considerable number of transformers suffered from acidity of the oil. Externally this became evident when the top covers and sides of the tanks above the oil level became perforated due to acid attack.

A systematic programme of checking oil was put into effect and over a period all units exhibiting severe acidity were withdrawn from service and overhauled. This involved removal of the core and windings from the tank, washing down with clean oil to remove sludge and loose foreign matter and to flush away the residue of acid oil. Generally the core and windings showed little deleterious effect although insulation was invariably hard and brittle. In practice this does not appear to have had any noticeably detrimental effect and the majority of these old transformers continue to give reliable service.

Considerable investigation and research in overseas countries has been devoted to the problem of transformer oil deterioration and the causes and effects of these processes, which are mainly observed in sludge and acid formation. The amount of literature on the subject is extremely voluminous but, briefly, in the earlier stages, the problem receiving most attention was the formation of sludge which tends to choke oil ways and passages in the windings, causing a restriction in the circulation of the oil and ultimately failure of windings due to local overheating. During the late 1920's a super refined oil known as 'A' grade was introduced as an oil free from sludging but unfortunately in practice this oil showed itself to be very subject to the formation of acid, which is one of the oxidation products formed due to a reaction which takes place in the presence of atmospheric oxygen.

A number of factors influence the rate of oxidation of transformer oil but amongst the most important are :-

(1) temperature of the oil - the rate of the chemical reaction between oil and air approximately doubles with each 10°C rise in temperature;

(2) presence of catalytic substances, bright copper being fairly active;

(3) the characteristics of the base oil and subsequent modifications and alterations produced during the refining processes;

(4) free access of oxygen to the hot oil surface;

(5) under certain circumstances where access of oxygen is restricted but not completely prevented the apparent rate of acid formation may increase, possibly due to acid products being retained and condensing on the inner surface of the transformer tank when this cools down under periods of light load; such condensed acids then enter the oil whereas in the case of a freely ventilated transformer, where there is a movement of air across the surface of the oil, most of the oxidation products will be carried away and not retained in the transformer;

(6) high humidity may accelerate acid formation;

(7) super refined oils which were supplied as 'A' grade are more subject to acid formation than 'B' grade, due to the removal in the refining process of certain natural substances which have the effect of reducing the rate of the chemical reaction between the oil and atmospheric oxygen;

(8) where in (7) above the removal of certain substances increased acid formation it was logical to expect that the addition of such substances would reduce such reaction; a number of chemical compounds have been isolated which do in fact have this effect and are now being added to transformer oils. Oils containing such substances are now widely used and are known as "inhibited oils";

(9) the rate at which the oil in a transformer oxidises is reduced when a conservator is fitted as this has the effect of reducing the surface area of oil in contact with the air and of maintaining the temperature of such oil at a lower temperature than that in the main tank. Similarly, a system of hermetically sealing a transformer and filling the space above the oil with inert gas will completely eliminate acid formation so long as all air continues to be completely excluded from contact with the oil.

In Port Elizabeth transformers supplied in the '30's and early '40's with 'A' grade oil and without conservators were mainly affected. All transformers in which oil and air come into contact are, however, subject to acid formation and it is possible to keep this process under observation by taking oil samples at regular intervals and conducting the appropriate tests. In Port Elizabeth oil samples are now taken at intervals of about one year.

B.S.S.148 sets out precautions which should be followed in taking samples to avoid contamination during the sampling process. We find that the basic procedure with some simplification can be followed without undue waste of time, the sample being taken from the drain valve at the bottom of the transformer directly into a preserving jar with a glass lid, the jar previously having been rinsed with a little oil from the same source.

The method of determining acidity as set out in B.S.S.148 is somewhat laborious and of unnecessarily high accuracy where routine transformer maintenance is concerned. Accordingly the method described below was devised to be simple and rapid, while having sufficient accuracy for the purpose, and suitable for an electrician to conduct.

(1) 20 c.c. of oil are measured off into a glass-stoppered bottle.

(2) About 20 c.c. of commercial methylated spirit is added and the whole vigorously shaken.

(3) A few drops of phenolphthalein indicator solution are added.

(4) The mixture is titrated with an N10 potassium hydroxide solution from a burette, the mixture being vigorously shaken after each addition of alkali. The end point being taken when the mixture begins to turn pink. Dark oils make the observation of the end point a trifle difficult, but with a little experience it can be determined with reasonably accuracy.

(5) The number of c.c. of KOH Solution added is divided by 3 to give the neutralisation in mg KOH/gm.

Derivation

$$\text{Acidity in mg. KOH/gm.} = \frac{\text{Weight of KOH in mg.}}{\text{Weight of oil}}$$

Weight of KOH in mg. = c.c. of N10 solution to neutralise the sample × 5.6

Weight of oil = c.c. × specific gravity of oil.

Specific gravity of transformer oil varies but is taken for this purpose as .84.

$$\therefore \text{ Acidity} = \frac{\text{c.c. KOH } 5.6}{20 \times .84}$$

$$= \frac{\text{c.c. KOH}}{3}$$

$$\text{i.e. Acidity in mg. KOH/gm} = \frac{\text{c.c. N10 KOH solution to neutralise 20 c.c. oil}}{3}$$

Working on the test method set out above to give acidity the transformer oil we have set the upper limit at 2.5 mg. KOH/gm., and change the oil when it reaches this figure. A commercial firm at one time offered to restore such oil to good condition but a trial batch of about 500 gallons did not prove satisfactory and at the present time all oil with acidity in excess of 2.5 mg/gm is scrapped. It is sold at about 10c/gallon to local firms who use it for oiling concrete moulds and such purposes.

The more recent development of inhibited oil holds out the prospect of longer oil life at a small increase in the initial purchase price. In 1960 a decision was taken to standardise on inhibited oil for all distribution transformers. Since that date all new transformers have been purchased with this type of oil and similarly only inhibited oil has been purchased for maintenance purposes, topping up etc. As this policy has only been in operation for a few years it is too soon to establish whether there is any marked increase in the useful life of such oil.

Each sample of oil is also tested for di-electric strength. The test is conducted in accordance with the procedure laid down in B.S.S.148, except that a shorter settling time is allowed, the oil being poured into the test cell with reasonable care to avoid unnecessary formation of bubbles; the sample is given about one minute to settle after which voltage is applied. We find that if the oil is in good condition and free from fibres, etc., it will give a good test despite settling for only one minute as against five minutes as laid down in B.S.S.148. This modification makes a marked increase in the rate at which samples can be tested. The minimum withstand voltage considered satisfactory is 25kV, and where a sample gives an unsatisfactory test a further sample is taken for confirmation.

When test results on the oil of a transformer are worse than the limits set out above, arrangements are put in hand to withdraw the unit from service and return it to the workshop where the oil is drained and filtered, or scrapped if acid. The core and windings are withdrawn, washed down in clean oil and checked over, the coil clamping being adjusted if necessary, all nuts and bolts checked for tightness, insulation of core bolts tested while the tank is being cleaned out. When completed the core is replaced in the tank and covered with oil and put on short circuit at a reduced voltage to dry the unit out. The heating current through the windings is arranged to be somewhere in the vicinity of rated full load and is switched on and off by a contactor controlled by a thermostat located in the oil and set to about 80°C. To conserve heat the oil level is kept below the cooling tubes so that they do not circulate the oil, no other precautions are taken to conserve heat and generally a core and windings will dry out in about 72 hours. With the thermostat control of the unit it is left unattended at night. Insulation resistance is measured morning, midday and afternoon and from these readings it is determined when the unit is dry.

Thereafter the oil is filtered to remove any fibrous material it may have collected and the tank is topped up with filtered oil, closed up, and is ready for further service. No attempt is made to measure loss figures to compare with the original test certificates but consideration is being given to setting up elementary test facilities which would allow these figures to be checked.

With the power available at the Distribution Workshop of about 100kVA it is possible to dry out transformers of up to 1000kVA capacity. Large transformers are given similar treatment but where the power requirements for drying out are beyond the limited capacity of the Distribution Workshop the unit is moved to a load centre where a more adequate power supply is available.

In one instance a 40 MVA 66kV/22kV transformer failed due to a fault in the 22kV winding. The transformer was transported to the Swartkops Power Station where heavy lifting facilities are available in the turbine hall. A local transformer manufacturer was called in to do the necessary repairs, with the assistance of the Council staff. The repairs necessitated dismantling the yoke, removal of the 66kV windings from the white phase limb and replacement of the 22kV winding by a new one which was sent out by the overseas manufacturer. On completion of re-assembly the core and windings, which had stood for several months awaiting the replacement winding, were dried out in the transformer tank without oil, using hot air supplied by a blower and supplemented by hot air produced by passing current through the windings. Considerable care was taken to observe that the heated air did not exceed 80°C and temperatures inside and outside the windings were taken at frequent intervals so as to avoid overheating any part of the winding.

The drying out process performed in this manner took approximately one week. By this time the heat had soaked through the core and the whole assembly was at a fairly uniform temperature, with insulation resistance figures showing that the drying out process was complete. The unit was then filled with hot de-aerated insulating oil from a filter unit. When the core and windings were covered with oil, the balance of assembly and installation of bushings and connections in the main tank proceeded normally to allow the unit to be sealed up. After attaching and connecting up the on load tap changer and filling with oil, the unit was ratio checked on all taps and then successfully tested with high voltage D.C.

TRANSFORMER CABLE END BOXES.

A few years ago several cable end boxes on outdoor transformers failed over a comparatively short period. The failures were usually accompanied by a heavy fault which blew the front cover off, but did not ignite the filling compound or cause fire except that in one incident where the transformer was equipped with automatic water sprinkler fire protection, this came into operation.

In all cases the end boxes were the transformer manufacturers standard equipment and while different boxes varied in detail they all had a flanged and bolted joint to allow the front of the box or the front cover to be removed for making off the cable. Each box had been made off, in the first instance, with proper care and attention and should have been able to have performed its duty as long as its associated transformer; the transformer might remain in situ for 10 to 20 years and accordingly the cable end boxes should be capable of similar service.

Investigation into each case of failure revealed the presence of moisture in the box with free water visible. The problem then was to determine how and why moisture entered the boxes, and what measures should be taken to keep them dry. Consideration was given to the possibility of non-destructive testing to determine when moisture had entered the box, but obviously any method which relied on change of resistance or capacitance would only indicate after moisture had entered the insulation when it would already be too late. It was, therefore, decided to open and examine all outdoor boxes and the following observations were made:-

(1) Boxes were generally of cast or fabricated construction but are not machined true so that the fit of the mating surfaces were often poor and a thick and resilient gasket had to be used.

(2) In some boxes there was an excessive pitch of flange bolts or the flange, or the cover plate, was of insufficient thickness to provide adequate rigidity.

(3) Plain cork gaskets which had been used in some cases had become hard with time and had lost their sealing properties. Neoprene bonded cork appeared to be distinctly superior in this respect.

(4) Roughness of flange faces allowed moisture to get between portions of the gasket and the flange resulting in the formation of rust. This rust apparently gradually expanded and forced the gasket away from the flange exposing fresh metal to attack so that the rust gradually crept through the flanged joint and ultimately formed a path for moisture to enter.

(5) Leakage into the box, when it occured, was generally somewhere along the top

joint on which water from rain, or dew would be likely to settle; there was also evidence of water lodging in bolt holes in the spaces between the head of the bolt and the nut and then having only to traverse a small part of the gasket width to enter the box.

From these observations it was concluded that under local conditions there is a likelihood that the cover seal of the normal manufacturer's outdoor cable end box will leak, if not immediately, then at some later date.

Fundamentally the design of the box attempts to provide a hermetically sealed chamber partially filled with cable compound and having an air space to permit expansion of the compound. With changes in temperature there will be variations in the pressure of the gas in the air space above the compound. It, therefore, follows that unless the joints and filler plugs form absolutely and permanently tight seals, there will be a tendency for the box to "breathe". This breathing process will be in the form of a rise in pressure as the box warms up in the morning as load comes on and with the heat from the sun to which it is exposed, leading to a loss of gas from the box if there is the slightest leak, to equalise internal pressure with atmospheric pressure. On cooling down there will be a drop in pressure in the box and external air will be drawn in and if this air is humid as it frequently is in the early evening in coastal areas, there is a danger that this breathing process will gradually introduce moisture from the atmosphere.

However, it was concluded that the main source of moisture was in the form of free water which would be drawn into the box if the box were wet externally by a heavy dew or rain. This effect would be most pronounced where a sudden shower of rain occurred at a time when the box was hot, and the "breathing in" process could allow an appreciable amount of rain water to enter the box. The operation of water jet fire extinguishing equipment for test purposes would be particularly likely to lead to water being drawn into the box and, in fact, it was transformers which were subjected to this treatment that first failed.

Working on these premises modifications were made to previous practice by the following alternative methods:-

(1) Providing a protective rain hood or cowl to cover the top and part of the sides of

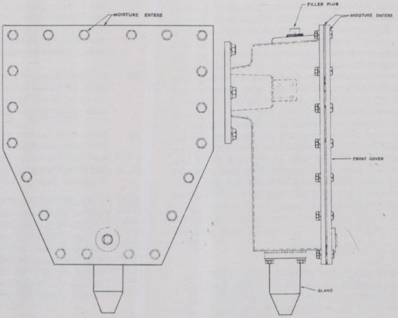
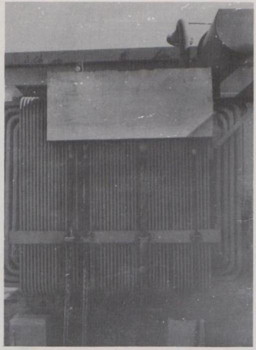


Fig. 1. Typical Cable and Box.



Transformer with protection cowl.

the box so as to prevent the box from becoming wet at any time; care has to be exercised to ensure that condensation which may occur on the underside of the cowl does not drip on to any flanged joint which may leak.

Where black bituminous compound is used, the hard setting types generally referred to as "tropical" in the manufacturers' specifications, is not favoured, despite the superior electrical strength, as a number of cases have been observed where cracks have developed in the hard setting compound. The preferred black compound is a soft one, which will gradually level itself at room temperature and this is now used as standard for all purposes. There is some likelihood of such compound migrating but as all M.V. cable ends are made off with oil resisting tapes as standard procedure, no trouble has been experienced from this source.

(2) Providing a form of conservator on each box and filling with a viscous fluid compound so that the box is completely filled with compound which is under a slight positive pressure due to the head from the conservator. Fig. 2. In this method the cable end has to be carefully made off with oil resistant tapes to keep the migration of compound to a reasonable amount; migration does still occur and where the other end of the cable terminates on indoor sub-station switchgear at a lower level than the outdoor box there is a tendency for oil to be transferred to the indoor box which leaks and tends to be untidy.

More recently, as an experiment, the cable end boxes on a transformer were fitted with a free air breather in place of the usual gasketed plug. This breather is in the form of a piece of pipe bent to the shape of an inverted U, the open leg being longer than the leg connected to the top of the box. It is intended that by preventing differential pressures gaskets will keep in better condition and in any event since there

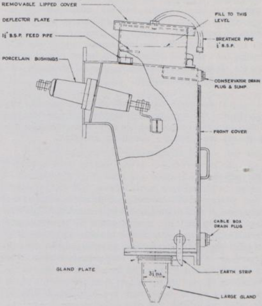


Fig. 2. Cable end box with conservator.

does not seem to be any possibility of permanently preventing the box from breathing this might just as well be allowed in the first instance.

ON LOAD TAP CHANGERS.

The maintenance of these follows a standard routine; they are all fitted with counters, the readings of which are taken at monthly intervals. Experience shows that it is advisable with midpoint reactor type to inspect and adjust the diverter switch contacts annually or at intervals of about 5000 operations; the oil at this stage is generally fairly heavily contaminated with carbon and the amount of wear and erosion on contact faces has got to the point where they will require adjustment. At this stage they will still be capable of making a large number of additional operations without coming to any harm but it is prudent to retain some factor of safety in case overhauls are delayed. It is not recommended that the faces of contacts be dressed smooth or polished but instead a light cut with a smooth file will take off any excessively high spots leaving the faces rough, in which condition they will continue to give satisfactory service. The majority of tap changers do less than 5000 tap operations in a year. The annual inspection programme, therefore, often limits the taps between overhauls to a lesser number than 5000. Resistance transition type tap changers seem to be capable of making double the number of tap changes between inspections as the amount of contact burning and erosion is less in this form of equipment. There is, however, no intention to increase the time period between inspections to a longer time than 12 months as this period is considered as the maximum that should be allowed without an examination of the mechanism.

At the same time as the diverter switches are overhauled the operating mechanisms are inspected and lubricated and brakes and all such items requiring adjustment are given the necessary attention.

SWITCHGEAR.

The conventional bulk oil circuit breaker is the only type of switch used in Port Elizabeth for high voltage working and has proved itself to be extremely reliable. It is essential that a breaker should be able to trip when called upon yet in many cases it may otherwise remain closed for long periods of time. The local atmosphere tends to be humid and can lead to the formation of rust on the bright steel components which make up a switch mechanism and precautions have to be taken to ensure that every switch mechanism remains in good working order.

All switchgear is, therefore, overhauled at regular intervals as a routine; the length of the period between overhauls will depend upon circumstances, duty and type of switchgear and position of importance in the system.

Power Station switchgear is overhauled annually while switchgear in main distribution sub-stations or load centres is overhauled at intervals of about two years. The less important switchgear in minor sub-stations is overhauled at intervals of about four years. These overhauls consist of lowering the tank checking for tightness of connections, alignment and general adjustment. Oil is replaced with filtered and tested oil and mechanisms and secondary wiring are checked and mechanism oiled and adjusted. The procedure is practically standard for all circuit breakers but experience shows that some types of equipment have odd peculiarities or weaknesses and where these are known special attention is given to these points.

The protective enclosures of oil circuit breaker mechanisms vary considerably in their effectiveness and in some cases leave most of the mechanism exposed to dust and airborne contamination. They are, therefore, liable to formation of rust on shafts and bearing surfaces and there is a real danger of moving parts "freezing up", making the mechanism inoperative. A light oil has been found to be fairly effective in controlling this form of atmospheric attack but care must be exercised to avoid excess oil as this tends to collect dust and becomes "gummy"

In the event of a switch in a minor distribution sub-station tripping on fault it is usual to arrange for an overhaul within a few days of the fault trip as it might otherwise be some considerable time before it would be due for a routine overhaul. Fault trips on this type of gear are infrequent so the few extra overhauls are no real burden to the maintenance staff. Fault trips occur more frequently on overhead line circuits particularly in the case of long rural feeders and here the procedure is to aim at overhaul after 25 to 50 fault trips depending on the type of switch and its duty, which is largely dependent upon the fault level at the point at which the switch is installed.

