Refer to Mr. Rodd. R. G. E

1960

34th Convention

ASSOCIATION OF MUNICIPAL ELECTRICITY UNDERTAKINGS OF SOUTHERN AFRICA

VERENIGING VAN MUNISIPALE ELEKTRISITEITS-ONDERNEMINGS VAN SUIDEDLIKE AFRIKA

34ste Konvensie

1960

NOTICE OF 34th ANNUAL CONVENTION

Notice is hereby given that the 34th Annual Convention of the Association will be held at the City Hall, Durban, from the 3rd May, to the 6th May, 1960, both days inclusive.

Executive Council meetings will be held at the Eden Roc Hotel.

DAVIDSON & EWING (PTY.) LTD.

per: R. G. EWING,

Secretaries.

AGENDA AND PROGRAMME

MONDAY, 2nd MAY, 1960.

9.30 a.m.—4.30 p.m.—Meeting of Executive Council — Eden Roc Hotel.

6.00 p.m.—7.30 p.m.—Civic Reception and Welcome, City Hall.

TUESDAY, 3rd MAY, 1960.

8.45 a.m.—Registration and Issue of Badges.

9.30 a.m.—Welcome and Official Opening by His Worship the Mayor of Durban, Councillor Cyril Milne.

Election of President.

Venue of next Convention.

Election of Vice-President.

10.30 a.m.—Refreshment Interval.

11.00 a.m.—Apologies and Greetings.

11.15 a.m.—Presentation (Past President's and Honorary Members' Medals and Certificates).

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: "Some economic aspects of nuclear power station operation," by W. Eric Phillips, D.Sc. Eng., LL.D. (Alberta), M.I.E.E., M.(S.A.) I.R.E., Sen. Mem. I.E.E., Professor of Electrical Engineering, University of Natal.

3.30 p.m.—Refreshments.

4.00 p.m.—Discussion on Paper.

5.00 p.m.—Adjournment.

8.00 p.m.—Cinema or Theatre Shows, or Night Flights over Durban.

WEDNESDAY, 4th MAY, 1960.

8.30 a.m.—Executive Council Meeting — Eden Roc Hotel.

9.30 a.m.—Convention Resumes.

Communications from Council.

Symposium on Supply of Electricity to Native Townships.

10.30 a.m.—Tea.

11.00 a.m.—Symposium on Supply of Electricity to Native Townships.

12.30 p.m.—Lunch.

2.30 p.m.—Paper: "A Survey of the Control of Stage Lighting," by J. T. Wood.

3.45 p.m.—Discussion on Papers.

4.30 p.m.—Adjournment.

8.15 p.m.—Members' Forum.

10.00 p.m.—Refreshments.

THURSDAY, 5th MAY, 1960.

8.30 a.m.—Meeting of Executive Council—Eden Roc Hotel.

9.30 a.m.—Convention Resumes.

Communications from Council.

Annual Report of Secretaries.

Appointment of Auditors.

Discussion on Reports of Sub-Committees and Representatives.

Discussion on Papers.

10.30 a.m.—Tea.

11.00 a.m.—Paper: "Electrical Protection of Distribution Systems," by J. Michel-Smith, Electricity Department, City of Durban.

12.30 p.m.—Luncheon Adjournment.

2.30 p.m.—Visits to Industries, etc., Kwa Mashu, etc.

8.30 p.m.—Convention Ball, in City Hall.

KENNISGEWING VAN DIE 34ste JAARLIKSE KONVENSIE

Hiermee word kennis gegee dat die 34ste Jaarlikse Konvensie van die Vereniging van 3 tot en met 6 Mei 1960 in die Stadsaal, Durban, gehou sal word.

Alle Konvensie vergaderings sal in die Eden Roc Hotel gehou word.

DAVIDSON & EWING (EDMS.) BPK.
per: R. G. EWING,
Sekretarisse.

AGENDA EN PROGRAM

MAANDAG, 2 MEI, 1960.

9.30 vm.—4.30 nm—Vergadering van Uitvoerende Raad — Eden Roc Hotel.

6 nm.—7.30 nm.—Burgelike Onthaal en Verwelkoming, Stadsaal.

DINSDAG 3 MEI, 1960.

8.45 vm.—Registrasie en Uitreiking van Kentekens.

9.30 vm.—Verwelkoming en Amptelike Opening deur Sy Ed. die Burgemeester van Durban, Raadslid Cyril Milne.
Benoeming van President.
Vergadering van volgende Konvensie.
Benoeming van Vise-President.

10.30 vm.—Pouse—Verversings.

11.00 vm.—Verskonings en Goeie Wense.

11.15 vm.—Toekenning van Erepennings en Sertifikate aan Oud-President en Erelede.

11.30 vm.—Benoeming van Uitvoerende Raad.

11.45 vm.—Presidentsrede.

12.45 nm.—Middagete.

2.30 nm.—Referaat: „Sommige van die ekonomiese aspekte insake kernkragsentrale-bedryf" deur W. Eric Phillips, D.Sc. Eng., LL.D. (Alberta), M.I.E.E., M.(S.A.)I.E.E., Sen. Mem. I.R.E., Professor in Elektrotegniese Ingenieurswese, Universiteit van Natal.

3.30 nm.—Pouse—Verversings.

4.00 nm.—Bespreking van Referaat.

5.00 nm.—Verdaging.

8.00 nm.—Bioskoop of Teatergeselskap, of Nag Vlugte oor Durban.

WOENSDAG, 4 MEI, 1960.

8.30 vm.—Vergadering van Uitvoerende Raad—Eden Roc Hotel.

9.30 vm.—Hervatting van Konvensie.
Aankondigings van Uitvoerende Raad.
Simposium oor Voorsiening van Elektrisiteit aan Bantoegebiede.

10.30 vm.—Verversings.

11.00 vm.—Simposium oor Voorsiening van Elektrisiteit aan Bantoegebiede.

12.30 vm.—Middagete.

2.30 nm.—Referaat: „'n Oorsig oor die beheer van verhoog-beligting," deur J. T. Wood.

3.45 nm.—Bespreking van Referate.

4.30 nm.—Verdaging.

8.15 nm.—Ledeforum.

10.00 nm.—Verversings.

DONDERDAG, 5 MEI 1960.

8.30 vm.—Vergadering van Uitvoerende Raad—Eden Roc Hotel.

9.30 vm.—Hervatting van Konvensie.
Aankondigings van Uitvoerende Raad.
Jaar verslag van Sekretarisse.
Benoeming van Ouditeure.
Bespreking van verslae van Onderkomitees en Verteenwoordigers.
Bespreking van Referate.

10.30 vm.—Verversings.

11.00 vm.—Referaat: „Elektrisiteitsbeskerming van distribusie-stelsels," deur J. Michel-Smith, Elektrisiteitsdepartement, Durban.

12.30 nm.—Middagete.

2.30 nm.—Besoeke aan Fabrieke, ens.
Kwa Mashu, ens.

8.30 nm.—Konvensie-dansparty by Stadsaal.

Agenda and Programme – Cont.

FRIDAY, 6th MAY, 1960.

9.30 a.m.—Convention Resumes.
Communications from Council.
Discussion regarding Papers, Reports, etc.

10.30 a.m.—Tea.

11.00 a.m.—Closing Session.

12 Noon—Meeting of Executive Council—Eden Roc Hotel.
Visits and Tours can be arranged for any who would like further outings. These can be arranged either through the Electrcity Department or the Official Convention Travel Agents, Messrs. Musgrove & Watson.

Agenda en Program – Verv.

VRYDAG, 6 MEI 1960.

9.30 vm.—Hervatting van Konvensie.
Aankondigings van Uitvoerende Raad.
Bespreking van Referate en verslae.

10.30 vm.—Verversings.

11.00 vm.—Afsluiting.

12.00 vm.—Vergadering van Uitvoerende Raad—Eden Roc Hotel.

nm.—Besoeke en Toere kan gereël word vir enigeen wie verdere uitstappies wil geniet. Hierdie kan gereël word deur die Elektrisiteitsdepartement of deur die offisiële Konvensie Reisagente, Mnre. Musgrove & Watson (Edms.) Bpk.

LADIES PROGRAMME

MONDAY, 2nd MAY, 1960.

6 p.m.—7.30 p.m.—Civic Reception, City Hall.

TUESDAY, 3rd MAY, 1960.

8.45 a.m.—Assemble for Registration, Issue of Badges and Official Opening.

10.30 a.m.—Tea.

11.00 a.m.—Apologies and Greetings.

11.15 a.m.—Presentation of Past President's and Honorary Members' Medals and Certificates.

11.45 a.m.—Presidential Address.
Free Afternoon.

8.00 p.m.—Cinema or Theatre Shows or Night Flights over Durban.

WEDNESDAY, 4th MAY, 1960.

a.m.—Free morning.

p.m.—Free afternoon.

8.15 p.m.—Members' Forum.

THURSDAY, 5th MAY, 1960.

a.m.—Drive and morning tea with the Mayoress.

p.m.—Visit to Industries, etc., etc.

8.30 p.m.—Convention Ball—City Hall.

FRIDAY, 6th MAY, 1960.

10.30 a.m.—Assemble for Tea and Closing Session.

p.m.—Visits and Tours can be arranged for any who would like further outings. These can be arranged either through the Electricity Department or the Official Convention Travel Agents, Messrs. Musgrove & Watson.

PROGRAM VIR DAMES

MAANDAG, 2 MEI 1960.

6 nm.—7.30 nm.—Burgelike Onthaal, Stadsaal.

DINSDAG, 3 MEI 1960.

8.45 vm.—Vergader vir Registrasie en Uitreiking van Kentekens en Amptelike Opening van Konvensie.

10.30 vm.—Verversings.

11,00 vm.—Verskonings en Goeie Wense.

11.15 vm.—Toekenning van Erepennings en Sertifikate aan Oud-President en Erelede.

11.45 vm.—Presidentsrede.
Namiddag vry.

8.00 nm.—Bioskoop of Teatergeselskap, of Nag vlugte oor Durban.

WOENSDAG, 4 MEI 1960.

vm.—Vry more.

nm.—Vry namiddag.

8.15 nm.—Ledeforum.

DONDERDAG, 5 MEI 1960.

vm.—Toertjie met verversings in geselskap van die Burgemeestersvrou.

nm.—Besoeke aan Fabrieke ens. Kwa Mashu, ens.

8.30 nm.—Konvensie-dansparty by Stadsaal.

VRYDAG, 6 MEI 1960.

10.30 vm.—Vergader vir Verversings en Afsluiting van Konvensie.

nm.—Besoeke en Toere kan gereël word vir enigeen wie verdere uitstappies wil geniet. Hierdie kan gereël word deur die Elektrisiteitsdepartement of deur die offisiële Konvensie Reisagente, Mnre. Musgrove & Watson (Edms.) Bpk.

A Survey of the Control of Stage Lighting

By J. T. WOOD

Progress prior to 1939

As we know, theatrical performances have existed for many centuries, and in all countries commenced in the open air, relying on daylight to enable the audiences to see the actors. No doubt with the decrease in time available for leisure and also in certain countries due to the vagaries of the weather, the performances had to take place at night and indoors so it became necessary to use artificial light to replace daylight and in the early times the use of this light was merely functional in that it was used to provide light on the acting area.

At first also little scenery was employed, the actual atmosphere being indicated by the text and costume. Later when scenery as we know it today was added, this was painted in very great detail to give the effect required and the great spectacles which filled the theatres tended to be mechanical. Several examples still exist of this machinery, of which the Royal Theatre in Drottningholm, Sweden, has an outstanding equipment which enabled the scenery to be changed in view of the audience by means of an elaborate system of ropes, levers and pulleys. The actual scenery still exists and the clouds, waves, etc., were beautifully painted in perspective and, although the movement imparted to them was rather stilted, the marvels of the mechanical systems must have been as much heralded as the modern systems of projection etc. are today and the system of floating clouds and rolling waves as important a feature of the old theatres as are the electrical effects and flying machines for the Rhinemaidens in the modern Opera Houses. Equally the thunder machines, a sort of wooden skittle alley, down which cannon balls were rolled, to fall finally with a resounding crash into a reinforced receptacle, have long since given way to the tape recorder and loudspeaker.

Although the Drottningholm Theatre used oil for its lighting, it is interesting to note that thought had been given to the conrol of lighting and arrangements provided to swing the wing lighting off stage, thus providing a dimming effect when required.

The oil lighting in due course gave way to gas and although we find apologies for smell and heat in some of the early playbills of the Opera House, Covent Garden, this new illuminant allowed much more dramatic use to be made of light and complete central control was obtained of the lighting. Equally arrangements were provided for "plugging in" side floods in much the same way as we would plug in a flood today. It is also interesting to note that the firm of Clémançon in Paris, who are responsible for installations in L'Opéra, the Comédie Française and most French theatres, had started in business making Gas boards and that the French word for switchboard, "jeu d'orgue," derives from the organ-like construction of these gas controls.

The first fully electric installation recorded in England was made by Mr. Siemens, who was then in England, in the Savoy Theatre in 1881 for Richard D'Oyley Carte. This was replaced in the 20's by a more modern installation which is at the moment being renewed. We have no record of the details of this installation, but we know that the early installations consisted of footlights and battens and the high-lighting was obtained by arc lights replacing the old lime lights, Sir Herbert Tree's production of *Drake* using forty of these.

The first dimmer was, of course, the liquid dimmer and although the last complete installation of liquid dimmer pots was removed in London last year, there are still many examples to be found in operation in Italy and elsewhere. One of the first important installations of this type in London was that at the London Coliseum which was installed in 1904, but Siemens had constructed a multicontact resistance dimmer with a fairly good load ratio, which was installed in the London Opera House (later known as the Stoll Theatre in Kingsway) and many continental theatres. These wire dimmers, of course, did not give such good load variation as the pot dimmer, which by judicious adjustment of the quantity of salt could be made to handle almost any required load and can be best compared with the variac of today. Both the liquid and Siemens resistance were drawn from a central control by means of tracker wire suitably counterweighted and this method is still employed in its many variations to this day.

In England and America after the 1914/18 war the liquid dimmer with its tracker wire control was replaced by the dead front panel control using multicontact resistance dimmers and combining all switching and fusing in one unit. This naturally led to rather large controls and the pure mechanics of moving a quantity of these resistances by hand limited the number as also did the space available on stage. These limitations did not apply to such an extent on the continent as the mechanical inertia of the system was overcome by the counterweight and so very compact control boards could be constructed. In England development was rather obstructed by the retention of D.C. in many theatres and although between the wars A.C. was available, in the larger cities, especially those with tramways, there was a reluctance on the part of the supply companies to shed the D.C. load of the theatres, particularly in view of the amount of money they would have to pay out for replacement of specialised equipment.

On the continent, however, the Bordoni transformer made its appearance in 1929 and was adopted by Siemens, whilst a rival patented by Ing. Salerni of the Rome Opera was eagerly adopted by A.E.G.. Both types enabled one or more brushes to be moved along the winding of a transformer and the form of construction enabled a direct replacement to be provided for the older type resistance units.

In consequence the mechanical side of these controls was developed to a high degree of perfection and the later models had in effect a full scene preset. Each control lever possessed a three-position locking knob which either freed the lever from the master shaft or caused the lever to move downwards by means of a clockwise or upwards by anticlockwise turn. Each lever was provided with adjustable trips for each direction and by setting these limits and the knobs as required, one operation of the shafts all the levers moved to the desired position. The size of these controls was also reasonable as the levers could be accommodated at 1¾″ spacings with 14″ between the rows.

Parallel with these developments considerable progress was made in the production of tungsten projector lamps and, whereas in the days of Tree forty or fifty circuits might well have covered the control of the footlights, battens and floodlighting equipment, the forty arc lamps were being replaced by tungsten lamps all requiring dimmers. In consequence the need for more and more control circuits became apparent.

In England and America theatres rarely belong to those who present the plays and so the tendency in these countries was for the control equipment to be of a portable nature, but in the continental theatres the size of the controls increased, one hundred or more circuits being commonplace, whereas in America and England the number of theatres so equiped could be counted on the fingers of one hand.

The equipment manufacturers, however, were aware of the needs and two methods of approach were used to enable this object to be achieved by the provision of controls for over one hundred circuits which could be operated by one man. In 1934 the specification for the Royal Opera House, Covent Garden, called for one hundred and thirty-four circuits and apart from the consideration of space, the size of the existing manual controls made their use impracticable. The existing multicontact dimmers were unsuitable for tracker wire operation and this form of control had always been unpopular due to maintenance troubles if the cable run was at all complicated, and in this case an existing building did not help. The invention by Mansell of the electro-magnetic clutch provided the solution and the dimmer bank was placed in a remote position, but the shafts were driven by hand by means of a fast and slow capstan wheel mounted on the perch platform.

The coupling and uncoupling of the individual dimmers by means of the clutches was accomplished by means of a two-way and off switch, above which was mounted a voltmeter giving a reading showing the position of the dimmer. This installation is still in full working order, and, although due for replacement, is in use nightly.

From this the Light Console (Bentham 1935) was a logical conclusion and this design which harnessed the electric organ console to the control of lighting was a unique step forward in the search for a means of controlling large numbers of circuits from a small console. The hand driven shafts of the Covent Garden system were easily replaced by motor driven shafts and the coupling of each circuit to the action was effected by the "stopkeys," which possessed the advantage of group control from the normal keyboard preset piston, permitting prearranged groups to be brought into operation at will.

The keyboard or "notes" became the operational centre of the control and by pressing the appropriate key the groups of dimmers could be raised, lowered, turned on or blacked out with ease. Moreover, the duplication of many of the general controls for foot operation freed the hands for setting up future arrangements. The drawback to the system was the fact that it was designed for direct operation by a lighting specialist and did not cater for the repetition of exact dimmer settings, as required today. For music hall, ice show, revue and large spectacles, however, it is still without rival and many large installations, such as Drury Lane with two hundred and sixteen circuits, bear witness to its efficiency.

Whilst this progress was made in England, the Americans were pursuing another line of thought with the introduction of the all-electric remote controlled dimmer system at the Radio City Music Hall in 1933. The use of a saturable reactor for control current had been well established, but the heavy saturating current required had prohibited its use for stage purposes although a simple reactor system had been installed in the Metropolitan Opera House, New York. The advent of the thyraton provided the means of controlling the saturating current from small potentiometers and led to the design of a control board by the General Electric Co. of America in conjunction with Kliegl Bros. which was installed at the Radio City Music Hall. Similar installations were supplied to the City Center and through the B.T.H. Company to the Odeon, formerly the Alhambra in London. These installations are of great importance as they provide the first examples of the all-electric multi-preset board. That at Radio City has five full presets enabling five cues to be preset and the lighting to be changed from one preset to another at any desired speed. These five presets are in addition to a master or rehearsal board which enables the lighting to be set up in the usual manner. This installation, which was for three hundred and fourteen circuits consisted of a large reactor room in which the dimmers were housed together with the fuses and main switches, and a control desk situated behind the conductor in the auditorium. The operator faced the stage and the five preset panels were at his back. As many know, the Music Hall is open for some fifteen hours a day, giving five performances on the stage lasting approximately one hour each. A new show is presented monthly and has to be rehearsed and lit during the night. In consequence it is quite usual to find that these monthly shows are planned to use six major lighting changes to suit the limitations of the board. The installation suffers from the main defects of the saturable reactor in that a considerable time lag occurs between the action taken at the control desk and the resulting operation of the lighting.

From the foregoing, it is clear that by 1939 there was already a definite trend in the development of preset and remote control of stage lighting, dividing into two clear-cut paths the all-electric system of America and the electro-mechanical system, either by clutch or tracker wire, of Europe.

Post War Development

At this point we must again consider the lighting technique which was changing rapidly and which was to have a marked effect on the future. In Germany, where the large theatre, fully mechanised, was the order of the day, running expense has never been a problem and in consequence, although many lighting units were designed for cyclorama effects, the spotlighting had remained under the control of individual operators from bridges, galleries or front of house positions, which resulted in the need for fewer sources of light. In England and America, where wages were either too low to attract suitable labour or too high to be economical, the trend was towards the use of a large number of spots controlled from the board. The necessity for touring also helped this trend in that the lighting could be positioned on arrival and large numbers of technical personnel would not be necessary during the performance. In consequence, at the end of the war the demand was definitely existing for control boards with a larger number of circuits than ever before and the space required became another problem.

As always during wartime, many developments were hastened by the unlimited money available for research and so at the end there were many new tools available for the theatre.

The first change of importance came from Sweden, where the simple reactor was investigated and due to the availability of high quality steels an efficient magnetic amplifier was produced, which consisted of two stages with feedback and required only small currents for its control. Moreover a load variation of 30 to 1 was obtained and with more recent models 50 to 1 or more. The first installation of some thirty circuits was installed at the studio theatre in Malmo and in 1950 the National Theatre in Oslo was completed with over one hundred circuits, followed by the Folkteatret in the same city with one hundred and eighty circuits.

At the same time George Izenour at Yale University and the author in England were working on the idea of dropping the reactor used in the Radio City installation and operating the lighting directly by means of thyratons. The Izenour method used two tubes back to back, producing single phase A.C. and the first installation was at Yale University where he was working, and consisted of forty-four circuits with ten full presets. The author's system used a simple three phase rectifier system producing D.C. which had the advantage of spreading the load evenly over the phases at all times and was provided as standard with one scene preset. The first fully operational installation was at Reykjavik in early 1950, followed closely by those at the Old Vic, Stratford-upon-Avon and many others.

As these two systems are examples of important principles in the construction of remote controls, it is worth emphasizing the essential differences in layout, as this affects the whole consideration of the subject.

The Izenour system consists of two essential components, a rehearsal desk, which is in effect a normal stage board in miniature, and a preset panel containing ten small levers for each circuit on the rehearsal panel, four hundred and forty for a forty-four circuit board etc. The rehearsal desk has a master crossover fader with switching facilities to permit any one preset to be faded to any other. It should be noted that the term "fade" is used here as in sound technique and denotes the blending of one setting into another and not the passing through a blackout position.

The method of operation is to find the necessary light settings on the rehearsal board and then transfer these to one of the presets. Thus for each cue one preset is required and it is assumed that by providing ten it would be possible to reset if necessary in order to maintain continuity.

The author regarded the problem in another way. From observation of the operation of large manual boards it became clear that at times the facilities were not sufficient and so the object of the design was twofold, first to reduce the size of the desk so that one person could reach the number of dimmer levers with ease, and secondly to add to the facilities already existing by providing a second fully operational panel with a cross fader: thus the simpler cues could be carried out normally and, when necessary, the other panel be brought into use, as opposed to the preset to preset arrangement of Izenour.

Both systems have the inherent disadvantage that when cross-fading from one preset to another all those circuits which are

Electrical Appliances for Communal Applications

By G. F. Browne, C.G.I.A., A.M.I.E.E., A.M.(S.A.)I.E.E., City of Salisbury, Electricity Department.

1. INTRODUCTION

At the present stage in development of native communities, economic factors largely prevent the extensive use of electricity by individual families. In order to bring improvements in living standards associated with a full use of electricity to any substantial proportion of the native population it is essential that the concept of communal use of facilities should be accepted.

Some progress has been made towards providing suitable electrical appliances for communal needs although so far these have been applied only for use by unmarried native males housed in hostels.

The magnitude of the achievement to date may be gauged from the fact that 35,000 natives housed in 50 hostels and other communal buildings consume about 8 million kilowatt hours per annum. Possibilities for further load development in existing hostels alone amount to not less than another 20 million units per annum.

2. BOILING TABLES

Traditionally the staple diet of the native is mealie porridge varied with occasional meat and vegetable stews. The food is cooked over an open fire in a pot or saucepan. Roasting or baking in ovens is unknown.

This type of cooking can be provided for excellently by means of electric boiling tables. A boiling table consists of a sturdy structural steel framework supporting heavy cast-iron hotplates. The iron plates are heated by means of tubular, metal-clad, mineral insulated, air heating elements clamped underneath. No heat control switches are provided and the tables are switched on and off from a central point inaccessible to the users.

It is essential to provide hot water for starting porridge and for subsequent washing of utensils. The former reduces cooking time and increases hourly throughput, resulting in savings in capital cost of buildings and equipment and in running costs. The latter is desirable for hygienic reasons.

Operating results have been good, some tables having been in use for 6 years or more with negligible expenditure on maintenance. Cracking of hotplates is liable to occur due to repeated heat cycling but, owing to sturdy construction and the type of elements used, this has had no markedly detrimental effect. Cracked hotplates continue to give good service even after several years.

Experience in Salisbury indicates that approximately 10 square inches of hotplate surface area should be allowed for each native and that the hotplates should be rated at about 1.1/3 kW per square foot. Water heating equipment capable of supplying about 1½ pints of hot water per hour per native and rated at 0.05 kW per native is adequate. Energy requirements amount to approximately 0.73 kW hours per native per day, including that used for water heating, at a cost in Salisbury of 0.48 pence.

Up to the present time two hundred 12 kW cooking tables have been installed by the Salisbury Municipality.

3. WATER HEATING

3.1 *General*

Domestic thermal storage type water-heaters are unsuitable for large scale communal applications owing to low heat recovery rate and the large number of appliances required.

Centrally placed water-heaters with hot water pumped to all points of utilisation through a piping ring main have proved satisfactory.