In sub-stations when the fault level is high and approaching the rating of the switchgear it is usual to overhaul switches after every fault trip. Contacts are sometimes heavily eroded by arcing during one or two fault trips and it has been necessary to fit replacements but generally the amount of damage sustained to the main contacts is small and they can usually be dressed up with a file.

Spring closing mechanisms are probably more prone to minor troubles than other types and in particular often fail to latch when the spring is discharged; this might be due to mechanism being worn or out of adjustment which condition is not necessarily evident when the breaker is closed manually, whereas the sudden release of the spring throws high stresses on the latches and other parts and may cause the toggle system to collapse. Some forms of spring closing mechanisms have no effective arrangement to absorb the spring energy if the mechanism fails to latch and if this occurs can result in serious damage, such as bent shafts and broken components. Particular care, therefore has to be taken to ensure that such mechanisms are kept in proper adjustment and to keep all parts free so that the latches are positive.

In addition to the routine or special overhaul of switchgear after fault trips it is the practice to trip test all circuit breakers in load centres at intervals of about three months. The practice has its merits and its disadvantages; the breaker is always tested by the operation of one of its associated protective relay elements. This procedure includes the relay trip circuit in the test and gives the assurance that the whole process is in good order, both mechanically and electrically.

Trip testing is carried out by the normal supervisory staff on a rota system so that each man, over a period, has the opportunity of operating the equipment in every load centre, thereby obtaining some familiarity with all the different types of switchgear and protective systems used on the network.

Objection might be raised to this practice on the grounds that a variety of individuals, some possibly less careful than others in the handling of relatively delicate relay elements, might do damage to the equipment. The danger certainly is there but happily, so far, no instance has been recorded of any mishap or damage to a relay, whereas several odd defects have been located and rectified as a result of this procedure. The trip testing routine requires a fair amount of time for operating as radial circuits have to be paralleled with others in the network to avoid interruption to consumers. This, of course, has the benefit of familiarising operating staff with the system and brings to their notice the problems which arise in parallelling areas which may have some phase angle difference due to differences of impedence and power factor of the loads.

PROTECTION.

Protective relay equipment plays an extremely important role in the proper functioning of the distribution system and it is essential that all such apparatus should be in good working order at all times.

Prior to the commissioning of all new equipment installed in important sub-stations full injection tests are carried out on protective circuits. In order to facilitate these tests all current transformers are purchased with test windings, usually 10 amp, to make them suitable for secondary injection testing. Where test windings are not available or where there is any doubt about connections the equipment is tested by means of current injection into the primary.

The commissioning tests, both prior to making alive and subsequent to application of load, are intended to ensure that the protection is in proper working order in the first instance, and thereafter it is only necessary to conduct routine tests at fairly long intervals. The correct operation of the unit type protection installed on transmission circuits is, of course, dependent upon the pilot circuits being kept in good condition. Pilot and telephone circuits are checked for insulation resistance and continuity each month and the insulation resistance figures are recorded. The relatively frequent check of pilot and telephone circuits is essential as these cables run many miles and are subject to damage from the numerous excavations that are made by the various bodies who instal underground services in an urban area - e.g. sewage - water - gas - Post Office - etc. The working voltage of the pilot cable being low it can suffer damage from a pick without this becoming evident until some while later. It is for this reason that each time insulation resistance readings are taken they are compared with previous readings as this procedure shows up faults before the insulation resistance has got too low for normal working.

Open circuits have also occurred due to ground movements, and possibly defective jointing, and the test for continuity is of considerable importance as an open circuit in a unit protection circuit will make it inoperative leaving only the "back-up" protection to clear any fault which might occur.

When precautions are taken to ensure that the protection is in proper operation condition at the time of commissioning it does not require a great deal of attention other than careful visual examination of relays from time to time with a manual check to see that movements are free and that the front covers are properly replaced to exclude dust. At intervals of approximately five years they are injection tested and adjusted, if necessary, to ensure that they retain their correct characteristics.

OVERHEAD LINES.

The rate at which exposed iron and steel rust or corrode at the coast is considerably higher than it is in inland centres. As might be expected, the worst conditions are usually found close to the sea front and gradually improve as one travels inland. Overhead mains in a coastal area, therefore, have to contend with aggressive atmospheric conditions and a considerable effort has to be expended to keep them in a healthy condition.

The successful control and prevention of corrosion processes in exposed metal structures is dependent upon the exclusion of moisture and atmospheric oxygen from the surface of the metal which can be achieved to only a limited extend by the application of paint. Ideally, the metal should be absolutely clean and free from oxide before the application of the paint but this condition is usually unattainable under practical conditions, and once a structure has become heavily corroded great difficulty is experienced in getting it clean prior to applying a protective paint. Any rust or corrosion which is left and painted over soon causes a break in the paint film and the corrosion action continues.

The problem has been exercising the ingenuity of chemists and engineers for more than a century and it is not surprising that a great number of paint systems, rust inhibitors, rust removers and the like are available commercially. In our experience the majority of these are either not effective or are not practical under field conditions. The rust inhibitors and rust removers are often corrosive and difficult to apply and in some cases require to be washed down with water after application. Painters who are required to apply such treatments at the top of a pole not unnaturally raise objections. In any case such treatments usually require excessive labour which makes the cost of treatment expensive. Comparative tests conducted locally on a variety of paints have led to the conclusion that the most practical results are obtained by removing old corrosion as completely as possible by chipping and wire brushing and thereafter applying one or two base coats of zinc chromate or red lead paint, either of which appear to be about equally effective. Preference is given to yellow zinc chromate due to its bright colour which makes it fairly easy to observe that is has been applied to the work without missing any areas; when a red or brown coloured base coat such as red lead is applied much greater care must be exercised to ensure that the work is properly covered.

The base coat should be followed by one or two coats of a good quality paint preferably of the alkyd base enamel type. Again it is advantageous to have the base coat a bright colour which will show if the wearing coat is not properly applied. The life of this form of paint treatment may be from two to six years depending upon the location of the equipment; inspections are required from time to time to ensure that repainting is put in hand before the paint has broken down and allowed active corrosion to become general again.

The most effective anti-corrosion protection is provided by the hot dip galvanising process or by a zinc sprayed coating which treatments can normally only be applied during the manufacture of the equipment. Even with this treatment it is advisable to paint the equipment to ensure that the zinc coating is not lost prematurely. It is not practical to paint portions of overhead equipment such as line hardware, insulator spindles, shackle straps, etc., and these must rely entirely on what protection galvanising can give them. Once the zinc coating has been lost corrosion sets in rapidly and they have to be replaced before they fail mechanically. Corrosion of insulator spindles or the pins of disc insulators can cause the porcelain to crack due to growth of the oxide layer around the pin setting up stresses in the porcelain. Cracks in porcelain lead to puncture type failure of the insulators and these are often difficult to locate particularly on rural lines where fault power is usually limited and insufficient to shatter the insulator. A fair amount of trouble has been experienced locally from this cause both on line insulators and on insulators fitted to isolators located on overhead lines or on outdoor busbar structures.

A cracked porcelain in a string of suspension type insulators can usually be detected by "ringing" the porcelains by giving each in turn a sharp blow with a light hammer. This method is rapid and practical and has been used in the absence of more sophisticated equipment necessary for measuring potential drop across a string of insulators.

In the case of switch insulators fitted to outdoor isolators on 22kV busbar structures there are generally two in series in each stack and as these are reasonably accessible from ground level, potential tests are made on live insulators by means of a neon type potential indicating device. This indicator is fixed to a long insulated rod and is adapted to have two prongs which conveniently connect it across one insulator from cap to pin. If no potential is indicated it is evident that the insulator is defective. All insulators forming part of outdoor bus structures are tested in this manner at intervals of six months.

Creosote impregnated poles, wood and steel poles are all subject to failure due to rot or corrosion at or just below the ground line. Since the collapse of a pole can have unfortunate consequences all poles are examined at this point at intervals of one year and any that are found to be defective are changed with as little delay as possible. In at least one instance the annual inspection revealed a high incidence of deterioration of certain wood poles and on investigation it was found that these belonged to a particular batch which had been in service for less than ten years and apparently had not been properly impregnated with creosote in the first instance.

All high voltage overhead lines are patrolled at monthly intervals to locate broken and damaged insulators and any other condition which may require attention. In the case of long radial lines, supply is interrupted for maintenance on a regular day in each month, e.g. the second Wednesday, from 2 p.m. to 5 p.m.

Consumers on these lines have accepted this arrangement without complaint and it assists greatly in planning and executing maintenance. The vehicles operated by the supervisory staff are equipped with two-way radio communication and this permits the proper co-ordination of all work in hand and holds the period of interruption of supply to a minimum.

SPARE PLANT.

There are times when criticism is levelled at the Engineer on the grounds that he is unnecessarily cautious when he duplicates vital parts of his Undertaking in order to ensure continuity of supply; the term "ring main" seems to give an impression of frivolous expenditure of the Undertaking's loan capital. Augmentation of equipment and extensions and additions to plant to meet increases in load are often delayed while the Engineer endeavours to convince his Council of the urgency of such action. Yet it is only possible to perform normal preventive maintenance if there is sufficient plant available to be able to take individual items out of commission for the necessary attention. The alternative to preventive maintenance is maintenance in the form of repairs after plant has broken down which is likely to be a lengthy and expensive process and will most certainly cause inconvenience to consumers and loss of revenue to the Undertaking. It is not, of course, necessary to have complete duplication of all equipment but the system should be so arranged that there is sufficient spare capacity available with facilities to permit loads to be transferred to enable any main item of plant to be taken out of service at any time.

This does not apply to smaller items such as sub-station transformers, etc., for which suitable spare units should be available and which can be changed in a comparatively short time in the event of a failure. Sub-stations must, of course, be designed and arranged to enable such changes to be made with reasonable rapidity; here we find that sub-stations located in private buildings often require considerable preparation for changing equipment. This is due to a tendency to locate such sub-stations in basements and to have to lower equipment through hatchways, the covers of which normally form part of the ground floor. Here it requires a liaison between the Architect and the Undertaking in the planning stages of the building to ensure that suitable lifting eyes are provided over the hatchway as part of the structure, that coverslabs are easily removable and that access is not impeded in any way.

RECORDS.

Having arranged the system to permit plant to be withdrawn from service for maintenance it is necessary to arrange an effective system of records to ensure that the necessary preventive maintenance is in fact carried out. It is not sufficient to rely on memory but records should be kept as simple as possible to avoid unnecessary clerical work.

Routine examination and cleaning of sub-stations is carried out on an almost continuous basis by an electrician who is suitably equipped for the purpose and is detailed each day with a group of sub-stations which he must visit.

SUBSTATION INSPECTIONS.

DATE ______________

SUBSTATION ______________

Transformer/s	Oil Level.	Temperature

Substation fixed and loose equipment:

Substation Lighting	Wire Screens
Notices (2)	Bolts & hinges oiled
Racking Handle etc.	Fire buckets

Substation cleaned and swept ______________

General Remarks:

SIGNATURE ______________

Fig. 3. Substation inspection record.

He is required to fill in a record sheet for each sub-station showing the result of his inspection. Fig. 3. He must note oil levels and temperature of transformers, and readings, tap change counters and switch trip counters, and must inspect the general condition of the sub-station noting anything abnormal such as oil leaks, hot connections, etc. Actual oil gauge readings are required, not just "O.K." Such record sheets are retained for a period after which they are destroyed. Sub-stations having batteries are visited for battery inspection at regular monthly intervals.

At 12 monthly intervals oil samples are taken from all transformers and tested and the results noted and entered into a record card, each transformer having its own card, giving main details and general history of the transformer and details of all repairs and major maintenance. The results of the routine oil tests can, therefore be traced over a number of years for each transformer. Figure 4 shows one side of a transformer record card. Electrical details are on the reverse.

In the early winter electricians and supervisory staff are detailed to visit all sub-stations at about the evening peak load and note all cable and transformer loadings; portable clip-on ammeters are used for reading the loading of low-voltage cables and transformers which are not normally equipped with ammeters. All such readings are recorded on sheets which are scrutinised in the office along with any special comments on transformer or feeder loading or temperatures. These readings give warning where it is necessary to increase capacity of equipment or to lay additional low voltage cables.

A system load test is conducted each year when readings are taken at five minute intervals for an hour over the morning peak and again for an hour over the evening peak. Endeavours are made to choose a day which is cool with rain and overcast skies on which high loads are likely to be obtained. All main sub-stations and load centres are read and the whole of the supervisory staff assisted by a number of electricians and apprentices are engaged in taking the readings; care is taken to check instruments prior to the test to ensure that readings are reliable. The load test readings are analysed by the Technical Office which produces graphical records for each major load centre showing morning and evening peak loads of:-

TYPE OF COOLING.		CORE & WINDINGS.	LBS.
TYPE OF CONNECTIONS. H.V.		WEIGHT OF OIL.	LBS.
	L.V.	TOTAL WEIGHT.	LBS.
OVERALL DIMENSIONS.	LENGTH:	OIL QUANTITY.	GALS.
	WIDTH:	DATE INSTALLED.	
	HEIGHT:	INITIAL COST.	
FITTINGS.			

OIL TESTS.

DATE.	KOH/GM	KV.	DATE.	KOH/GM	KV.	DATE.	KOH/GM	KV.	DATE.	KOH/GM	KV.	DATE.	KOH/GM	KV.

MAINTENANCE.

DATE.	FITTER.	REMARKS

GENERAL:

Fig. 4. Transformer record card. (Electrical details on reverse side.)

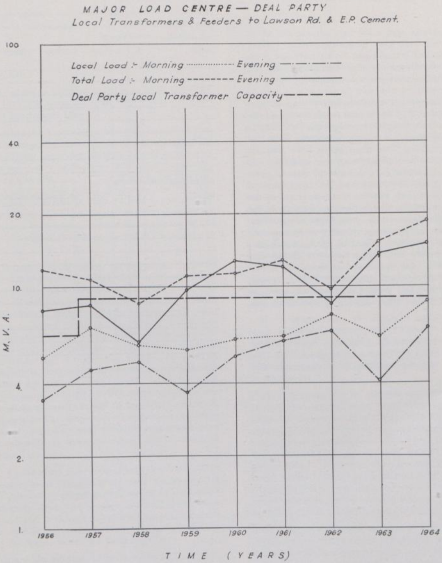


Fig. 6. Annual load test.
Graphic record of typical substation.

(a) The load centre as a whole;

(b) The main stepdown transformers.

The analysis also takes into account the whole system including load flow diagrams, feeder loading and sub-station and transformer load trends and from this analysis the extensions and developments for the following and subsequent years are planned.

In concluding I would draw attention to the fact that any programme of work, and in particular a preventive maintenance programme, depends for its success on the availability of trained personnel. This Undertaking has suffered for many years from frequent changes of staff, both supervisory and artisan, and this is now aggravated by a severe shortage of artisans. This state of affairs has led from time to time to omissions and neglect of some parts of the maintenance programme and a lack of continuity in the direction of individual sections of the Undertaking. Over a period of time an employee, whether he be supervisory or artisan, acquires a fund of specialised knowledge which enables him to perform his duties with greater efficiency and speed and it would be in the interests of municipal electricity Undertakings to ensure at all times that their employment conditions are at least as attractive as those offered by commerce and industry.

Finally I wish to thank the City Council of Port Elizabeth and the City Electrical Engineer, Mr. D. Murray Nobbs for the opportunity of presenting this paper.

SUBSTATION LOAD READINGS

Substation:-

Date: .... Time: .... Weather: ....

Ambient Temperature: ....°C. Substation Temp.: ....°C.

H.V. Switchboard - Ammeter Readings.

Circuit	R.	W.	B.	C.T. Ratio.	Remarks.

L.V. Dis Board - Circuit Loading.

Circuit	R.	W.	B.	Hot Connections and Remarks.

Labels Required:-

Fig. 5.

SOME NOTES ON TARIFFS

by

W. H. MILTON.

1.00. Preamble.

1.01. This paper is intended to bring to light the large number of tariffs of quite different form which are in use overseas at the present time.

1.02. What is termed, the marginal cost theory, is also mentioned in some detail and the basis and objects of the theory are briefly described because there is ample evidence that the theory is likely to be adopted extensively for application in practice. This is due to the fact that economists have sounded a note of warning that the present-day design of tariffs is likely to lead to uneconomic development calling for consequential modifications which might then have very serious repercussions on the future economy, not only of the industry, but of the countries concerned.

1.03. In order to bring home the difference in tariff structures which are in application, a relatively large number of tariffs are described in detail. In some cases, the description is detailed in order that a quite small difference in their incidence on consumer costs may become apparent. This is done to show that consumers are expected to have considerable ability in understanding the application of tariffs as they affect individual requirements and use of electricity, because the desired results can only be achieved if all consumers are educated to understand the tariffs. The required education must also enable consumers to appreciate or realise the necessity for designing tariffs in the forms which are used. Consumer relations are improved when consumers realise that the supply authority must obtain an economic return on its investments to meet consumer requirements as individuals or classes.

1.04. It is quite clear that, in overseas countries, there is no objection to the complexity of a tariff on the grounds that such complexity cannot be understood by the consumers supplied. Quite the reverse is expected of consumers, and tariff designers do not fear introducing complexities because the consumer may not understand the necessity for tariffs taking the form they do.

1.05. It is also the intention of the paper to indicate that, although the analyses of costs is resulting in a clearer picture of the origin of those costs, there is still considerable divergence of opinion as to the manner in which the costs should be covered by the tariff designer. In other words, no very clear-cut rules can yet be laid down so that standard tariffs of exactly the same form may be specified for application anywhere.

1.06. Mention is made in the paper of the basis of tariffs in application, not only for large user supplies, but also in respect of supply to domestic consumers and other small users. It will be found that the domestic and small user supplies are furnished on a wide range of tariff structures. In many cases, the room basis of establishing a fixed monthly income is applied with variations in its form. For example, in some cases, only unit rates are used but the number of units at various rates supplied during a month is controlled by the number of rooms. In some other cases, an assessment of loading is used to establish either a fixed monthly charge, or the number of units to be supplied at a high rate (or rates), before a low rate becomes applicable. The very simple form of tariff comprising a monthly charge which is independent of the area or size of the domestic premises supplied coupled with the application of a block rate unit tariff or even a simple single unit rate is also in use. The argument in support of this latter system is that we lack sufficient information to determine to what extent the domestic demand contributes to the required installed capacity costs.