Usually a water-heating system inherently has some storage capacity and this may be useful for dealing with peak requirements. Having regard to expected peak demand for hot water, and to the electricity tariff applicable, a balance must be achieved between kW rating and heat storage capacity. In line with Salisbury electricity tariffs, systems installed have small heat storage capacities and are capable of producing hot water at approximately the same rate as it is used. Capital costs are thereby kept to a minimum without any increase in running costs.

3.2 *Resistance element water-heaters*

Where soft water is available water-heaters employing resistance immersion elements can be used successfully and have least capital cost.

A typical example now being installed by the City of Salisbury is rated at 300 kW. It comprises a 600 gallon storage vessel from which hot water is pumped through a piping ring main covering four floors in two buildings. The system is designed for a continuous draw-off of 1,400 gallons of 130°F. water per hour for ablutions and laundry purposes. The water-heater is controlled by a thermostat and a single contractor. Safety features include an excess temperature thermostat and a low water level cut-out both arranged to trip a main circuit-breaker. Hot water will be supplied for 4 hours daily except at week-ends when it will be available for 12 hour periods. On this basis energy consumption is expected to be 1.7 kW hours per native per day at a cost of 1.1 pence.

3.3 *Electrode water-heaters*

Electrode water-heating systems are similar to the resistance element type except that heat is generated directly by passing current through water by means of immersed electrodes.

Generally the resistance of City water is too low to be used effectively without chemical dosing. Dosing consists of adding a small amount of washing soda or common salt, in Salisbury about 4½ ounces per 100 gallons is sufficient. Tannin may be added as a corrosion inhibitor.

Because of chemical dosing it is necessary to isolate the electrode water-heater from the building pipework.

A typical system consists of a hot water storage vessel connected to closed circuit piping traversing the building and feeding all the points at which hot water is utilised. The water in the vessel and piping is kept in constant circulation by means of a motor driven pump. Heat is generated in the electrode water-heater and is transferred to the water in the storage vessel by means of a heat exchanger through which hot water is circulated continuously. The heat exchanger may consist of a nest of copper pipes inside the storage vessel.

Three 110 kW electrode water-heaters and one rated at 65 kW have been installed by Salisbury Municipality.

4. STEAM RAISING

Where cooked food is supplied to large numbers of natives it can be cooked most conveniently in large steam heated pans. The advantages of steam raising by electricity for this purpose are as follows:—

(a) Rapid response of boilers to fluctuating steam demand.

(b) No boilerhouse is required. The boilers may be placed in the kitchen at considerable saving in building costs. Cost of steam piping and heat losses is kept to a minimum.

(c) Cleanliness in operation and no waste for disposal.

(d) Boilers are almost fully automatic and require a minimum of attendance and maintenance.

(e) Electrode steam boilers are inherently safe against damage due to low water level.

A steam generating system now under construction for the City of Salisbury comprises two identical electrode type steam boilers each rated at 380 volts, 600 kW with a combined output of 4,000 pounds of steam per hour. The boilers work into the same steam range and they can be used separately or together. Normal working gauge pressure is 30 lbs./sq. in., and all condensate is returned to the hotwell.

The boilers are fitted with automatic load controllers to ensure that steam production is adjusted continuously in accordance with varying requirements. Each controller consists of a pressure sensitive device which exercises control by starting and stopping boiler feed pump and also by operating a feed water bye-pass valve. The controllers work in conjunction so that one boiler only accepts load when steam requirements do not exeed its capacity. To satisfy large steam demands the boilers share the load. The boilers alternate automatically in the leading and trailing roles every 24 hours and they are subject to remote supervisory control for load shedding.

The kitchen in which this equipment is to be used will supply cooked meals to 4,000 natives and the installed capacity of steam raising equipment is 0.3 kW per native. Electricity consumption for steam raising is expected to be about 1.35 kW hours per native per day at a cost of 0.88 pence.

5. MISCELLANEOUS ELECTRICAL APPLIANCES AND APPLICATIONS

In Salisbury, as elsewhere, new uses for electricity in native areas arise almost daily.

An important innovation is the provision of hot water for ablutions and laundry purposes throughout a large hostel accommodating 1,000 natives. This is new today but it is foreseen that in the not too distant future this amenitywill have to be provided in all hostels.

Manufacture of native beer utilises mixers, conveyors, centrifuges, pumps and refrigeration equipment, to all of which electricity is vital. Distribution of the product is facilitated by the use of compressors, pumps, agitators, and electronic beer dispensers. Now that light wines and European style beer are available to natives, no beer kiosk is complete without cold storage equipment.

Newest recreational amenities are outdoor dance floors each with a permanent installation of 500 coloured lamps, tape or record player, amplifier and loudspeakers.

Plenty of floodlighting is required at all social centres. Applications include novel floodlighting equipment for a portable boxing arena, and a naval searchlight mounted on a 40 foot high lattice tower is used for crowd control at a native sports stadium. As a matter of interest the searchlight was installed previously at the Kariba Dam.

A full scheme has been prepared for floodlighting a football pitch to English Football Association standards and this will be a first class amenity when it becomes reality.

All Municipal townships and hostels are covered by broadcasting networks. Outdoor exponential horn loudspeakers and 500 watt amplifiers are used in townships and three hostel complexes are served by 250 watt amplifiers. Hostel amplifiers can be used independently or in conjunction with township equipment. In emergency, overriding control permits all equipment to be operated, or put out of action, by remote control.

Administration and security requirements make it essential to provide a VHF radio communication system for the Native Administration in the near future.

6. CONCLUSION

So far the main large scale application of electricity in native areas has been for cooking and development has taken the easier path by providing facilities only for natives housed in hostels.

Experience gained to date must be considered as a preparation for the real task ahead, that of making the benefits conferred by a full use of electricity available to all The only approach which has any hope of economic success in the foreseeable future is to develop communal facilities to the native townships, particularly to families. greatest extent.

For example it is suggested that in new townships communal kitchens should be provided for neighbourhood groups of say 50 families. Townships could be laid out so that kitchens are reasonably convenient to all houses and, in fact, the kitchens should be made the focal point of the area. It should be surrounded by a fenced off open space containing shade trees, benches for the mothers and playground equipment for the children. It would provide a pleasant place for the women of the neighbourhood to meet, perhaps rivalling the attractions of the local beer garden and certainly having more beneficial results. Initially these kitchens could be equippel with boiling tables but development of suitable electric ovens is desirable.

One development which will have very far reaching social consequences is the establishment of communal bath houses in native townships, similar to those which have existed for many years in the cities of Europe. Here natives will be able to obtain hot baths with soap and towels, at moderate charges. This may be considered by some as far fetched and fanciful but I prefer to believe that it is inevitable progress.

Opportunities for influencing the pattern of development of native people for good exist in this work and it is perhaps particularly gratifying to those concerned with electricity supply that the possibility of very considerable load building is also present.

The Electrical Reticulation of kwa Mashu Bantu Township, Durban

By D. R. Hill

Introduction

The problem of devising an economic reticulation for Bantu Townships is one that is confronting most Municipal Supply Authorities in the country today. It is generally recognised that electricity in the home plays a considerable part in improving the social life of a community, and from experience already gained, it is evident that this is particularly true in respect of Bantu Townships. This aspect, however, is not primarily the concern of the engineer but at the same time, co-operation between all persons involved in directing activities relating to native communities is essential in order that the best results can be obtained from all available resources.

Several papers have now been written on the subject of reticulating Bantu Townships and these together with subsequent discussions appear to have covered the subject fairly thoroughly. I feel that these papers have all made a very valuable contribution to the sources of information now available for the guidance of both present and future engineers engaged in this particular type of work and, although this paper probably contains little that is not already familiar to most of us, I hope that it will serve the purpose of again focussing attention on the problems involved and at the same time available to those interested, the methods employed and experiences gained at kwaMashu.

At this stage, I would like to give a few statistical details in order to present a general picture of kwaMashu Bantu Township and the electrical work involved in reticulating the Township.

The Township which is situated 8 miles north of the centre of Durban, covers an area of 3,000 acres and will be divided into 10 neighbourhood units. Of these 10 neighbourhood units, 9 will be in the form of Bantu village units, for family housing and will contain approximately 11,000 dwellings whilst the remaining area will be developed on the cottage hostel system and provide for approximately 17,000 beds. The total ultimate population of the Township is estimated at approximately 100,000 persons.

Finance

In common with other similar schemes, the capital cost of the electrical reticulation at kwaMashu is being financed from Native Services Levy and Government Housing Funds subject to the approval of the Minister for Bantu Administration and Development.

The financial arrangements are as follows:—

1. Cost of access from existing City Mains to the Scheme to be financed as a grant from Native Services Levy Funds.

2. Cost of major distribution system to provide for eventual full reticulation of the scheme including domestic supplies, to be financed as a grant from Native Services Levy Funds.

3. Cost of street lighting in village units. A rudimentary form of street lighting with lights spaced 300 ft. apart in every second road to be financed as a grant from Native Services Levy Funds and the additional cost of supplementing the street lighting system to provide lights 150 ft. apart in all roads, to be financed from Government Housing Funds.

4. Cost of reticulation in Hostel Area. The low tension reticulation including street lighting and the internal wiring of the hostel buildings to be financed from Government Housing Funds.

Financial Implications of a Low Voltage Reticulation Throughout the Township

It will be noted that provision has not been made for financing the low voltage reticulation required for domestic supplies and possibly the internal wiring of the 11,000 houses in the Township.

The source from which the necessary capital can be made available and the determination of an economic tariff are two problems presenting difficulties in this respect and at the present time, these matters are still under consideration.

Under the existing policy of the Government, the Local Authority is expected to provide the additional capital required to fully reticulate the Township in order to make domestic supplies available in addition to the street lighting already being provided. The additional capital required for this work including the internal wiring of all houses, is estimated at approximately £600,000 to be spent over several years, and it is hoped that it will be possible to obtain some form of Government assitance in this respect and thereby ease the burden on the City's ratepayers.

It is felt that although there will be a large number of potential consumers in the Township, it is probable that for the first few years, a comparatively small number will be able to afford electricity. In view of this, it will be realised that to provide electricity to a relatively small number of consumers in an area as large as kwaMashu, a considerable amount of initial capital expenditure will be involved. Suggestions to reduce the initial high capital expenditure by establishing certain areas or zones in which domestic supplies would be made available have not met with favour for various reasons, from the Local Bantu Administration Department, and furthermore, the arrangement may possibly conflict with the terms of the Electricity Act.

The second problem, which is the determination of an economic tariff, also presents certain difficulties, as the tariff applied must be sufficiently attractive to encourage people to wire their homes and make use of electricity. From investigations already carried out, it appears that the anticipated revenue at kwaMashu, based on the Electricity Department's existing tariffs, will not be sufficient to cover generation and distribution costs. This problem has not yet been resolved and is the cause of considerable concern at the moment.

In order to indicate the revenue that can be expected from Bantu townships I have taken the liberty of analysing and presenting details of the average consumption of 1,200 consumers at Chesterville Bantu Township, Durban, in a manner similar to that presented in respect of Eastern Bantu Township, Johannesburg, in a paper read by Mr. Masson at last year's convention, as I feel that these statistics give a clear picture of the position.

The April, 1959 unit consumption figures have been taken and are analysed as follows: —

(a)	2%	used between	5	and	10 units p.m.
(b)	15%	„ „	11	„	20 „ „
(c)	17%	„ „	21	„	30 „ „
(d)	14%	„ „	31	„	40 „ „
(e)	12%	„ „	41	„	50 „ „
(f)	8%	„ „	51	„	60 „ „
(g)	18%	„ „	61	„	100 „ „
(h)	9%	„ „	101	„	200 „ „
(i)	5%	used more than 200 units per month			

For consumers classified above, the corresponding average revenue based on the Electricity Department's Tariff for private residences is as follows: —

	1955/1956 Tariff	1959/1960 Tariff
(a)	From 2/6 minimum	2/6 minimum
(b)	„ 2/7 to 5/-	2/7 to 5/-
(c)	„ 5/1 to 6/9	5/1 to 7/-
(d)	„ 6/10 to 7/4	7/1 to 7/8
(e)	„ 7/5 to 7/11	7/9 to 8/4
(f)	„ 8/- to 8/6	8/5 to 9/-
(g)	„ 8/7 to 10/10	9/1 to 11/8
(h)	„ 10/11 to 16/8	11/9 to 18/4
(i)	„ 16/9 & higher	18/5 & higher

An indication of the load growth in Chesterville, is given by the graph (Fig. 1) showing the average consumption per consumer over the 12 month period from August to July for the years 1955/1956 and 1958/59.

It would appear, therefore, that for a number of years some form of subsidy will be necessary to make up the deficit between revenue and expenditure if existing tariffs

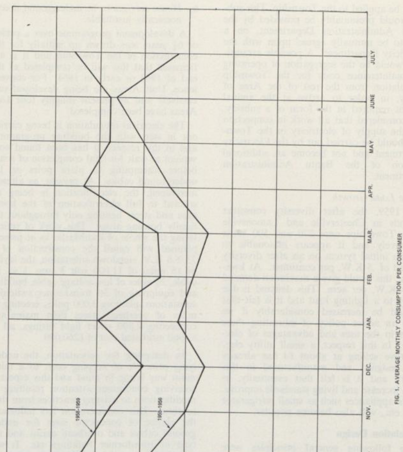


FIG. 1. AVERAGE MONTHLY CONSUMPTION PER CONSUMER
CHESTERVILLE.
DURBAN.

Fig. 1.

are to be applied to the Township. This subsidy would presumably be provided by the Bantu Administration Department, on a basis to be mutually agreed upon with the Electricity Department. A possible arrangement would be the segregation of operating and maintenance costs for the Township Reticulation from the rest of the Area of Supply, in order to arrive at the annual amount required in the form of a subsidy. It is considered that all work in connection with the supply of electricity in the Township should be carried out by the Electricity Department and not become an additional function of the Bantu Administration Department.

Future Load Growth

In 1959, the after diversity consumer demands in Chesterville and Lamontville Bantu Townships were 270 and 500 watts respectively and it appears reasonable to plan an initial system on an after diversity demand of .5 K.W. per consumer. At kwaMashu, this would give a maximum demand of 3.3 K.W. per acre. This demand is due mainly to a lighting load and it is felt that it could be increased considerably if we adopt an active policy of educating these people in the uses and advantages of electricity. In this respect, a small utility electric stove selling at about £4 has already been designed and manufactured in this country and it is felt that eventually, as wages increase and living standards improve, further appliances such as small refrigerator units, etc., will also become popular.

Reticulation Design

The following general principles were adopted when the initial plans for the reticulation were prepared.

1. The high voltage reticulation to be an underground system.
2. Transformer kiosks to consist of brick buildings to be erected by Bantu labour.
3. All street lighting mains to be overhead.
4. Low voltage reticulation to be overhead in the family housing areas.
5. In the Hostel Area, all hostel buildings to be supplied by means of an underground low voltage reticulation.
6. House services to be underground if economically justifiable.

A development programme over a period of 6½ years was drawn up initially for the construction of the Township and it is anticipated that this will be completed at the end of 1963 or early in 1964. For convenience, Unit Areas are being developed successively and at present roughly four Unit Areas have been completed.

The electrical reticulation is being carried out in step with the building programme, and in this respect, it has been found convenient to wait for final completion of roads before attempting to plant poles or lay underground cables. At present, as already mentioned, the electrification is being restricted to full electrification of the hostel area and street lighting only throughout the family housing areas. This work of reticulating the whole of kwaMashu as at present planned will entail the construction of a 33/6.6 K.V. stepdown substation, the laying of 15 miles of 11,000 volt 3 core .1 sq. in. cable, 20 miles of low voltage cable, building and equipping of 30 transformer/switching substations, planting 3,000 poles, erecting 80 miles of overhead street light mains and connecting 2,800 street light fittings, all at a total estimated cost of £260,000.

In designing the reticulation, the underlying principle of keeping costs to a minimum was borne in mind and this aspect is receiving continuous attention resulting in modifications to existing practices from time to time. This consideration has influenced the choice of conductor sizes for underground cables and overhead mains and the type of transformer buildings etc. It was considered essential to install an adequate basic 6,600 volt reticulation which could be extended at a later date, and so enable further transformer substations to be connected into the system as and when required. A master plan of the 6,600 volt system layout to suit the physical layout of the Township, was prepared and the schematic layout of this plan for various stages of development are shown in Fig. 2.

From this drawing, it will be noted that it was necessary to resort in one instance to a temporary 6,600 volt overhead main to sites as are required to meet the future township loading. Kiosk sites should not be larger than necessary otherwise they will reduce the number of residential stands available and present the Engineer with the problem of keeping the sites free of weeds and rubbish. A site measuring 15 ft. x 12 ft. plus building line restrictions appears to be adequate for a capacity of 500 kVA.

3.22 *Load Centre Design*

The returns appear to favour the brick building no dubt due to the comparatively low cost of such structures erected by native labour. The brick building appears to be justified for important load centres, switching or linking stations.

In a number of reticulation schemes pole transformers are used although they are not as popular as would be expected. It would seem, however, that serious consideration should be given to pole transformers for use in areas where the load density is low or where the load is a developing one.

Steel kiosks are used by a number of authorities but insufficient information has been received to indicate whether they should only be used say in areas where the load density is low or whether their cost justifies the additional maintenance they require.

3.25 *Kiosk Equipment*

Slightly more than half of the undertakings use oil circuit breakers for the E.H.T. protection of the transformers and the balance use H.R.C. fuses.

L.T. protection is by H.R.C. fuses.

3.3 *H.T. and L.T. Feeders and Distributors*

3.31 *E.H.T. Feeder Cables*

Roughly 75% of the Undertakings have installed underground cables for the E.H.T. distribution within the townships. Of the remaining 25% who have adopted overhead E.H.T. mains, no indication has been given that unsatisfactory service has been given from these mains.

3.32 *L.T. Distribution*

3.321 *L.T. Distributors*

With one exception the replies to the questionnaire show that overhead mains are used exclufor L.T. distribution.

3.322 *Conductor Materials*

Approximately 66% of the Undertakings reviewed use copper conductors and the balance use aluminium.

All aluminium appears to be slightly more extensively used then steel core aluminium conductors.

Conductor Configuration

Vertical configuration is used in 70% of the reticulation schemes and the balance use horizontal configuration.

3.324 *Neutral Earthing*

Multiple earthed neutral system has been adopted by 75% of the Undertakings.

3.4 *Street Lighting*

Tungsten lighting is by far the more popular form of lighting and 85% of the undertakings use this type.

Two undertakings have used mercury and sodium fittings for main roads and access roads to the townships.

Fluorescent fittings are used by 15% of the Undertakings and they are all of the high power factor type.

Fluorescent fittings using lamp wattages of 60 and 80 watt capacity are in service whereas tungsten lamps from 75 to 200 watt capacity are in use. The most popular sizes of tungsten lamps appears to be either 150 or 200 watt.

Spacing of street lamps varies from 120 to 400 ft. Where street lighting has been financed exclusively from Natives Services Levy Funds then lighting has been provided either in every second street or else lighting at every street intersection with no lighting along the length of the blocks.

4.0 HOUSE WIRING AND SERVICE CONNECTIONS

4.1 *Wiring Methods*

One Undertaking has installed PVC sheathed wiring, one has wiring run in cleats and the remaining 85% have used the conventional conduit system.

4.2 *Standards of Wiring Work*

From the returns received it is evident that the wiring work carried out has been of a high standard. Approximately 75% of the returns indicate that lighting points are mounted in the centre of the rooms and the lighting switch is placed in the same room as the light it controls. The remainder of the replies indicate that wall bracket lights are provided with the lighting switches for the various rooms grouped at one point.

Only one Authority has provided a 30 ampere cooker control outlet.

Two Authorities have used ceiling switches with no maintenance problems, whilst two Authorities have had unsatisfactory experience. The remainder of the replies indicate that ceiling switches have not been used.

4.3 *Special Features*

One Federation member has had experience with communal kitchens for housing schemes but it appears that there is no demand for such facilities in the towns in the Union.

4.4 *Wiring Maintenance*

Roughly two thirds of the Municipalities bear the cost of the maintenance of house wiring installations and the balance expect the consumer to pay for maintenance.

4.5 *House Service Connections*

Overhead services are indicated in 66% of the replies and the balance provide underground service cables. It is interesting to note that PVC insulation is being adopted for practically all overhead and underground services.

5.0 BANTU ARTISANS AND CONTRACTORS

The returns indicate that 25% of the Municipalities employ natives to do wiring and maintenance of house installations.

Very little information has been received regarding the wages paid to electrical trainees. The Native Building Workers Act lays down minimum rates of pay for trainees and one Municipality has adopted these rates. A second Municipality is treating trainees as salaried staff at higher rates than laid down in the Act.

Native electrical contractors are operating in Pretoria and Salisbury.

6.0 UNIT COSTS

6.1 *Street Lighting Reticulation Schemes*

The cost of street lighting schemes is dependent upon such factors as size of stand, whether overhead or underground E.H.T. cables have been provided, spacing of lights, excavation and load centre costs.

The returns indicate that construction costs work out at something between £2 2s. and £12 per stand. For a lamp spacing of 240 to 300 ft. using wooden poles and aluminium overhead conductors, a unit cost of £5 per stand measuring 40 ft. x 70 ft. appears reasonable.

6.2 *Reticulation of Domestic Power and Street Lighting*

The returns indicate that the average cost per stand for township reticulation which includes E.H.T. feeder cable within the township, load centres, low voltage mains and street lighting is as set out below:—

A. *Designed for an After Diversity Maximum Demand of 1kW Per Stand*

(i) Complete underground cable system for a township with stands measuring 45 ft. x 75 ft.—approximately £45 per stand including service connections.

(ii) Complete overhead mains system for a township with 40 ft. x 80 ft.—£25 per stand excl. s/c connections.

B. *Designed for an After Diversity Maximum Demand of 0.75 kW Per Stand*

(i) Underground E.H.T. and overhead low voltage mains to supply 40 ft. x 70 ft. stands—£22 10s. per stand.

C. Designed for an After Diversity Maximum Demand of 0.5 *kW Per Stand*

(i) Underground E.H.T. and overhead low voltage mains 40 ft. x 70 ft. stands—£20 per stand.

6.3 *Street Lighting Fittings*

Street lighting fittings costing from £2 10s. to £10 for tungsten lighting are used. The average priced fitting used would appear to be of the order of £3 10s.

Fluorescent fittings cost from £5 10s. to £22 although the average price is approxi- £7 10s.

7.0 EXTENT OF WORK TO BE CARRIED OUT

There are approximately 144,000 houses built in the areas supplied by the 24 Undertakings included in this survey. Of this total 32,500 houses have been provided with electricity supply.

There are approximately 19,000 of the wired houses which have 15 ampere socket outlet whereas the remaining 13,500 permit the use of lighting only.

8.0 CONCLUSION

The decisions made today are those with which we will have to live for many years to come. Errors in planning can be costly and practically irremediable. It is therefore recommended that: —

(a) For any native township a complete scheme for street lighting and reticulation should be planned and this design should be used as a master plan.

(b) If the initial development is to be rudimentary street lighting then go ahead with such portions of the master plan that are necessary for the service required. Omit any load centres that are not required but follow the E.H.T. cable route planned to tie in with such load centres.

(c) Where the designed plan has been shaved down to the minimum requirements considered essential by the Electrical Undertaking it must be adhered to and there should be no compromise. Expedients which may result in lower initial expenditure but destroy the planning must be strongly resisted.

This report was made possible by the work of the members who completed the questionnaire and in some cases went to extra trouble to provide supplementary information. To these members a very special vote of thanks is due.