1.07. In some cases, the supply to domestic as well as small industrial consumers is controlled on the basis of the availability of demand. The availability is then controlled either by miniature circuit breakers or by high rupturing capacity fuses and many consumers are supplied on this basis.

1.08. The industrial or commercial class of consumer is often also charged on the basis of his assessed demand which takes into account the number and rating of the appliances and the lighting system installed. In other cases, the maximum demand of such consumers is actually measured and that measurement may be on the basis of kW or kVA. The period for determining maximum demand varies from 15 minutes to 1 hour and it has been suggested that for domestic purposes a two-hour demand period might provide a solution if the demand of this type of supply is to be incorporated as an element in this tariff.

1.09. Large users are charged in the normal manner applied by members of this association but the most prevalent system is a charge based on the annual maximum demand of the consumer supplied measured during winter months.

1.10. Provision is made in almost all cases for benefits if the peak load is controlled during the winter period and also if the supply is used during specified off-peak periods.

1.11. Where opinions are expressed, they must not be taken as representing the views of the Electricity Supply Commission, being the Author's own views resulting from his study of the problem and his observations from publications on the subject and interviews with the responsible officials overseas.

2.00. General Notes.

2.01. Papers have been presented in the past on the subject of electricity tariffs, one dealing particularly with the principles of design from the Author's point of view and the latest dealing far more generally with the aspect of electricity charges.

2.02. The earlier paper delivered to the Association, dealt with the principles of design based on cost analysis but in the later paper a very definite impression is created that a tariff designer should give very serious consideration to the allocation of costs between consumers and classes of consumers on the basis of "what the traffic can bear".

2.03. Whilst the view - that charges should be based on the ability of the consumer to pay - has received considerable support in the past on the basis that this method makes available electricity to the largest number of consumers possible, it has become increasingly clear to the authorities responsible for the development of the electricity supply industry that this basis is not in the general National interest because it falsifies the economic bases of choice by users of electricity.

2.04. As many may be aware, it has fallen to my lot to propose tariff revisions from time to time and also tariffs to initiate electricity supply in some of Escom's Undertakings.

2.05. Any revision of Escom's standard tariffs, which appear in the schedules to Escom's Licences, requires the approval of the Electricity Control Board (E.C.B.) and before such approval is given, the proposals are advertised and subject to objection from consumers and potential consumers in the area concerned.

2.06. In the event of objections being lodged, in proper manner, a public hearing before the Control Board is then required. Only after the date set down for such a hearing will the Control Board give its decision with due regard to the objections raised and any support to those objections which may have been put forward during the course of the public hearing.

2.07. In these circumstances, it is not surprising that, for some time past, the Electricity Control Board has required that it be furnished with full supporting data in respect of Escom's proposed tariffs showing how the charges are arrived at and what steps are to be taken to safe-guard the interests of existing consumers when additional consumers are secured (more particularly when Areas of Supply are extended).

2.08. In other words, Escom's tariffs are designed on the basis of estimates founded on historic evidence and taking into account projected future developments which may deviate from the historic conditions when applied to the future.

2.09. When an electricity undertaking is permitted to make a profit, and attempts to do so, greater freedom in the design of tariffs is permitted the designer than is the case when an undertaking is required to so operate as to produce, as near as possible, neither a surplus nor a deficit - which is encumbent upon Escom.

2.10. The greater freedom to which I have referred is permitted because the designer will have received, presumably, a directive as to the sources from which the surplus is expected and, is likely to receive some guidance as to the distribution of the relative percentage surplus among the various classes of consumers. For example, those in control of the undertaking, and with the power to do so, may instruct the designer that the surplus should be obtained from one section of the consumers, even to the extent of permitting another section or sections to be supplied at less than their pro-rata share of cost (not necessarily at a loss).

2.11. On the other hand, when neither a surplus nor a deficit is permissible and, in particular, when it is clearly laid down that in the event of a surplus or deficit resulting from the application of standard tariffs, the revenue from the standard prices shall be decreased or increased for all classes of consumers in equal proportions (to dissipate the surplus or cover the deficit) the designer has no freedom of choice. It is clearly implied that each class of consumers is required to meet its pro-rata share of the cost of the supply, because the surplus or deficit is assumed to be proportional to the revenue obtained from each class.

2.12. To fulfil the requirements laid down in this manner, it is clearly necessary for the designer to determine, as accurately as possible, the contributions to total cost arising from the requirements of each separate class of consumer.

2.13. Similar careful analysis of cost distribution is desirable when a surplus is to be obtained. The allocation of actual cost between the classes is used to ascertain approximately the source of surplus the designer aims at deriving from the several classes of consumers separately. It enables him to avoid a tariff which would result in a loss from any one class, in the event of the use by such a class of consumer increasing disproportionately with the passage of time, unless he has been required to subsidise that class.

2.14. The analyses of the cost structure of developed undertakings has led to the introduction of what is often termed the "marginal cost theory" to take care of changing costs due to development. This theory is applied by some supply authorities and is gaining considerable ground overseas.

2.15. Very briefly, what this theory sets out is the necessity for establishing a minimum unit rate which can be applied for a relatively long period of time without the risk of incurring a loss from the sale of increasing quantities of energy. Similar care is also required in respect of the sale of demand, but I feel it desirable to deal first with the unit rate aspect.

2.16. On a broad basis, the marginal energy cost may be described as the cost of supplying an additional unit of energy to a consumer during a particular period of time. It will be appreciated from this that the marginal cost varies according to plant availability at the time when a consumer or group of consumers receiving supply requires that additional unit. There is therefore a variation during the year of the marginal cost at a given time of day as well as hourly variation with the time of day. It is at once apparent that unit rates assessed in this manner can only be considered in theory because it would be quite impracticable to provide the necessary metering equipment to apply unit rates which vary with time of day and time of year. A compromise is therefore necessary.

2.17. Very careful examination of this problem has taken place overseas and it is comforting to learn that the difference of marginal costs between say winter and summer may be so small as to permit an average being taken without giving rise to cause for concern.

2.18. On the other hand, the "time of day" differences have been shown by examination to be appreciable. In consequence, time of day tariffs are not at all uncommon overseas. These aspects will be dealt with in greater detail after mentioning the marginal demand costs.

2.19. As is to be expected from the foregoing, the marginal demand cost is the cost involved in supplying an additional kilowatt of maximum demand on the assumption that the plant being used to meet the demand is fully loaded at the particular time the additional kilowatt is required. In other words, it is based upon the average cost per kilowatt of providing additional plant to meet the requirement for that additional kilowatt.

2.20. If the additional kilowatt is required at a time other than the time of peak load on the generating installation, that additional kilowatt can be supplied in most cases from existing plant and its cost is therefore reflected in the marginal cost of energy at that time. The marginal cost of demand is therefore clearly related to the cost of the additional kilowatt at a time that new plant must be installed to meet the requirement. In other words, at a time when existing plant is not available to meet the requirement. It must also be understood that the additional kilowatt is one of a number, because the addition of such a small quantity would not be the actual deciding factor, or last straw, demanding additional plant.

2.21. The cost per kilowatt of providing the additional plant to be taken into account is not necessarily the total cost per kilowatt of providing, operating, maintaining and supervising the additional plant itself because a credit must be passed on the basis that the new plant will be utilised for base load purposes because of its higher efficiency and therefore will reduce running (energy) costs at the time of peak in consequence.

2.22. In order that this aspect may be better understood, it is necessary to appreciate the conditions of operation of generating plant from time to time. Unless an undertaking has an excess of generating plant capacity (which is not desirable in the interests of economy), at the time of the annual maximum peak demand, all generating plant will be brought into service. This then means that plant ranking from the highest to the lowest operating efficiency will all be in service. If an additional kilowatt is to be supplied, being from new plant, that new plant would take over the load from the less efficient plant (kW for kW) for the period the low efficiency plant would have been in operation and a credit to the marginal capacity costs is then due from the energy cost account.

2.23. The marginal energy and capacity costs or overall marginal costs must not be derived only from the actual costs prevailing at the time the analysis is made. The marginal costs on the basis of estimates for several years into the future must also be studied in order that long-term marginal cost figures may be determined. The necessity for a long-term study arises from the aim at establishing rates which will remain applicable for a long time.

2.24. The next stage in the application of this theory is to determine, as accurately as possible, the contribution to the peak demand of the system made by each of the classes of consumers and then the marginal capacity costs may be allocated pro-rata to those peak contributions.

2.25. The marginal capacity cost may be incorporated in a unit rate applicable to units used during the peak period. When considering the peak loading, it is possible to allocate a number of hours during the year when the load requires all plant to be in service and the number of units supplied during those hours can then be used to cover the marginal capacity cost. For the purpose of determining an average unit rate for the total supply during the peak period, the overall total of units is then used. This rate may be used for distribution in bulk.

2.26. The proportion of the total supplied to each separate class of consumers is used when determining the average cost per unit of supplying separate classes at marginal cost rates. The likely difference in the rates applied to classes arises from the difference in the "shape" of the load curves during the hours of peak taken into account.

2.27. From the units supplied during the hours of peak, it is possible to establish a unit rate which avoids the application of a demand rate and that rate is then the minimum rate at which units may be supplied during the peak hours.

2.28. Unit rates which vary with the season of the year and also for the periods into which the 24-hour day is subdivided are in actual use.

2.29. Metering certainly becomes complicated, but multi-dial meters are available to reduce the number of individual meters required in applying tariffs designed in this manner. Time switches and/or remote controlled relays are used to select the appropriate dial or dials for recording use.

2.30. In application of this theory, some authorities avoid the full implication but nevertheless it is generally agreed that the minimum unit rate which can be incorporated in any tariff is the appropriate marginal cost. In consequence, some of the unit rates applied are high in relation to present-day unit rates which are used in the Republic, when they approximate average "fuel" cost.

2.31. During the course of a recent overseas visit, it was found that the tariffs applied generally by the members of this association and by Escom are far less complicated than those applied in overseas countries.

2.32. Most of the authorities overseas hold the view that the tariffs available should be readily understood by their consumers. This is because the supply authorities are very much concerned that the form of energy a consumer decides to use and the manner of its use should be correct from the aspect of overall economy and the charge for each form of energy should therefore be based on economic costing. For example, if the utilisation of oil or gas would be more economic, in reality, in the National interests, then the tariffs offered by suppliers of these various sources of energy should be designed in such a way that the consumer's choice is correct. There is, of course, no intention to use compulsion, because it is appreciated that each consumer should be free to choose the type of energy which he prefers. The point is that a consumer should be able to realise what his preference will cost him. Therefore his preference should be realistic and not distorted by false competitive values in tariff rates.

2.33. In Great Britain, electricity's principal competitor is gas but there is no question of a "price war" in an endeavour to sway consumers in their choice between gas and electricity. Other competitors are, of course, oil, coal and smokeless fuel. It is hoped, and expected, that a consumer's choice will be based on sound economic grounds, then being in the National interest.

2.34. In Holland, I gained the impression that, there is considerable concern arising from the discovery of a vast source of natural gas. Control will present a very difficult problem if premature obsolescence of existing assets is to be avoided. This may even affect Great Britain, because it it not at all unlikely that a supply of natural gas from Holland will be offered to Great Britain. Holland's neighbours may also be affected.

2.35. What surprised me, was that the consumers overseas are supposed to have such a clear understanding of the details of the tariffs available to them that their choice between the tariffs may be correct on an economic basis.

2.36. Neither time, space, nor your patience would permit me to quote a schedule of the tariffs from all the countries which I recently visited because the total number of distinctly different tariffs amounts to several hundred. In order to illustrate this point, it may suffice if I quote just a few. Those I have selected may serve to illustrate the considerable difference in methods adopted - all directed towards the common aim of correctly charging the user!

2.37. In order to avoid confusion and to facilitate an examination of the comparisons, my comments deal with the different classes of consumer in turn and, after quoting examples from various countries of the type of tariff applicable to what we term Large Power Users, I will proceed to the small user or domestic class tariff.

3.00. Examples of Tariffs - Large Users.

3.01. Just as in the Republic the large user class is charged on a maximum demand basis and the classification, in some cases, is applied to consumers who require as little as 20 kilowatts of maximum demand.

3.02. The small user is, on the other hand, permitted to take supply at small user tariff rates for demands as high as 40 kilowatts.

3.03. There is no distinct common assessment used to distinguish between what I have referred to as the large user and small user classes, each supply authority having its own views on this subject.

3.04. A typical large user tariff applied in Great Britain is as follows:-

3.05. For commercial and miscellaneous purposes, furnished at high voltage, there is a monthly maximum demand charge which is applied as one twelfth of the annual maximum demand charge. The annual maximum demand charge is graded as follows:-

R19.00 for each of the first 20 kilowatts of the chargeable demand;
R17.50 for each of the next 180 kilowatts of the chargeable demand;
R16.50 for each of the next 300 kilowatts of the chargeable demand;
R15.50 for each of the next 500 kilowatts of the chargeable demand;
R15.00 for each additional kilowatt (over 1,000 kW) of the chargeable demand.

3.06. The chargeable demand in respect of any month is deemed to be the highest maximum demand established in any of the 12 months up to and including that month. During the first 12 months of supply, the chargeable demand is deemed to be the highest maximum demand established in any of those first 12 months and the demand charge in respect of each of the first 11 months is calculated on the highest demand after the date of commencement of supply and retrospective adjustment made for previous months in each monthly account and a final adjustment in the account for the 12th month.

3.07. In other words, the maximum demand charge is based on the annual maximum demand and not on the actual monthly maximum demand as generally applied in the Republic.

3.08. There is an adjustment for power factor, the tariff being applicable to any power factor between unity and 0.85 lagging. The adjustment for power factor is by way of a demand surcharge of 1% for each 0.01 by which the average lagging power factor in a month is less than 0.85. It is noteworthy that the average lagging power is computed from readings of a kilowatt hour meter and a non-reversing sine meter. In other words, the power factor is defined as being the resultant of the total kWhr (energy) component of the supply in a month and the total kVAhr reactive lagging component of that load in a month. It follows that the poor power factor often associated with light load conditions is taken into account, not being disregarded as would be the case if the power factor of the consumer's load required to be associated with the time of maximum demand (which is the case in kVA maximum demand tariffs).

3.09. The charge per unit is also graded from approximately 0.9 cent to 0.5 cent, the grading being based on the number of units per month per kilowatt of the chargeable demand and being in three steps. There is an adjustment on account of the cost of coal which is applicable on a monthly basis being in respect of the cost of coal in the preceding month. The adjustment is in very small steps being by 0.00051c per one cent variation in the cost of fuel.

3.10. In this case, the maximum demand is measured on a half-hourly basis, though in some cases, either a one-hour or a quarter-hour basis is applied. If two points of supply are furnished to any one consumer, the maximum demand is the arithmetical sum of the demand established at each of the points of supply (in other words, diversity is not taken into account).

3.11. If the supply is required for industrial purposes provided at high voltage, the maximum demand charges are decreased from those previously mentioned, and become R16.50, R16.00, R15.50, R15.00, and R14.50 for the same "steps" in the demand as mentioned earlier. It is to be observed that, for the first 20 kilowatts of chargeable demand the decrease is R1.50, and the decrease becomes smaller in each step to a final decrease of only 50 cents for demand in excess of 1,000 kilowatts.

3.12. The same adjustment of 1% is applicable for power factor as in the previous tariff.

3.13. The unit rates are also decreased for the first two steps although the number of units per kilowatt in each step remains unaltered. The decrease in the first two steps in the unit rate is 0.04 of a cent, the final block being charged at the same rate in both these tariffs.

3.14. A special tariff is also provided for off-peak (referred to as restricted hour) supplies for thermal storage purposes also given at high voltage. In this case, a graded tariff is available depending upon the off-peak hours during which the consumer requires supply.

3.15. If the supply is restricted to the hours between 10 p.m. and 7 a.m., the tariff is 0.44 cent per unit. If, however, the consumer desires the supply to be furnished for extended hours, then an off-peak rate is available for a supply furnished between 7 p.m. and 7 a.m. and also between noon on any Saturday and 7 a.m. on the following Monday, and in this case the unit rate is increased to 0.55 cent per unit. Further extended hours are also considered as off-peak when the supply is made available between 7 p.m. and 7 a.m., and between noon on Saturday and 7 a.m. on the following Monday as well as during any three hours between 11 a.m. and 4.30 p.m. which are from time to time specified by the supply authority. In this case, a still higher unit rate is applicable, being 0.6 cent per unit.

3.16. All these unit rates are again subject to the same small adjustment of 0.00051 cent per unit for each cent by which the fuel cost varies from the stated basic cost.

3.17. When off-peak supplies are used, there is an appropriate monthly charge to cover the cost of metering and time-switch equipment which is provided by the supply authority to control these supplies. In addition to the monthly charge for the metering and time-switch equipment, the consumer is required to provide, at his own cost, suitable switchgear or contactors for controlling the supply, control being effected by time-switch, or other method of control by the supply authority.

3.18. Perhaps the most important restriction applied to the availability of these off-peak tariffs is that the consumer may not use electricity at any other time for the same purpose as his use of the restricted hour supply. For example, if the supply is required for thermal storage space heating, supplementary heaters may not be connected to the normal circuits of the consumer and therefore, unless all necessary space heating required by the consumer is provided from the thermal storage source, supplementary space heating must be obtained from the use of gas, oil, or other fuel. It is also necessary, of course, for the restricted hour supply circuit to be completely isolated from all other circuits, and in such manner, that it is not possible to make unwitting use of the circuit for any other purpose than that specified in the first instance.

3.19. The supply authority also has the right to charge the consumer with the cost to which it may be put in providing the necessary equipment to furnish the off-peak supply.

3.20. In another area, a maximum demand tariff is applicable when the requirement of the consumer exceeds 40 kVA and the maximum demand charge is again graded for the purpose of applying this tariff.

3.21. When the maximum demand is less than 75 kVA, the charge for maximum demand is based on kilowatt measurement being R4.25 per kilowatt in the winter months and R1.00 per kW in the summer months.

3.22. If the maximum demand exceeds 75 kVA, then the graded tariff becomes applicable on the basis of measured kVA. There is also a difference in the charges for the demand created in the winter months and the demand created in the summer months.

3.23. The charge per kVA of maximum demand is graded on the basis of the first 200 kVA, the next 300 kVA, the next 500 kVA and kVA in addition to 1,000 kVA.

3.24. For the winter months, the first block is charged at R3.70 per kVA, the second block at R3.27, the third block at R3.025 and for kVA in excess of 1,000 the charge is R2.80 per kVA.

3.25. In the summer months, the foregoing charges are reduced to 90 cents for the first block, 82.5 cents for the second block, 78 cents for the third block and 75 cents per kVA for the demand in excess of 1,000 kVA.