	Benoni	Boksburg	Bloem-fontein	Bulawayo	Cape Town	Durban	East London	Estcourt	Germiston	Heidelburg Transvaal	Johannes-burg
A. General											
No. of towns'ps or settled com.	3	3	1	6	2	4	3	1	3	1	20
No. of dwelling units	11,805	2,595	4,956	10,006	1,096	6,354	4,827	156	17,000	640	40,000
How many dwellings:											
Lighting only	—	—	—	756	8	—	—	106	—	—	—
Lighting and Cooking	10,724	126	300	90	484	1,500	237	—	50	640	3,100
Average family income											
Where no supply available..	—			£10. 3s.				£8	5% below £6		
Lighting supply only	—	£18–£20	Less than £15 p.m.	£8 8s.	£20 p.m.	£12–£15	£12–£13	£8	5% .. £10 70% .. £15	£9	£16
Lighting and other purposes	£16			£14 4s.				£8	20% ab £15		
Who is responsible for payment for electricity consumed	Consumer	Consumer	Consumer	Municipality & Consumer	Consumer	Consumer	Consumer	Municipality	Consumer	Consumer	Consumer
B. Town Planning Details											
Any difficulty due to Town Planner's design	No	No	Yes	No	Yes–resul. in deviat. mid-bound. const	Yes	Yes	No	Not unduly	Yes	Yes
Are street corners splayed.. ..	1 township	2 town's. No 1 town'p Yes	No	Existing No Future Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Do curved streets make erection of O/H mains difficult	No	—	Yes	Yes	Yes	Yes	Yes	No	Yes	—	Fair difficulty
What size sites are provided for load centres..	45' x 75' 50' x 50'	50' x 50'	40' x 30'	30' x 30'	12' x 12' 40' x 60'	10' x 15'	50' x 50'	Not provided	25' x 15' 40' x 75'	—	15' x 17' 20' x 20'
C. Financing of Schemes											
Work financed out of the Natives Services Levy	—	Bulk supply	Bulk spp. & S.L. imp. sts	—	Street lighting wir. blocks sgle & mar. quarters	Bulk supp. & rudi. S.L. completion of street lighting	Street lighting	—	Rudimentary SL	—	Bulk sup. & Rudi'tary SL
Work financed out of the National Housing Loans	—	Street lighting	—	—			Nil	—	—	SL & LT Reticulation	Limited amount of S.L.
Work financed out of the Local Authorities' own funds	External loan	LV reti-culation	Balance of work	All work	Domestic supply	Wiring	Reticulation Wiring	All work	—	—	Intermed.SL. LV Reticula. Hse. wiring
Work financed out of Other sources..	—	—	—	—	—	Sup. 3 tow's. Elec. Dept.	—	—	—	—	—
D. Design Details											
Are E.H.T. mains O/H or U/G	U/G	O/H out. township U/G Inside township	U/G	O/H	U/G	1 town. U/G. 3 town O/H.	U/G	U/G	U/G	O/H	U/G
Are L.T. mains O/H or U/G ..	2 town U/G 1 town. O/H	O/H	O/H	O/H	O/H	O/H Generally	O/H	O/H	O/H	O/H	O/H
Where are poles planted	Near build. line	Near kerb	Near kerb	Rear boundary	Where pos. rear bound.	Near kerb	Near kerb	Near build. line	Near build. line	Near kerb	Side Roads build. line Mn. rd. kerb
Do you operate with M.E.N. ..	2 town yes 1 town no	Yes	Steel pole instl.-Yes	Yes	Yes	No	Yes	No	Yes	Yes	Yes
Conductor configuration	2 town–Hori.	Horizontal	Old–Horizon New–Verti.	Vertical	Vertical	Horizontal	Vertical	Horizontal	Vertical	Vertical	Vertical
Conductor materials	Copper	Copper	Copper	Copper	Copper	Copper	Copper	Copper	S.C. Alum.	S.C. Alum.	All Alum.
Type of Load centre	Brick	2 Steel 3 Brick	1 Steel Bal. Brick	Pole transfr. Generally 1 steel 2 brick	Brick & O/D tran. enclo.	1 town. brick 3 pole transf.	New–steel Old–Brick	Brick	Brick	Steel	Brick Kiosks
Capacity of Load centres	300–500 K.V.A.	200–300 KVA.	500 KVA.	Pole transf. 200 KVA. Steel kiosk 300 KVA. Brick kiosk 500 KVA.	500 KVA.	Brick 300 KVA	500 KVA	75 KVA.	500 KVA.	200 KVA.	400 KVA.
E.H.T. protection of transformer	O.C.B.	O.C.B.	O.C.B.	Pole transfr. fuses Brick kiosk O.C.B.	O.C.B.	O.C.B.	O.C.B.	Fuse	O.C.B. or HRC. SwF.	O.C.B.	O.C.B.
Street lighting fittings:											
Wattage	100 w. Tung. 160w. Fluore.	100 w.	150 w.	250 w.	100 w.	75 w.	60 & 150 w.	100 w.	200 w.	150 w.	60 w.
Spacing..	Tungs. 130' Fluore. 400'	Main rd. 150' oth'r 150–300'	300'	150'–200'	200' main rd. 400' other rd.	150'	120'–150'	—	190'–800'	180'	240'
Type	Tung & Fluor	Tungsten	Tungsten	Tungsten	Tungsten	Tungsten	Tungsten	Tungsten	Tungsten	Tungsten	Fluorescent

Krugersdorp	Ladysmith	Paarl	Peri Urban Pretoria	Pietermaritzburg	Pretoria	Port Elizabeth	Roodepoort/Maraisburg	Salisbury	Sasolburg	Umtali	Uitenhage	Ventersdorp
2	1	1	1	2	3	3	1	3	3	1	1	1
3,301	970	288	2,308 Provision for 150	—	10,000	10,025	5,000	9,740	450	2,000	3,500	—
294	—	280		1,300	—	3,800	—	5,044	—	2,000	620	8
—	200	—	—	25	1,552	100	700	696	375	30	90	—
£11	£5–7 p.m.		—	—		£12		—			£11	£6 to £7
£12	£5–£7 p.m.	£10–£15	—	£10	£15	£12	£20	£11.10 plus rent	£16	£8 plus rent	£11	£12 to £20
£13	£10		—	—		—		£25 to £30			£32	—
Consumer	Consumer or Employer	Council	Consumer	Municipality	Consumer	Consumer	Consumer	Cost of light. Includ. rent	Consumer	Employer	Consumer	Consumer
Yes	Not unduly	Yes	No	No	Yes	—	Yes	Not unduly	Yes	No	No	No
Yes	No	Yes	No	No	Yes	Yes	No	—	No	No	Yes	No
Yes	Yes	Yes	No	Yes	In some cases	—	Yes	Yes	Yes	Yes	No	No
—	—	—	—	20' x 30'	—	—	20' x 35'	20' x 20'	30' x 30'	50' x 50'	—	None
Bulk sup. & SL Maj. Rds.	—	Nil	Bulk sup. & street light.	Nil	Bulk sup. & rudi. S.L.	—	Bulk sup. & rudi. S.L.	—	—	—	Nil	—
S.L. secondary Road	Portion	Yes	—	S.L. and Wiring	Nil	—	—	—	—	—	House Wiring	—
Grade "A" SL.	Portion	—	—	Reticulation and S/C	For early schemes only 2/3 kaffir beer profit for LT. reticu. SL.	—	Balance reticulation & SL. wiring	Yes	External loans for All work	All work	Reticulation	Yes
—	—	—	—	—		—	—	—	—	—	—	—
U/G	O/H	O/H	U/G	O/H	O/H	U/G	U/G	O/H and U/G	U/G	U/G	O/H	O/H
O/H	O/H	O/H	O/H	O/H	O/H	U/G	O/H	O/H	O/H	O/H	O/H	O/H
Near kerb	Near building	Rear boundary & near kerb	Near build.	Near kerb	Near kerb	—	Near kerb	Rear boundary	Near building	Near kerb	Near building	Near building
Yes	Yes	Yes	Yes	No	Yes	—	No	Yes	Yes	Yes	No	No
Vertical All Alum.	Vertical Cop. & Alum.	Horizontal Copper	Vertical All Alum.	Vertical Aluminium	Horizontal Copper	— —	Horizontal Copper	Vertical Copper	Vertical Copper	Vertical Copper	Vertical Copper	Horizontal Copper
Steel	Pole Transf.	Brick	Brick	Pole transf. Brick kiosks	Pole Transf.	Steel and Brick	Brick kiosks	Pole Transf. Steel kiosks Brick kiosks	Brick kiosk	Brick	Pole transfr. Brick kiosks	—
300 KVA.	100 KVA.	600 KVA.	200 KVA.	Pole transf. 100 KVA. Brick 400 kva	200 KVA.	200 KVA.	300 KVA.	750 KVA.	200 KVA.	500 KVA.	150 KVA.	—
O.C.B.	HRC. fuse	Dropout fuse	O.C.B.	Switchfuse	O.C.B.	O.C.B.	O.C.B.	HRC fuses	Switch fuse	HRC fuse	Fuses	—
Fluore. 80w. Tung. 150w.	F 40 w. T 100 w.	100 w.	80 w.	150 w. and 200 w.	150 w.	200 w.	100 w.	80 w.	200 w.	200 w.	100 w.	150 w.
240'	300'	240'–300'	240'	300'	150'	200'	270'	200'	150'	300'	300'	300'
Fluor & Tung	Tungsten	Tungsten	Fluorescent	Tungsten	Tungsten	Tungsten	Tungsten	'M.rd. Merc. and Sodium S.rd. Fluor.	Acc. rd. Sod. Main rd. Mer. S. rd. Tung.	Tungsten	Tungsten	Tungsten

	Benoni	Boksburg	Bloem-fontein	Bulawayo	Cape Town	Durban	East London	Estcourt	Germiston	Heidelburg Transvaal	Johannes-burg
D. Design Details—Continued											
Flourescent street light fittings:											
Type of Starter	Instant	—	—	—	—	—	—	—	—	—	Hot cathode
Do multitube fittings have separate ballasts ..	Yes	—	—	—	—	—	—	—	—	—	Yes
Are they high p.f. type ..	Yes	—	—	—	—	—	—	—	—	—	Yes
No. of tubes per fitting ..	2	—	—	—	—	—	—	—	—	—	2
Length of tube	5 ft	—	—	—	—	—	—	—	—	—	3 ft.
Are street lights provided in every street	Yes	Yes	No	No	Yes	Yes	No	Yes	No	Yes	Old town Yes New town No
Approx. cost of street lighting fittings	T £1 7s. 6d. F £22 8s. 0d.	£2 7s. 6d.	£3 0s. 0d.	£2 10s. 0d.	£6 0s. 0d.	£3 0s. 0d.	£2. 10s. 0d.	£3 0s. 0d.	£3 7s. 6d.	£3 7s. 6d.	£5 10s. 0d.
Approx. cost of street lighting wire guards	—	10/-	—	£1 1s. 6d.	6/-	—	£2 0s. 0d.	—	—	—	—
House S/C Type of insulation O/H services	A.M.E. P.V.C.	P.V.C.	P.V.C. P.I.L.C.A.	P.V.C.	P.V.C.	P.V.C.	A.M.E.	P.V.C.	—	P.V.C.	—
House S/C Type of insulation U/G services	P.V.C.	P.V.C.	P.V.C.	—	—	P.I.L.C.A.	P.V.C.	—	P.V.C.	—	P.V.C.
House S/C Size of conductor ..	O/H.0085'sq. U/G.0225'sq.	O/H 2— No. 10 SWG. U/G .007 x 2	O/H No. 6 SWG.	0.0225 sq. in.	7/.044	0.0225	.0145 sq. in.	10 S.W.G.	From .007 sq. in.	10 S.W.G.	.0225 sq. in.
House S/C Size of meter/amperes	20 & 40	10	40	40 amp.	As required	10	5 to 25 amp.	—	from 10 amp.	5 amp.	10 & 20 amp.
E. Tariff.											
For Bulk supply to townships ..	Escom + 5%	1d. per unit	Not metered	Standard	Accord. with I.M.T.A. Memoran.	Standard	Cost	Escom	Escom	—	Standard
For consumers	20kwh. @ 3d. Bal at 1d.	Standard	Standard	3d. per unit min 8/- p.m.	Standard	Standard	Standard	—	Standard	1/3d. per la. mcb. 1d. kwh.	Standard
Is sup. available 24 hours per day	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	—	Yes
Are current limiters used ..	No	No	No	Yes	No	No	No	No	No	Tariff accor. to mcb cap.	No
Do yoy levy a fixed charge:				2½a. 12/6pm. 5 ,, ,, 22/6 ,, 7½ ,, ,, 32/6 ,, 15 ,, ,, 45/- ,, 22½ ,, ,, 60/- ,, 30 ,, ,, 75/- ,,							
Lighting only	No	—	No		No	—	—	2/6d. p. mon.	—	—	No
Unrestricted use..	No	—	No		No	—	—	—	—	—	No
Have you a special tariff for African township	Domestic tarff is a special one	—	Under considera.	No	Min. room ch not app. to Nat. consu.	No	—	—	Yes	No	No
F. Metering											
Do you meter individual consu.	Yes	Yes	Yes	Spec. cases	Yes	Yes	Yes	No	Yes	Yes	Yes
Are prepayment meters used ..	No	No	No	No	No	No	No	No	No	No	No
Any problems with prepayment meters	—	—	—	—	—	—	—	—	—	—	—
G. Consumption and Demand											
Annual consumption. Fixed tariff — Lighting only	—	—	—	260 kwh. to 767 kwh.	—	—	—	530 kwh.	—	—	—
Annual consumption. Fixed tariff — Unrestricted..	—	—	—	—	—	—	—	—	—	—	—
Annual consumption. Metered—Lighting only	—	—	—	—	130 kwh.	—	—	—	—	—	—
Annual consumption. Metered—Unrestricted use..	320 to 460 kwh.	600 kwh.	2400 kwh.	2,508 kwh.	1200 kwh.	3000 kwh. Lamontville 840 kwh. Chesterville	1564 kwh.	—	960 to 1,200 kwh.	420 w.	637 kwh.
After diversity demand — Fixed tariff Lighting	—	—	—	—	—	—	—	—	—	—	—
After diversity demand — Fixed tariff unrestricted	—	—	—	—	—	—	—	—	—	—	—
After diversity demand—Metered lighting..	—	—	—	—	130 w.	—	—	—	—	—	—
After diversity demand—Metered unrestricted..	220 to 400 w.	—	500 w.	—	740 w.	500w. Lamon. 270w. Chest.	750 w.	—	—	276 w.	400 w.
How are accounts collected — payable at	Township Office	Town Hall	Treasury	Payable at office	Township Office	Township Office	Township Office	—	Payable at Office	Mun. offices	Nat. met. rea. Pay. at office

Krugersdorp	Ladysmith	Paarl	Peri Urban Pretoria	Pietermaritzburg	Pretoria	Port Elizabeth	Roodepoort/Maraisburg	Salisbury	Sasolburg	Umtali	Uitenhage	Ventersdorp
Yes	—	—	Instant	—	—	—	—	Instant	—	—	—	—
Yes	—	—	No	—	—	—	—	No	—	—	—	—
—	Yes	—	Yes	—	—	—	—	Yes	—	—	—	—
2	1	—	2	—	—	—	—	2	—	—	—	—
4 ft.	3 ft.	—	2'	—	—	—	—	—	—	—	—	—
Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	No
£16.10s. M.R £2 secondy.	£5	£4. 10s. 0d.	£8 12s. 6d.	£3 10s. 0d.	£1 10s. 0d.	£10	£3 0s. 0d.	£6 15s. 0d.	£18 Mercury £13 Sodium £3 Tungsten	£5	£2 10s. 0d.	£5 10s. 0d.
—	—	—	—	—	—	£1	10s.	—	—	—	£1	—
Old V.R.I.	P.V.C.	A.M.E.	—	A.M.E.	P.V.C.	P.V.C.	P.V.C.	P.V.C.	—	P.V.C.	P.V.C.	—
New P.I.L.C.	—	—	P.V.C.	—	—	P.I.L.C.	—	—	P.I.L.C. P.V.C.	—	—	—
7/.036 and .0225 10 amp.	7/.044 20 amp.	10 S.W.G. —	0.01 sq. in. 20 amp.	0.0225 sq. in. 10 amp.	0.0225 sq. in. Not used	0.0225 sq. in. —	7/.044 20 amp.	— —	0.0225 sq. in. 40 amp.	No. 8 S.W.G. Not used	7/.036 in. No	0.01 sq. in. 10 amp.
Escom	—	Escom	J.C.C. Bulk	—	Standard 3/6d. p.m. p. 1 amp. mcb. 1.10s. p.m. p. 15 amp mcb.	1d. per unit	Escom	—	Assesed Cost	1.75d. per unit 1 amp. limiter free 5 amp. lim. 15/– p.m.	1½d. per unit	Cost
Standard Yes	Standard Yes	7/6d. v.m. 0.95 kwh. Yes	Standard No	Standard Yes	Yes	Standard Yes	Standard Yes	Standard Yes	Standard Yes	No	Standard No	3d. per KWH. Yes
No	No	No	No	Yes	Yes	Yes	10 amp. mcb	Yes 1 & 5 amp.	No	Yes	Yes	No
—	—	—	No	No charge	—	6/– p.m. per 1/2 amp mcb	—	Included in rent	—	—	1 amp. lim. 2/– per m.	—
—	—	—	No	2/– per appliance	Yes	—	—	10/– 5 amp. limiter	—	—	No	—
No	No	No	No	No	—	No	7/6d. covers wiring and connection	No	—	No	No	No
Yes	Yes	No	Yes	Economic houses only	only if dem. ex. 15 amp.	Yes	Yes	74 houses	Yes	No	Spec. cases	Yes
—	No	No	No	No	No	Yes	No	No	No	—	No	No
—	—	—	—	—	—	No experien.	—	No	—	—	—	—
—	—	—	—	—	—	350 kwh.	—	1 amp limiter 400 kwh.	—	—	220 kwh.	—
—	21	—	—	930 kwh.	1,000 kwh.	—	—	5 amp limiter 2,000 kwh.	—	—	—	—
—	—	—	—	—	—	—	—	1,000 kwh.	360 kwh.	—	—	240 kwh.
—	—	—	—	480 kwh.	—	2,500 kwh.	500 to 1,500 kwh.	3,000 kwh.	500 kwh.	—	—	240 kwh.
—	—	—	—	105 w.	—	Nil	—	1 amp limiter 250 w.	—	—	50 w.	—
—	—	—	—	160 w.	410 w.	—	—	5 amp limiter 600 w.	—	—	—	—
—	—	—	—	—	—	—	150 w.	300 w.	—	—	—	180 kwh.
—	208 w.	—	—	350 w.	—	—	—	1.0 kw.	750 w.	—	—	—
Native meter reader	Payable at office	—	—	Payable at office	Payable at office	Payable at office	Payable NEAD	Payable at office	Payable at office	—	Payable at office	Payable at office

	Benoni	Boksburg	Bloem-fontein	Bulawayo	Cape Town	Durban	East London	Estcourt	Germiston	Heidelburg Transvaal	Johannes-burg
H. Reticulation costs											
(a) **Street lighting reticulation scheme.**											
No. of stands in town'p con.	—	—	1,593	2,800	1,651	11,500	995	—	10,000	—	3,238
Size of stand	—	—	50' x 100'	30' x 100' 40' x 80'	40' x 65'	40' x 70'	40' x 80'	—	40' x 75'	—	40' x 70'
Cost per stand, street lighting	—	—	£8 4s. 9d.	£13	£4	£10	£18 0s. 0d.	—	£10	—	£4 5s. 0d.
Cost per street lamp erected	—	—	£80	£40	£38	Est. £56	£122. 8s. 0d.	—	£200	—	£42 4s. 0d.
(b) **Street lighting and domes. power**											
No. of stands in township	8,751	Stirton 1,180 Galeview 416	4,956	350	1,651	—	85	156	4,000	640	3,100
Size of stands	45' x 75'	St. 50'x50' Gale 75'x75'	50' x 100'	40', 50', 25' x 80'	40' x 65'	—	40 x 80	50' x 100' 40' x 70'	45' x 75'	40' x 70'	40' x 70'
A.d.m.d. catered for	1 KVA.	0.5 KVA.	—	1.0 KVA.	0.5 KVA.	—	Bus. only	100 w.	0.5 KVA.	0.3 KVA.	0.5 KVA.
Average cost per stand including street lighting	U/G reti. £45 incl. S/C ca.	Stirt. £12/10 Gale. £19/5	£40	£29	Est. £27	—	£32 6s. 6d.	—	£13 10s. 0d.	LT mains SL £6 5s. 0d.	£19 15s. 0d.
I. Wiring.											
No. of houses wired	8,184	125	250 Domes. 50 Business	11	492	1,500	346	106	50	—	3,100
Size of service cable	0.0225 sq. in.	.007 or 10 swg	O/H 7/.052 in.	O/H .0225 sq. in.	7/.044 sq. in.	0.0225 sq. in.	0.0225 sq. in.	10 SWG.	—	7/.036 3/.036	.0225 sq. in.
Cost of service cable	Incl. in Cost of reticula.	O/H ± £15 U/G ± £25	£8-10 1 ph. £16-10 3 ph.	£10	O/H £3-0-0	O/H £8 est.	O/H £14	O/H	U/G	£7 10s. incl. meter	£11 15s. 0d.
Cost of meter	£3 13s. 4d.	No charge	Incl. s/c cst.	£4 approx.	10/-	£3 13s. 0d.	incl. s/c cst.	—	—	—	£3 13s. 4d.
Cost of limiter, fuses or m.c.b.	—	mcb fuse £1	—	mcb 12/6 ea.	12/6d.	mcb. —	—	—	16/3	16/-	12/6
Cost of house wiring (L = light S = socket)	(3L 1S) £11 10s 0d.	—	—	5L 2S £24 8s 2d.	2 L £9	4L 2S £30	—	—	—	2L 1S £5	2L 1S £3-10s
Cost of house wiring	£8 11s. 0d.	—	—	5 L 2 S £20.4	4L 1S £14-10	6L 2S £40	—	—	—	4 L 1 S £6-10	3L 2S £5 13s.
Cost of house wiring	£10 10s. 0d.	—	—	—	5L 1S £16	—	—	—	—	—	3L 1S £4 15s.
Cost of house wiring	£12 19s. 0d. £16 10s. 0d.	—	—	—	—	—	—	—	—	—	3L 1S £5 10s.
No. of sockets per house	1	—	—	2	1	2	Consumer provides wiring.	—	Houses wired by Consumer	2	1
Type and rating of socket outlets	15 amp. 3 pin	—	—	—	15 amp.	15 amp. 3 pin		—		15 amp. 3 pin	15 amp. 3 pin
Are cooker control units provided	No			—	No	No		—		No	No
Wiring system used	Conduit	Cleated	Cleat-ceil. Con. no ceil.	Cleat & Conduit	Conduit	Conduit	To be done by private contractor	Conduit		Conduit	Conduit
Are lights mounted in centre of rooms	Yes	Yes	Yes	Yes	Yes	Not necessarily		Yes		Wall bracket	Wall bracket
Are lighting switches grouped in one position	3 Grouped 2 individual	No	optional	Both group. and individ.	No	No		No		Yes	Yes
Are ceiling switches used	—	—	—	Yes	No	No		No		No	No
J. Special Features											
Have communal kitch. been used	No	No	No	No	No	No	No	No	No	No	No
Any special service layouts	No	No	No	—	No	No	No	No	No	—	No
Any special design features	No	No	No	—	No	No	No	No	No	—	No
K. Maintenance											
Who is resp. for wiring mainten.	Municipality	Consumer	Consumer	236 Municip. 600 Employ.	Municipality	Municipality	Consumer	Municipality	Consumer	Consumer	Municipality
L. Bantu artisans and contrac.											
Do native wiremen carry out installation work	Yes	will be perm. New town.	No	No	No	No	No	No	No	No	No
Do native wiremen carry out maintenance work	Yes	will be perm. New town.	No	No	No	No	No	No	No	No	No
Are native contractors permitted	Yes	Not at pres't	No	As soon as available	No	Yes	No	No	Yes	No	Yes
How many nat. cont. in your area	None	—	—	None	None	None	None	None	None	—	None
Are connection fees charged for individual dwellings	Private hous time & mat.	Yes time & mat.	—	Home owner. £14.14s.hse.	No	£4	—	—	Yes	—	—
Other connection fees	—	—	—	—	—	£6 for U/G con.		—	—	—	—
Wages paid to electrical trainees											
1st Year	£15 10s p.m. C £7 19 3d.	—	—	—	—	—	—	—	—	—	—
2nd Year	£16 5s p.m. C £7.19.3d.	—	—	—	—	—	—	—	—	—	—
3rd Year	£17 0s. p.m. C £8.13.4d.	—	—	—	—	—	—	—	—	—	—
4th Year	£17 15s. p.m. C £9.10.8d.	—	—	—	—	—	—	—	—	—	—
5th Year	£18 5s. p.m. C £9.10.8d.	—	—	—	—	—	—	—	—	—	—
C = C.O.L.A.											
Wages paid to qual. nat. artisans	—	—	—	—	—	—	—	—	—	—	—

Krugersdorp	Ladysmith	Paarl	Peri Urban Pretoria	Pietermaritzburg	Pretoria	Port Elizabeth	Roodepoort/Maraisburg	Salisbury	Sasolburg	Umtali	Uitenhage	Ventersdorp
1,300	969	280	2,308	806	—	15,000	5,000	—	—	—	—	—
40' x 70'	45' x 75'	60' x 80'	50' x 100'	25' x 55'	—	50' x 60'	40' x 75'	—	—	—	—	—
£5 1. 0d.	—	£5 3s. 3d.	£9 12s. 0d.	£2 2s. 0d.	—	—	—	£12 all roads £5 side rds.	—	—	—	—
£39 0s. 0d.	£2	—	£49 0s. 0d.	£14. 15s. 0d.	—	—	—	£64 main rd. £31 side rd.	—	—	—	—
—	980	280	Not yet available	1,325 40' x 50'	10,000	—	5,000	—	450	—	620	—
—	45' x 75'	60' x 80'		60' x 100'	40' x 80'	—	40' x 75'	—	45' x 80'	—	40' x 70'	—
—	1.0 KVA.	10 KVA. LT. & SL.		0.225 KVA.	1.0 KVA.	—	0.3 KVA.	—	1.5 KVA.	0.3 KVA.	0.25 KVA.	—
—	£3 8s. 8d.	£5 3s. 3d.		Approx. £5	£25 to £27	—	—	—	£22 10s. 0d.	—	—	—
294	200	280	Not	1,325	1,552	3,900	700	5,740	375	3,200	620	8
7/.036 7/.044	7/.036	10 swg. 7/.036	yet	0.0225 sq. in.	0.0225 sq. in.	0.0225 sq. in.	O/H 7/.044	—	.022 and 0.0145	7/.036 in.	O/H 7/.036	O/H
Cost plus 10%	O/H £1 15s. 0d.	—	available	£10 0s. 0d.	O/H £15	U/G £20	£2 10s. 0d.	O/H 1 ph. £8	£7	O/H	£4	—
no charge	£3 5s. 0d.	—		£3 5s. 0d.	—	—	£3 11s. 6d.	—	£3 3s 4d.	—	—	—
—	—	—		10/- to 15/-	16/-	15/-	—	16/9	14/6	15/-	£1	—
—	4L 1S £16	—		5 L 1 S £11	4 L 1 S —	1 L £5	4 L 1 S £12	4 L £18	5 L 1 S £10	—	2 L £6	—
—	—	—		—	—	3 L 1 S £14		4 L 1 S £21 6 L 2 S £45 Incl. cooker	5 L £7 10s.	—	—	—
—	—	—	—	—	—	—	—		—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—
—	2	—	—	1	1	—	1	1 & 2	1	—	—	—
—	15 amp. 3 pin	—	—	15 amp. 3 pin	15 amp. 3 pin	15 amp.	15 amp.	5 & 15 amp.	15 amp. 3 pin	13 amp.	—	—
—	—	—	—	No	No	Nil	No	30 amp.	No	—	No	No
Conduit	Conduit	Conduit	—	Conduit	Conduit	Conduit	Conduit	Conduit	Conduit	Conduit	Sheathed	Cleated
—	Yes	Yes	—	Both wall br. & cen. mount.	Yes	Yes	Yes	Yes	Yes	Wall brack.	Yes	Yes
Yes	No	No	—	Yes	No	No	Yes	No	No	Yes	No	No
No	No	—	—	No	No	No	Yes	Yes no prob.	Yes no prob.	Unsatisfac.	No	No
—	No	No	No	No	No	No	No	Yes	No	No—being Considered	No	No
—	—	No	No	No	No	No	—	No	No	No	No	No
—	No	No	No	No	No	No	—	No	No	No	—	—
Municipality	Consumer	Priv. cont.	Consumer	Municipality	Municipality	Municipality	Municipality	Municipality	Municipality	Municipality	Restd. sup. Municipality Meter. Cons.	—
No	No	No	No	No	Yes	No	Yes	No	Yes	Yes	Yes	No
No	No	No	No	No	Proposed	Yes	Yes	No	Yes	Yes	Yes	No
No	None avail.	No	Yes	No	Yes	Yes	Yes	Yes	No	No	None available	None available
None	None	—	None	None	2	None	None	4	None	—	None	None
Yes	£5 per hse.	—	Time and Material	Yes	Time and Material	Yes	—	£1 per dwelling	—	—	£15	£5
—	—	—	—	—	—	—	—	—	—	—	At cost	At cost
—	—	—	—	—	Rates-Build. Workers Act	—	£1-17-6 p.w. 18/3 cola.	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	£7 per week incl. c.o.l.a.	£5 p.w. incl. COLA.	—	—	£2 16/- p.w.	—	—

House Wiring and Service Connections in Bantu Townships

By G. Masson

INDEX

1.0 INTRODUCTION

Local Authorities and Authorities established by the Government for the purpose have performed almost unbelievable feats in their task of providing decent housing and the training of Native building workers. Large townships with neat houses, administrative buildings, etc., have arisen but one wonders whether the absence of adequate lighting in the homes and the streets is not perhaps responsible for the creation of a residential jungle with a climate of crime and conflict, delinquency and decadence.