3.26. The foregoing charges are in respect of a low voltage supply. Where the supply is furnished at high voltage, the demand charge for the various blocks in winter is reduced to R3.525, R3.10, R2.87, and R1.65 per kVA for the demand in excess of 1,000 kVA. The summer charges are all reduced by 2.5 cents per kVA below the summer month charges set out for the low voltage supply.

3.27. The winter months are regarded as being from the 1st November to the last day of February, and the summer months constitute the balance of the annual period.

3.28. The unit rates applicable, differ between the low voltage and high voltage supplies but are the same for both the summer and winter months. The units are charged on a block rate system, the first block per kVA or kilowatt of maximum demand being followed by a second block with twice the number of units per kVA or kilowatt of maximum demand and thereafter the remainder being charged at the lowest rate.

3.29. For the low voltage supply the unit rate is 0.73 cent per unit in the first block, followed by 0.58 cent per unit in the second block, the remaining units being charged at 0.47 cent per unit. For the high voltage supply, these charges become 0.71c in the first block, 0.56c in the second block, the remainder being charged at 0.46c per unit.

3.30. The unit rate is subject to variation, as previously described, by 0.00054 cent per cent variation in the fuel cost per ton for the low voltage supplies, remaining at 0.00051 cent per unit per cent variation in the cost of coal per ton in the case of the high voltage supplies.

3.31. The kilowatt maximum demand is determined in the usual way but the kVA maximum demand is determined by measuring the kilovolt ampere hours when assessing the demand on a half-hour period.

3.32. In Holland, the tariffs available to consumers differ in the large number of areas into which Holland is subdivided although there is an overall Governmental control aimed at stabilisation and standardisation. These aims have not been achieved up to the present time. The tariffs applicable in Holland are even more complicated than those I have already mentioned. The unit prices are again graded, as for example, from 5,000 units per month to over 200,000 units per month in nine steps which vary in price from 0.8 of a cent (Dutch) down to a minimum of 0.3 cent per unit (Dutch), to all of which figures there is an appreciable addition for the actual cost of fuel used (as distinct from a small adjustment).

3.33. The charge for the maximum demand is also graded, both in respect of the voltage of supply and in blocks of kilowatts of maximum demand. The maximum demand charge is comprised of two components, the one being in respect of the demand the consumer is entitled to impose upon the system (which is rather equivalent to a notified maximum demand) and the other component being in respect of the actual measured maximum demand.

3.34. In one case, the charges are raised in respect of up to the first 100 kilowatts, for the following 100 kilowatts, for the following 300 kilowatts, for the following 500 kilowatts, for the following 1,000 kilowatts, and for demand in excess of 2,000 kilowatts.

3.35. For the component of notified maximum demand, the charge for the first block per kilowatt per annum is 60 florins, thereafter reducing in the stages of the blocks to 39.60 florins per kilowatt for the demand in excess of 2,000 kilowatts. For the component of the charge arising from the actual maximum demand over the same range, the charge is 2.20 florins per kilowatt for the first 100 kilowatts reducing to 1.25 florins per kilowatt for the demand in excess of 2,000 kilowatts. This latter component of the charges, however, is not complete, because to each of the components must be added the cost of 18 kilograms of fuel, all charges being on an annual basis though payable monthly. The cost of fuel used for this increment is determined from the average cost of the fuel delivered into bunkers or tanks (where fuel oil is used); the actual cost is adjusted to the basis of 7,500 kilogram-calories per kilogram, all increased by 2%.

3.36. The unit rates are also subject to adjustment by the addition of the cost of 0.5 of a kilogram of fuel, the cost of fuel also being adjusted to the basic price.

3.37. If the supply is furnished at low voltage, the measured maximum demand is increased by 2% for the purpose of applying the charges and the measured units are increased by 3% for the same purpose.

3.38. Provision is made for a reduction in charges to consumers if they agree to reduce their load during the peak load period. For example, if the consumer, well in advance, undertakes to reduce his load by at least 15% in the months of November, December and January, during successive periods of 2 hours falling between 6.50 and 9.10 in the morning <u>or</u> between 3.50 and 6.10 in the afternoon or, alternatively, for one hour between 7.20 and 8.40 in the morning <u>in addition</u> to one hour between 4.20 and 5.40 in the afternoon, the maximum demand charge is adjusted to give him the benefit of the reduced incidence on potential peaks. The adjustment is made by reducing the off-peak period maximum demand by 40% of the excess of the off-peak maximum demand over the maximum demand registered during the "peak period" (established in the months of November, December and January during stated hours, which cover the system annual potential peak period).

3.39. There is also a special night rate at the option of the consumer, the tariff for units supplied during the period being 0.4 cent per unit for the first 20,000 units per month used during the hours from 10 p.m. to 7 a.m., plus 0.3 cent per unit for additional units used during that period, both prices being subject to the addition of the cost of 0.45 of a kilogram of fuel.

3.40. The method of applying this demand formula is to reduce the maximum demand created outside the restricted hours by 40% of the difference between the actual maximum demand created during those hours and the demand created during the restricted hours. In other words, approximately 60% of the demand charge is in respect of the utilisation of the transmission and distribution systems.

3.41. In another section of Holland, the complicated tariffs which consumers are required to understand fully may be illustrated from the following. For industrial users, two tariffs are regarded as the most important by the supply authority and are described as the kW/kWhr tariff and the square root of time tariff.

3.42. In the first tariff there is a monthly fixed charge plus a charge for the maximum demand plus a charge per kilowatt hour which is made up of the basic price to which is added an amount depending upon the cost of the fuel.

3.43. The charge for the maximum demand is graded in blocks of demand and also takes into account the maximum demand created during the peak period and the maximum demand created outside those hours.

3.44. The charge for the maximum demand during the peak period drops from 60 florins per kilowatt for the first 25 kilowatts in four stages to 52.50 florins per kilowatt in excess of 100 kW during the peak period. For the demand outside the peak period, the first 25 kilowatts is charged for at 30 florins per kilowatt dropping the same four stages to 22.50 florins per kilowatt in excess of 100 kilowatts. This latter amount is charged for the whole demand if there is no demand created during the peak period or, alternatively, is applied to the number of kilowatts of maximum demand created during the off-peak period in excess of the maximum demand created during the peak period.

3.45. The basic unit rate is 1.75 cents (Dutch) per unit plus an extra charge per unit in cents of

$$0.65 \frac{4500}{1000} + 0.4 \frac{Bv - 4500}{1000}$$

The item Bv is the average price in cents per 1,000 kilograms (based on 7,500 kilogram-calories per kilogram) of the fuel actually used, subject to a minimum cost of 4,500c. This proviso to the formula ensures that the second portion cannot be negative.

3.46. The alternative tariff, at the option of the consumer, does not include a maximum demand charge as such, the charge for demand being incorporated in the unit rate by the application of a specified formula, which takes into account indirectly both maximum demand and units used.

3.47. The formula required the use of a numeral obtained from a schedule which associates the actual maximum demand with the numerals to be used and a time "T" which is the calculated number of hours during which the actual units used would have been used had the consumer's maximum demand remained constant for those hours.

3.48. In order to arrive at the price per unit, the numeral corresponding with the consumer's actual maximum demand (as set out in a schedule) is divided by the square root of the time "T" derived in the foregoing manner subject, however, to that square root not exceeding 70 (the equivalent of 4,900 hours). The numeral corresponding with the maximum demand varies from 1.6404 times an actual maximum demand of 100 kilowatts to 0.12048 times a maximum demand of 10,000 kilowatts, the variation in this factor is not, however, proportionate. The actual schedule of equivalent numerals used in the tariff specifies 25 actual maximum demands with 25 corresponding numerals, an intermediate demand between two demands specified in the schedule corresponding with a calculated proportionate intermediate numeral.

3.49. It therefore follows that the basic price per unit varies with the consumer's load factor and is obviously a composite of a demand charge and unit rate.

3.50. The unit rate derived from the foregoing formula is also increased by the addition of an amount calculated on the basis of the extra amount derived for the increase in the basic rate of the alternative tariff but in this case the factor of 0.65 is variable for calculated equivalent hours of constant load (not then being limited to a maximum of 4,900 hours) between 2,000 and 6,000 hours. For up to 2,000 hours the factor of 0.65 is applicable but for 6,000 hours the factor reduces to 0.4. For intervening hours between 2,000 and 6,000 there is a pro-rata reduction of the factor from 0.65 to 0.4.

3.51. This alternative tariff is for supply at the nearest power station or the nearest 110kV stepdown substation. The cost of transmission from this source is a separate charge and is calculated for each specific case.

3.52. Both tariffs include an additional monthly fixed charge.

3.53. On the basis of a consumer having a maximum demand of 100 kilowatts and using 300,000 units per annum, comparison between these two tariffs will show that the first of the alternatives would result in an average cost of the order of 7.2 cents (Dutch) per unit while the second tariff would result in an average cost of the order of 6.2 cents per unit, or an advantage of approximately 1 cent per unit arising from adopting the second alternative. If the load factor is less than that represented by this example, the difference is less.

3.54. In France and Germany, the large user tariffs are by agreement and incorporate demand and unit elements also, in some cases, these elements being graded.

3.55. In Switzerland, large users are dealt with on the basis of maximum demand and unit rates but it is not usual to find a distinction between summer and winter loading owing to the unusual conditions controlling the cost of generation for supply in Switzerland.

3.56. Any requirement of over 10 kilowatts is charged on the basis of maximum demand, the charge being of the order of 5 Swiss francs per kilowatt per month. In this case, the maximum demand period is 15 minutes.

3.57. For industrial supplies, the charge is of the order of 4 Swiss francs per kilowatt per month plus the unit rate and the unit rate is established on the basis of 3-yearly intervals of use when the charge is then fixed. The charge varies between 9 cents and 7 cents per unit according to the total number of units used per annum.

3.58. Domestic consumers are charged quarterly and industrial consumers monthly. A special charge is applied to furnace loads being approximately 2 cents less than for other purposes.

3.59. No special charges are offered for off-peak use as far as industry is concerned and it is significant that no consumer may increase his maximum demand above the specified demand to which he is entitled in terms of his agreement without first discussing the matter with the supply authority. On the other hand, in the event of the consumer not using the maximum demand allocated to him, he may be required to reduce his notified maximum demand to a realistic figure.

3.60. In all the circumstances, details of the tariffs applicable in Switzerland are not important when considering general tariff trends and their application elsewhere.

4.00. Examples of Tariffs - Small Users.

4.01. Coming to the domestic and small user type of tariff, the consumers in Great Britain again have a choice which is, however, restricted. The tariffs differ in the various areas into which the British system is divided under the control of Area Boards and, in some cases, in sections of each area. In the case of one of the areas, the choice open to the domestic type of consumer lies between the following tariffs:-

4.02. For a private residence, the first is a two-part tariff which calls for the payment of a fixed charge, which is on a weekly basis, the rate being 17.5 cents per week, the units being charged at a flat rate of 1.25 cents per unit. The average charge per unit resulting from the application of this tariff is limited to a maximum of 5 cents per unit.

4.03. The second tariff differentiates between night and day use. In this case the charge is increased to 29 cents per week for the residence, the charge for units used during the non-restricted period being the same as in the first tariff namely 1.25 cent per unit, but being reduced to approximately 0.7 cent per unit (somewhat more than half the unrestricted period rate) for units supplied during the restricted hours (9 p.m. and 7 a.m.).

4.04. A third tariff is also available on a two-part prepayment basis. In this case, the weekly rate falls between the two other alternative rates being 23 cents per week but the unit rate is the same as in the first case.

4.04. A point which is often overlooked when tariffs are published is taken care of in the case of the alternatives viz. that once a consumer has elected to take his supply on one tariff, he may change to another tariff only by giving appropriate notice and the notice is not acceptable unless the supply on the selected tariff has been furnished for one complete year at least.

4.06. A limit is imposed in respect of the maximum demand to which these tariffs are applicable. In the particular case mentioned, the tariffs are not applicable to a demand in excess of 40 kVA.

4.07. It is often found that business premises are combined with private premises, and then separate tariffs become applicable, the foregoing tariffs being reserved for application to private premises (with no complications).

4.08. When premises are combined, there are again three tariffs available to the consumers. The two-part rate tariff incorporates a fixed payment per quarter of R10.95. In the night and day rate tariff, the charge for each quarter is R12.25. The unit rates are the same as for domestic supplies. In place of the two-part pre-payment tariff, a block-rate tariff is applicable and the rates are 5 cents per unit for the first block, 1.875 cent per unit for the second block, and 1.25 cent per unit thereafter. The block-rate is applicable to the numbers of units used per quarter.

4.09. In addition to the foregoing six tariff rates, the consumers in both of these classes also have the choice of a block tariff offered in three alternative forms.

4.10. In the first of these, the charge per unit in each block is the same as that applied in respect of combined premises but, whereas the number of units in each block for the purpose of combined premises is a fixed number, the number of units in the first two blocks in this alternative is graded on the basis of the maximum demand to be made available to the consumer. The grading commences with up to 5 kVA, with more units in each block, and proceeds in blocks of 5 kVA up to 40 kVA. The number of units in each block is increased pro-rata to each 5 kVA of availability, in other words, the consumer requiring between 35 and 40 kVA is required to pay for eight times as many units in each of the first two blocks as a consumer whose requirement is limited to 5 kVA. The ultimate unit rate is, however, 0.02c less than for the other tariffs.

4.11. It is difficult to visualise any advantage to a consumer arising from this tariff in relation to the alternatives available for his selection.

4.12. An alternative to the foregoing graded block tariff is one which includes night and day rates and in that case there is a fixed charge of R1.30 to which is added an additional amount of R1.30 for each 5kVA or part thereof by which the maximum demand exceeds the day assessed demand.

4.13. The grading of the blocks also differs from that already mentioned, the grading in the case of this tariff being based on the day assessed maximum demand requirement of the consumer. The units used during the restricted hour (off-Peak) period between 7 p.m. and 7 a.m. are again supplied at the same reduced rate as that applicable in the other night and day tariff conditions.

4.14. In addition, provision is made for a block week-end tariff. In this case, there is a fixed charge per quarter of R1.95 plus R1.95 for each 5kVA or part thereof by which the maximum demand, which the authority is required to provide, exceeds the day assessed demand.

4.15. The number of units in each of the blocks of the block-rate again differs from the previous calculations because the grading per 5kVA of demand is based on the day assessed demand and not the maximum the consumer requires the authority to meet, off-peak rates in this case being applicable to use during the hours between 7 p.m. and 7 a.m. on any day and between the hours of 7 a.m. and 7 p.m. on any Saturday and Sunday (that is from 7 p.m. on Friday to 7 a.m. on Monday).

4.16. In order to apply these tariffs, it is necessary for the supply authority to assess the day demand and this is done on the basis of what the authority may reasonably expect as the maximum demand on the premises between the hours of 7 a.m. and 7 p.m. on any day except Saturday and Sunday. Obviously, some tests must be carried out in this connection and whether or not the consumer may have abused the tariff after such tests are carried out, is open to question. To guard against this possibility, the authority has the right to enter upon the premises at any time to re-assess the consumer's requirement.

4.17. There is also a general off-peak tariff offered which is applicable to those circuits controlled by time-switches and which can only be used during the period set by the supply authority. As previously, there are three alternatives arising from the different time periods when the supply is to be made available. In the first case where the supply is made available only between the hours of 10 p.m. and 7 a.m. the charge for the supply is 0.6 cent per unit and a fixed charge per quarter is also raised of R1.30.

4.18. In the second case, the hours of availability are between 1 p.m. and 4 p.m. and between 10 p.m. and 7.30 a.m. In this case, the unit rates are increased to 0.67c per unit, the fixed charge remaining the same as R1.30. It is not clear why an additional half-hour is added to the night period.

4.19. The third tariff involves an increased night period. The day period is from 1 p.m. to 4 p.m. as before but the night period is extended by commencing at 7 p.m. and continuing till 7.30 a.m. In this case the unit rate is increased to 0.7 cent per unit, the quarterly charge remaining at R1.30. As previously, this tariff is only applicable when the assessed demand is less than 40kVA and the assessed demand is also the demand which the authority may reasonably anticipate as the maximum requirement of the consumer's installation.

4.20. A feature of the foregoing tariffs available to the small user class is that they do not take into account variation in the number of rooms or in the floor area of the premises, loading being taken into account to some extent in the alternatives available. This is not a condition universally applied in Great Britain, tariffs being in force in some of the areas making provision for charges varying with the number of rooms on a physical count or floor area basis.

4.21. The view was expressed that, if the tariff of charges, to this type of premises, is aimed at reflecting the incidence of capacity as well as energy costs, the distribution of charges amongst the individual consumers would be unfair unless regard is had to the actual time of day and daily variations in the incidence of the loading of individual consumers or, at least, types of domestic users. On these grounds, any attempt to charge on the basis of the assessed maximum demand or the measured maximum demand of premises does not result in an equitable distribution of costs between individual consumers, because the time and frequency of maximum use is ignored.

4.22. In some cases, limited maximum demand availability is applied and the charges are based on the limit selected by the consumer. This is also subject to the same criticism levelled at associating the charges with potential or measured demand.

4.23. On the other hand, it was claimed that a tariff comprising a standard charge to cover such items as bookkeeping costs etc. which are independent of both demand and unit consumption coupled with a sliding scale of charges for the units supplied is more equitable. It is admitted that even such a tariff will be unfair in its incidence on many consumers, because it assumes that the contribution to the cost of meeting demand has little relation to the number of units used.

4.24. It has been suggested that a simple flat rate tariff (covering marginal costs) is all that is required until sufficient data has been collected to enable a more equitable tariff to be introduced. The suggestion seems to be based on the view that half measures taken in the direction known to be necessary should be ignored.

4.25. A surprising objection to the use of m.c.b's for control of limited maximum demand availability was the stated cost of this equipment which had been assessed at approximately R14 per consumer service and, in consequence, high rupturing capacity fuses are used for the limitation. This is done although the normal assessment of maximum demand is based on the average demand over half an hour.

4.26. In Holland, several tariffs are in force for the small user class, some being based on floor area and others on the maximum demand made available to the consumer. The control of the available supply differs, the phrasing of the tariff permitting the use of miniature circuit breakers or fuses. It was difficult to ascertain whether the miniature circuit breakers were actually used for the purpose of controlling the available demand but when fuses were installed they were of the high rupturing capacity type.

4.27. There are many instances of special tariffs being designed to differentiate positively between types of premises such as dwellings, offices, shops, churches, schools, halls, cafes, etc. all of which have particular tariffs applicable to their requirements.