2.0 PROBLEMS TO BE FACED IN THE PROVISION OF SERVICES

The Authorities have laid down that:—

(i) The cost of the bulk supply of electricity may be charged to the Natives Service Levy.

(ii) That the Local Authority must finance reticulation schemes out of its own loan funds, and

(iii) the provision of domestic installations must be on an economic basis.

Since the cost of wiring and service cables has to be paid by the tenant who can probably ill afford to pay an economic rental, it is essential that the installation be designed at a price that will not be a hardship to the consumer. The notes that follow are based on the assumption that:—

(a) The installation is to be provided at the least possible cost consistent with safety, and that

(b) it meets the consumer's requirements even though it is on an austerity basis.

3.0 RECOVERY OF LOAN CHARGES

If the Local Authority has to recover the cost of domestic electrical wiring it must either be in the form of rent or a monthly surcharge to users of electricity. Tenants who have been paying a determined house rent will resist any increase in their rent to cater for the cost of wiring even though this amenity has been provided and a monthly surcharge to consumers appears to be the answer.

The Johannesburg City Council has laid down in its tariff that where it wires and connects to a main supply a private house built on land owned by the Council and provision for such cost has not been made in the rental, a charge of 6d. per month for every £5.0.0 of such cost shall be made additional to the tariff charges for electricity consumed.

It has been assumed that the life of the installation provided is 30 years and reference to an annuity table shows that the repayment of a loan of £100.0.0 at 4⅞% interest, requires an annual contribution of £6.378 for a period of 30 years. This works out at approximately 6¼d. per month for a £5.0.0 loan and for convenience of application the cost has been taken to the nearest penny.

4.0 HOUSE WIRING

4.1 *Installation Design*

The basic requirements appear to be a lighting point in each room and a 15 amp. socket outlet for each house. The provision of only one socket outlet can be criticised if it is proposed to encourage the use of electrical appliances but it is assumed that for some years to come the consumer will not be able to afford many appliances.

In Johannesburg we are faced with the problem of wiring houses built more than 10 years ago. These houses, in common with those being built today, have no ceiling provided but we find that many tenants have constructed ceilings which are not strong enough to support even a lighting point. We have therefore decided on the wall bracket which is cheaper in both first cost and maintenance than the centrally mounted pendant light.

4.2 *Wiring Methods and Materials*

Reduction in the cost of an installation can be effected by making the best use of skilled and semi-skilled labour, mechanisation and possibly by the use of alternative wiring materials.

The Native houses are of standard types and there is every incentive to use mass production methods. Mass production has the advantage that semi-skilled labour can be used for repetition work and waste is rigidly controlled.

The prefabricated wiring harness is therefore the answer to the problem and the decision to be made is what type of installation and materials should be used. It is therefore proposed to discuss the advantages and disadvantages of the materials available.

(a) Mineral Insulated Metal Sheathed Cable.

The cost of this excellent cable is comparable with the cost of an equivalent length of conduit and insulated wire. It is quicker to erect than conduit but it has the disadvantage that the gland necessary to terminate a cable run is expensive. Bearing in mind the relatively short length of run required for lighting points in Native houses, it is found that this method of wiring is too expensive.

(b) Tought Rubber or P.V.C. Sheathed and Flexible Wire Braided Cables.

The advantages and disadvantages of these materials are:—

Advantages:

(i) Cheap in first cost even allowing for the extra cost of the special terminating fittings and the earth wire required for the cables with an insulated sheath.

(ii) Wiring kits can be made up very cheaply and without the necessity for special workshops equipment.

Disadvantages:

(i) The cable is not very rigid and must be closely supported where it is run on vertical walls. Due to the soft bricks used for internal walls, fixings are difficult. Alternatively, it can be encased in conduit which provides both support and mechanical protection for cable within reach. These requirements are expensive and can, for certain installations make this type of wiring equally as expensive as standard conduit wiring.

(ii) The cable lends itself to tampering by unauthorised persons and tee connections can readily be made in the length of a run.

(c) Conduit and V.I.R. or P.V.C. Insulated Conductors.

If a conduit installation has to be made up on site then the cost of screwing and bending makes it expensive.

It is appreciated that similar rooms in in different houses are not absolutely identical but any small variations in the fixing of fittings or switches is not important. Wiring harnesses can therefore be made up using standard manufactured lengths of conduit to the best advantage and with little waste. On this basis it is proved that this method of wiring is compeitive in cost with the other wiring methods available.

4.3 *Cost of Wiring Installations Completed*

Figures 1 to 4 show the floor plan of the various types of houses wired and details of the points provided and the costs using conduit construction (4.2C) are shown.

Type	Number of Lights	Number of Socket Outlets	Cost of Wiring
Fig. 1	2	1	£3.10.0d.
Fig. 2	3	1	£4.15.0d.
Fig. 3	3	1	£5.10.0d.
Fig. 4	4	2	£5.13.0d.

The work complied with the following requirements:—

(i) The installation was carried out by European wiremen.

(ii) Lighting points are mounted at an average height of 7′ 6″ and angle batten holders are mounted back to back as indicated in Figure 5. The conduit through the wall is used to carry wiring and to support the lights to the wall.

(iii) Although a switch is provided for each light, the light switches are grouped as shown on Figures 1 to 4.

(iv) The lights and socket outlets are independently wired but are controlled by a single circuit breaker.

5.0 COST OF METERS, METER BOXES AND MAIN SWITCH

It has been found that difficulty has been experienced in obtaining access to houses for meter reading. A galvanised sheet metal box mounted on an outside wall has therefore been provided to house the meter, miniature circuit breaker and service cable terminal blocks. The cost of this equipment is:—

	£	s.	d.
Meter box		19	0
Hardboard meter board ...		2	0
Meter	£3	13	4
M.c.b. and terminal blocks		15	0
	£5	9	4

6.0 SERVICE CABLES

Underground service cables have been installed with one connection from the overhead mains to serve from 6 to 12 houses. The connection from the pole is taken to the centre of the group of houses to be fed and from this point loop connections are provided. The service cables were laid in ground where the digging was roughly 60% soil and 40% hard digging (shale and sandstone) and the installed costs averaged as follows:—

(a) Service from mains to 1st house. Average length 106 ft. 0225 x 2 £14.8.1d.

(b) Loop cable house to house £10.0.5d.

Due to the layout of stands it was found that on average 8 houses were fed from each connection to the mains. The average cost per house for service connections thus amounted to

$$\frac{£14.8.1d. + £10.0.5d.}{8} = £11.16.8d. \text{ per house.}$$

It should be noted that in many cases the loop service cable forms its own feeder cable and does in fact reduce slightly, the cost of street mains. Since, however, poles are required for street lighting the saving is mainly in the cost of conductor. It would, however, seem just that any savings effected in this way should be credited to the cost of service connections.

7.0 CONCLUSION

No comment has been made in this contribution to the possible savings to be effected by the use of Bantu trainee wiremen since we have not made use of such labour in Johannesburg. It is, however, hoped that those who have been able to use Native labour will be able to give figures on the comparisons between the cost of labour using licensed European Wiremen and the registered Native Trainee.

These notes have been submitted to show the reductions that have been effected with the standard materials available today. Further reductions can no doubt be effected by the use of overhead service connections. Overhead services are not, however, greatly favoured for the 60,000 houses to be wired in this area bearing in mind the low height of the house roofs, and the maintenance that will be required to keep such services in a safe condition.

The author's thanks are due to Mr. R. W. Kane, General Manager and Chief Elec-

trical Engineer of the City of Johannesburg, for permission to use the information presented in this contribution to the symposium.

FIG. 1

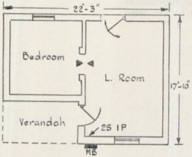
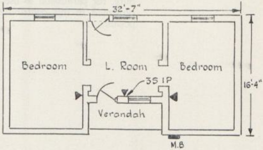


FIG. 3



LEGEND

- ◀ LIGHTING BRACKET
- S LIGHTING SWITCH
- P SOCKET OUTLET
- MB METER RECEPTACLE

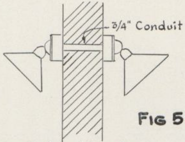


FIG 5

BACK TO BACK WALL BRACKETS.

FIG. 2

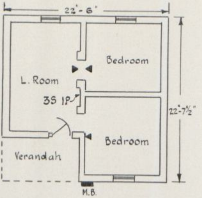
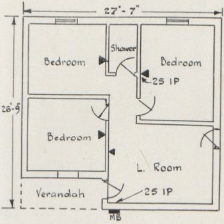


FIG. 4.



Reticulation in Non-European Townships

Submitted by Electricity Department
City of Bloemfontein

The purpose of this paper not to indicate how reticulation of Non-European Townships should be, but rather to air some views on the subject, in the hope that more information on the technical and economical aspects of the problem will become available from discussion.

In Bloemfontein the general reticulation of these Townships has not yet been tackled, although the matter has been under consideration departmentally for some time. We have in fact not satisfied ourselves that it can be done on an economic basis, so far we have only provided a certain amount of street lighting, generally in every alternate street and too widely spaced to be really considered as an attempt at illumination of the road surface, the main object being to provide lights for pedestrians are naturally also for supervision of the area by night. Government and Municipal buildings, Churches, schools and a certain number of private houses belonging to the more well to do residents have however been connected and consumption charged for under the normal applicable tariffs.

In the latter part of the previous sentence lies, I think, the main difference of our Non-European areas from most of these areas elsewhere. By far the bulk of Non-European housing in our areas is privately owned by Non-Europeans. We think that we can claim to be the originators of the present site and service schemes, as Bloemfontein for many years has made ground available to its Non-European inhabitants on the basis of a monthly rental (stand rent) and bought materials in bulk to be made available at cost to the inhabitants to build their own houses to suit their taste and pocket under the paternal surveillance of the City Non-European Affairs Department.

Speaking strictly legally, the builder of such a house acquires only the right of occupation, as the ground remains the property of the Council, in practice however, over many years such properties have been sold, let, bequeathed and generally dealt with as private property.

This arrangement suited the inhabitants very well as can be judged from the fact that of over 5,000 houses in Batho and Bochabela villages only 500 are Council owned while in Heatherdale the village for Coloured people there is a bare dozen out of 400. This very large percentage of private ownership has however made the planned standard installations by the local authority impossible, while hire purchase schemes for installations could also not be considered, especially as the facility was not available to the European areas.

Conditions are however changing and of late. As referred to earlier, not only public buildings, but a fair sprinkle of private dwellings have been connected up under exactly the same conditions as in the European areas of the City, a fair crosscut of the type of present consumer is indicated by slides which will be shown.

Having regard to the present wage levels which are expected to rise quite steeply in the not too distant future, and the cost of coal, wood, paraffin, candles etc., it would appear that if capital can be kept very low, a case could be made out for the economic supply of these areas, which should considerably improve living conditions for these people, and perhaps almost as important, make the general use of radio in Non-European houses possible. It seems a pity that in the latest extensions to the native townships, namely the Government controlled site and service scheme, electricity in the homes should have been considered a luxury as funds from the Service Levy fund are made available for street-lighting only. This complicates matters somewhat as the street lighting is usually almost on integral part of the reticulation, and as the capital of the Levy fund was extracted from european employers for better native housing, the use of such funds might have materially reduced loan charges thus making it possible to bring the modern amenity of electric power within the reach of a far greater number of inhabitants, capital being today one of the major items in electricity costs.

The problem is thus to make electricity available to the lowest income groups of the population on an economic basis without any form of subsidy. To make this possible it is necessary in the first place to design a reticulation system which brings capital cost to irreducible minimum, keeps the maintenance cost low and does not sacrifice safety for cost.

Secondly the absolute minimum in cash payments must be expected from prospective consumers. This entails including the connection to the premises and the wiring installation in the design and cost of the reticulation system.

Thirdly, for social and economic reasons the scheme must be erected and maintained by Non-European staff stationed in the areas.

Finally, tariffs must be divorced from those generally applicable in the European areas, in order to derive the benefit of special low cost design, and the cater for the generally low income level, but bearing in mind that very well to do consumers will also have to be catered for.

Design

To design a scheme involving minimum capital outlay right into the consumers premises, I think that current practice will have to be entirely disregarded. The market will have to be studied for materials likely to promote the objective, and careful use made of materials considered suitable. Basically an overhead system is cheaper in first cost than an underground one, but maintenance is generally higher, particularly with open conductors in native areas where throwing of wires over the conductors seems to be a pet diversion of the youth of the village! An underground system offers greater stability, but can be very expensive, particularly where hard digging is encountered, and if cost is saved on the depth of excavation, damage to cables may result which take time to locate and are fairly costly to repair.

A lightweight aerial cable would therefore seem to be indicated for HT or LT mains, using as supports, the streetlight standards. Aluminium cored cables with plastic insulation and sheath and built-in steel or steel cored suspension wire provide these physical qualities and are available on the market, although not tried yet as far as I know in this country. The 11KV cable has three cores with a steel suspension wire moulded into the P.V.C. sheath which thus takes on a figure of eight shape in section. The low tension cable has three or more separate insulated cores and one steel cored bare core to act as support and neutral laid up together with rather a long lay, such however that the cores remain together when suspended. To reduce weight and possibly cost of overhead joints where these may be necessary a technique using a suitable Apoxy Resin could no doubt be evolved. To maintain flexibility in operation while at the same time avoiding the danger of exposed H.V. bushings becoming a target for stone and wire throwers, a small metal kiosk at ground level would be necessary. The transformer may be of the American rural type with built in H.V. and L.V. overload protection and lighting arrestors. In this case the only further equipment in the kiosk would be splitter fuses or isolators for fault location up or down the line from the step down point.

Having provided insulated cables for the mains it would be natural to retain the inherent advantages of cable for the services to the consumers as well. With great variety in size shape and quality of the roof as can be judged from the slides taken in the native villages, aerial cable for this purpose seems excluded. For the services to premises P.V.C. insulated aluminium cored, wire armoured and P.V.C. sheathed cable is thus proposed. This type of cable would have the advantage of simpler make off. No particular make off beyond tidying up with plastic tape, is in fact required. The cable could for reasons of cost not be buried more than 15 to 18 inches underground, but with the wire armour earthed, reasonable protection would be afforded to persons in the event of mechanical damage to the cables, while the P.V.C. insulation should limit extensive damage to the cable as a result of moisture. To limit the cost of cable, we visualise feeding three consumers from one take-off from the mains, making use of a small overground splitter-box on the building line, to facilitate locating faulty sections.

As far as the installations are concerned it is not intended to limit supply in any way and normal single phase metering is therefore proposed with a miniature circuit breaker as service protection and possibly to determine demand charge. Three consumers circuits controlled by a splitter switch would complete the distribution board.

The type of wiring to be used is still undecided both on account of the nature of some of the buildings and the cost factor which must be kept to a minimum. Of the three circuits, one would be an optional stove circuit, in twin 7/20 s.w.g. one in twin 7/22 s.w.g. would supply two 3 pin 15A safety plugs, and the third, in twin 3/22 s.w.g. would supply lighting up to six points.

The material which appears to suit the circumstances seems to be two core wire braided cable, which could be stapled to convenient woodwork, the braiding being bonded through and serving as earth conductor. For lighting points batten holders with E.I. shade and an adjacent ceiling switch on a common block would suffice.

Costs

It has unfortunately not been able to get costs on some of the cables considered for the purpose, but bearing in mind existing fixed and variable costs and the fact that the average charge to consumers should not exceed the average amount now spent by them on coal, wood, paraffin and candles, the average charge in our case should not exceed 30/- which for us would limit the capital spent in the area per consumer to £50. This is possibly a stiff target considering that it covers H.T. and L.T. mains, services and house installations in the area concerned, but it should not be beyond the design ingenuity of manufacturers and supply engineers.

Staff

Without wishing to get embroiled in politics it is necessary to say that if the native is expected to take care of himself in his own area, the time has come to see that nothing is done in native areas by Europeans which could possibly be done by the Non-Europeans themselves. It would in any case avoid risks that European staff might be exposed to.

For the present the availability of skilled Non-European workers is low but for the installation of a scheme such as envisaged, it would be desirable to recruit a small number of Non-European artisans, while every Electricity Department must have a number of old hands among its Non-European employees, who with a short training course could be let loose on construction work which will not involve coming near live equipment. This would result in a considerable saving on labour which would be reflected back to the benefit of the Non-European residents in reduced construction capital. Supervision at engineering level would, for the present at least, until Non-European engineers become available, have to be undertaken by the Department's engineering staff, while planning would in any case be a function of the Department's Distribution Engineer and his planning assistants. This I think would be in accordance with the Government policy of separate development with full co-operation.

Metering

In conclusion I would like to say a few words on metering of such supplies. The very limited capital available creates the temptation to control the supply by means of a limiter and to raise a fixed charge, which to be economic must be equivalent to the average cost per consumer. But the very fact that there is no individual responsibility makes for waste in the use of power, which in turn increases the average cost and may finally make the service unacceptable to the consumers.

To work down the minimum cost there must be individual responsibility by metering and to bring supply within the reach of all, the determination of the fixed charge should be on a basis complying as closely as possible with consumer requirements.

Demand meters have been used by certain undertakings, but for the present purpose I favour the use of miniature circuit breakers, which I suggested to the convention some years ago for the double purpose of protecting the installation and fixing the standing charge. The ideal breaker would be one with a magnetic trip for fault protection and a thermic trip reliably adjustable from 1 amp to 5 amps.

The cost of a single phase meter, would for such installation be a serious item of cost, and world markets may have to be scoured to see if this item cannot be reduced.

House Wiring, Earthing and Service Connections at Langa Native Township, Cape Town

Submitted by Electricity Department
City of Cape Town

General

The Native Township at Langa is situated about 8 miles due east of Cape Town and is about 813 acres in area.

It consists of both Married Quarters and Single Quarters, and houses a total population of about 25,000 people of whom about 18,000 live in the Single Quarters. When the scheme was started in 1927, the accommodation was designed for 5,000 people, so that today the population is 5 times as great as the original scheme.

Married Quarters

All Married Quarters are single storey buildings arranged on a simple 2- or 4-room layout. (See diagram S.F.3251). All have asbestos roofs and cavity brick walls. Each dwelling consists of 4 rooms and a toilet, and has 5 lighting points. There are generally 4 such dwelling to a block. (See photograph No. 1). Those built initially had no electrical installations, except a few which were provided by the tenants themselves under the Council's Assisted Wiring Scheme.

In 1940, a total of 204 of these dwelling blocks were built (see photograph No. 2), and wired for lights and one power plug. A 3-phase, 4-wire supply was given to a central point (see photograph No. 3), the single phase meters being mounted in a common meter box (see photograph No. 4), and the tariff being the ordinary Council Domestic Rate for Lighting and Power. The installations were carried out by the Council's Electricity Department, all lights having their own switch drops.

In 1956, 148 blocks (which were built in 1953) were similarly wired, the plug being next to the meter board in the kitchen. (See photograph No. 5.) These units were all given single phase connections (see photograph No. 6) and separately metered, the tariff being as above.

As these houses were all occupied, the installation of lighting and power could not be carried out in the most economical manner, and in fact the work presented several problems peculiar to a Native Location, such as varying conditions of cleanliness and order, and a pungent interior aroma.

The combined main switch and distribution board in the kitchen measures 16" x 9" x 2" deep, and is held on by a ⅜" dia. "U" shaped bolt cast in the wall. At the top is mounted a 5-way neutral earthing bar in a metal case, and to this are connected the mains neutral, the connections to the spike and water pipe and the neutrals of the 2 lighting circuits.

The live main goes through the splitter switch and via the 2 splitter fuses to the lighting circuits. (See diagram S.F.3252).

Batten type lampholders with a wide base are used, screwed directly on to a surface type conduit box. At first, brass B.C. holders were used, but so many were damaged or stolen that a change to bakelite E.S. holders was made, and all later buildings are so equipped. The use of E.S. holders also discourages the theft of lamps. The lampholders, unfortunately, are the weakest part of the whole installation, being subject to severe twisting strains, and the insulation is the weakest part of the lampholder.

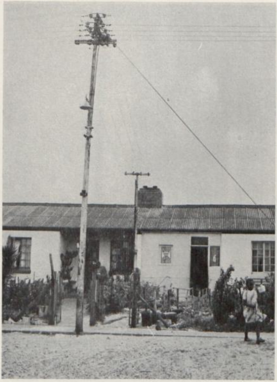
Installation Work

The order of work in all buildings is as follows:—

(1) The conduit runs marked on the drawings are measured up, and the

No. 1. Early examples of Married Quarters.

No. 2. Later type of Married Quarters with 3-phase supply to blocks and common metering point.



No. 3. Married Quarters showing 3-phase supply to blocks.

measurements checked from the buildings.

(2) All conduit is cut, screwed and bundled up ready for each unit.

(3) The conduit is erected in the units, the runs following the beams, walls being avoided wherever possible.

(4) The units are then wired and fittings erected.

(5) Mains connection and earthing are completed as soon as the wooden pole and the earthing spike are in position outside the kitchen door. The spikes are put down by the building unit, using water pressure to "jumper" them into the sand, which is done rapidly. (See photograph No. 6.)

The pole is 16 ft. long and is about 4 ft. in the ground.

The full staff consisted of nine men, four electricians and five labourers, the work being subdivided as under:—

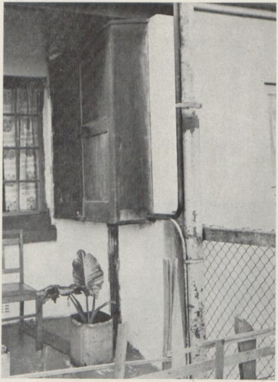
Erecting Conduit—2 electricians and 2 labourers.