4.28. In some instances, the marginal cost theory has been actually applied but it was admitted that there was considerable difficulty in applying the calculated tariff in the case of the domestic class of use and also, for the small power use on farms. The reason for this is the high unit rate which results from the calculation.

4.29. In view of the peculiar nature of many premises in Holland, when the floor area basis is used, the area of attics is discounted in the count and, in most cases, the area of cellars is omitted. Much depends upon the manner in which these sections of many of the buildings are used.

4.30. In the case of France, somewhat more complicated tariffs are applicable.

4.31. It will probably suffice to deal only with some of the domestic type of tariffs to illustrate the lengths to which the designers of the tariffs have gone in the interests of improving load factor.

4.32. The simple domestic tariff is based on the count of the number of rooms and the allocation of a limited maximum demand based on that count. For example, a single room dwelling has an allowance of 2 kVA, from 2 to 4 rooms the allowance is 3 kVA, for 5 and 6 it is 4 kVA, for 7 and 8 it is 5 kVA, for 9 and 10 it is 6 kVA, and for 11 or more it is 8 kVA. In counting the rooms the kitchen, passages, bathrooms etc. are taken together and count as one room. If a larger supply is required, for any of the foregoing premises, the tariff applies on the basis of the equivalent number of rooms for the larger supply.

4.33. The tariff is then applied in steps and the number of units associated with each step is graded according to the number of rooms in the count.

4.34. As an example, the first block of units is charged at 35.3 centimes, the second block at 26.3 centimes and the additional units at 14.8 centimes in winter (1st November to the 30th April) or 8.7 centimes per unit in the summer (1st May to the 31st October).

4.35. The number of units per room is not proportional to the number of rooms. For example, for a single room supply, 60 units are included in the first block and 30 in the second block, whereas for the six-room supply, 240 units are included in the first block and 120 in the second block. When the number of rooms exceeds 6, there is added to the first block 60 units per additional room and to the second block 30 units per additional room which means that the average number of units per room in the first and second blocks begins to increase after the count reaches 6 rooms.

4.36. As an alternative to this tariff, the domestic consumer may choose a tariff based on differential charges between night and day and on-peak use. A charge in addition to a unit rate is also made in respect of the number of rooms, being a fixed charge which rises from 1 franc for a one-room supply to 8 francs per month for 10 rooms or more.

4.37. The unit rates which are applicable in the case of this tariff are 27.7 centimes per unit for units used during the peak period, 26.6 centimes per unit for units used during the day and 8.7 centimes per unit for use during the night in winter or 6.5 centimes per unit for units used during the night in summer.

4.38. The so-called night hours are defined as being between the hours of 11 a.m. and 2 p.m. and the hours between 6 p.m. and 7 a.m., the remaining hours being termed day-use hours.

4.39. The peak period hours, which apply only during the winter months (1st November to 30th April), are defined as being between 3 p.m. and 6 p.m.

4.40. To enjoy the foregoing alternative tariff the consumer is assessed as having 10 kVA available.

4.41. One can imagine the accounting difficulties arising from the adoption of this form of tariff.

4.42. For non-domestic use the supply is made available on the basis of limited kVA. In this case, the number of units in each step varies with kVA and the months of the year. From April to September, the first block is calculated at 35 units per kVA and at 55 units per kVA during the winter months.

4.43. The second block is calculated at 25 units per kVA of demand made available for the months of April to September inclusive and 45 units per kVA for the winter months.

4.44. The charge for the first block of units is 39.1 centimes per unit, for the second block is 29.9 centimes per unit, and for the third block 18.7 centimes per unit.

4.45. It is a condition of this tariff that not less than 600 units are used per two-monthly period.

4.46. If the maximum demand required exceeds 20 kVA then the number of units contained in the first block remains constant at 45 units per kVA throughout the year and the second block remains constant at 35 units per kVA throughout the year. It will be noted that the total number of units in each block per annum is the same in both these tariffs.

4.47. The prices, however, are lower, being 24.3 centimes per unit in the first block, 19.9 centimes in the second block, and 15.2 centimes per unit for the remaining units. It is a condition of this tariff that not less than 5,000 kilowatt hours be utilised per two months.

4.48. In Switzerland, the accounting costs associated with generation and the distribution of costs in the tariffs is rendered difficult by reason of the nature of generation. Hydro electric generation is used during the summer months to meet the total requirement and for export of power but in the winter months electricity is imported and the import-export from Switzerland makes costing difficult from the point of view of internal use.

4.49. For the domestic supplies the room basis is also used and the charge is approximately 10 Swiss francs per room per annum, the unit rate varying between summer and winter and being of the order of 7 cents for summer and 9 cents per unit for the winter period. Off-peak rates are also applicable and the off-peak hours are from 10 p.m. to 6 a.m. when half the normal unit rate is charged.

4.50. Impulse or ripple control is used to control the time metering. Space heating is not encouraged because the supply authorities are not sure of the benefits which would result in view of their difficulties regarding generation during the winter period.

4.51. The situation of the mountain farms makes rural development expensive and difficult.

4.52. In Western Germany large users are charged for measured demand. In some cases the charge is on a monthly basis and in others on an annual basis, there being no seasonal variation in prices. The average of the three highest demands during a year is used for the annual basis.

4.53. Separate tariffs are applied for lighting and power purposes in a single installation.

4.54. The tariffs provide for a fixed charge based on the installed capacity for both lighting (per 100 watts) in addition to power (per 500 watts). The charge for power purposes is graduated according to the size of items of plant comprising the installation.

4.55. In assessing the charge for industrial purposes, the maximum size of motor is included in the assessment at 100%, to this is added 66% of the rating of the next size of motor, and the remaining aggregate of motor capacity is included at 33 % of its total rating. For the purpose of applying the tariff, one horse-power is regarded as 0.75 of a kilowatt. In this way, measurement of the maximum demand is avoided.

4.56. The domestic tariff is on the room basis there being a monthly fixed charge based on the number of rooms. The maximum size of a room in the count is 30 square meters. In the event of any room being larger than 30 square meters the excess over 30 square meters is counted as one additional room per 30 square meters or portion thereof.

4.57. It is usual to find that a lower unit rate is applicable during the night hours being from 70% to 80% of the day-time tariff and the night hours are regarded as being from 7 p.m. to 6 a.m. in summer and from 10 p.m. to 6 a.m. in winter.

4.58. In those cases where the maximum demand of large users is actually measured, measurement of the maximum demand during the night hours is omitted by agreement. On the other hand, the excess of the maximum demand at night over the day-time peak is usually limited.

5.00. Comments.

5.01. From all of the foregoing, it will be seen that designers in Europe are faced with considerable difficulty in framing their tariffs and the application of those tariffs is by no means a simple matter.

5.02. Comprehensive remarks on the tariffs for what is termed in this country "the small power user class" would only be confusing as we usually refer to the use of motive power equipment or its equivalent. The method of charging for this particular type of load differs very widely in the countries I visited and there does not seem to be any definite majority of opinion on this subject. In some cases, the possible demand is assessed and in others even small demands are measured and the charge raised accordingly; in other cases, it is based only on the number of units used.

5.03. Because of the expressed desire to ensure economic use of electricity in the light of the tariffs, and to encourage consumers to improve utilisation of plant during off-peak periods, it is recognised that consumers must be assisted to a full realisation of what can be done and what can be saved.

5.04. To that end, extensive organisations are employed in order to furnish the appropriate advice to the consumers and to bring home to them the availability and benefits of electricity supply.

5.05. Among the activities of these organisations is the equipping and staffing of large show-rooms in suitable localities to enable all manner of equipment to be displayed and demonstrated. In some cases, appropriate pamphlets, setting out the alternative tariffs available to a consumer and the conditions under which those tariffs become applicable, are available and, in some such pamphlets, the advantage of one tariff over another is explained.

5.06. In some areas, hire-purchase facilities are available and actually include the cost of installing appliances. To go even further in this direction, the supply authorities will themselves install consumers' equipment and do house-wiring work, the house-wiring contractor or appliance dealer, who introduces the client, receiving a percentage bonus.

5.07. To assist the tariff designers, a relatively large staff is employed in measurement of load and the preparation of data relative to loading and the distribution of load on the system arising from the habits of the consumers supplied which are reported upon. This data is available to a sufficient extent from samples to enable the supply authorities to formulate load curves of the various classes of consumers and even types of consumers in those classes. From such curves, it is possible to estimate, reasonably accurately, the effect of redistribution of load resulting from successful advertising and encouraging the use of electricity.

5.08. From such data, the cost of supply, taking into account future development, may be analysed so as to ensure that the work done in developing the use of electricity is achieved to the accompaniment of economic return on the investments involved.

6.00. Conclusion:

6.01. The object of including so much detail in these notes is to illustrate the wide variety of decisions which have been taken to achieve the same result.

6.02. It is well known that any attempt at making a sweeping change in the form and design of tariffs is likely to be met with very strong opposition from consumers. This is, of course, a natural reaction, because we are prone to object instinctively to any material change affecting our past experience. Admitting that sweeping changes may result in a higher incidence of cost on some consumers while others benefit, it is not only those consumers whose costs are increased who protest.

6.03. In these circumstances, the multiplicity and peculiar form of the tariffs in force, in some cases, has undoubtedly resulted from the influence of historic precedent. As time passes, that influence loses its force and the abolition of undesirable features becomes a gradual process of elimination.

6.04. On the other hand, there still remains a considerable diversity of opinion as to the responsibility for, and consequent allocation of, costs between consumers in classes and even between consumers in any one class itself.

6.05. From the widely different tariffs which are being applied overseas, it would seem possible to select examples in support of almost any proposal which may be put forward, either in the form of a complex or of a ruthlessly simplified tariff. To select a single suitable reference, however, would not be reasonable because all the evidence points to some middle course through the tangle as being the correct one to pursue.

6.06. It is abundantly evident that the marginal cost theory has many supporters in its application and it will not be surprising to find, as time passes, a change in the tariff forms employed resulting from marginal cost analyses, and further attempts to apply the theory in practice.

6.07. Serious studies of an extensive nature are in progress in regard to the non-industrial consumer loading and requirements in an endeavour to establish some definite pattern of demand and use of electricity by the consumers in this class. It would not be surprising to find that the general classification which is at present used may be broken down into a number of sections which would have the effect of increasing the number of classes of consumer for the purposes of tariff application.

6.08. In view of these conclusions, it is necessary to draw attention to some further aspects of marginal cost applications which were not mentioned earlier in this paper. When calculating the marginal costs, the accounting costs and part of the administrative costs are not taken into account but only those costs associated directly with generation and distribution.

6.09. If the calculated marginal cost unit rate is applied to all units supplied during the period used in the calculation, obviously, it will be found that the revenue from the sale of units during the period will exceed the total running costs in the period thus resulting in a surplus from this source.

6.10. In the same way the marginal capacity costs will produce a similar effect.

6.11. Such surplusses may then be set against the accounting cost and unallocated administration costs. It is unlikely that the surplus will equal these costs and some balance will remain. The allocation of that balance, which may be positive or negative, presents some difficulty.

6.12. It might well be recovered on a per consumer basis, or by allocation to either the unit rate or the demand rate portions included in the tariffs or by a combination of two or more of these methods. Allocation on the basis of demand or units is frowned upon owing to the resulting distortion of the tariff rates, and recovery should be by way of some charge which the consumer can neither avoid nor reduce in its incidence.

6.13. Persons who have propounded, discussed, and considered the application of the marginal cost theory have recommended that the theory should be applied even when the calculated charges arising from the theory would produce an excess of total revenue over total annual expenditure. To meet this case, they have suggested that a form of negative charge be introduced to distribute any such surplus, but again in an "unavoidable" manner.

6.14. Bearing in mind that the intention is to secure correct economic development, each element in the designed tariff must be such as to encourage correct behaviour of the consumer in his use of electricity.

6.15. This means that the elements must not be so fixed that a consumer is encouraged to reduce his own cost unless the supply authority thereby avoids incurring a similar cost. For example, an excessive demand charge is likely to encourage a consumer to reduce his demand when lost revenue will exceed reduced cost. Too low a demand rate has the reverse effect because a consumer who increases his demand involves the supply authority in added expenditure in excess of the added revenue. This applies to the unit rate as well as the demand rate in relation to the alternatives available for a consumer's choice.

6.16. The necessity for adopting the theory is claimed to be that it is essential that increasing use of electricity with the passage of time should not be uneconomic to the electricity supply industry or the consumer. This is because uneconomic development will inevitably result in the requirement for an increase or decrease in price, and result in the conclusion that some other means of providing for the development should have been introduced at the outset. This is a very serious situation because, unless development takes place on an overall economic basis, the resulting development may be such that it is not possible to restore the economic position at a future time because of the investment in plant and equipment which would then become obsolescent. In other words, the dead capital might prevent the correct procedure being adopted because it is then too late. Other countries may have adopted the correct methods at an earlier time and then be placed in a more advantageous position than countries which had been dilatory.

6.17. Of course, a difficult situation arises from the fact that accurate and detailed knowledge of consumer loading characteristics are essential before the theory can be applied correctly in practice. The necessary complete data is usually lacking, and is expensive to acquire at the outset. This means that data from outside sources may be used and later found to be inaccurate due to differences in consumer behaviour that could not be foreseen or correctly assessed.

6.18. From what has been set out in these notes, it is my opinion that the tariffs generally applied by members of this association do not offer as much difficulty in development as is experienced overseas.

6.19. As is usual in tariff matters, my notes pose a problem without stating a solution. Much of what has been stated will be of value only to those who are faced with deciding upon future policy in the matter of tariff design and application and I trust therefore that the notes will serve as a useful reference to that end.

6.20. In conclusion, I wish to place on record my thanks to the Electricity Supply Commission for permitting me to present these notes and also to acknowledge my appreciation for the time afforded me by senior officials of the Electricity Supply Authorities of Eire, Great Britain, Holland, Germany, France and Switzerland in discussing the matter of tariffs with them recently.

1.00. Aanhef.

1.01. Hierdie referaat is daarop gemik om die aandag te vestig op die groot aantal tariewe van heeltemal uiteenlopende aard wat tans in die buiteland gebruik word.

1.02. Die sogenaamde grenskosteteorie word ook in breë trekke behandel en die grondslag en oogmerke van die teorie word kortliks uiteengesit omdat daar voldoende bewys bestaan dat dié teorie stellig grootskeeps in die praktyk toegepas gaan word. Dit word toegeskryf aan die feit dat ekonome 'n waarskuwing laat hoor het dat die huidige tariefgrondslag stellig tot onekonomiese ontwikkeling sal lei wat gevolglik wysigings sal verg wat weer baie ernstige gevolge kan inhou vir die toekomstige ekonomie, nie net van die nywerhede nie maar ook van die betrokke lande.

(Met die grenskosteteorie word daar rekening gehou met die gemiddelde koste per eenheid wat aangegaan word om 'n bykomende eenheid te lewer in die spitslasure wanneer al die beskikbare uitrusting ingespan moet word. Hierdie grenskoste word ten opsigte van bedryfs- sowel as vermoë-elemente bereken.

Die boekhoukoste word nie in aanmerking geneem nie op grond daarvan dat dit nouer saamhang met die getal verbruikers aan wie krag voorsien word as met die grenskoste daarvan om 'n bykomende eenheid energie te lewer of in nog 'n kilowatt van die maksimum aanvraag te voorsien. Hierteenoor is minstens 'n gedeelte van die administrasiekoste daarmee gemoeid en moet dit dus in aanmerking geneem word.

Wanneer daar met die grensvermoëkoste gewerk word, moet daar aanvaar word dat die koste van uitrusting per kVA of per kW wat nodig is om die vermoë van die ontwikkeluitrusting te verhoog, die heersende gemiddelde koste is van die jongste bykomende groot eenhede wat geïnstalleer word. Hierdie koste word dan omgereken in die grenskoste met behoorlike inagneming van die feit dat nog 'n kilowatt van sodanige uitrusting in die spitstydperk beskikbaar sal wees en dat dit die bedryfskoste sal verminder vanweë die hoër rendement van die basisbelasting.

Die grenskoste bepaal die laagste syfer wat as tarief toegepas kan word en sal gevolglik 'n oorskot oplewer as dit toegepas word op die eenhede en aanvraag wat verkoop is. Hierdie oorskot kan dan aangewend word om die uitstaande bedrag aan administrasiekoste te verminder. Die saldo van die koste, of dit positief of negatief is, moet dan op so 'n grondslag aan die verbruikers toegewys word dat dit nie die wyse raak waarop die verbruiker besluit om sy elektrisiteit te verbruik, deur byvoorbeeld maksimum aanvraag te vermy nie. Dit is omdat die saldo van koste nie verband hou met òf aanvraag òf energie nie, hoewel dit uit die een of ander van hierdie elemente verhaal kan word.

Hierdie sake word uitvoeriger in die referaat bespreek.

1.03. Ten einde die verskil in tariefstrukture was toegepas word, tuis te bring, word 'n betreklik groot aantal tariewe uitvoerig behandel. In sommige gevalle word dit uitvoerig uiteengesit ten einde 'n klein verskilletjie in hulle trefvlak ten opsigte van verbruikerskoste duidelik te stel. Dit word gedoen om aan te toon dat daar van verbruikers verwag word om redelik goed te begryp hoe tariewe ten opsigte van indiwiduele behoeftes en elektrisiteitsverbruik toegepas word, want die gewenste resultate kan net bereik word as al die verbruikers oor genoeg kennis beskik om die tariewe te begryp. Verbruikers moet ook so ingelig word dat hulle kan besef of insien waarom dit noodsaaklik is dat tariewe bereken word in die vorms wat hulle gebruik word. Verbruikers verkeer op 'n beter voet met die voorsieningsowerheid as hulle besef dat die behoeftes van verbruikers as indiwiduele of klasse te voorsien.

1.04. Die is heeltemal duidelik dat daar in die buiteland geen beswaar teen ingewikkelde tariewe bestaan op grond

dit noodsaaklik is dat tariewe bereken word in die vorms wat hulle gebruik word. Verbruikers verkeer op 'n beter voet met die voorsieningsowerheid as hulle besef dat die behoeftes van verbruikers as indiwiduele of klasse te voorsien.

1.04. Dit is heeltemal duidelik dat daar in die buiteland geen beswaar teen ingewikkelde tariewe bestaan op grond daarvan dat die verbruikers wat voorsien word, dit nie kan begryp nie, maar juis die teenoorgestelde word van hulle verwag. Tariefberekenaars skroom nie om die tariewe ingewikkeld te maak nie, want die verbruiker verstaan dalk tog nie waarom dit sekere vorms moet aanneem nie.