Wiring and Fittings—1 electrician and 1 labourer.

Mains and Earthing—1 electrician and 1 labourer.

Plus one labourer for cutting and screwing conduit.

This staff set-up was found to work satisfactorily, and the average cost per point, including service mains connections, worked



No. 4. Married Quarters showing common metering point, 3-phase supply and conduits to other houses in block.

The installations are all of the surface type, run on the beams and walls. The walls are not plastered, but are bagged and then whitewashed. Where conduits are run on the ceilings, the line of the beam is followed.

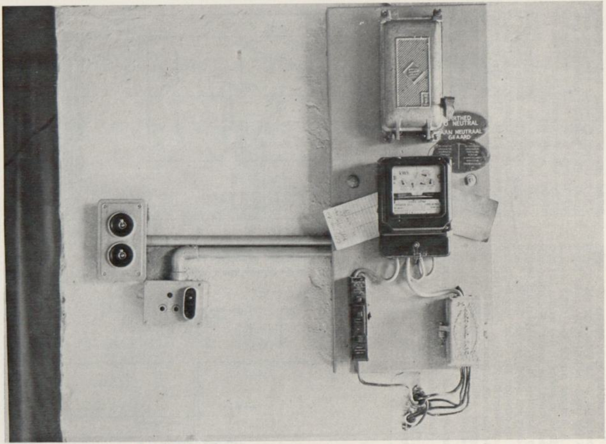
The conduit is heavy gauge, butt-welded, screwed type, ¾" dia., with fittings to match. Particular care is taken to ensure that the conduit system is electrically and mechanically continuous to ensure a safe and durable installation. All the runs are as simple and direct as possible, to save time and labour.

In the earlier installations, 3" round wood blocks and brass batten-holders were used at lighting points with vulcanised rubber insulated conductors.

In the later installations, P.V.C. insulated conductors were used throughout, with wide-base batten-holders mounted on surface type conduit boxes. Switches are single gang industrial type, and power plugs where used are of the same type.

Only one lighting circuit is required, the average number of points being 5. A 15 ampere splitter switch is mounted on the top of the meter board, with one circuit for lights and the other for the power plug. (See photograph No. 5.)

When the houses are let, 60 watt clear lamps are put in, but no shades are fitted.



No. 5. Latest Married Quarters (1956) showing industrial type socket outlet and separate metering.

The earthing is by means of a spike, connection to the water pipe and bonding to the system neutral at the meter board.

A frequent trouble met with, which is difficult to control, is that tenants buy electrical fittings and mount and connect these up themselves in ways which are unsatisfactory and even dangerous. Another danger is the persistent use of bell wire for "extensions" from lampholders. Plug-in type electric stoves are popular and many are in use, together with kettles and irons, but very few hotplates or radiators.

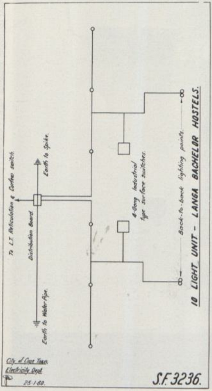
Bachelor Hostels (Single Storey Blocks)

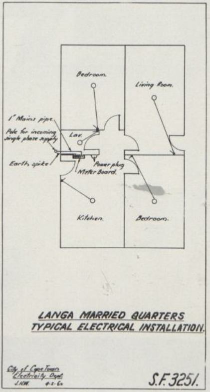
(Photographs Nos. 7 & 8.)

The electrical work on these began in 1954. The main blocks, 104 ft. long, are divided into two sections with a dividing wall. Each section consists of two 5-roomed hostels with 3 bedrooms, toilet and a common kitchen, across which a dividing wall can be built, if required, later. These are referred to as 10-light "units."

Each room has one lighting point, with a common switch point in the passage. As in the Married Quarters, all work is surface in screwed conduit. There are no power plugs provided. The installations were designed with great care, the main points being good quality materials and multiple earthing for safety, with easy erection and low overall cost.

With this in view, switch-drops in the rooms were omitted, a 4-gang 5 amp. industrial type switch being used. (See sketch





No. 6. Rear view of Married Quarters (1956) showing wooden pole and single phase incoming supply also earth to spike. This is similar to the Bachelor Quarters.

No. 7. General view of Bachelor Hostels.

No. S.F. 3236 and photograph No. 9.) The kitchen light has a single-way ironclad switch on the distribution board. (See photograph No. 10.)

Maintenance troubles are chiefly cracked and broken lampholders, especially the long shrouded type required in the toilets and showers. Switch troubles are avoided by the use of the industrial type as these, properly fixed, are practically indestructible.

The trouble encountered in the Married Quarters of tenants putting up lighting fittings of their own does not occur in the Bachelor Hostels. The Hostel tenants, however, have a bad habit of using an old lampholder as an adapter, with flex roughly twisted on, which is a highly dangerous arrangement.

All the Bachelor Hostels and the eight 4-storey blocks of Men's Quarters are supplied from a separate overhead network controlled by a main switch (called a "curfew" switch) operated by a watchman. The switching times are as under:

	On	Off
Summer	8.00 p.m.	6.00 p.m.
Winter	6.00 p.m.	8.00 a.m.

This is necessary as it has been found that the natives leave the switches in their rooms "on" all day, leading to great wastage of current and burning out of lamps.

The metering equipment (main kWH meter and 3 check meters) is located in the same brick cubicle as the curfew switch, as this forms a convenient point for bulk metering.

The rent for all the Bachelor Hostels is £1 per man per month, including water and electricity.

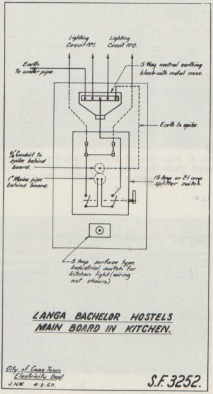
Shops

A block of shops and trade stalls in two back-to-back sections was built in 1958 to replace twelve earlier shops which were only galvanised iron shacks. Each section consists of 5 shops and 10 trade stalls. (See photograph No. 11.)

A common meter room is used, one for each section, and single phase energy is charged for under Rates 1 and 6. (Lighting & Power.)

A 3-phase 4-wire 0.0225 sq. in. plastic armoured cable is run from a special set of overhead mains (not fed through the curfew switch already referred to) to each meter room. Four bus-bars, in the form of cable, are run on battens round the walls about 18 inches above ground level, and the meters (30 per meter room) fed from these.

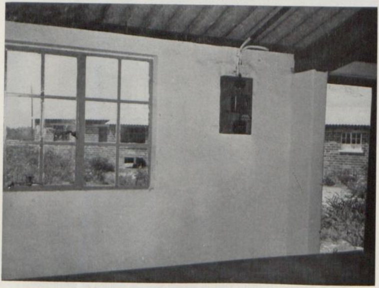
The installations in the shops and stalls are similar to those already described, except that each shop has a 10 gallon water heater supplying either a sink or a hand basin. The butcher's shops also have special refrigeration in their cool rooms.



No. 8. Bachelor Hostels showing the "diamond" formation of blocks. Kew Town Housing Scheme in distance.

No. 9. Bachelor Hostels. View in kitchen showing position of distribution board and 4-gang switch in passage.

No. 10. Bachelor Hostels. Kitchen, showing position of light switch and earth conduit to water pipe.



No. 11. New shops, 1958, showing centre block.

Notes on the High Tension and Low Tension Reticulation and Street Lighting Langa Native Towship, Cape Town

Submitted by Electricity Department,
City of Cape Town.

The township of Langa was established about 1927, the development of somewhat more than half the total taking place in the first few years. Some 25 years later bachelor quarters were erected in the remainder of the township to complete the development of the area.

The electricity supply was originally taken by means of an 11kV overhead line to a single sub-station, but when the final expansion took place the overhead line was replaced by an underground cable spur from the nearest sub-station. In addition a second sub-station, Washington Street, was established to cater for the load in the bachelor quarters.

The feeder replacing the overhead line consists of approximately 600 yards 0.06 sq. in. 3-core 11kV. cable from Grenville Avenue Substation to Langa Substation. The feeder from the latter to Washington Street Substation is approximately 1,000 yards of 0.0225 sq. in. 3-core 11kV. cable.

The spur feeder from the ring main is protected at Grenville Avenue Substation by overload and earth fault inverse time delay relays, and the transformer at Washington Street Substation is protected on the 11kV. side by means of overload trip coils and an earth fault relay at Langa Substation.

The low tension feeders at both substations are protected by AC trip coils in the oil circuit breakers. The transformers at Langa Substation are protected by overload trip coils with time lag fuses and an earth fault relay.

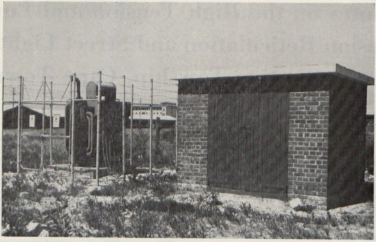
The transformer capacity in the township is 1350 kVA, made up of two 300 kVA units at Langa Substation and one 750 kVA unit at Washington Street Substation. At Langa Substation the peak load is about 375 kVA while at Washington Street the peak reaches 600 kVA.

Consumers in the older section of the township fed from Langa Substation are individually metered, while the consumption in the bachelor quarters is metered in bulk. Consequently the substation at Washington Street consists of a transformer on a slab, and a brick kiosk to house the two low tension oil circuit breakers and the metering equipment. The high and low tension oil circuit breakers at Langa Substation are housed in a brick building of typical design, with the transformers on slabs outside the building.

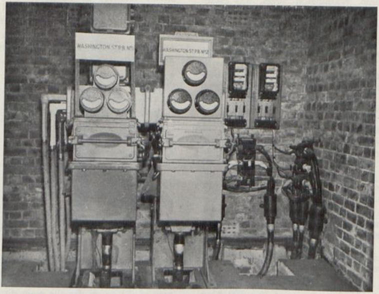
The estimated cost of providing the above installations today is as follows: —

Langa Substation	
0.06 sq. in. 11kV feeder from Grenville Avenue Substation	£1,400
Substation Building	£1,800
Switchgear	£4,000
Transformers	£1,600
Washington Street Substation	
0.0225 sq. in. 11kV. feeder from Langa Substation	£2,000
Brick kiosk and wire enclosure	£500
Switchgear, metering equipment	£600
Transformer	£1,500
	£13,400

The low tension reticulation consists of a 380 volt three-phase four-wire system using copper conductors with a cross-sectional area of 0.1 sq. in. for the main distribution and 0.05 and 0.025 sq. in. for branch lines.



General view of Washington Street Substation, Langa Township.



Interior view of brick kiosk at Washington Street Substation showing L.T. switchgear with the bulk metering equipment on the right.

Typical construction used for overhead mains in older section of Langa Township.

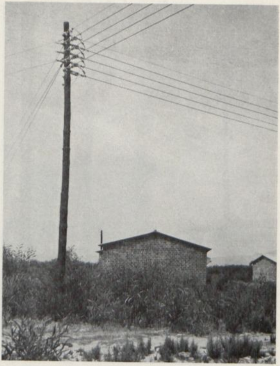
Three low tension feeders emanate from Langa Substation and two from Washington Street Substation, and in addition there is a street lighting supply at each centre.

In the older portion of Langa Township the standard method of construction with 30 foot steel poles and cross-arms was employed for the low tension mains, the pole spacing being approximately 35 yards. However, for the sake of economy in the area where the new bachelor quarters are situated, wooden poles have been used extensively, with the conductors mounted vertically on the poles instead of horizontally on cross-arms.

At present-day prices the average cost of erecting low tension mains using wooden poles with copper conductors mounted on the poles shows a saving of 30-35% over the conventional method using steel poles and cross-arms. Of course, the main saving is in the price of the poles.

In main streets the spacing of street lights is approximately 60-70 yards, but elsewhere the distance between lamps is increased to approximately 100 yards. There are altogether 300 street lights in the township, all of them being 100 watt incandescent lamps.

It is estimated that the cost of providing the low tension reticulation and street lighting in Langa Township at today's prices would be approximately £22,000 for the older part and £13,000 for the newer section. Of this amount about £3,000 would be spent in providing street lighting conductors and fittings.



Typical construction used for overhead mains in newer section of Langa Township.

Electrical Appliances for Communal Applications

By G. F. Browne, C.G.I.A., A.M.I.E.E.,
A.M.(S.A.)I.E.E., City of Salisbury,
Electricity Department.

1. INTRODUCTION

At the present stage in development of native communities, economic factors largely prevent the extensive use of electricity by individual families. In order to bring improvements in living standards associated with a full use of electricity to any substantial proportion of the native population it is essential that the concept of communal use of facilities should be accepted.

Some progress has been made towards providing suitable electrical appliances for communal needs although so far these have been applied only for use by unmarried native males housed in hostels.

The magnitude of the achievement to date may be gauged from the fact that 35,000 natives housed in 50 hostels and other communal buildings consume about 8 million kilowatt hours per annum. Possibilities for further load development in existing hostels alone amount to not less than another 20 million units per annum.

2. BOILING TABLES

Traditionally the staple diet of the native is mealie porridge varied with occasional meat and vegetable stews. The food is cooked over an open fire in a pot or saucepan. Roasting or baking in ovens is unknown.

This type of cooking can be provided for excellently by means of electric boiling tables. A boiling table consists of a sturdy structural steel framework supporting heavy cast-iron hotplates. The iron plates are heated by means of tubular, metal-clad, mineral insulated, air heating elements clamped underneath. No heat control switches are provided and the tables are switched on and off from a central point inaccessible to the users.

It is essential to provide hot water for starting porridge and for subsequent washing of utensils. The former reduces cooking time and increases hourly throughput, resulting in savings in capital cost of buildings and equipment and in running costs. The latter is desirable for hygienic reasons.

Operating results have been good, some tables having been in use for 6 years or more with negligible expenditure on maintenance. Cracking of hotplates is liable to occur due to repeated heat cycling but, owing to sturdy construction and the type of elements used, this has had no markedly detrimental effect. Cracked hotplates continue to give good service even after several years.

Experience in Salisbury indicates that approximately 10 square inches of hotplate surface area should be allowed for each native and that the hotplates should be rated at about 1.1/3 kW per square foot. Water heating equipment capable of supplying about 1½ pints of hot water per hour per native and rated at 0.05 kW per native is adequate. Energy requirements amount to approximately 0.73 kW hours per native per day, including that used for water heating, at a cost in Salisbury of 0.48 pence.

Up to the present time two hundred 12 kW cooking tables have been installed by the Salisbury Municipality.

3. WATER HEATING

3.1 *General*

Domestic thermal storage type water-heaters are unsuitable for large scale communal applications owing to low heat recovery rate and the large number of appliances required.

Centrally placed water-heaters with hot water pumped to all points of utilisation through a piping ring main have proved satisfactory.

Usually a water-heating system inherently has some storage capacity and this may be useful for dealing with peak requirements. Having regard to expected peak demand for hot water, and to the electricity tariff applicable, a balance must be achieved between kW rating and heat storage capacity. In line with Salisbury electricity tariffs, systems installed have small heat storage capacities and are capable of producing hot water at approximately the same rate as it is used. Capital costs are thereby kept to a minimum without any increase in running costs.

3.2 *Resistance element water-heaters*

Where soft water is available water-heaters employing resistance immersion elements can be used successfully and have least capital cost.

A typical example now being installed by the City of Salisbury is rated at 300 kW. It comprises a 600 gallon storage vessel from which hot water is pumped through a piping ring main covering four floors in two buildings. The system is designed for a continuous draw-off of 1,400 gallons of 130°F. water per hour for ablutions and laundry purposes. The water-heater is controlled by a thermostat and a single contractor. Safety features include an excess temperature thermostat and a low water level cut-out both arranged to trip a main circuit-breaker. Hot water will be supplied for 4 hours daily except at week-ends when it will be available for 12 hour periods. On this basis energy consumption is expected to be 1.7 kW hours per native per day at a cost of 1.1 pence.

3.3 *Electrode water-heaters*

Electrode water-heating systems are similar to the resistance element type except that heat is generated directly by passing current through water by means of immersed electrodes.

Generally the resistance of City water is too low to be used effectively without chemical dosing. Dosing consists of adding a small amount of washing soda or common salt, in Salisbury about 4½ ounces per 100 gallons is sufficient. Tannin may be added as a corrosion inhibitor.

Because of chemical dosing it is necessary to isolate the electrode water-heater from the building pipework.

A typical system consists of a hot water storage vessel connected to closed circuit piping traversing the building and feeding all the points at which hot water is utilised. The water in the vessel and piping is kept in constant circulation by means of a motor driven pump. Heat is generated in the electrode water-heater and is transferred to the water in the storage vessel by means of a heat exchanger through which hot water is circulated continuously. The heat exchanger may consist of a nest of copper pipes inside the storage vessel.

Three 110 kW electrode water-heaters and one rated at 65 kW have been installed by Salisbury Municipality.

4. STEAM RAISING

Where cooked food is supplied to large numbers of natives it can be cooked most conveniently in large steam heated pans. The advantages of steam raising by electricity for this purpose are as follows: —

(a) Rapid response of boilers to fluctuating steam demand.

(b) No boilerhouse is required. The boilers may be placed in the kitchen at considerable saving in building costs. Cost of steam piping and heat losses is kept to a minimum.

(c) Cleanliness in operation and no waste for disposal.

(d) Boilers are almost fully automatic and require a minimum of attendance and maintenance.

(e) Electrode steam boilers are inherently safe against damage due to low water level.

A steam generating system now under construction for the City of Salisbury comprises two identical electrode type steam boilers each rated at 380 volts, 600 kW with a combined output of 4,000 pounds of steam per hour. The boilers work into the same steam range and they can be used separately or together. Normal working gauge pressure is 30 lbs./sq. in., and all condensate is returned to the hotwell.

The boilers are fitted with automatic load controllers to ensure that steam production is adjusted continuously in accordance with varying requirements. Each controller consists of a pressure sensitive device which exercises control by starting and stopping boiler feed pump and also by operating a feed water bye-pass valve. The controllers work in conjunction so that one boiler only accepts load when steam requirements do not exeed its capacity. To satisfy large steam demands the boilers share the load. The boilers alternate automatically in the leading and trailing roles every 24 hours and they are subject to remote supervisory control for load shedding.

The kitchen in which this equipment is to be used will supply cooked meals to 4,000 natives and the installed capacity of steam raising equipment is 0.3 kW per native. Electricity consumption for steam raising is expected to be about 1.35 kW hours per native per day at a cost of 0.88 pence.

5. MISCELLANEOUS ELECTRICAL APPLIANCES AND APPLICATIONS

In Salisbury, as elsewhere, new uses for electricity in native areas arise almost daily.

An important innovation is the provision of hot water for ablutions and laundry purposes throughout a large hostel accommodating 1,000 natives. This is new today but it is foreseen that in the not too distant future this amenitywill have to be provided in all hostels.

Manufacture of native beer utilises mixers, conveyors, centrifuges, pumps and refrigeration equipment, to all of which electricity is vital. Distribution of the product is facilitated by the use of compressors, pumps, agitators, and electronic beer dispensers. Now that light wines and European style beer are available to natives, no beer kiosk is complete without cold storage equipment.

Newest recreational amenities are outdoor dance floors each with a permanent installation of 500 coloured lamps, tape or record player, amplifier and loudspeakers.

Plenty of floodlighting is required at all social centres. Applications include novel floodlighting equipment for a portable boxing arena, and a naval searchlight mounted on a 40 foot high lattice tower is used for crowd control at a native sports stadium. As a matter of interest the searchlight was installed previously at the Kariba Dam.

A full scheme has been prepared for floodlighting a football pitch to English Football Association standards and this will be a first class amenity when it becomes reality.

All Municipal townships and hostels are covered by broadcasting networks. Outdoor exponential horn loudspeakers and 500 watt amplifiers are used in townships and three hostel complexes are served by 250 watt amplifiers. Hostel amplifiers can be used independently or in conjunction with township equipment. In emergency, overriding control permits all equipment to be operated, or put out of action, by remote control.

Administration and security requirements make it essential to provide a VHF radio communication system for the Native Administration in the near future.

6. CONCLUSION

So far the main large scale application of electricity in native areas has been for cooking and development has taken the easier path by providing facilities only for natives housed in hostels.

Experience gained to date must be considered as a preparation for the real task ahead, that of making the benefits conferred by a full use of electricity available to all The only approach which has any hope of economic success in the foreseeable future is to develop communal facilities to the native townships, particularly to families. greatest extent.

For example it is suggested that in new townships communal kitchens should be provided for neighbourhood groups of say 50 families. Townships could be laid out so that kitchens are reasonably convenient to all houses and, in fact, the kitchens should be made the focal point of the area. It should be surrounded by a fenced off open space containing shade trees, benches for the mothers and playground equipment for the children. It would provide a pleasant place for the women of the neighbourhood to meet, perhaps rivalling the attractions of the local beer garden and certainly having more beneficial results. Initially these kitchens could be equippel with boiling tables but development of suitable electric ovens is desirable.

Financial Implications of a Low Voltage Reticulation Throughout the Township

It will be noted that provision has not been made for financing the low voltage reticulation required for domestic supplies and possibly the internal wiring of the 11,000 houses in the Township.

The source from which the necessary capital can be made available and the determination of an economic tariff are two problems presenting difficulties in this respect and at the present time, these matters are still under consideration.

Under the existing policy of the Government, the Local Authority is expected to provide the additional capital required to fully reticulate the Township in order to make domestic supplies available in addition to the street lighting already being provided. The additional capital required for this work including the internal wiring of all houses, is estimated at approximately £600,000 to be spent over several years, and it is hoped that it will be possible to obtain some form of Government assitance in this respect and thereby ease the burden on the City's ratepayers.

It is felt that although there will be a large number of potential consumers in the Township, it is probable that for the first few years, a comparatively small number will be able to afford electricity. In view of this, it will be realised that to provide electricity to a relatively small number of consumers in an area as large as kwaMashu, a considerable amount of initial capital expenditure will be involved. Suggestions to reduce the initial high capital expenditure by establishing certain areas or zones in which domestic supplies would be made available have not met with favour for various reasons, from the Local Bantu Administration Department, and furthermore, the arrangement may possibly conflict with the terms of the Electricity Act.

The second problem, which is the determination of an economic tariff, also presents certain difficulties, as the tariff applied must be sufficiently attractive to encourage people to wire their homes and make use of electricity. From investigations already carried out, it appears that the anticipated revenue at kwaMashu, based on the Electricity Department's existing tariffs, will not be sufficient to cover generation and distribution costs. This problem has not yet been resolved and is the cause of considerable concern at the moment.

In order to indicate the revenue that can be expected from Bantu townships I have taken the liberty of analysing and presenting details of the average consumption of 1,200 consumers at Chesterville Bantu Township, Durban, in a manner similar to that presented in respect of Eastern Bantu Township, Johannesburg, in a paper read by Mr. Masson at last year's convention, as I feel that these statistics give a clear picture of the position.

The April, 1959 unit consumption figures have been taken and are analysed as follows: —

(a) 2% used between 5 and 10 units p.m.
(b) 15% „ „ 11 „ 20 „ „
(c) 17% „ „ 21 „ 30 „ „
(d) 14% „ „ 31 „ 40 „ „
(e) 12% „ „ 41 „ 50 „ „
(f) 8% „ „ 51 „ 60 „ „
(g) 18% „ „ 61 „ 100 „ „
(h) 9% „ „ 101 „ 200 „ „
(i) 5% used more than 200 units per month

For consumers classified above, the corresponding average revenue based on the Electricity Department's Tariff for private residences is as follows: —

	1955/1956 Tariff	1959/1960 Tariff
(a)	From 2/6 minimum	2/6 minimum
(b)	„ 2/7 to 5/-	2/7 to 5/-
(c)	„ 5/1 to 6/9	5/1 to 7/-
(d)	„ 6/10 to 7/4	7/1 to 7/8
(e)	„ 7/5 to 7/11	7/9 to 8/4
(f)	„ 8/- to 8/6	8/5 to 9/-
(g)	„ 8/7 to 10/10	9/1 to 11/8
(h)	„ 10/11 to 16/8	11/9 to 18/4
(i)	„ 16/9 & higher	18/5 & higher

An indication of the load growth in Chesterville, is given by the graph (Fig. 1) showing the average consumption per consumer over the 12 month period from August to July for the years 1955/1956 and 1958/59.

It would appear, therefore, that for a number of years some form of subsidy will be necessary to make up the deficit between revenue and expenditure if existing tariffs

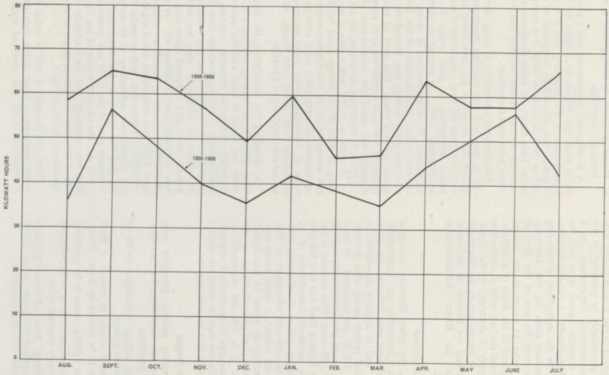


FIG. 1. AVERAGE MONTHLY CONSUMPTION PER CONSUMER
CHESTERVILLE. DURBAN.

Fig. 1.

are to be applied to the Township. This subsidy would presumably be provided by the Bantu Administration Department, on a basis to be mutually agreed upon with the Electricity Department. A possible arrangement would be the segregation of operating and maintenance costs for the Township Reticulation from the rest of the Area of Supply, in order to arrive at the annual amount required in the form of a subsidy. It is considered that all work in connection with the supply of electricity in the Township should be carried out by the Electricity Department and not become an additional function of the Bantu Administration Department.

Future Load Growth

In 1959, the after diversity consumer demands in Chesterville and Lamontville Bantu Townships were 270 and 500 watts respectively and it appears reasonable to plan an initial system on an after diversity demand of .5 K.W. per consumer. At kwaMashu, this would give a maximum demand of 3.3 K.W. per acre. This demand is due mainly to a lighting load and it is felt that it could be increased considerably if we adopt an active policy of educating these people in the uses and advantages of electricity. In this respect, a small utility electric stove selling at about £4 has already been designed and manufactured in this country and it is felt that eventually, as wages increase and living standards improve, further appliances such as small refrigerator units, etc., will also become popular.

Reticulation Design

The following general principles were adopted when the initial plans for the reticulation were prepared.

1. The high voltage reticulation to be an underground system.
2. Transformer kiosks to consist of brick buildings to be erected by Bantu labour.
3. All street lighting mains to be overhead.
4. Low voltage reticulation to be overhead in the family housing areas.
5. In the Hostel Area, all hostel buildings to be supplied by means of an underground low voltage reticulation.
6. House services to be underground if economically justifiable.

A development programme over a period of 6½ years was drawn up initially for the construction of the Township and it is anticipated that this will be completed at the end of 1963 or early in 1964. For convenience, Unit Areas are being developed successively and at present roughly four Unit Areas have been completed.

The electrical reticulation is being carried out in step with the building programme, and in this respect, it has been found convenient to wait for final completion of roads before attempting to plant poles or lay underground cables. At present, as already mentioned, the electrification is being restricted to full electrification of the hostel area and street lighting only throughout the family housing areas. This work of reticulating the whole of kwaMashu as at present planned will entail the construction of a 33/6.6 K.V. stepdown substation, the laying of 15 miles of 11,000 volt 3 core .1 sq. in. cable, 20 miles of low voltage cable, building and equipping of 30 transformer/switching substations, planting 3,000 poles, erecting 80 miles of overhead street light mains and connecting 2,800 street light fittings, all at a total estimated cost of £260,000.

In designing the reticulation, the underlying principle of keeping costs to a minimum was borne in mind and this aspect is receiving continuous attention resulting in modifications to existing practices from time to time. This consideration has influenced the choice of conductor sizes for underground cables and overhead mains and the type of transformer buildings etc. It was considered essential to install an adequate basic 6,600 volt reticulation which could be extended at a later date, and so enable further transformer substations to be connected into the system as and when required. A master plan of the 6,600 volt system layout to suit the physical layout of the Township, was prepared and the schematic layout of this plan for various stages of development are shown in Fig. 2.

From this drawing, it will be noted that it was necessary to resort in one instance to a temporary 6,600 volt overhead main to

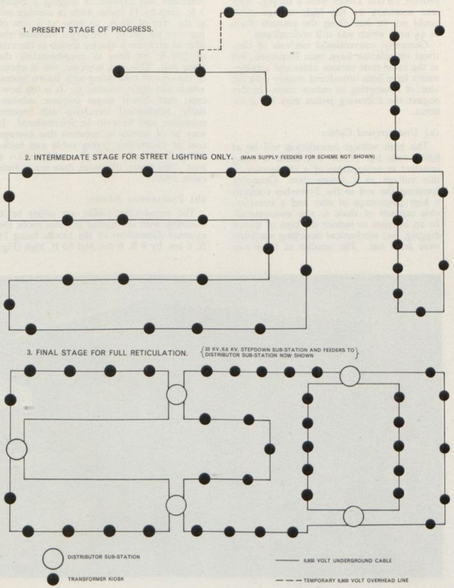


FIG. 2. SCHEMATIC LAYOUTS OF 6600 VOLT SYSTEM.

Fig. 2.

provide certain kiosks with a supply. This was necessary as the high voltage cable could not be laid along the planned route in an area which was still undeveloped.

Generally, conventional methods of electrical reticulation have been employed, but at the same time various ideas and arrangements have been introduced mainly with the idea of attempting to reduce costs. In this respect the following points may be of interest.

(a) *Underground Cables*

The high voltage reticulation will be at 6,600 volts but 11,000 volt cable is being installed in anticipation of a changeover to this voltage at a future date. Generally speaking the soil in the Township contains a high percentage of clay and a considerable amount of shale is also encountered. In an attempt to reduce the cost of trench digging, two mechanical trenching machines were tried out. The smaller of these two machines was capable of digging a trench 3 ft. deep by 12 inches wide in average soil at the rate of 40 ft. an hour at a cost of just over 6d. per ft. The larger machine was able to excavate a similar trench at the rate of 250 ft. an hour at approximately the same cost. This cost, however, was in excess of the cost of excavating with Bantu labour which was again resorted to. It is felt however, that should wages increase substantially, mechanical trenching will become economic and have to be reconsidered. It may be of interest to mention that average cost of excavating, laying cable and backfilling the trench in the Township is 3/- a foot. This figure, of course, does not include cable costs.

(b) *Transformer Kiosks*

The transformer kiosks are utility brick buildings with corrugated asbestos roofs, the external dimensions of the kiosks being 14 ft. 6 ins. by 9 ft. 6 ins. and 10 ft. high (Fig.

Fig. 3.

3 Transformer Kiosk). The buildings are being constructed with Bantu labour under European supervision at a cost of £200 each. They provide adequate accommodation for a 300 K.V.A. transformer, a 3 way ring main panel and low voltage distribution boards for L.V. and street lighting supplies, the ring main panels being manufactured in the Department's workshops. The panels are fitted with three airbreak switches and the overall cost is considerably less than that of the more usual type of panel fitted with oil immersed links.

(c) *Low Voltage Reticulation*
Overhead Mains:

As already mentioned, street lighting throughout the Township is being supplied from single phase overhead mains. Up to the present, supplies of electricity have only been given to public and administrative buildings but as the intention is to ultimately fully reticulate the Township with a three phase, four wire overhead mains system, the layout of the street light mains has been planned with this object in view.

The usual difficulties experienced in laying out the overhead mains are familiar to all engaged in this type of work. The tendency to design townships with curved streets, splayed corners and irregular stand boundaries prevails with the usual resultant difficulties.

In the interests of economy, connection between two lines crossing at road intersections with splayed corners is being made by vertical mid-span jumpers and in isolated cases where this is not possible, an underground loop cable is used to connect the two lines together.

Creosoted wood poles with copper conductors are being used throughout. 30 ft. poles are generally used but where ground has been filled for road construction it has been necessary in certain cases, to plant poles at the foot of the bank and in order to maintain adequate ground clearance, 35 ft. poles have been employed.

(Fig. 4 is a photograph of a typical road in kwaMashu showing the type of overhead mains construction.

Service Connections

Domestic suplies of electricity have not yet been provided in the family housing areas. The type of service connection to be used is still under consideration although underground cable services are generally favoured, and are at present being provided to shops and various other public buildings.

In the Hostel Area, all hostel buildings are being supplied by a completely underground low voltage reticulation system. In desgning this reticulation, it was necessary to make certain assumptions regarding electrical load and diversity. The Hostel Area consists of 32 and 16 bed bungalow type buildings. 300 K.V.A. transformers in brick kiosks have been strategically placed to supply buildings containing approximately 3,000 beds. Five main .1 sq. in. L.V. feeder cables radiate from each kiosk. The feeders are graded, depending upon voltage conditions, along their length down to .06 sq. in., .04 sq. in. and .0225 sq. in. with single phase .0225 sq. in. service cable T-offs to the individual buildings. A system of

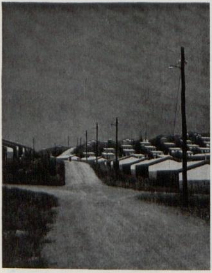


Fig. 4.

looping from one building to the next is being adopted where this will mean a saving in both labour and cable.

In order to facilitate looping, a special type cast iron distribution box has been designed (Fig. 5). The box, which is mounted outside the building, has two compartments. The upper compartment contains the normal distribution board for the building and is fitted with miniature circuit breakers. The lower compartment can be fitted with one or two cable entry glands as required, and the loop cable joint is made in this compartment. The box is completely weatherproof, being fitted with a sliding door which cannot be inadvertently left in the open position. Other adventages of the box are its rugged construction and non-rusting properties. The cable connections to the box shown in Fig. 5 had not been made at the time of taking the photograph.

Up to the present, paper insulated lead covered armoured cables have been used

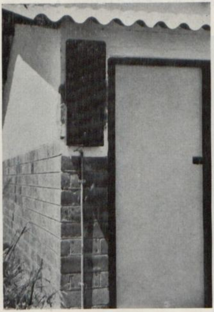


Fig. 5.

for the L.V. reticulation in the hostel area, but it is the intention to make use of plastic insulated cables to a greater or lesser extent depending on the economic aspect of their use. The new continuous current rating of plastic insulated cables has eliminated one disadvantage over the paper insulated cables. It is doubtful however, whether the use of plastic insulated cables in this particular type of reticulation will effect much in the way of a saving owing to the high cost of the gland flttings. This matter is being investigated and in any event, the saving in actual labour with plastic cables may be a deciding factor in their favour.

A further saving in cable costs could possibly be effected by adopting a multiple earthing system using the outer sheath and armouring as the fourth core in a concentric cable.

(d) *Street Lighting*

A simple type of cast iron street light bracket fltted with a plastic or fibre glass reflector and complete with all other fittings at a total cost of £2 5s. each is being installed throughout the Township (Fig. 6). The brackets are fitted with a 75 watt incandescent lamp and mounted at a height of 20 ft. above road level. It has not been found necessary to provide wire guards over lamps to protect them from stone throwing and from experience it has been found that this type of damage only occurs in non-built up areas.

Other types of street lighting such as fluorescent, sodium or mercury vapour are not considered suitable, mainly from a cost point of view but it is possible that one of these more effective types of lighting will be employed in the main roads, at a later date.

Street lighting in the Township is controlled by Solar Dial type electric spring guided time switches installed in the main substations. A contractor is energised by the time switch which in turn energises the street light circuits. Several circuits, each protected with a miniature circuit breaker, radiate out from each supply point. A cascade system is used to energise the contactors at each transformer kiosk, all control equipment being installed in the substations or kiosks.

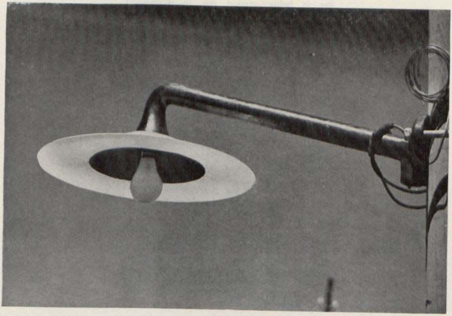


Fig. 6.

(e) *Internal Wiring of Residential Building*

The type of wiring suitable for residences in Bantu Townships is generally dictated by the conditions encountered and the necessity to keep costs as low as possible. For example, with open ceilings, cleat wiring is not considered advisable owing to possible interference by the occupants. Black conduit is also considered to be unsuitable due to corrosion caused by limewashed walls. Pre-fabricated wiring harnesses have been tried out but subsequent maintenance difficulties have tended to preclude the use of this method. As a result of past experience, therefore, the policy of wiring in galvanised conduit has been adopted. It is also felt that wood mounting blocks should not be used as these are likely to harbour vermin, and deteriorate rapidly with rough treatment.

The layout of the wiring installation and the number of points provided, will of course, affect the cost. In this respect, it is considered essential to provide suitable socket outlets, otherwise the use of multiway adaptors and makeshift connections to lampholders increases subsequent maintenance costs, and in any event, if the Bantu is to be encouraged to use electrical appliances, the proper facilities must be provided. The practice of fitting miniature circuit breakers on distribution boards has been generally adopted as these have the advantage of limiting circuit loading and preventing the insertion of fencing wire and hairpins as "fuses."

At Chesterville in 1955, 1,265 houses were wired using galvanised screwed conduit at a cost of £23 per house, this being a contract price. Each house consisted of 2 bedrooms, a kitchen and diningroom with one light per room and two socket outlets. At kwaMashu, a bungalow type hostel building with 16 living rooms providing accommodation for 32 single persons and complete with ablution and laundry facilities, is at present being wire under contract at an average cost of £110 per building. The wiring is being carried out in galvanised screwed conduit and 21 lighting points and 8 socket outlets are being provided per building.

Conclusion

The problems, both financial and technical, that are being encountered in providing electricity supplies at kwaMashu are common to all Electricity Supply Authorities and although there are several approaches to these matters, it is hoped that this paper will serve a useful purpose in making available a general picture of the position at kwaMashu.

The actual methods of reticulation are generally speaking, conventional, but again it is hoped that the descriptions of this aspect of the electrification have proved of interest to those persons connected with this type of work.

In conclusion I would like to express my thanks to the City Electrical Engineer, Durban, for having been given the opportunity of presenting this paper to the Association, and also my thanks to my colleagues in the Durban Electricity Department for their assistance in its preparation.

Annual Report of the Secretaries and Accounts

To the President and Members of the Association.

Mr. President, Gentlemen,

It gives me great pleasure to submit to to you the Annual Report of your Association together with the Revenue and Expenditure Account and Balance Sheet for the financial year ended 29th February, 1960.

Obituary:

I deeply regret having to formally record the passing of the following Members not previously mentioned in the Annual Report. They were referred to by the President at the 33rd Convention:

Mr. E. Poole originally of Durban was a foundation member of the Association and first acted as Secretary Treasurer in 1917. His association with the A.M.E.U. lasted for 15 years.

Mr. Coulthard, a former Member of the Association, also passed away prior to the 33rd Convention.

Thirty-third Convention:

The 33rd Convention of the Association was held in Johannesburg from Tuesday, 12th May, to Friday, 15th May, 1959. Delegates were welcomed to the Convention by His Worship the Acting Mayor of Johannesburg, Councilor A. Gorshel.

The Convention was formally opened by Mr. R. Gettliffe, President of the South African Institute of Electrical Engineers, and a record total of 570 members, delegates, representatives, officials, visitors and ladies attended.

On behalf of the President, Members of the Association and all others who attended the 33rd Convention held at the Cranbrooke Hotel, Johannesburg, it is my pleasure to place on record appreciation to His Worship the Mayor and City Councillors of Johannesburg for the hospitality extended to those attending the Convention as well as for the assistance rendered in connection therewith.

It is indeed a pleasure to have the opportunity of recording appreciation for the work of the President. In recording the proposal of Mr. Kane as President, Councillor Ross-Spencer referred to his outstanding ability to keep calm and unruffled irrespective of problems and irritations. It is this quality coupled with an inimitable sense of humour and an ever willingness to do a job of work that contributed so largely to the success of the Johannesburg Convention in 1959. To Mr. and Mrs. Kane I extend the sincere thanks of all.

The first paper presented at the Convention was "Nuclear Power" by Mr. A. E. Powell. This paper introducing as it did for the first time discussion at a Convention on a subject which will in the more or less distant future be one for ever increasing consideration and study by those responsible for the provision of electricity supplies was unanimously accepted as an outstanding contribution to the Proceedings of the Association. The remaining papers were "The Supply of Electricity to Native Townships" by Mr. G. Masson and "The Development of a Method of Reticulation for the Johannesburg Township of Montgomery Park" by Mr. W. Barnard, B.Sc.(Eng.), A.M.I.E.E., A.M.(S.A.)I.E.E. Mr. Masson's paper, dealing as it did with an aspect of the development of Undertakings which is receiving particular attention at the present time, aroused a great deal of interest and as a result it was decided that the programme of the 34th Convention should include a symposium devoted to the further discussion of various aspects of Electricity Supply to Native Townships. Mr. Barnard's paper evoked much informative discussion on reticulation problems.

Members' Forum maintained its usual high standard and provided many members with an opportunity for discussion on a wide variety of problems.

The Convention unanimously accepted the invitation to hold the 34th Convention in Durban.

Membership:

The following new members were elected during the year ended 29th February, 1960:

Councillor Members:

- Peri-Urban Areas Health Board.
- Lydenburg Municipality.
- Stilfontein Health Committee.
- Orkney Health Committee.
- Tarkastad Municipality.
- Hermanus Municipality.
- Stutterheim Municipality.
- Kenhardt Municipality.

Engineer Members:

- A Billington Eales (Stutterheim).
- H. A. Durr (Peri-Urban Areas Health Board).
- H. A. McIntyre (Assistant Electrical Engineer, Vereeniging).
- R. K. Jooste (Oudtshoorn).
- B. G. van Heerden (Heidelberg).
- P. J. Botes (Assistant Electrical Engineer, Roodepoort).
- G. R. Beard (Grahamstown).
- E. de C. Pretorius (Assistant Electrical Engineer, Klerksdorp).
- H. J. Koeslag (Riversdale).
- H. Zausmer (Hermanus).

Associates:

- M. J. Ross (Brandfort).
- B. F. Carpenter (Middelburg, Tvl.).
- J. H. Bester (Ventersdorp).
- J. H. Jordaan (Vryburg).
- G. T. van Wyk Schoombee (Lydenburg).
- J. S. Lochner (Ladybrand).
- C. P. Laas (Kenhardt).

Associate Members:

- A. B. Cowen, Chairman and Chief Engineer, Southern Rhodesia Electricity Commission.
- G. R. Peterson, Deputy Chief Executive, Federal Power Board of Rhodesia and Nyasaland.

Affiliate Members:

- The Morgen Crucible Co. (S.A.) (Pty.) Ltd.
- The English Electric Co. (C.A.) (Pvt.) Ltd.
- N.V. Nederlandsche Kabelfabrieken, Ltd.
- African Lamps (Pty.) Ltd.

	1958/59	1959/60
Councillor Members	112	120
Engineer Members	109	119
Honorary Members	13	12
Associate Members	31	30
Associates	1	9
Technical Associates	1	–
Affliates	87	90

Finance:

The Income and Expenditure Account for the year under review and the Balance Sheet as at the 29th February, 1960, which are submitted to you herewith do not, I feel, call for any particular comment. The excess of Income over Expenditure of £152 19s. 1d. is not unsatisfactory when it is considered that the Presidential chain has been written off, heavier than normal printing and stationery charges were incurred due in part to the printing of the Constitution, and a reduced profit was made on the Proceedings due principally to a reduction in advertising, resultant upon various amalgamations. It will be noted that the accumulated funds of the Association now total £4,744 17s. 2d.

Messrs. Kane and Downey continued to be members of the Finance Committee during the year under review and I again thank them sincerely for their assistance to the Association in this capacity. The continued support of the advertisers in the Proceedings is acknowledged with appreciation.

General:

The Regional Branches of the Association in the Eastern Cape and Natal are developing and will clearly play an increasingly important part in the work of the Association.

Johannesburg acted this year as host for the Mid-year Executive Meeting and on behalf of all we convey thanks for the hospitality extended on the occasion of the meeting.

The essential work of the various Sub-Committees of the Association as well as its representatives on other Technical Committees and Organisations has continued during the year under review. To the various individuals concerned we convey the appreciation of the Association for their most valuable work on behalf of all Member Undertakings.

To you, Mr. President as well as all other Members of the Executive Council I express sincere thanks for the continued assistance and courtesy which you have extended to us over the past year.

To the Association and all its Members we extend best wishes for 1960/61.

R. G. EWING,
for DAVIDSON & EWING (PTY.) LTD.
Secretaries.

5th March, 1960.

ASSOCIATION OF MUNICIPAL ELECTRICITY UNDERTAKINGS OF SOUTHERN AFRICA

BALANCE SHEET — 29th FEBRUARY, 1960

1959				1959		
4,592	ACCUMULATED FUNDS		4,744 17 2	1	PRESIDENTIAL BADGE Nominal Value	1 0 0
4,114	Balance at 28th February, 1959	4,591 18 1		46	FURNITURE AND FITTINGS—at cost less depreciation	55 0 0
478	*Add*: Excess of Income over Expenditure for the year ended 29th February, 1960	152 19 1		3,773	INVESTMENTS—Fixed Deposits at, and Savings Account with, Building Society including interest accrued	3,964 9 10
123	PROVISION FOR AGENTS' COMMISSION		88 10 6	448	DEBTORS	938 9 0
—	CREDITORS		898 9 0	20	PAYMENTS IN ADVANCE	20 0 0
				10	DEPOSIT—Davidson & Ewing (Proprietary) Limited	10 0 0
				417	CASH AT BANK	742 17 10
£4,715			£5,731 16 8	£4,715		£5,731 16 8

Davidson & Ewing (Pty.) Ltd.,
Per R. G. EWING,
Secretaries.

R. W. KANE,
President.

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 29th February, 1960; we have satisfied ourselves of the existence of the securities and have received all the information and explanations we have 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 29th February, 1960, according to the best of our information and explanations given to us and as shown by the books of the Association.

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

Johannesburg, 8th March, 1960.

ASSOCIATION OF MUNICIPAL ELECTRICITY UNDERTAKINGS OF SOUTHERN AFRICA

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 29th FEBRUARY, 1960

1959				1959		
19	Audit Fee, 1959		18 18 0	168	Interest on Fixed Deposits and Savings Account	191 15 1
—	Bad Debts—Sale of Proceedings		1 0 0	242	Proceedings—Schedule 1	102 17 6
12	Bank Charges		11 14 6	1,290	Subscriptions—Affiliates	1,395 0 0
1,413	Convention Expenses		1,446 4 1	1,715	Subscriptions — Council and Other	1,753 15 0
5	Depreciation — Furniture and Fittings		6 5 6	4	Sundry Revenue	15 0
324	Executive Council Expenses		295 13 7			
191	Attendance at Half-yearly meetings	295 13 7				
133	Attendance at other meetings	—				
8	Insurance		17 8 9			
43	Postages and Telegrams (general)		87 9 3			
—	Presidential Chain written off		60 0 0			
176	Printing and Stationery (general)		338 12 10			
900	Secretarial Fees		900 0 0			
15	Subscriptions Paid		15 0 0			
3	Sundry Expenses		57 18 6			
23	Telephone		34 18 6			
478	Excess of Income over Expenditure Transferred to Accumulated Funds		152 19 1			
£3,419			£3,444 2 7	£3,419		£3,444 2 7

ASSOCIATION OF MUNICIPAL ELECTRICITY UNDERTAKINGS OF SOUTHERN AFRICA

Schedule I

PROCEEDINGS:		
Advertising—Gross		958 10 0
Less: Provision for Agents Commission 1960	88 10 6	
Add: Underprovision for Agents Commission 1959	2 6 0	90 16 6
		867 13 6
Add: Sales		226 0 0
		1,093 13 6
Less: Cost of printing	894 19 0	
Sales Commissions	95 17 0	990 16 0
		£102 17 6

Reports of Committees

ELECTRICAL WIREMEN'S REGISTRATION BOARD

Mr. President, Ladies and Gentlemen,

I am indebted to the Wiremen's Board for permission to produce the statistics and information quoted in this report.

I note that it is some time since our members have had details of the composition of the Board and consequently I am repeating their names.

The Chairman is Mr. G. J. Malan, Chief Inspector of Machinery (Factories) and the members are Messrs. T. D. Bowness, A. Elisio, J. M. Fraser, B. G. Lindeque and R. W. Kane.

There have been 10 meetings of the Board during 1959 and in all 481 applications for registration have been considered. 669 Candidates took the examination for Section A with 21.1% passes, whilst for Section B, 455 sat with 70.5% passes. There were 11 practical examinations (Section B) and 4 written examinations (Section A).

During the year under review 8 applicants were exempted from examinations and 339 were registered after passing the prescribed examinations or a total of 347 applicants were registred during 1959. This brings the total registrations from 1940 to 7,554.

The Chairman, in addressing Convention during 1959 reported that 41 areas had been determined during May, 1959. For record purposes there are:—

The Municipal areas of:—

Beaufort West, Bethal, Bethlehem, Brits, Burgersdorp, Caledon, Carolina, Ceres, Christiana, De Aar, Ermelo, Estcourt, Ficksburg, Graaff Reinet, Harrismith, Hennenman, Kuruman, Ladybrand, Ladysmith, Louis Trichardt, Middelburg (Transvaal), Moorreesburg, Mossel Bay, Odendaalsrus, Parys, Riversdale, Senekal, Somerset East, Swellendam, Umtata, Upington, Ventersburg, Vryburg, Vryheid, Warmbad, Wolmaransstad and Wolseley.

The Village Management Boards of Sasolburg, Virginia and Welkom.

The Magisterial district of Lower Tugela.

The total number of determined areas to the end of 1959 is 114.

In addition the Board during the latter portion of 1959 has recommended to the Minister that the Magisterial district of Umzinto which includes Scottburgh and Umkomaas of the Natal South Coast should be determined and the customary 12 months' notice has been given. The necessary notice to determine the municipal areas of Bothaville and Winburg was enforced during 1959 and final determination was published early in 1960.