1.05. Hoewel ontledings van koste 'n duideliker beeld bied van hoe hierdie kostes ontstaan, word daar met hierdie referaat beoog om op die aansienlike meningsverskil te wys oor die wyse waarop daar in die tariefberekening vir die koste voorsiening gemaak moet word. Daar kan dus nog nie presiese reëls voorgeskryf word waarvolgens standaardtariewe ook elders net so toegepas kan word nie.

1.06. Die grondslag waarop tariewe vir grootkragtoevoer toegepas word, word ook in die referaat vermeld. Daar sal gevind word dat huishoudelike en kleingebruikertoevoere volgens 'n wye verskeidenheid tariefstrukture gelewer word. In baie gevalle word die kamergrondslag in verskillende vorme toegepas om 'n vaste maandelikse inkomste te verkry. In sommige gevalle word byvoorbeeld net eenheidstariewe in 'n maand gelewer word, word nogtans volgens die getal kamers bepaal. In ander gevalle word daar soms 'n lasberaming gebruik om die vaste bedrag per maand te bepaal, of die getal eenhede wat op 'n hoë tarief (of tariewe) gelewer moet word alvorens 'n lae tarief van toepassing word. Die eenvoudige tipe tarief wat bestaan uit 'n bedrag per maand volgens die gebied of die omvang van die woonperseel wat voorsien word, tesame met 'n blokeenheidstarief of selfs 'n eenvoudige enkeleenheidstarief, word ook gebruik. As rede vir laasgenoemde stelsel word aangevoer dat ons nie oor voldoende inligting beskik om te bepaal in watter mate die huishoudelike aanvraag vir die koste van die verlangde geïnstalleerde vermoë verantwoordelik is nie.

1.07. In sommige gevalle word die toevoer aan huishoudelike sowel as klein nywerheidsverbruikers beheer volgens die aanvraag wat daar is. Die toevoer word dan met behulp van miniatuurstroombrekers of met sekerings met 'n hoë breekvermoë beheer en talle verbruikers word op hierdie grondslag van krag voorsien.

1.08. Die nywerheids- of handelsklas verbruiker moet dikwels ook betaal ooreenkomstig sy geraamde aanvraag en hiervoor word die getal en kenvermoë van die toestelle en die geïnstalleerde verligtingstelsel in ag geneem. In ander gevalle word die werklike maksimum aanvraag van sulke verbruikers gemeet en dit kan geskied op die grondslag van kW of kVA. Die tydperk waarvolgens maksimum aanvraag bepaal word, wissel van 15 minute tot een uur en daar is aan die hand gedoen dat 'n aanvraagtydperk van twee uur 'n oplossing vir huishoudelike doeleindes kan bied indien die aanvraag van hierdie tipe toevoer as 'n element in hierdie tarief vervat moet word.

1.09. Groot verbruikers moet betaal op die normale wyse wat lede van hierdie Vereniging toepas, maar in die mees algemene stelsel moet die verbruiker betaal vir die maksimum aanvraag per jaar soos dit in die wintermaande gemeet word.

1.10. In byna al die gevalle word daar vir toegewings voorsiening gemaak indien die spitsbelasting in die wintertydperk beheer word en ook indien die toevoer in die tydperke buite die spitsure gebruik word.

1.11. Waar daar menings uitgespreek is, moet dit nie as die menings van die Elektrisiteitsvoorsieningskommissie beskou word nie maar as spreker se eie menings waartoe hy geraak het uit sy bestudering van die vraagstuk en sy gevolgtrekkings uit publikasies oor die onderwerp en onderhoude met verantwoordelike beamptes in die buiteland.

ANNUAL REPORT OF THE SECRETARIES.

To the President and Members of the Association.

Mr. President, Gentlemen,

It gives me great pleasure to submit to you the Annual Report of your Association together with the Revenue and Expenditure Account and Balance Sheet for the financial year ended 28th February, 1965.

OBITUARY:

It is with great regret that we record the death on 4th November, 1964, of Mr. H. J. G. Simpson, who was admitted to Associate Membership in 1927 and was granted Retired Membership on this status being introduced last year.

THIRTY-EIGHTH CONVENTION:

The 38th Convention of the Association was held in Windhoek from Tuesday, 19th May to Friday, 22nd May, 1964.

Delegates were welcomed to Windhoek by His Worship the Mayor, Councillor J. Levinson, and the welcome to the Convention was conveyed by the Deputy Mayor of Welkom, Councillor W. F. Meyer. The official opening of the Convention was performed by the Honourable Mr. W. C. du Plessis, Administrator of South West Africa. The total attendance of members, delegates, representatives, officials, visitors and ladies numbered 292.

On behalf of the President, members of the Association and all others who attended the Convention, it is hard to express our appreciation to His Worship the Mayor and Town Councillors of Windhoek for the outstanding hospitality extended to us. To His Worship the Mayor and Town Councillors of Welkom we likewise extend appreciation for their assistance towards the Convention. To the citizens and officials of Windhoek, who contributed so much to the organisation of the Convention, we also record our appreciation. Last, but not least, I feel that I cannot let this opportunity pass without personally recording the name of Mrs. Levinson, the most charming Mayoress of Windhoek, whose hospitality and friendliness will long be remembered by us all. I have much pleasure in placing on record the appreciation of all for the efficient discharge of his duties by the President. At times he was confronted with great difficulties, but, through his calm approach, they were all resolved. Grateful thanks are also extended to Mrs. Barton for her support and assistance.

The first paper presented to the Convention was "Psychological Aspects of Productivity" by Dr. A. Vlok, D. Phil., University of South Africa, which set a high standard and was most thought provoking.

JAARVERSLAG VAN DIE SEKRETARISSE.

AAN: Die President en lede van die Vereniging.

Mnr. President en here,

Dit doen my genoeë om die jaarverslag van u vereniging met die inkomste- en uitgawerekening en balansstaat vir die finansiële jaar wat op 28 Februarie 1965 verstryk het, aan u voor te lê.

STERFLYS:

Met leedwese moet ons die afsterwe op 4 November 1964 aanteken van Mnr. H.J.G. Simpson, wie in 1927 as verbonde lid tot die vereniging toegelaat is en rustende lidmaatskap toegeken is toe hierdie status verlede jaar ingevoer is.

AG-EN-DERTIGSTE KONVENSIE:

Die 38ste konvensie van die vereniging is vanaf Dinsdag 19 Mei tot Vrydag 22 Mei 1964 in Windhoek gehou.

Sy Edelagbare, die Burgemeester van Windhoek, Raadslid J. Levinson, het die afgevaardiges op Windhoek welkom geheet en die verwelkoming na die konvensie is waargeneem deur Raadslid W. F. Meyer, onderburgemeester van Welkom. Die amptelike opening van die konvensie is waargeneem deur sy edelagbare, Mnr. W. C. du Plessis, Administrateur van Suid-Wes Afrika. Die groot totaal van lede, afgevaardigdes, verteenwoordigers, amptenare, besoekers en dames was 292.

Namens die President, lede van die vereniging en almal wat die konvensie bygewoon het, wil ons waardering uitspreek teenoor sy edelagbare, die burgemeester en Raadslede van Windhoek vir die voortreflike gasvryheid aan ons betoon en ons vind dit voorwaar geen maklike taak nie. Ook teenoor die burgemeester en raadslede van Welkom ons dank en waardering vir die bystand met die konvensie. Ook ons dank aan die inwoners en amptenare van Windhoek vir hulle hulp in verband met die organisasie van die konvensie.

Laastens maar beslis, nie die minste nie, kan ek nie die geleentheid laat verby gaan sonder om die naam van Mevr. Levinson aan te teken nie, wie se vriendelikheid en gasvryheid as burgemeestersvrou van Windhoek nog lank deur ons almal sal onthou word. Dit doen my genoeë om namens almal ons waardering aan te teken vir die doeltreffende wyse waarop die President sy pligte vervul het. Menigmaal het hy voor moeilike vraagstukke te staan gekom wat egter deur sy kalme optrede opgelos is. Baie dankie ook aan Mevr. Barton vir haar bystand en ondersteuning.

Die eerste referaat gelewer by die konvensie was die van Dr. A. Vlok, D. Phil., Universiteit van S.A., getitel „Sielkundige aspekte van Produktiwiteit". Dit het 'n hoë standaard gestel en was prikkelend van aard.

There followed a paper "Some Aspects of Power Cables in Underground Distribution" by Mr. I. L. Hobbs. which, with its practical approach to some of the problems which confront those responsible for electricity distribution, both in large and small undertakings, was very well received.

The paper "Responsibility of Councillors and Engineers under the General Laws and Certain Statutes" by Councillor W.F. Meyer, B.A., L.L.B., evoked interesting discussion and dealt with a subject which is of increasing importance to those responsible for the management of Electricity Supply Undertakings.

The final paper of the Convention was "A Review of Low Voltage Installation Protection Practice in South Africa" by Mr. F.J. Prins, B.Sc. (Eng.); M.Com. (B & A). In this paper we once again had a thesis on a subject which is of continuous practical importance to the engineer, and interesting discussion thereon took place.

To all those responsible for presenting papers we express our sincere appreciation.

Mr. P. A. Giles officiated for the first time as Quizmaster at the Members' Forum and, as usual, many practical problems were discussed. Our thanks are extended to Mr. Giles for undertaking this task.

It was unanimously agreed to accept the invitation from Port Elizabeth to hold the 39th Convention in that City.

Arising from discussion in Convention, certain amendments to the Constitution were adopted which have the effect of altering the status of the former "Vice-President" to "President Elect", and creating two new classes of membership, viz. "Retired" and "Associate Undertaking".

MEMBERSHIP:

The following new members were elected during the year ended 28th February, 1965:

Councillor Members:

Municipality of Wolmaranstad
Municipality of Gobabis
Municipality of Carolina
Municipality of Bloemhof
Municipality of Keetmanshoop
Municipality of Meyerton.

Engineer Members:

A.J. van den Berg (Krugersdorp)
J.J. Barrie (Edenvale)
A.A. van Wyk (Meyerton)
M.H.L. Boshoff (Uitenhage).

Associates:

C.D. de Bruyn (Willowmore).

Die volgende referaat "Enige aspekte van kragkabels in ondergrondse verspreiding" deur Mnr. I. L. Hobbs het gehandel oor die praktiese probleme wat almal in beheer van distribusie in klein sowel as groot ondernemings teëkom, is baie goed ontvang.

Die referaat van Raadslid W. F. Meyer, B.A., L.L.B. oor „Die aanspreeklikheid van Raadslede en Ingenieurs onder die gemene reg en sekere statute" het lewendige bespreking uitgelok en het gehandel oor 'n aangeleentheid wat meer en meer van belang word vir diegenes in beheer van Elektrisiteitsvoorsienings-ondernemings.

Die laaste referaat op die konvensie deur Mnr. F. J. Prins, B.Sc. (Ing.) M.Com. (B & A) was getitel „Beskerming in laespanning verspreiding". Dit het gehandel oor 'n onderwerp van voortdurende praktiese belang vir die ingenieur en 'n interessante bespreking het gevolg.

'n Woord van waardering aan almal wat verantwoordelik was vir die lewering van referate.

Mnr. P.A. Giles het vir die eerste keer as vraesteller by die ingenieursforum opgetree en soos gewoonlik is baie praktiese probleme bespreek. Ons sê dankie aan Mnr. Giles dat hy die taak onderneem het.

Daar was eenparig besluit om die uitnodiging van Port Elizabeth om die 39ste konvensie daar te hou, te aanvaar.

Voortvloeinde uit besprekings op die konvensie is besluit om sekere wysigings aan die grondwet aan te bring wat die effek het om die amp van „vise-president" na die van „aanstaande President" te verander. Ook is die nuwe klasse van lidmate, n.l. „Rustende" en „Geassosieerde Ondernemings" geskep.

LIDMAATSKAP:

Die volgende nuwe lede is verkies gedurende die jaar wat op 28 February 1965 eindig:

Raad-lede:

Munisipaliteit van Wolmaranstad
Munisipaliteit van Gobabis
Munisipaliteit van Carolina
Munisipaliteit van Bloemhof
Munisipaliteit van Keetmanshoop
Munisipaliteit van Meyerton.

Ingenieur-lede:

A.J. van den Berg (Krugersdorp)
J.J. Barrie (Edenvale)
A.A. van Wyk (Meyerton)
M.H.L. Boshoff (Uitenhage).

Ge-assosieerdes:

C.D. de Bruyn (Willowmore).

ASSOCIATION OF MUNICIPAL ELECTRICITY UNDERTAKINGS OF SOUTHERN AFRICA.

BALANCE SHEET - 28th FEBRUARY, 1965.

1964			
7,528	ACCUMULATED FUNDS		7,687.43
7,487	Balance at 1st March, 1964	7,527.93	
41	Add: Excess of Income over Expenditure for the year	159.50	
633	PROVISIONS		488.42
78	Agents Commission	219.42	
555	Provision for Loss on 1964 Proceedings	269.00	
113	SUNDRY CREDITORS		7.66
97	SUBSCRIPTIONS IN ADVANCE		37.80
-	AFFILIATION FEES IN ADVANCE		105.00
-	REPRESENTATIVE AND LADIES FEES IN ADVANCE		18.00
7,096	HOTEL AND AIR DEPOSITS RECEIVED IN ADVANCE 1964 CONVENTION		-
R15,467			R8,344.31

1964			
2	PRESIDENTIAL BADGE Nominal Value		2.00
72	FURNITURE AND FITTINGS At cost less depreciation		64.95
6,811	INVESTMENTS		7,045.65
2,000	200 Class "B" Indefinite fully paid Shares of R10. each	2,000.00	
4,702	Fixed Deposit	4,933.50	
109	Savings Account	112.15	
30	DEBTORS LESS PROVISION FOR BAD DEBTS.		-
222	PAYMENTS IN ADVANCE		542.59
222	1965 Convention	95.59	
-	Proceedings	447.00	
20	DEPOSIT Davidson and Ewing (Proprietary) Limited		20.00
8,310	CASH AT BANK		669.12
R15,467			R8,344.31

R. W. BARTON : President.

DAVIDSON AND EWING (PROPRIETARY) LIMITED :

PER: R.G. EWING Secretaries.

Report of the Auditors to the Members of the Association of Municipal Electricity Undertakings of Southern Africa.

We report that we have examined the books, accounts and vouchers of the Association for the year ended 28th February, 1965; we have satisfied ourselves of the existence of the securities and have received all the information and explanations we required. In our opinion the above Balance Sheet is properly drawn up so as to exhibit a true and fair view of the state of the affairs of the Association as at 28th February, 1965, according to the best of our information and the explanations given to us and as shown by the books of the Association.

Johannesburg, 25th March, 1965.

SAVORY, BRINK, CREMER & CO.
Chartered Accountants (S.A.), Auditors.

ASSOCIATION OF MUNICIPAL ELECTRICITY UNDERTAKINGS OF SOUTHERN AFRICA.

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 28th FEBRUARY, 1965

1964.			1964		
70	Audit Fees - 1964	70.00	382	Income from Investments	349.99
32	Bank Charges	37.34	2,468	Subscriptions and Attendance Fees - Affiliates	2,004.00
2,789	Convention Expenses	2,234.91	4,464	Subscriptions - Council and Other	4,048.00
8	Depreciation - Furniture & Fittings	7.22	2	Bad Debts Recovered	-
725	Executive Council Expenses	993.03			
4	Insurance	4.45			
-	Legal Fees	21.00			
684	Loss on Sale of Proceedings	388.39			
128	Bad Debts - Advertising in Proceedings	-			
236	Postages and Telegrams (General)	218.32			
499	Printing and Stationery (General)	274.89			
1,800	Secretarial Fees	1,800.00			
30	Subscriptions Paid	40.00			
52	Sundry Expenses	6.00			
103	Telephone	81.74			
115	Travelling Expenses (General)	65.20			
41	Excess of Income over Expenditure transferred to Accumulated Funds	159.50			
R7,316		R6,401.99	R7,316		R6,401.99

Associate Members:

W. Bozyczko (Formerly Municipal Electrical Engineer, Edenvale).

The following resignations took place:

Councillor Members:

Ermelo Municipality.

Engineer Members:

B.G. van Heerden (Ermelo)

Affiliates:

Shell S.A. (Pty.) Limited.
The Union Steel Corporation of S.A. Limited.

Associate Members:

G.R. Petersen
G.E.H. Jones
W.J.F.S. Lutsch.

The following were transferred to Retired Membership:

A.R. Campbell
J.W. Phillips.

Comparative membership figures are as follows:

	1963/64	1964/65
Councillor Members	130	135
Engineer Members	123	116
Honorary Members	13	15
Associate Members	34	30
Associates	14	15
Affiliates	86	84
Retired Members	-	2

FINANCE:

The Income and Expenditure Account for the year under review and the Balance Sheet as at 28th February, 1965, which are submitted to you reflect an excess of income over expenditure of R159.50 (£79.15.0.). The Accumulated Funds of the Association now stand at R7,687.43 (£3,843.14.3d.).

It is noteworthy that there has been some increase in advertising revenue during the year, and we express our appreciation to those who have contributed to this source of income of revenue.

I feel that this is the appropriate point in the Report to record that, at the Mid-Year Executive Meeting held last November, it was decided that, with effect from the 1965 Proceedings, these would be subject to editing with a view to omitting all the irrelevant matter. This, it is hoped, will help to offset rising costs due to other factors.

Once again labour problems in the Printing Industry have resulted in long delays in the production of the Pro-

Verbonde lede:

W. Bozyczko (Vroeër Munisipale Elektrotegniese Ingenieur, Edenvale).

Die volgende het bedank:-

Raad-lede:

Ermelo Munisipaliteit.

Ingenieur-lede:

B.G. van Heerden (Ermelo)

Ge-affilieerdes:

Shell S.A. (Edms.) Beperk.
Die Unie Staal Korporasie van S.A. Beperk.

Verbonde Lede:

G.R. Petersen
G.E.H. Jones
W.J.F.S. Lutsch.

Die volgende is na rustende lidmaatskap oorgeplaas:

A.R. Campbell
J.W. Phillips.

Vergelykend likmaatskap syfers is soos volg:-

	1963/64	1964/65
Raad-lede	130	135
Ingenieur-lede	123	116
Ere-lede	13	15
Verbonde lede	34	30
Ge-assosieerdes	14	15
Ge-affilieerdes	86	84
Rustende lede	-	2

FINANSIES:

Die inkomste- en uitgawerekening vir die jaar onder oorsig en die balansstaat soos op 28 Februarie 1965, wat voorgelê word, weerspieël 'n oorskot van inkomste oor uitgawe van R159.50 (£79.15.0.).

Die opgehoopte fondse van die vereniging staan nou op R7,687.43 (£3,843.14.3d.).

Kennis word geneem van die verhoging in inkomste uit advertensies gedurende die jaar, en ons betuig ons waardering teenoor diegene wat bygedra het tot die bron van inkomste.

Ek voel dit is nou die aangewese plek in die verslag om aan te teken dat daar op die halfjaar-vergadering van die Uitvoerende Raad gehou verlede November, besluit is om vanaf die 1965 verrigtinge, die publikasie te redigeer ten einde onbelangrike stof uit te skakel. Ons hoop om langs hierdie weg die stygende kostes die hoof te bied. My innige dank aan die lede van die geldsake komitee, Mnr. C.G. Lombard (sameroeper) en Mnr. R.W. Leishman, vir hulle hulp gedurende die jaar.

ceedings with resultant embarrassment to all concerned. We hope that more satisfactory arrangements can be made for the production of the 1965 edition.

I wish to convey sincere thanks to the members of the Finance Committee, Mr. C.G. Lombard (Convenor) and Mr. R.W. Leishman, for their assistance during the year.

REGIONAL BRANCHES:

The Regional Branches operating in the Eastern Cape, Natal and Highveld have continued their work in the interests of the membership of the Association, and I wish to record the appreciation of all concerned for the work undertaken in this connection by some of our members, as well as to those towns and cities who, over the years, have acted as hosts for various meetings of the Branches.

During the year preliminary steps were taken towards the establishment of a Branch in Rhodesia, and we look forward to this and other Branches completing the pattern of the Association's activities in this respect.

MID-YEAR EXECUTIVE MEETING:

The Mid-Year Executive Meeting held in 1964 took place in Johannesburg. On behalf of the President and Executive Council, sincere thanks are conveyed to His Worship the Mayor and Councillors of Johannesburg for the hospitality extended to the Executive on this occasion.

SUB-COMMITTEES AND REPRESENTATIVES:

Once again I have pleasure in conveying the thanks of the Association to the members of the various Technical Sub-Committees and our representatives on other organisations for their unstinted assistance. Again, it is difficult to undertake the amount of work involved in carrying out these duties, which continues to be of the utmost importance to the membership of the Association and of the electricity industry as a whole. The reports by the Convenors or Representatives on these various activities are in many cases by no means a full indication of the work of the "back-room boys" of the Association.

THE FUTURE:

It is over many years that discussion has taken place at various levels on the desirability or otherwise of holding Conventions of organisations connected with work of local authorities in the Republic at annual or longer intervals.

In the light of decisions recently taken by the United Municipal Executive this is now a matter which must be adopted by our Association as a whole, and provision has accordingly been made for discussion on this most important subject to take place at the 1965 Convention. It would indeed be interesting to hear the outcome of the discussions, but I am confident that, whatever decision is taken, and whatever re-organisation of the Association

Arbeidsprobleme in die Drukkers Nywerheid het weereens lang vertragings in die produksie van die Verrigtings veroorsaak met die gevolg dat alle betrokkenes in verleentheid gestel is. Ons hoop dat meer bevredigende reëlings vir die produksie van die 1965 uitgawe getref kan word.

STREEKTAKKE:

Streektakke bestaan in die Ooskaap, Natal en Hoëveld en het hulle werk in belang van die lede van die vereniging voortgesit. Ons dank teenoor dié lede wie hulle met werwing beywer het en die dorpe en stede wat oor die jare as gashere tydens vergaderings van die takke opgetree het.

Gedurende die jaar is voorlopige stappe gedoen om 'n tak in Rhodesië te vestig en ons verwelkom hulle en enige ander tak wat sal bydra om diè patroon van die vereniging se aktiwiteite af te rond.

HALFJAAR-VERGADERING VAN UITVOERENDE RAAD.

Die halfjaar-vergadering van die Uitvoerende Raad vir 1964 het in Johannesburg plaasgevind. Namens die President en die Raad ons innige dank aan sy edelagbare die Burgemeester en Raadslede van Johannesburg vir die gasvryheid bewys by die geleentheid.

SUB-KOMITEES EN VERTEENWOORDIGERS:

Weereens het ek genoeë om namens die vereniging dank te betuig teenoor die lede op die verskillende tegniese sub-komitees en ons verteenwoordigers op ander organisasies vir hulle onbaatsugtige bystand. Dit is moeilik om die werk wat aan die pligte gekoppel is te onderneem en wat tog van soveel belang is vir lede van die vereniging en die elektriese nywerheid as geheel. Die verslae van die sameroepers en verteenwoordigers oor die verskillende werksaamhede is in baie opsigte geen volledige bewys van die werk wat deur die stille werkers van die vereniging gedoen word nie.

DIE TOEKOMS:

Besprekings op verskillende vlakke is nou-al baie jare aan die gang oor die wenslikheid al dan nie om konvensies, van organisasies betrokke by die werksaamhede van plaaslike besture in die Republiek, jaarliks of met langer tussenposes te hou.

In die lig van onlangse besluite van die Verenigde Munisipale Bestuur is dit 'n aangeleentheid waaroor die konvensie in geheel nou 'n besluit sal moet uitbring en reëlings is getref vir bespreking van hierdie baie belangrike saak tydens die 1965 konvensie.

Die uitslag van die bespreking word met belangstelling afgewag. Ons voel egter oortuig dat, wat die uitslag van die besprekings ook al mag wees en watter herorganisasie van die vereniging ook al nodig mag word, metodes gevind sal word om die goeie werk van die vereniging in belang van die lede voort te sit.

may be necessary, ways and means will be found of continuing the work of the Association to the best advantage of its members.

To you, Mr. President, and all Members of the Executive Council, I express sincere thanks for your assistance and courtesy during the past year.

To the Association and all its Members we extend best wishes for 1965/66.

R.G. EWING
for Davidson & Ewing (Pty.) Ltd.
SECRETARIES.

Aan u, Mnr. President, en al die lede van die Uitvoerende Raad, my innige dank vir die hulp en hoflikheid gedurende die jaar.

Aan die vereniging en al die lede ons goeie wense vir 1965/66.

R. W. EWING
vir DAVIDSON & EWING (EDMS.) BPK.
SEKRETARISSE.

THE ASSOCIATION OF MUNICIPAL ELECTRICITY UNDERTAKINGS OF SOUTHERN AFRICA.

DIE VERENIGING VAN MUNISIPALE ELEKTRISITEITS-ONDERNEMINGS VAN SUIDELIKE AFRIKA.

PROPOSED AMENDMENTS TO CONSTITUTION:

VOORGESTELDE WYSIGINGS AAN GRONDWEL:

Rule 1 (iii):

At the end of the paragraph delete the semicolon and add "and such representative shall be White".

Artikel 1 (iii):

Aan die einde van die paragraaf skrap die kommapunt en voeg in „en sodanige verteenwoordiger sal 'n blanke persoon wees".

Rule 6 (1):

After "natural persons" delete full-stop and add "who are White and who are situated or living in the Republic of South Africa, Southern Rhodesia or any border-territory".

Artikel 6 (1):

Na „natuurlike persone" skrap die punt en voeg in „wat blanke is en wat gevestig is of woonagtig is in die Republiek van Suid-Afrika, Suid-Rhodesia of enige aangrensende gebied.

Rule 9 (3):

In the scale of contributions alter the word "Guineas" to "Rand" and the amounts from "6, 8, 10, 12, 14, 16, 20, 25, 30" to "15, 17, 21, 25, 30, 35, 45, 55, 65".

Artikel 9 (3):

In die skaal van bydraes verander die woord „Ghienies" na „Rand" en die bedrae van „6, 8, 10, 12, 14, 16, 20, 25, 30" na „15, 17, 21, 25, 30, 35, 45, 55, 65".

Rule 9 (4):

Alter the words "two guineas" to "R4.50" and "five guineas" to R10.50".

Artikel 9 (4):

Verander die woorde „twee ghienies" na „R4.50" en „vyf ghienies" na „R10.50".

Rule 11 (2):

Between "Honorary Members" and "have" add "and Associate Members".

Artikel 11 (2):

Tussen „ere-lede" en „stemreg" vieg in „Verbonde lede".

Rule 14 (2):

In list of Territories substitute "Southern Rhodesia" for "Federation of Rhodesia and Nyasaland".

Artikel 14 (2):

In lys van Gebiede vervang „Federasie van Rhodesia en Nyasaland" met „Suid Rhodesia".

Rule 22 (5):

Substitute "three" for "five" the second time it occurs in this paragraph.

Artikel 22 (5):

Vervang „vyf" met „drie" die tweede keer wat dit in hierdie paragraaf voorkom.

ANNUAL REPORT :
RIGHTS OF SUPPLY SUB-COMMITTEE.

The Committee did not meet during the past year and there have been no further developments.

C. LOMBARD
CONVENOR.

ANNUAL REPORT: S.A.I.E.E. COMMITTEE TO REVISE THE CODE OF PRACTICE FOR OVERHEAD LINES FOR CONDITIONS PREVAILING IN SOUTH AFRICA.

As the A.M.E.U. representative on this Committee, I have to report that the Drafting Sub-Committee has met once during the year under review and may have to meet once more to finalise the revision of Section 5 of the Code before reporting back to the Main Committee.

C. LOMBARD
REPRESENTATIVE.

ANNUAL REPORT OF THE RECOMMENDATIONS COMMITTEE FOR NEW ELECTRICAL COMMODITIES.

This Committee is constituted as follows:

(1) A.M.E.U. :
Mr. C. Lombard
Mr. R.W. Barton.

(2) Johannesburg City Council :
Mr. R. Leishman.

(3) S.A. Bureau of Standards :
Mr. A.A. Middlecote
Mr. D.I. Jones.

(4) S.A.I.E.E. Wiring Regulations Committee :
Mr. J.T. Williams
Mr. J.C. Fraser.

(5) Electricity Supply Commission :
Mr. J.W. Barnard
Mr. W. Stern-Stenerson.

(6) Electrical Engineering & Allied Industries Association :
Mr. J. Morrison.

(7) Electrical Contractors Association of South Africa :
Mr. F.B. Gibson
Mr. J.M. Fraser.

(8) Secretaries :
Messrs. Davidson & Ewing (Pty.) Ltd.

JAARVERSLAG :
„REG VAN VOORSIENING" ONDERKOMITEE.

Die Komitee het nie gedurende die afgelope jaar vergader nie en daar was geen verdere verwikkelings nie.

C. LOMBARD.
SAMEROEPER.

JAARVERSLAG S.A.I.E.I. - KOMITEE BELAS MET DIE HERSIENING VAN DIE GEBRUIKSKODE VIR BOGRONDSE GELEIDINGS VIR TOESTANDE SOOS IN SUID AFRIKA AANGETREF.

In my hoedanigheid as verteenwoordiger op hierdie Komitee moet ek rapporteer dat die Onderkomitee wat aangestel is om 'n hersiene konsepkode op te stel eenmaal gedurende die jaar bymekaar gekom het en sal moontlik nog eenkeer moet vergader om die hersiening van Artikel 5 van die Kode af te handel voordat daar aan die Hoofkomitee verslag gedoen word.

C. LOMBARD
VERTEENWOORDIGER.

JAARVERSLAG VAN DIE KOMITEE BELAS MET AANBEVELINGS OOR NUWE ELEKTRIESE HANDELSWARE.

Hierdie Komitee is soos volg saamgestel:

(1) V.M.E.O. :
Mnr. C. Lombard
Mnr. R.W. Barton.

(2) Stadsraad Johannesburg :
Mnr. R. Leishman.

(3) S.A. Buro vir Standaarde :
Mnr. A.A. Middlecote
Mnr. D.I. Jones.

(4) S.A.I.E.I. Bedradingsregistrasiekomitee :
Mnr. J.T. Williams
Mnr. J.C. Fraser.

(5) Elektrisiteitsvoorsieningskommissie :
Mnr. J.W. Barnard
Mnr. W. Sternerson.

(6) Elektrotegniese Ingenieurswese en Geallieerde Nywerheidsvereniging :
Mnr. J. Morrison.

(7) Elektrotegniese Aannemersvereniging van Suid Afrika :
Mnr. F.B. Gibson
Mnr. J.M. Fraser.

(8) Sekretarisse :
Mnre. Davidson & Ewing (Edms.) Bpk.

One meeting was held during the year and all recommendations, which are, of course, private and confidential, were made known to members through the medium of the News Bulletin.

In comparison with previous years applications received and considered during the year under review have been relatively few and these all have been finalised.

The Committee does not consider application in respect of Commodities in respect of which a Standard Specification exists. One application under this category was received during the year.

In view of the increasing demand for connections to caravans from the supply mains, it was decided to recommend to the S.A. Bureau of Standards that the Sub-Committee is responsible for drafting a code of Practice for caravan parks should also include regulations regarding the supply of electricity to caravans in the Code.

Our thanks, are due to the representatives of the various organisations and bodies who served on the Committee for their generous and valuable assistance and also to the S. A. Bureau of Standards for its co-operation in carrying out tests on commodities where necessary.

C. LOMBARD
CONVENOR.

Daar is een vergadering gehou gedurende die jaar en alle aanbevelings wat uit die aard van die saak, privaat en vertroulik is, is deur middel van 'n nuusbrief aan lede bekend gemaak.

In vergelyking met vorige jare was die aantal aansoeke wat gedurende die jaar onder bespreking oorweeg is, betreklik laag is en hulle is almal afgehandel.

Die Komitee oorweeg nie aansoeke ten opsigte van handelsware waarvoor daar 'n bestaande Standard-spesifikasie is nie. Slegs een sodanige aansoek is gedurende die jaar ontvang.

Met die oog op die toenemende vraag na elektriese aansluitings vir karavane van kragnette af, is daar besluit om by die S.A. Buro vir Standaarde aan te beveel dat die onderkomitee wat belas is met die opstel van 'n Konsepgebruikskode in karavaanparke ook regulasies vir die voorsiening van elektrisiteit aan karavane by die kode moet insluit.

Ons is dank verskuldig aan verteenwoordigers van die verskillende organisasies en liggame wat in die Komitee gedien het, vir hulle offervaardige en waardevolle hulp en ook aan die S.A. Buro vir Standaarde vir die samewerking met die toets van artikels waar dit nodig was.

C. LOMBARD
SAAMROEPER.

ANNUAL REPORT.

ELECTRICAL WIREMEN'S REGISTRATION BOARD.

The Board was constituted as follows during 1964:

Chairman : Mr. J.J. Groenewald.
Members : Mr. J.M. Fraser.
Mr. F. Leemans.
Mr. R.W. Dickens.
Mr. T. Gregg.
Mr. C. Lombard.

The Board held 12 ordinary and one extra ordinary meetings during the year. Applications for registration from 874 persons were considered and 867 of these were accepted as candidates for the prescribed examinations.

Five written examinations were conducted at the examination centres during the year, involving a total of 1061 candidates.

There were also 14 practical examinations at the eight most important centres during the year and 160 of the 430 candidates were successful and qualified for registration.

The number of registration certificates issued during the year totalled 379 bringing the total issued since 1940 to 8796.

JAARVERSLAG:

REGISTRASIERAAD VIR ELEKTROTEGNIESE DRAADWERKERS.

Die Raad was soos volg gedurende 1964 saamgestel:

Voorsitter: Mnr. J.J. Groenewald
Lede : Mnr. J.M. Fraser
Mnr. F. Leemans
Mnr. R.W. Dickens
Mnr. T. Gregg
Mnr. C. Lombard.

Die Raad het 12 gewone en eén buitengewone vergaderings gedurende die jaar gehou. Aansoeke om registrasie van 874 persone is oorweeg en 867 van hulle is aanvaar as kandidate vir die voorgeskrewe eksamens.

Vyf skriftelike eksamens is by die 29 eksamensentrums gedurende die jaar gehou waarby 'n totale aantal van 1061 kandidate betrokke was.

Daar was ook 14 praktiese eksamens by die 8 vernaamste sentrums gedurende die jaar gehou en 260 uit die 430 kandidate was suksesvol en het vir registrasie gekwalifiseer.

Die totale aantal registrasiesertifikate gedurende die jaar uitgereik het 379 beloop wat die totale aantal uitgereik sedert 1940 op 8796 te staan bring.

The increase in the number of applications for registration dealt with was to a large extent due to the whole of the Republic being declared a determined area with effect as from the 1st September, 1964, in terms of Section 18 of the Act.

The Board has given consideration to difficulties which are being experienced by immigrants who are not sufficiently proficient in one of the official languages to write the examinations and it is hoped that it will be possible for arrangements to be made in the near future for such candidates to write the examination in their native language.

It is regretted to report that the Chairman, Mr. J. J. Groenewald who has been transferred to another Department will sever his connection with the Board in the near future. He has our best wishes in his new sphere of work.

In conclusion I wish to thank the Board for making the statistics quoted available to me for inclusion in this Report.

C. LOMBARD
REPRESENTATIVE.

Die verhoging in die aantal aansoeke vir registrasie wat behandel is, kan tot 'n groot mate daaraan toegeskryf word dat die hele Republiek met ingang 1 September 1964 'n bepaalde gebied verklaar is ooreenkomstig Artikel 18 van die Wet.

Die Raad het aandag geskenk aan moeilikhede wat deur immigrante ondervind word wat nie oor voldoende kennis van een van die amptelike landstale beskik om die skriftelike eksamens af te lê nie en daar word gehoop dat reëlings in die nabye toekoms getref kan word om dit vir sulke kandidate moontlik te maak om die eksamen in hulle moedertaal te skryf.

Dit spyt my om verslag te moet doen dat die Voorsitter, Mnr. J.J. Groenewald wat na 'n ander Departement verplaas is, binnekort sy bande met die Raad sal verbreek. Ons beste wense vergesel hom in sy nuwe werkkring.

Ten laaste moet ek die Raad bedank dat die statistieke wat aangehaal word tot my beskikking gestel is vir insluiting in hierdie verslag.

C. LOMBARD
VERTEENWOORDIGER.

ANNUAL REPORT ON THE ACTIVITIES OF THE PHYSICS AND ELECTRICAL ENGINEERING SUBSECTION OF THE S.A. BUREAU OF STANDARDS.