During the year under review the Witwatersrand Technical College informed the Department of Labour that they would no longer be able to conduct the practical examination (Section B) and arrangements have been made for this examination to be conducted at the Olifantsfontein Trade Testing Organisation under the Department of Education, Arts and Science. This affects the Witwatersrand area only.

Following a query from a number of centres it was obvious that the thorny question of continuous supervision was causing some concern and at the September meeting of the Board it was agreed to recommend that Section 20 of the Act be amended so as to permit members of the restricted classes referred to therein to work under constant personal supervision, except in the ultimate year of apprenticeship or training when such supervision need not be personal. Members will recollect that this was discussed, together with other proposed amendments as far back as 1953 and finally reported in some detail in the 1957 proceedings, reflecting the decision of the Board taken during 1956. Since 1956 a few amendments have been adopted and the Board has again asked the Department of Labour to proceed with the outstanding amendments.

The Board has been informed that consideration will be given to the proposed amendments during the 1961 session.

R. W. Kane, Representative.

S.A.B.S. ACTIVITIES: REPORT OF REPRESENTATIVE

Mr. Chairman and Gentlemen,

I have pleasure in presenting the report of the activities of the S.A.B.S. during the past year:

S.A.B.S. 97—*Paper Insulated Cables for General Purposes*

The revision of this specification was completed and was approved by the Standards Council on 5th October, 1959. Additional requirements and tests were incorporated in the revised specification. The Specification is at present at the printers, but roneod copies are available.

S.A.B.S. 98—*Paper Insulated Cables for Heavy Duty*

As S.A.B.S. 98/1954 is out of print, this specification was re-written in order to fall into line with S.A.B.S. 97. This document has been circulated to the members of the Cable Committee. Closing date for comment 1st February, 1960.

S.A.B.S. 150—*P.V.C. Insulated Cables*

In connection with the use of P.V.C. insulated cables another important and somewhat unusual aspect should be brought to the attention of all concerned. During 1959 a multi-core P.V.C. insulated, bedded, armoured and served cable laid in soil in which bad meat had been buried some years previously, was severely damaged by contact with the soil.

In this respect it should be pointed out that all commonly used plasticizers are fat-soluble and as fatty acids (stearic, Myristic, palmitic and similar long chain acids) are normally produced when meat is decomposed trouble may be expected if these acids are allowed to come into contact with plasticized P.V.C.

Aldehydes and Carbonyl-components which are produced by chemical decomposition and fats, also act as solvents of P.V.C.-materials.

In the above-mentioned case, samples of the soil were examined and found to be acid and also to contain aldehydes and carbonyl-components. It should, however, be stressed that in this case the circumstances were exceptional.

S.A.B.S. 165-1959 *Lampholders*

This specification, which covers both bayonet-cap and Edison-type screw lampholders, was approved by the Standards Council on the 8th June, 1959 and has now been published.

S.A.B.S. 166-1959 *Overhead Service Line Connector Boxes*

This specification was finalised at the 2nd meeting of the Committee on the 18th September, 1958. It was approved by the Standards Council on the 8th June, 1959, and is now available in printed form.

S.A.B.S. 184 *Electric Heating Pads and Blankets*

The specification for heating pads and blankets was finalised at a meeting held on the 17th September, 1959, and will be submitted to the Standards Council for approval on the 4th April, 1960.

S.A.B.S. 185 *Immersion Heaters for Portable Electrical Appliances*

1st Meeting—23rd June, 1959.

Sent out for comment. Return date 30th November, 1959.

2nd Meeting—18th February, 1960.

S.A.B.S. 186 *Impulsing Energy Regulators for Electric Heating Units*

After discussion of the first committee draft at a meeting held on the 22nd September, 1959, a draft for comment was issued; the return date for which is the 28th February, 1960.

*S.A.B.S. SV*122 *Safety Specification for Domestic Radio and Electronic Apparatus*

Two meetings were held in 1959; one on the 15th September and the other on the 27th October. The specification has now been issued for comment, the return date being 30th June, 1960.

Electrical Equipment Safety Specifications

The series of electrical equipment safety specifications were first published in 1950. These were subsequently amended in 1953. At that time it was decided that nine of these specifications, viz. SV 101, 102, 103, 104, 107, 109, 112, 117 and 121 be recommended for compulsory declaration. With this end in view these safety specifications were submitted to the Government legal advisers. As a result of their deliberations it was noted that:—

(a) Reference could not be made in a compulsory specification to a non-compulsory specification (in this case SV 100 and SV 119) and

(b) that only standard specifications, as opposed to safety specifications could be made compulsory.

In view of this it was decided by the Standards Council that the appropriate requirements of SV 100 be written into each of the individual specifications, that SV 119 be also declared a compulsory specification and further, that the ten specifications be renumbered and that these specifications, listed below, be declared standard specifications to which the S.A.B.S.-ellipse mark be applied:—

Old No.	*New No.*	*Title*
SV 101-1953	SV 124-1955	Manually Operated Air Break Switches.
SV 102-1953	SV 125-1955	Portable Electric Immersion Heaters.
SV 103-1953	SV 126-1955	Electric Air Heaters and Radiators.
SV 104-1953	SV 127-1955	Flexible Cords for Power and Lighting.
SV 107-1953	SV 128-1955	Portable Elec. Appliances for Heating Liquids.
SV 109-1953	SV 129-1955	Plugs and Socket-Outlets.
SV 112-1953	SV 130-1955	Electric Hand-lamps.
SV 117-1953	SV 131-1955	Electric Stoves and Hotplates.
SV 119-1953	SV 132-1955	Lampholders and Bayonet Lampholders Adaptors.
SV 121-1953	SV 133-1955	Apparatus Connectors.

Other changes requested by the legal advisers were also made. The Minister of Economic Affairs has now decided that the compulsory declaration of these specifications be proceeded with.

In order to clear up certain points, particularly instances in which discrepancies existed between these safety and the corresponding latest series of "quality" specifications, a committee meeting was held on the 3rd November, 1959.

The revised specifications are now being prepared for submission to the Standards Council on the 4th April, 1960, after which they will be published in the Government Gazette.

S.A.B.S. 171 *Low Voltage Lightning Arrestors*

This specification has now been submitted to the Standards Council in its final form and is expected to be published early in 1960.

S.A.B.S. 517 *Power Transformer Specification*

Committee meetings have been held to discuss the first draft. Sub-committees are now busy on certain contentious sections which will be reviewed by the main committee before the specification is submitted for general comment.

S.A.B.S. 179 *High and Low Voltage Bushings Specification*

The draft specification has been discussed by the committee and investigations by the S.A.B.S. of queries raised by the committee are now under investigation. These are expected to be clarified by mid 1960.

S.A.B.S. 178 *High Voltage Insulators*

The position is the same as in the case of the Porcelain Bushing Specification.

S.A.B.S. 516 *Motor Cycle Battery Specification*

This specification has been sent out for comment and finality of I.E.C. proposals is awaited before this specification is taken further.

In conclusion I should like to express my appreciation and thanks to all members of the staff of the Bureau of Standards for their willingness and co-operation in all matters during the year and to members of the A.M.E.U. who have so kindly and willingly given up valuable time and have rendered such good service on the various Technical Committees of the Bureau of Standards.

J. C. Downey, Representative.

REPORT OF THE RECOMMENDATIONS COMMITTEE FOR NEW ELECTRICAL COMMODITIES

The Committee's composition was slightly altered through the old Safety Precautions Committee falling away and being replaced by the new Wiring Regulations Committee of the South African Institute of Electrical Engineers. The composition is therefore as follows:—

A.M.E.U.; Bureau of Standards, S.A.I.E.E. (Wiring Regulation Committee); Electricity Supply Commission; Electrical Engineering and Allied Industries Association; Electrical Contractors Association of South Africa; Johannesburg City Council.

Three meetings were held during the year and members were kept informed of the findings through the usual news bulletins.

A noticeable trend is the appearance on the market of special wiring commodities such as special skirting and floor joists to take the place of tubing.

The re-appearance of quick heating water heaters is also noticeable, but the Committee still has these under consideration.

P.V.C. tubing to replace the conventional conduit has also come to the fore.

J. L. van der Walt, Representative.

RIGHTS OF SUPPLY SUB-COMMITTEE

The Association's Hon. Legal Adviser has prepared a Memorandum on the South African urban local authority's right to supply electricity within its area of jurisdiction and this has been circularised to all members of the Association.

The Committee met once during the past year.

C. Lombard, Convenor.

IMPORT DUTY—OVERHEAD LINE HARDWARE

It will be recalled that it was reported at the last Convention that application had been made to the Board of Trade and Industries for an increase in import duty on overhead line hardware. The Convention then resolved that representations be made to the Board to oppose any such increase.

VERSLAG VAN DIE AANBEVELINGSKOMITEE VIR ELEKTRIESE WARE

Die samestelling van die komitee het ietwat verander deurdat die ou Veiligheidsvoorsorg-komitee deur die nuwe Bedradingsregulasies-komitee van die Suid-Afrikaanse Instituut van Elektrotegniese Ingenieurs vervang is. Die samestelling is dus soos volg:

V.M.E.O.; Buro vir Standaarde; S.A.I.E.E. (Bedradingsregulasie-komitee); Elektrisiteitsvoorsieningskommissie; Electrical Engineering and Allied Industries Association; Elektriese Kontrakteursvereniging van Suid-Afrika en Stadsraad van Johannesburg.

Daar was drie vergaderings gedurende die jaar gehou en lede is van die bevindings deur die gewone nuusbriewe verwittig.

'n Opmerkbare neiging is die voorkoms van besondere bedradingsmateriaal in die vorm van vloerlyste en vloerbalke, albei van staal, wat ook geskik is om die plek van die gewone staalbuise te neem.

Die herverskyning van vinnige waterverwarmers is ook opmerkbaar.

P.V.C. geleierbuise tree nou ook na vore om die gewone staal geleierbuise te vervang.

J. L. van der Walt, Verteenwoordiger.

ONDERKOMITEE REG VAN VOORSIENING

Die Vereniging se Ere-regsadviseur het 'n Memorandum voorberei oor die Suid-Afrikaanse Stedelike Plaaslike Bestuur se reg om elektrisiteit binne sy regsgebied te voorsien en dit is aan alle lede van die Vereniging omgestuur.

Die Komitee het eenkeer in die loop van die jaar vergader.

C. Lombard, Saamroeper.

INVOERREGTE: YSTERWARE VIR BOGRONDSE GELEIDINGS

Onthou sal word dat daar tydens die laaste Konvensie gerapporteer is dat by die Raad van Handel en Nywerheid aansoek gedoen is om verhoging van die invoerregte op ysterware vir bogrondse geleidings. Die Konvensie het toe besluit dat vertoë tot die Raad gerig word om sodanige verhoging te opponeer.

On receipt of these represntations, the Board requested the Association to furnish it with certain information which was not at all readily available. A meeting with certain local manufacturers of overhead line hardware was held and it was established that the present range of overhead line hardware manufactured in the Union was very limited and mainly confined to certain items which were foundry products. This information was conveyed to the Board with the submission that if additional protection should be found necessary, this should be limited to certain cast items which were within this range of economic local manufacture.

It was further suggested that a Technical Advisory Committee should be formed in order to investigate matters of this nature and advise the Board and that the A.M.E.U., Escom, Assocom, and the S.A. Federated Chamber of Industries should be represented on this Committee.

The Board's final decision in regard to this matter is not yet known.

C. Lombard.

Die Raad het die Vereniging by ontvangs van sodanige vertoë om sekere inligting gevra wat gladnie juis maklik bekombaar was nie. 'n Vergadering is met sekere plaaslike fabrikante van ysterware vir bogrondse geleidings belê en daartydens is dit bevestig dat die huidige reeks ysterware wat in die Unie vervaardig word, uiters skraal is en hoofsaaklik tot sekere items beperk wat gieteryprodukte is. Dié inligting is aan die Raad oorgedra met die standpunt dat beskerming net tot sekere gegote ware beperk moet word binne die reeks plaaslike ekonomiese vervaardiging as bykomende beskerming dan noodsaaklik gevind sou word.

Voorts is aan die hand gedoen dat 'n Tegniese Advieskomitee in die lewe geroep word om sake van so 'n aard te ondersoek en om die Raad te adviseer, en dat die VMEO, Eskom, die Handelskamers en die S.A. Gefedereerde Kamer van Nywerhede in die komitee verteenwoordig word.

Die Raad se finale besluit in verband met hierdie saak is nog nie bekend nie.

C. Lombard.

WIRING REGULATIONS COMMITTEE

As reported by Mr. Fraser at the 33rd Convention of the A.M.E.U. last year the Safety Precautions Committee held its last meeting on the 22nd June, 1959, and the first meeting of the newly formed Wiring Regulations Committee was held on the 21st July, 1959, and since that date there have been four further meetings.

The Railways are not represented on this Committee and in addition there are Advisory Committees in the Cape and Natal which are serving a very useful purpose.

The Committee dealt with a number of queries from supply authorities and others on the regulations, but has been mainly concerned with a revision of earlier amendments and consideration of further proposals prior to the essential reprint of the Regulations, the Afrikaans version being out of print.

The January, 1960 amended version of the Second Edition of the Wiring Regulations was released by the printers recently at a cost of 7s. 6d. per copy.

In general the amendments to the Regulations consist of minor alterations to the section covering definitions of terms and to Regulations 222, 304, 309, 310, 322, 401(H), 502(J), 504(A), 401(O), 504(E), 606(E), 606(J), 606(K) (1955 Edition), 901(C), 903, 116(B), 1116(C), 1201, 1202, 1203, 1302(E) (Afrikaans version only), all the Tables and the respective indexes.

Regulation 305, 402(L), 405(L), 606(J) (1955 Edition), 606(I), 901(D) (1955 Edition), 1222(E) and 1222(F) have been deleted with the adjustment to existing and remaining designations where necessary. A new Regulation 411 has been introduced.

The major alterations of interest concern the location of the main switch and fuses, the minimum rating of conductors for various circuits, the use of shaver socket outlets in bathrooms, earthed concentric wiring, the quantity of socket outlets on a circuit and the permissible current rating of conductors.

J. C. Downey, Representative.

Some Economic Aspects of Nuclear Power Station Operation

By ERIC PHILLIPS, D.Sc.Eng., LL.D.
(Alberta), M.I.E.E., M.(S.A.)I.E.E.,
Sen. Mem. I.R.E., Professor of Electrical
Engineering, University of Natal.

Power with which to drive machines has been the most important force in relieving man from physical drudgery and providing leisure for spiritual and mental development. Unfortunately, power expansion in many parts of the world is already being limited by the growing shortage of water resources and fossil fuels. But now there is a prospect of a nuclear power era which may have an influence just as far reaching as the Industrial Revolution.

World production of electricity at the beginning of the century amounted to about 9,000 million kWh per annum, and at present is not far short of 1,500,000 million kWh per annum. The rate of increase in electricity usage is growing at an annual rate between 6% and 16%. This rapid increase has taken place in every country. Although the rate of increase was slightly faster at the beginning of the century than in the later years, and although there are very wide disparities in per capita consumption. It is striking to note that Europe and the United States, which already have twice and six time, respectively, the world average consumption per head of population, show no signs of reaching saturation. On the contrary, the rate of increase in Europe and the United States, since the war, has averaged over 10% a year.

Figure 1 shows that the growth in electricity production follows a fairly smooth trend with a slight but steady continuous slowing down in the rate of growth. As the thermal efficiencies of steam stations get closer to the limit set by thermodynamics, it is not possible to expect in the future as big a reduction in the real price of electricity due to this factor as has occurred in the past, but it is doubtful whether that will greatly affect the demand. The estimates that have been published of the increase in electricity production expected by the United States, the Soviet Union and the United Kingdom point to a continued upsurge of demand, and it seems reasonable to forecast that this will continue on the lines suggested by Figure 1 so as to reach about nine million million kWh a year, inclusive of hydro-electricity by the end of the century. If average thermal efficiencies have reached 33% by then, this alone will be equivalent to 3,500 million tons of coal a year.

The total demand for commercial energy can be expected to increase for some time at least, at a rate that does not seem likely to be less than 2% per annum and may be more. The rate of consumption of energy is likely to be not less than 7,500 million tons of coal equivalent by the year 2,000, as compared with 2,750 million tons in 1950. Unless nuclear energy becomes more economically attractive than hydro-electricity, supplies from the latter source may amount to the equivalent of nearly a thousand million tons of coal per annum by the year 2,000 and ultimately to about 2,500 million tons of coal a year. The evidence at present available suggests that the total recoverable resources of solid and liquid fuels and natural gas are of the order of 3½ million million tons, although it must be emphasised that the recoverable reserve is a function of the demand for fuel, of extractive techniques and of the discovery of possible new sources.

If the total demand for the primary fuels continues its long term growth of 2% per annum, and if no relief were available from nuclear or other new sources of energy, the reserves of solid fuels, liquid fuels and natural gas would have been reduced by the year 2025 to about 300 years of life at the then existing rate of consumption. At a rate of growth of 3% per annum, they would have been reduced to about 120 years of life at the then current rate of use. If expansion continued at 2% per annum to the year 2050 (implying a total consumption per head of about four times that of 1950) the remaining reserves would fall to about 150 years; with a 3% rate of growth, they would be within 40 years of exhaustion. In many countries a decline in consumption would have been enforced long before then.

The need to supplement present sources of energy by a new source, however, is considerably more urgent than is implied by a calculation of possible overall demands and reserves. Experience has shown, in some countries at least, the increasing difficulties of attracting workers to coal-mining; difficulties which are likely to become greater as the standards of living rise. Of the world supplies of energy in 1950, about 25% were derived from coal. But, world output of coal has been increasing by only about 0.5% per annum, and if it is assumed that it is impossible to raise this rate of increase, then only 2,000 million tons of coal per annum would be forthcoming by the year 2000 out of a total of some 7,500 million tons of coal equivalent required on the basis of a 2% compound growth of demand.

Figure 2 shows the possible demand for the conventional sources of energy in the absence of a new source. These figures are put forward with very great diffidence. The projection of compound interest curves can lead to surprisingly absurd results in surprisingly few years, and the estimates of reserves have a substantial margin of error. But a 2% growth in total use of primary fuel has already been maintained for one hundred years and there is no immediate sign of a downward grade save in respect of the rate of population increase of a few nations. It would not be difficult to advance more sensational figures.

It should be apparent that, even if conservative estimates of economic growth and of the future demand for energy are made, the world is not far distant, measured in the units of time in which we think of the history of nations, and even of the lives of individuals, from the moment when, in the

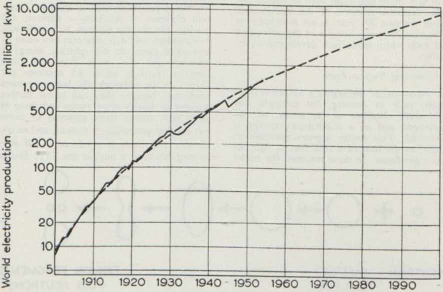


Figure 1 World production of electricity 1900-1954 with fitted trend (broken line). (Robinson & Daniel, Geneva P-757.)

	Total energy	Coal	Hydroelectricity	Oil and natural gas*
1950	2·8	1·6	0·2	1·0
2000	7·4	2·0	0·9	4·5
2025	12·1	2·3	2·2	7·6

Figure 2 Possible demand for the conventional sources of energy in the absence of a new source (10^9 tons of coal equivalent). (Robinson & Daniel, Geneva P-757.)

absence of a new source, scarcity of fuel will begin to create serious problems. The remarkable material progress of the human race during the past two centuries has largely sprung from the opportunities presented first, by coal and steam power, and more recently, by oil and hydro-electricity, to supplement human and animal muscles with other forms of energy. The wealth of the wealthier nations is due to the fact that they employ many times more energy per worker than the poorer countries. There is no task more important than to ensure that the dramatic advance of the human race over the past 200 years is not reversed over the next 200 years because of the exhaustion of fuels which made such development possible.

Atoms and Nuclear Fuels

When matter undergoes a chemical reaction, such as burning, for example, the planetary electrons of its atoms are rearranged and as a consequence energy is released. This energy appears generally as heat, as the heat of a coal fire, or light, as in a gas flame. In these reactions the nuclei of the atoms taking part are undisturbed. In some circumstances, however, it is possible to produce a reaction in which a nucleus is disturbed or even broken up, and when this is done very much more energy may be released than is possible when only the planetary electrons are involved. Unlike chemical reactions, nuclear reactions cannot generally be made to spread from one atom to the next; each nucleus has to be treated individually, but there is one exception to this rule, the reaction called nuclear fission, which is the cornerstone of nuclear power. Fission is produced when a nucleus of certain elements is struck by a neutron; the nucleus absorbs the neutron, its equilibrium is disturbed, and it is split into two more or less equal parts. In this splitting, energy is released and also more than one fresh neutron (actually about 2.5 neutrons per fission on the average); the latter are most important because they can cause further fissions in neighbouring atoms and these in their turn release more neutrons to cause yet another generation of fissions, and so on. In this way there is produced a self sustaining reaction, a nuclear fire. The fission

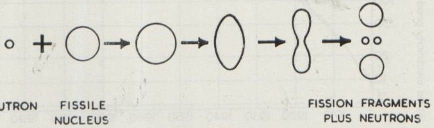


Figure 3 "Liquid Drop" model

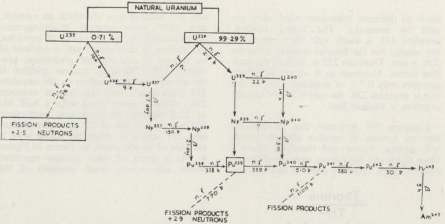


Figure 4
The irradiation of natural uranium in a flux of thermal neutrons (Blainey: J. (S. A.) I.M.M. Vol. 58.)

process may be qualitatively, and to a considerav1e extent quantatively, explained in terms of the "Liquid Drop" model of the atomic nucleus illustrated in Figure 3.

If the 2.5 neutrons emitted per fission each caused further fissions, there would be about six neutrons in the next generation, 15 in the next, and so on. A rapidly divergent chain reaction would follow resulting in an explosion. If, however, the volume of fissile material were small, most of the neutrons would escape from the surface instead of causing further fissions and the net re-production rate would be less than unity instead of 2.5. In this case the reaction would rapidly cease.

The fission fragments are unstable atoms whose nuclei transform by radio-active decay until they become stable. Most fission fragments undergo several transformations before reaching a stable state and the final products may be solids or gases. The fission products in irradiated fuel elements constitute an intense source of gamma and beta radiation so that the spent fuel elements require heavy shielding and remote handling techniques.

There are many fuels in which an ordinary fire can burn—coal, oil, gas, wood, even metals—but only one naturally occurring material will sustain a nuclear fire. That is the element uranium, a metal heavier than lead. Fission of the uranium nucleus by neutron bombardment was discovered by Hahn and Strassmann in 1939. By December, 1952, a controlled chain reaction in a large mass of uranium had been achieved by Fermi in Chicago, and by July, 1945, an explosive chain reaction had been achieved in Alamogordo, New Mexico.

Questions often asked at this point are: "How do you light one of these nuclear fires? Do you have to switch on your reactor?" The answer is that the uranium is throwing off neutrons continuously, even before it is put into the reactor, but that the nuclear fire begins only when there is a sufficient quantity of uranium assembled in the favourable conditions of the reactor to sustain a chain reaction. This quantity is called the critical size. When the nuclear fire "lights," the reactor is said to "go critical" or "become divergent." A point to be remembered is that only a small fraction of the atoms in the uranium will "burn" in the nuclear sense.

Natural uranium consists of a mixture of two kinds of atoms, one of which is a little lighter than the other. These different atoms, known as isotopes of uranium, behave similarly in ordinary chemical reactions, but their nuclei differ in a way that leads to different behaviour when they are split by neutrons. The lighter isotope, uranium 235, is easily split by neutrons of low energy but the heavier isotope, uranium 238, is not. Uranium 235 is, in fact, the part that burns. Uranium as it occurs in nature contains only 0.7% of uranium 235; all the rest is uranium 238. So only 0.7% of natural uranium is nuclear fuel.

Uranium 238, however, can be changed into an isotope of another element which will undergo fission and therefore "burn." Once again the ubiquitous neutron plays an essential part. When a neutron hits a uranium 238 nucleus it is absorbed; as a result, and after some internal re-arrangement accompanied by the emission of particles, the nucleus is transmuted into a nucleus of an isotope of the element plutonium, plutonium 239. The main nuclear reaction is the absorption of a neutron by the uranium 238 nucleus to form the isotope uranium 239, which is short lived with a half life of 23.5 minutes decaying into neptunium 239 with a half life of 2.3 days and plutonium 239 which is relatively stable with a half life of 24,400 years, as shown in Figure 4. As a result of other nuclear reactions which also occur, small amounts of the

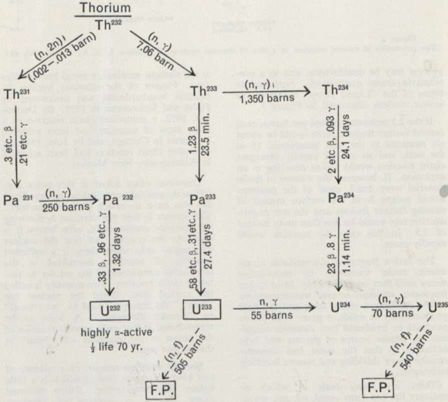


Figure 5 Neutron irradiation of thorium in a nuclear reactor. (Blainey: J. (S. A.) I.M.M. Vol. 58.)

higher plutonium isotopes and minute amounts of americium 243 are formed. This new material plutonium 239 is an even better nuclear fuel than uranium 235. In a similar manner, as shown in Figure 5, a third nuclear fuel can be made by exposing the element thorium to neutrons; the thorium isotope of mass 232 absorbs neutrons and is transmuted into uranium 233, a fissile isotope of uranium which does not exist in nature.