1. COMPULSORY SAFETY SPECIFICATIONS.

The following safety specifications were declared compulsory specifications with effect from the 3rd July, 1965 in an extraordinary Government Gazette No. 847 dated 3rd July, 1964:

SPECIFICATION	DESCRIPTION
SV 124 - 1962	Manually operated air-break switches.
SV 125 - 1962	Portable electric immersion heaters.
SV 126 - 1962	Electric air heaters and radiators.
SV 127 - 1962	Flexible cords for power and lighting purposes.
SV 128 - 1962	Portable electric appliances for heating liquids.
SV 129 - 1962	Plugs, socket outlets, and socket outlet adaptors.
SV 130 - 1962	Electric hand-lamps.
SV 131 - 1962	Electric stoves and hotplates.
SV 132 - 1962	Lampholders and bayonet-cap lampholder adaptors.
SV 133 - 1962	Apparatus connectors for portable domestic appliances.

JAARVERSLAG OOR DIE WERKSAAMHEDE VAN DIE ONDERAFDELINGS FISIKA EN ELEKTROTEGNIESE INGENIEURSWESE VAN DIE S.A. BURO VIR STANDAARDE.

1. VERPLIGTE VEILIGHEIDSPESIFIKASIES:

In 'n buitengewone staatskoerant nr. 847 van 3 Julie 1964, is die volgende veiligheidspesifikasies tot verpligte spesifikasies verklaar met effek vanaf 3 Julie 1965.

SPESIFIKASIE	BESKRYWING
SV 124 - 1962	Hand-lugbreukskakelaars.
SV 125 - 1962	Draagbare elektriese dompelverwarmers
SV 126 - 1962	Elektriese lug- en stralingsverwarmers.
SV 127 - 1962	Buigbare koorde vir krag- en verligtingsdoeleindes.
SV 128 - 1962	Draagbare elektriese toestelle vir die verwarming van vloeistowwe.
SV 129 - 1962	Kontakproppe, kontaksokke en verdeelproppe.
SV 130 - 1962	Elektriese handlampe.
SV 131 - 1962	Elektriese stowe en verwarmingsplate.
SV 132 - 1962	Lamphouers en aansluitproppe vir bajonetlamphouers.
SV 133 - 1962	Verbinders vir draagbare elektriese toestelle vir huishoudelike gebruik.

The ten specifications appear as ten schedules in the proclamation and these schedules, numbered accordingly, replace the existing SV 124 to 133 series.

The effect of this proclamation is that the sale of any article included in the ten schedules and not conforming to the requirements of the schedules will be illegal and may result in a prosecution. The description of the word "sale" is very wide and is not limited to the actual action of selling.

Lampholders, switches and flexible cords are not confined to the apparatus listed in the schedules, but also include these items when sold as accessories of any piece of equipment not listed in the schedules such as parts of a reading lamp, a switch in a radio set or the flexible cord attached to a food mixer, etc.

This is the first proclamation of its kind in terms of the Standards Act, 1962 for electrical accessories and is a great step forward to make the use of electricity safer.

2. NEW PROJECTS.

2.1 The S.A.B.S. has decided to appoint a technical committee to co-ordinate with the technical committees T.C. 26 of I.E.C. and T.C. 44 of I.S.O. Arc welding machines are covered by the work of this committee and your association is here represented by Mr. J. von Ahlften.

2.2 A specification is being prepared for busbar trunkings and Mr. A. F. Turnbull, alternate Mr. J. M. Gericke, are your representatives.

2.3 A classification of areas subject to explosion dangers is being undertaken by the Bureau and your representatives on this committee are Messrs. Vorster and L. Futcher (Alternate).

2.4 Other projects for which the drafting of specifications and codes of practice are under consideration are:-

Cable sealing boxes;
H.V. Lightning arrestors;
Traffic Signals;
Electrical Hairdriers.

3. ESTABLISHED COMMITTEES.

A comprehensive list of S.A.B.S. committees and your representatives is included in the proceedings of the 1964 convention and is not now repeated.

The work of commodity sub-committees has been streamlined by the Bureau during the year in order to keep in step with the rapid rate of development in the country with the result that many sub-committees had a busy time. The progress made by the sub-committee drafting the code of practice for the "lighting of streets and highways" must be highlighted here. The last meeting of this committee was held in October, 1964, and the document has now been sent

Die tien spesifikasies verskyn as tien skedules in die kennisgewing en hierdie tien skedules, genommer een tot tien, vervang die bestaande SV 124 tot 133 reeks.

Die uitwerking van hierdie afkondiging is dat die verkoop van enige artikel, gedek deur die 10 skedules, voldoen nie, onwettig is en tot vervolging mag lei. Die woord „verloop" word baie breed bepaal en is nie net beperk tot die werklike handling van verkoop nie.

Lamphouers, skakelaars en buigbare koord is nie ook net beperk tot apparaat gedek deur die skedules nie, maar tot alle sulke items wat verkoop word, al vorm hulle ook 'n onderdeel of onderdele van apparaat wat nie deur die skedules gedek word nie, byvoorbeeld onderdele van 'n leeslamp, 'n skakelaar in 'n radio, die buigbare koord vasgeheg aan 'n kosmenger, ens.

Dit is die eerste afkondiging van sy soort kragtens die Wet op Standaarde, 1962, ten opsigte van elektriese toebehore en is 'n groot stap vorentoe om die gebruik van elektrisiteit veiliger te maak.

2. NUWE PROJEKTE:

2.1 Die Suid-Afrikaanse Buro vir Standaarde het besluit om 'n Tegniese komitee saam te stel om beter koordinasie met die tegniese komitees TC 26 van I.E.C. en TC 44 van I.S.O. te bewerkstellig. Die onderwerp boogsweismasjiene word deur die werksaamhede van hierdie komitees gedek. U vereniging word op hierdie komitee verteenwoordig deur mnr. J. von Ahlften.

2.2 'n Spesifikasie word tans voorberei vir GELEISTAMVOERDERS en Mnr. A. F. Turnbull, plaasvervanger Mnr. J. M. Gericke, is die verteenwoordigers.

2.3 Die indeling van gebiede blootgestel aan ontploffingsgevare word nou deur die Buro onderneem en u verteenwoordigers op die komitee is Mnr. Vorster en L. Futcher (plaasvervanger).

2.4 Ander projekte waarvoor die opstel van spesifikasies of gebruikskodes tans oorweeg word, is:-

Kabelverseëlkaste;
Hoëspanningsblitsafleiers;
Verkeersligte;
Elektriese haardroërs.

3. BESTAANDE KOMITEES:

'n Omvattende lys van SABS Komitees met die name van u verteenwoordigers is ingesluit in die verrigtinge van die 1964 konvensie en word nie nou herhaal nie.

Die Buro se hantering van Kommoditeitskomitees is gedurende die afgelope jaar vaartbelyn om aan te pas by die snelle ontwikkelingstempo van die land met die gevolg dat etlike van die sub-komitees baie bedryg was.

Die vordering van die Komitee belas met die opstel van 'n gebruikskode van die „VERLIGTING VAN overseas for comments which close on the 10th May, 1965. This is an original work resulting from years of hard work by the working group and deserves the support and thanks of every engineer. The final document will probably be published during 1965.

We thank the officials of the S.A.B.S. for their assistance and help and also appreciate the sacrifices made by the engineers who represent the A.M.E.U. on the sub-committees.

The specifications and codes of practice resulting from this co-operation are there to simplify the task of the engineers and make the use of electricity safer for the public.

PROGRESS REPORT.

S.A.B.S. 187, H.V. AND L.V. THROUGH BUSHINGS.

Document being prepared for discussion after overseas comments.

S.A.B.S. 188 - STANDARD THROUGH INSULATORS.

Document being prepared for discussion after overseas comments.

S.A.B.S. 780, DISTRIBUTION TRANSFORMERS.

New document was prepared after amendments in the I.E.C. document.

These papers are now being prepared for the next meeting.

S.A.B.S. 767 - EARTH LEAKAGE PROTECTION UNITS.

This specification was approved by the Council of the S.A.B.S. on the 7th December, 1964, and is now being prepared for the printers.

ELECTRICAL ARC WELDING TRANSFORMERS.

A number of tests were carried out in the year under review on various transformers in order to determine to what extent the interference radiation requirements as set out in G.P.O. regulations R654 of the 27th April, 1962 were met.

CHOKES FOR FLUORESCENT LAMPS.

The final draft is now being edited by the working group for placing before the committee.

CODE OF PRACTICE FOR LIGHTING OF STREETS AND HIGHWAYS.

This document has been sent overseas for comment. Closing date 10th May, 1965.

S.A.B.S. 153 - ELECTRIC STOVES AND HEATING PLATES.

The document of the revised specification is now being edited before submitting same to the Council of the S.A.B.S. for approval.

STRATE EN HOOFWEë" moet hier spesiaal genoem word. Die laaste vergadering van die komitee is gehou in Oktober 1964, waarna die dokument oorsee gestuur is vir kommentaar. Die sluitingsdatum vir kommentaar is 10 Mei 1964. Dit is 'n oorspronklike produk van jare van harde werk deur die werkgroep en verdien die steun en dank van elke ingenieur. Die finale publikasie behoort gedurende 1965 die lig te sien.

Ons is die amptenare van die SABS baie dank verskuldig vir hulle samewerking en hulp, asook die ingenieurslede wat as u verteenwoordigers opgetree het en dikwels kosbare tyd opgeoffer het om vergaderings by te woon.

Uit hierdie samewerking volg die spesifikasies en gebruikskodes was die ingenieur se taak vereenvoudig en die gebruik van elektrisiteit deur die publiek veiliger maak.

VORDERINGSVERSLAG VAN PROJEKTE:

SABS 187, HOOG- EN LAAGSPANNINGSDEURVOERINGS.

Dokument vir bespreking word voorberei na oorsese kommentaar.

SABS 188, STANDAARD DEURVOERISOLATORE.

Dokument vir bespreking word voorberei na oorsese kommentaar.

SABS 780, DISTRIBUSIETRANSFORMATORE.

Nuwe dokument is opgestel na veranderings aangebring in die I.E.K.-dokument. Hierdie dokument word nou in gereedheid gebring vir die volgende vergadering.

SABS 767, AARDLEKBESKERMINGSEENHEDE.

Hierdie spesifikasie is op 7 Desember 1964 deur die Raad van die Suid-Afrikaanse Buro vir Standaarde goedgekeur en word nou gereed gemaak vir die drukkers.

ELEKTRIESE VLAMBOOGSWEISTRANSFORMATORE.

'n Reeks toetse is gedurende die jaar onder beskouing gedoen op 'n verskeidenheid van transformatore om te bepaal in hoe verre hulle voldoen aan Poskantoorregulasie R654 van 27 April 1962 in verband met steuringsuitstralings.

SMOORSPOELE VIR FLUORESSEERLAMPE.

Die finale konsep word nou deur die werkgroepe redaksioneel nagegaan vir voorlegging aan die komitee.

GEBRUIKSKODE VIR DIE BELIGTING VAN STRATE EN HOOFWEë.

Die dokument is tans oorsee versprei vir kommentaar. Sluitingsdatum 10 Mei 1965.

SABS 153, ELEKTRIESE STOWE EN VERWARMINGS PLATE.

Die dokument van die hersiene spesifikasie word redaksioneel nagesien voordat dit vir goedkeuring aan die Raad van die SABS voorgelê word.

METER BOXES.

The next meeting on this subject is planned for the near future.

S.A.B.S. 755 - METAL SHEATHED MINERAL INSULATED AIR HEATING UNITS.

This specification was approved by the Council of the S.A.B.S. on the 19th October, 1964.

S.A.B.S. 766 - BASIC REQUIREMENTS FOR ELECTRONIC APPARATUS: HOUSEHOLD RADIO RECEIVERS FOR RADIO TRANSMISSIONS IN THE M.W.; S.W., AND U.S.W. BANDS.

This specification was completed and approved by the Council of the S.A.B.S. on the 15th February, 1965.

SAFETY SPECIFICATION FOR ELECTRIC DOMESTIC REFRIGERATORS AND DEEP FREEZE UNITS.

This specification is now being prepared for approval by the Council of the S.A.B.S.

BUSBAR TRUNKINGS.

The comments on this specification will be discussed at a meeting to be held on the 24th March, 1965.

S.A.B.S. 158 - ELECTRIC KETTLES AND SIMILAR APPARATUS FOR THE HEATING OF LIQUIDS.

The revised specification is now being edited for submitting to the Council of the S.A.B.S.

S.A.B.S. 159 - ELECTRIC IRONS.

This specification was reviewed at a meeting held on the 24th February, 1965 and is now being prepared for comments.

S.A.B.S. 160 - ELECTRIC AIR HEATERS.

The revised specification is now being edited for the approval of the Council of the S.A.B.S.

S.A.B.S. 167 - CONNECTORS FOR DOMESTIC ELECTRIC APPARATUS.

A joint meeting of the committees on this specification and S.A.B.S. 158 was held on the 20th October, 1964 in order to decide what type of connector had to be standardised. A small working group of 3 members were appointed to report back towards the end of March, 1965 on the practical aspects and economics of the matter.

S.A.B.S. 03 - CODE OF PRACTICE FOR THE PROTECTION OF BUILDINGS AGAINST LIGHTNING.

The revision of this code is nearly complete except for certain aspects on the protection of buildings housing explosives and inflammable materials.

AFRIKAANSE ELEKTROTEGNIESE NOMENKLATUUR-COMMITTEE.

This committee met 10 times during the year and good progress was made with the compilation of the Afrikaans Electrical Nomenclature.

G.C. THERON.

VERBINDINGSKASTE VIR ELEKTRISITEITSMETERS.

'n Verdere vergadering in verband met hierdie aangeleentheid word vir die nabye toekoms beplan.

SABS 755 - METAALOMHULDE LUGVERHITTINGSEENHEDE MET MINERAALISOLERING.

Hierdie spesifikasie is op 19 Oktober 1964 deur die Raad van die SABS goedgekeur.

SABS 766 - BASIESE STANDAARDE VIR ELEKTRONIESE APPARAAT: HUISHOUDELIKE RADIO-ONTVANGERS VIR RADIO-UITSENDINGS OP DIE MF, HF EN BHF-BANDE.

Die spesifikasie is voltooi en op 15 Februarie 1965 deur die Raad van die SABS goedgekeur.

VEILIGHEIDSPESIFIKASIE VIR ELEKTRIESE HUISHOUDELIKE YSKASTE EN VIRESKASTE.

Hierdie spesifikasie word tans gereed gemaak vir voorlegging aan die Raad van die SABS.

GELEISTAMVOERDERS.

Die kommentaar op hierdie spesifikasie sal op 'n vergadering beplan vir 24 Maart 1965 bespreek word.

SABS 158 - ELEKTRIESE KETELS EN SOORTGELYKE APPARAAT VIR DIE VERHITTING VAN VLOEISTOWWE.

Die hersiene spesifikasie word nou redaksioneel nagegaan vir voorlegging aan die Raad van die SABS.

SABS 159 - ELEKTRIESE STRYKYSTERS.

Hierdie spesifikasie is op 'n vergadering gehou op 24 Februarie 1965 hersien en word nou reggemaak om vir kommentaar uitgestuur te word.

SABS 160 - ELEKTRIESE LUGVERWARMERS.

Die hersiene spesifikasie word redaksioneel nagegaan vir voorlegging aan die Raad van die SABS.

SABS 167, AANSLUITERS VIR HUISHOUDELIKE ELEKTRIESE APPARAAT.

'n Gesamentlike vergadering van die komitees verantwoordelik vir hierdie spesifikasie en SABS 158 is op 20 Oktober 1964 gehou om uitsluitsel oor die tipe aansluiter wat gestandaardiseer behoort te word, te verkry. 'n Klein werkkomitee van drie lede is uiteindelik aangestel om op die praktiese en ekonomiese aspekte in te gaan en moet teen die einde van Maart 1965 terug raporteer.

SABS 03 - GEBRUIKSKODE VIR DIE BESKERMING VAN GEBOUE TEEN BLITSONTLADINGS.

Die hersiening van hierdie kode het 'n gevorderde stadium bereik en daar moet nou nog net sekere aspekte van die beskerming van geboue waarin plofstowwe en ontvlambare stowwe opgeberg word, gefinaliseer word.

AFRIKAANSE ELEKTROTEGNIESE NOMENKLATUURKOMITEE.

Hierdie komitee het tien keer gedurende die jaar vergader en goeie vordering is gemaak met die opstelling van die Afrikaanse Elektrotegniese Nomenklatuur.

G. C. THERON.

Annual Report: Hot-dip Galvanized Zinc Coatings.

Two series of meetings have been held by the committee appointed by the Council of the South African Bureau of Standards to prepare a specification for the quality of galvanizing on structural steel, fasteners and threaded articles, pipes, castings and forgings.

The first series of meetings in June, 1963, were exploratory in character and served to express the various views of the designer, fabricator, galvanizer and user.

The second set of meetings in April, 1964, reconciled the views of the various representatives and considered an omnibus specification to cover the above articles. Further meetings will be held to discuss wire products and galvanized sheets.

P. A. GILES,

Representative.

Jaarverslag: Warm-gedompelde Gegalvaniseerde Sinklae.

Die komitee, aangestel deur die Raad van die Suid Afrikaanse Buro van Standaarde, het twee reekse vergaderings belê ter voorbereiding van 'n spesifikasie ten opsigte die gehalte van versinking van boustaal, knippe, skroefbedrade voorwerpe, pype, giet en smeestukke.

Die eerste reeks byeenkomste, in Junie, 1963, was navorsend van aard en het gedien om uiting te verleen aan die sienswyses van ontwerper, maker, galvaniseerder en verbruiker.

Die tweede groep byeenkomste, in April, 1964, het gedien om die sienswyses van die verskillende verteenwoordigers te versoen en het oorweging geskenk aan 'n omvattende omskrywing om bogenoemde artikels te dek. Verdere vergaderings sal gehou word om draadprodukte en sinkplate te bespreek.

P. A. GILES,

Verteenwoordiger.

Annual Report: Orange River Hydro Electric Project Sub-committee.

This sub-committee has met three times during the year. A circular was sent out to towns within economic range of the hydro-electric stations and 49 replies have been received. The information has been collated and forwarded, together with an interim report, to the United Municipal Executive for comment and action.

G. J. MULLER and P. A. GILES,

Members of the Sub-committee.

Jaarverslag: Oranjerivier Hidro-elektriese-skema Sub-komitee.

Hierdie sub-komitee het drie keer byeengekom gedurende die jaar. 'n Omsendbrief was versprei onder die dorpe binne die ekonomiese bestek van die hidro-elektriese stasies en 49 antwoorde was ontvang. Die inligting was kollasioneer en aangestuur, vergesel van 'n interim verslag, na die Verenigde Munisipale Uitvoerraad vir kommentaar en handeling.

G. J. MULLER en P. A. GILES,

Lede van die Sub-komitee.