These three then, uranium 235, plutonium 239, and uranium 233, are the fuels of the atomic age; the essential raw materials from which they are extracted or made by nuclear transmutation, are natural uranium and thorium. For an explosive fission reaction to occur substantially pure uranium 235 is needed: for a controlled reaction to occur ordinary uranium containing the two isotopes in normal proportions may be used if steps are taken to prevent the fast neutrons released at fission from encountering uranium nuclei until their speeds have been reduced to low values. The striking thing about these nuclear fuels, compared with ordinary chemical fuels, is the enormous amount of energy that is released for each pound of fuel burnt. Thus a pound of uranium if all the atoms in it were made to undergo fission, would release as much energy as three million pounds (or 1,300 tons) of coal. Such complete utilisation of uranium has yet to be realised in practice, though the fact that non-fissile uranium 238 can be transmuted into fissile plutonium implies that it is theoreticaly possible.

The energy released in fission is imparted in the first instance to the two fragments into which the nucleus is split causing them to move apart with great speed. No way of using the energy of these fragments directly has yet been devised but the motion through the uranium heats the metal and this heat can be removed and converted into mechanical energy by a steam engine or gas turbine. In short, atomic energy can be obtained by burning an uncommon fuel in an uncommon way and then using the heat obtained in a quite ordinary manner.

Nuclear Reactors

The new fuels are burnt in new and different furnaces called nuclear reactors or atomic piles. As has been said a nuclear fire is propagated by the neutrons released in fission, about 2.5 for each uranium atom split. Some of these neutrons may be lost, for example, by being absorbed in materials other than fuel atoms or by escaping from the fuel, but provided enough of them remain to produce as many new fissions in the next generation as there were in the first, the chain reaction is maintained—the fire continues to burn at a constant rate. This state of affairs can be realised only if there is a certain minimum amount of fuel, the so called critical size. With amounts less than critical, so many neutrons escape that fewer fissions are produced in the second generation than occur in the flrst, and the fire dies out. In practice a reactor is designed so that it contains rather more than the critical amount of fuel. A surplus of neutrons is then available, capable of producing more fissions in the second generation than there were in the first. Left to itself the fire would then spread, but by inserting neutron absorbing material, the surplus of neutrons can be mopped up and the flre kept burning at the desired constant heat.

Neutrons released in fission are moving at high speed; they are capable of producing more fissions at this stage, but the likelihood that they will do so is fairly small and consequently a reaction can be maintained only in highly concentrated nuclear fuel. On the other hand, if the neutrons are slowed down, the likelihood that they will produce fissions is greatly increased, although, at the same time, they are also more likely to be captured without producing fission. Nevertheless, the balance is in favour of flssion and a reaction can be maintained in less concentrated fuel. So there are two broad classes of reactors, fast-fission reactors in which the neutrons are used at high speed and thermal-fission reactors in which neutrons are slowed down to so-called thermal energies. This slowing down is done by allowing the neutrons to bump about among the atoms of some light material, called a moderator; a neutron bounces off the the light atoms and loses energy at each bounce, just as a snooker ball loses energy as it collides with one ball after another of the pool, until ultimately its energy is very

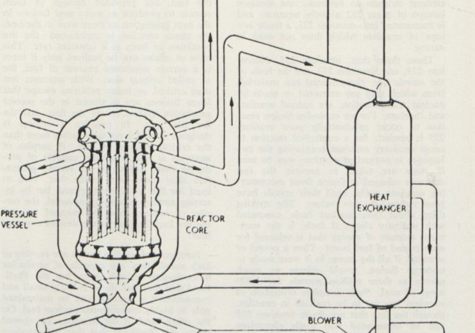


Figure 6 Reactor gas flow (Jay: Calder Hall.)

small indeed. It should be noticed that the moderating action affects only the energy of the neutrons producing fission; it does not alter either the energy produced in fission or the power level at which the reactor operates.

Fermi used carbon in the form of pure graphite as the "moderator" in the first reactor built in Chicago. It contained ten tons of uranium rods of 1 ins. diameter (some as metal, some as oxide rods) forming a lattice of 8 ins. pitch; these were inserted into a hundred tons of pure graphite, so that most of the neutrons emitted at fission were obliged to traverse at least 7 ins. of graphite, losing energy at each collision with a carbon atom; and they re-enter uranium metal at such low velocity that absorption by uranium 238 is just about equal to absorption by uranium 235, causing fission. This principal of construction is basic to all the reactors built since 1942

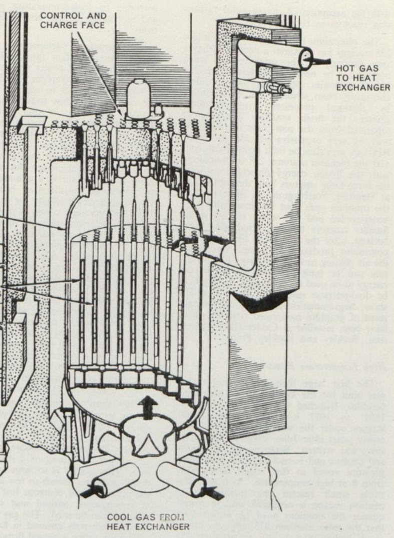


Fig. 7
Arrangement of nuclear reactor core inside pressure vessel.
(Jay: Calder Hall.)

with the exception of the so-called fast-fission reactors to be described later.

The plutonium formed after the uranium 238 nucleus has captured a neutron behaves very similarly to the uranium 235 when bombarded by neutrons, undergoing fission for all velocities. Plutonium which differs chemically from uranium can be separated by chemical processes from uranium, whereas the fissile uranium 235 may be separated from the non-fissile uranium 238 only by very expensive physical processes. Reactors may thus be built primarily to convert the plentiful uranium 238 to plutonium, with the fission energy discarded as were the three large reactors built during the war at Hanford, Washington. In these reactors the uranium rods clad in aluminium, were water-cooled and the water ran to waste. Smaller reactors built at Windscale, Cumberland, after the war, were likewise solely plutonium producers and were air-cooled, the air passing to waste. Alternatively, reactors can be built primarily to enable the energy to be used economically, or they may be dual-purpose reactors. Figures 6 and 7 show, diagrammatically, the general arrangement of graphite moderated reactors which have been installed at Calder Hall, Hunterston, Berkley and Kinkley Point.

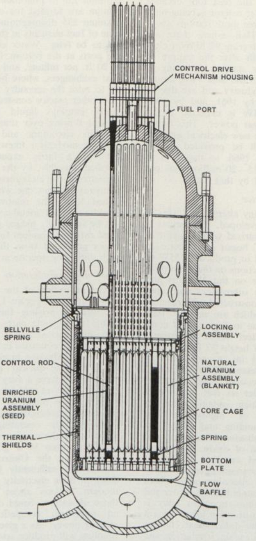
High Temperature Reactors

The first large high-temperature reactor was built for the United States submarine Nautilus launched on the 21st January, 1954: in 1957 it completed its 20,000 leagues under the sea without refuelling—ninety years after Jules Verne's imaginative story was written. Water is the moderator and coolant and is enclosed in a thick steel pressure vessel so that steam is available from it at high-temperature. As it is a relatively small reactor the probability of neutron escape is negligible and in consequence the uranium must be enriched so that the ratio uranium 235/uranium 238 is much higher than 1/140; as uranium 235 costs about $10 per gramme the fuel cost is high but the performance of the submarine probably justifies this. To prevent uranium from coming in contact with the water moderator, each piece of uranium is clad in a thin sheet of zirconium alloy, a metal not corroded by high-temperature pure water, and not having a high absorption for neutrons.

The second high-temperature reactor to be put into operation (June, 1954) was a 30 MW land-based power station in Russia. The moderator is graphite and the uranium is water-cooled, but to avoid a large high pressure vesel, hollow rods of uranium are encased separately in thin stainless steel tubing through which high pressure water at 1,500 lbs./ins.^{2} is pumped and raised to 480°F.—without boiling—by energy fission. The separate cooling of each element makes for a complicated design but reduces the water in the reactor to a minimum. This is an important consideration because water has an appreciable affinity for neutrons, and so its use represents a loss of neutrons available for the fission process; in addition the sudden removal of water would result in a rise of neutron population, and an increase of reactivity which might be of dangerous magnitude. The core of the reactor is small, a cylinder 5 ft. in diameter and 6 ft. high enclosed in a graphite reflector; so neutron loss is high both from escape, and from absorption in the coolant and stainless-steel tubes encasing the fuel elements: the fuel must be enriched by from 0.7% to 5% of uranium 235—with two consequences, a high cost of power generation and a low yield of plutonium, only three atoms of plutonium being produced for every ten atoms of uranium 235 undergoing fission.

The third successful high-temperature reactor to operate is the dual-purpose reactor at Calder Hall. The moderator is graphite and cooling is done by carbon dioxide gas at high-pressure contained in a steel pressure-vessel of 2 ins. wall thickness. This reactor is so large and constructional materials absorb so few neutrons that the proportion of neutrons lost is very low; in consequence natural and not enriched uranium can be used. The gas flowing over the uranium rods encased in finned magnesium-alloy tubes is passed through four heat exchanges, where steam is raised and used to drive two 23 MW turbines.

In Great Britain, owing to the coal shortage and the continued rapid increase in the demand for electricity—an approximate



Longitudinal section of the 240 MW high-pressure water-cooled water-moderated reactor at Shippingport, United States.

Figure 8

doubling in each of the past four decades —the gas-cooled power reactor is being built on a large scale. Three more stations about the size of Calder Hall—where there are now two reactors delivering 92 MW of electricity—are being built after the pattern of the first; four larger stations operating at higher pressures but of the same basic design are being built by industry and are due to produce 1,400 MW by 1961, and by 1965 a total of 6,000 MW is expected to be generated from nuclear power. This represents one third of the new electrical generating plant which will be provided in the United Kingdom by 1966, so that coal to the extent of about 15—20 million tons per annum will be saved by that date.

Other Types of Reactor

There are very many alternative forms of reactor now being developed. The largest in America is the pressurised water reactor at Shippingport, which began to operate in 1957 and is designed to produce 60 MW of electric power; it functions on the same principles as the reactor on the Nautilus and there are very many submarines and other naval vessels being constructed with reactors of this type, all of which use enriched fuel. It is shown in outline in Figure 8; it comprises a 250 ton steel vessel of internal diameter 9 ft. and of height 33 ft., having a wall thickness of 8½ ins. to withstand an operating internal pressure of 2,000 lbs./in.^{2} and made in two sections bolted together. The core is a cylinder six feet in diameter and six feet high which contains a number of sub-assemblies of highly enriched uranium 235, surrounding and being surrounded by more sub-assemblies of natural uranium in the form of oxide. Each sub-assembly of enriched uranium consists of many thin plates of uranium-zirconium alloy sandwiched between zirconium alloy plates welded to prevent contact between water and uranium. The uranium-zirconium alloy is used in preference to uranium metal since it does not undergo the dimensional changes which uranium exhibits under irradiation, and the sandwich cladding is not corroded by water at 550°F. As 60% of the power is generated in the natural uranium sub-assemblies and 40% in the enriched, there is unlike the Russian reactor, a large conversion of uranium 238 to plutonium: 8 atoms of plutonium are formed for every 10 atoms of uranium 235 disintegrating, and so the lifetime of fuel elements in the reactor is expected to be long. Water enters the vessel at the ports at the bottom, flows past the core at 20 ft. per minute, and then passes to the heat exchangers, where heat energy is given up to raise the secondry water to 500°F.

Another reactor constructed in the United States employs liquid sodium metal as coolant flowing over uranium rods encased in thin zirconium and over blocks of graphite moderator likewise encased in zirconium: a fairly expensive construction justified, possibly, by the avoidance of high pressures in the attainment of high operating temperatures, but one which also needs enriched fuel. The relative merits of these liquid or liquid metal-cooled reactors cannot be accurately judged yet and all of them need enriched uranium fuel, the cost of electricity generated from them is likely to be high until they operate at very large powers.

Economic Consideration

The projection of the world demand for power curve of Figure 1, together with the pressure on existing fuel supplies already being felt in some parts of the world, suggests that nuclear power will become essential to many countries in the next decade or two. Any reduction in electricity generating costs due to nuclear power will unfortunately not have a very great effect on the selling price of electricity to most consumers, since much of this price is composed of transmission and distribution costs.

While only operating experience can demonstrate the exact cost of electricity, the fact that, even in a geographically small country like the United Kingdom, many regions are sufficiently far from the coal-fields to have electricity generation costs in modern stations about 25% higher than those of stations based on coal-fields, gives an important competitive advantage to nuclear power. As a given weight of natural uranium will produce several thousand times as much electric power as the same weight of coal, transport costs of nuclear fuel will be negligible compared with the cost of transporting coal or of transmitting electric power over long distances.

The capital costs of building nuclear power stations will, of course, vary considerably between different countries, according to local conditions. In addition, where capital is scarce, interest rates, and where applicable, profit rates, will tend to be high. In such countries, the development of nuclear power, owing to the high proportion of capital charges to total costs, is likely to be much slower than in countries where capital is plentiful. In the long run, however, the negligible transport costs of nuclear fuel should offset the scarcity of capital and enable nuclear power to be brought to the under-developed regions of the world.

Capital Costs

In order to sustain a chain reaction at full power a natural uranium graphite-moderated reactor must contain many tons of expensive fuel and many hundreds of tons of graphite moderator. In addition, it must be surrounded by a radiation shield consisting mainly of thousands of tons of concrete. If the capital cost per kilowatt is to be kept down to a reasonable level, the rate of heat output of the reactor must be high. Using gas as a coolant, this can only be achieved economically if the gas is pressurised to increase its density and so keep down the pumping power necessary to remove a given amount of heat. Thus the reactor must be placed in a large and expensive pressure vessel, making the whole assembly even more costly, and necessitating a very high heat output if it is to be economical. Nuclear power stations are therefore, at first, bound to be large running into hundreds of megawatts of electrical capacity. The initial stations will only be suitable for large integrated electricity systems, unless in a smaller system the risk of temporary loss of a considerable portion of the total capacity of the system is accepted.

In spite of all that can be done to keep down the capital cost per kilowatt, it is considerably higher than that of a coal or fuel-oil fired station, depending to a considerable extent on the nature of the site; and as a measure of conservative finance it is considered wise to depreciate the station over a shorter period than usual. Costs have in fact been based on a life of fifteen years instead of the usual twenty-five years and upwards. In addition, a natural uranium power reactor contains a stock of fuel costing, per kilowatt of electrical capacity, about half the total capital cost per kilowatt of a coal-burning station; and this incurs interest charges in addition to the fuel running cost. As a result, at equal load factors the total capital charges per kilowatt-hour would be about three times as large as that of a conventional power station. In spite of the expected low running costs of nuclear power stations, the first ones will, therefore, only be competitive if these high capital charges per kilowatt are spread over as large a number of kilowatt-hours of electricity as possible, i.e. if they are operated throughout their life at an average load of possibly 80% of capacity. At this load factor, assuming actual capital charges of 9% on capital cost and 4% interest on the fuel stock, the total capital costs per kilowatt-hour will be about 0.4 pence.

The competitiveness of later natural uranium fuelled power stations will extend to lower load factors, but as the need to build new stations to meet peak loads will not rise while there is a pool of older but not worn-out coal-burning stations, and in any case nuclear stations will be insufficient to meet base loads for many years, the chances of their being operated at low load factors are remote.

As time goes by, the proportion of total generation costs due to capital charges may be expected to fall for three reasons. First, the capital cost per kilowatt may be expected to fall in the future as experience is gained, as specialised components are developed and especially as further development enables the heat rate of the reactor to be raised. If this last factor were allowed to have its full effect in reducing capital costs, the generating capacity of the power station would become even larger. Secondly, it is hoped that the actual life of these stations will be a good deal longer than has been allowed for in the conservative accounting adopted. This alone may reduce the capital cost per kilowatt-hour by one third. Thirdly, the value of the plutonium by-product, which is dealt with more fully later, may eventually fall when supplies become plentiful. This may not, however, be for very many years.

Fuel Costs

Until there has been more operating experience, the exact level of running costs in a natural uranium power station can only be estimated, since it will largely depend on the quantity of heat that can be extracted from each ton of fuel before it must be rejected. This irradiation level depends on the nuclear characteristics of the reactor and fuel and on the metallurgical characteristics of the fuel and cans under heat and irradiation. One of the most important aspects of the nuclear characteristics of the reactor and fuel is the conversion factor, i.e. the number of atoms of fissile material created for each fissile atom consumed. The closer this factor is to unity, the more heat can be extracted from the fuel before its contribution to the reactivity of the whole reactor becomes unacceptably low, i.e. before it would be in danger of stopping the nuclear reaction in much the same way as too small a proportion of coal to ash would put out a coal fire. The conversion of fertile uranium 238 to fissile plutonium enables the plutonium remaining in the fuel after radiation to be extracted by chemical or other means and sold giving a reduction in the net running costs in the power station.

The gross cost, per kilowatt-hour, of the nuclear fuel is expected to be about 0.3 pence, at first. This should be reduced, in due course, by measures to increase the number of kilowatt-hours extracted per pounds worth of fuel, and by a reduction in fuel fabrication costs. From this gross fuel cost must be deducted the value of the plutonium extracted from the spent fuel, allowance being made for the cost of fuel processing. The exact value of plutonium as a civil fuel is not yet known, but fuel processing costs are expected to fall rapidly in the near future, and it is thought that the net credit for fuel irradiated in a natural uranium reactor will reduce its net fuel cost to not much more than 0.2 pence per kilowatt-hour.

The extraction and disposal of radioactive fission products from irradiated fuel is a nuisance in a nuclear power system, but adds very little to total electricity generation costs. In due course these fission products may become valuable by-products whose market value offsets the cost of extracting them.

Operating costs, i.e. labour, maintenance and insurance costs, are expected to be about the same per kilowatt-hour as for conventional power stations. Total running costs, after allowing for the plutonium credit, are therefore expected to be about 0.3 pence per kilowatt-hour.

The sum of capital and running costs should therefore be about 0.7 pence per kilowatt-hour. An important point about these first stations is that their low running cost makes it most unlikely that they will ever become uneconomic to operate, since the chances of building, at any time during their life, a power station with total generation costs lower than the quoted figure are very small.

Possible Future Developments

It is clear that the development of nuclear power stations must be primarily concerned with a continuous reduction in the cost of electricity produced, while maintaining the highest possible standard of reliability of operation. As in an orthodox power station, the running costs of a nuclear station depend mainly on the capital cost and the fuel cost. Unlike, however, an orthodox station, in which the fuel cost depends almost entirely on the thermal efficiency of the station, the fuel cost of a nuclear station is related to several factors which greatly affect the design of the reactor. Before attempting to predict lines of future development in reactor design it is necessary to understand these factors, and possibly a good starting point is a consideration of the Calder Hall gas-cooled reactor of which there has been some operating experience.

In this reactor during fission of the uranium 235 nucleus, about 2.5 neutrons are emitted; one of these is required to cause another fission and thus carry on the chain reaction; 0.8 of the 1.5 surplus neutrons are absorbed in the uranium 238; hence for every atom of uranium 235 which undergoes fission, about 0.8 atoms of plutonium are formed, and thus during the life of the fuel in the pile there is a gradual net loss of fissile material. This effect is initially marked because in some ways one atom of plutonium is equivalent to more than one atom of uranium 235, but eventually the depletion of fissile material in the fuel is such that it must be removed from the reactor and replaced by fresh fuel, or the chain reaction can no longer continue. This occurs when each tonne of fuel has produced about 2,500 megawatt-days of heat; since the complete fissioning of one kilogram of uranium produces about 1,000 megawatt-days of heat about 2½ kilograms of the uranium in every tonne of fuel has been "burnt". Only one four hundredth part of the potential energy of the uranium has therefore been used. However, the spent fuel contains some plutonium and the remainder of the uranium 235 and uranium 238 is potentially valuable. Unfortunately the cost of extracting the plutonium is so high that the value of the spent fuel is very low, in this case only about a quarter of the cost of fresh fuel.

Suppose now that the reactor had a conversion ratio of unity. Roughly speaking the quantity of fissile material would remain constant and it should be theoretically possible to burn up all of the uranium without removing it from the reactor. In fact, of course, this would not be possible, since the fuel elements would become structurally useless after only a fraction of the theoretical possible burn-up, due to irradiation damage in the fuel. However, if the material difficulties could be overcome to the extent of achieved burn-ups of, say, 10,000 megawatt-days/tonne, it is clear that the fuel cost could be roughly quartered.

If enriched fuel is required in a reactor the initial fuel cost increases disproportionately. The cost of separating uranium 235 from uranium 238 as it occurs in natural uranium is very costly, and in consequence the price of the separated uranium 235 is very high. The quoted United States price is $10 per gramme; the English price for natural uranium is £20,000 per tonne, so that if no value is given to the uranium 238, the price of the uranium 235 in the natural uranium is less than £3 per gramme. Thus for a reactor requiring enriched fuel having twice as much uranium 235 in it as natural uranium, the cost of fresh fuel would be at least £90,000 per tonne. If a burn-up of about 2,500 megawatt-days per tonne were obtained the spent fuel would still be highly enriched; however, the high cost of processing would again depress its value, and the fuel costs of such a reactor would be much higher than one using natural uranium. Only by obtaining much higher burn-ups from each charge of fuel could the costs be made comparable. There are thus three requisites for low fuel costs:—

1. The use of fuel having the lowest possible proportion of fissile to fertile material.
2. Obtaining a high conversion ratio and making the fuel very resistant to irradiation damage so that a high degree of burn-up can be obtained.
3. Reducing the cost of processing fresh fuel.

One of the most important future developments is likely to be the use of liquid fuel. This will remove the need for fabricating the fuel elements required in solid-fuelled reactors, and will considerably simplify the processing of the spent fuel. At the same time it will remove the limitations on burn-up with solid-fuel elements due to irradiation damage. Reactors using liquid fuels will in fact probably employ a system of continuous fuel processing and it should be possible to remove fission products as they are formed so that there is no loss of neutrons by absorption in them; thus the conversion ratio will be improved.

A very important factor which has not yet been mentioned is the choice of fuel cycle. At present the only fissile material available is uranium 235, and the only fertile material uranium 238. When the first natural uranium reactors have been operating for some time, however, supplies of plutonium will be available. Another very important source of fuel is the metal thorium which on neutron bombardment is transmuted into the isotope uranium 233 which is fissile. Thus there will be an eventual choice of three fissile materials and two fertile ones.

Because of the absorption of neutrons in uranium 235 without causing fission the conversion ratio of a reactor using this fuel will always be less than unity. Uranium 233, however, if used in a thermal reactor, provides about 1.3 excess neutrons so that it should be possible to obtain a conversion ratio greater than unity. Plutonium makes possible the highest conversion ratio of all, since if used in a fast reactor, i.e. a reactor without a moderator (so that all the reactions in the core occur at high neutron energies), it provides an excess of about 1.67 neutrons. Thus a fast reactor using plutonium and uranium 238 as the fertile material should be capable of producing fresh plutonium considerably faster than it burns out.

Having established the basic requirements of reactor design, consideration will now be given to a few of the possible types of reactor which may best meet these requirements. Very many different types are technically feasible, but only four will be discussed, two being of the solid-fuel type and two the liquid fuel variety.

The Gas-cooled Thermal Reactor

This is of the Calder Hall type and is necessarily of large size since to function on natural Uranium a big graphite core is necessary. The fuel rating is low and in consequence the capital cost is high, about

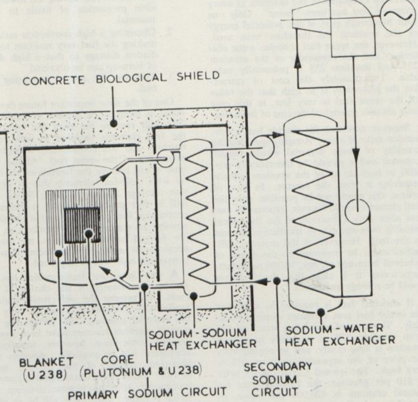


Fig. 9
Fast reactor.

twice as high as a modern coal-fire station. There is no doubt that in future designs it will be possible to increase considerably the heat output without any increase in size and without reducing the burn-up of fuel obtained. Further improvements will be possible when supplies of enriched fuel become available. It may become economic to operate the reactor on the uranium 233/thorium cycle if sufficiently high heat ratings can be obtained. Conversion ratios of about unity should be possible with the potential large increases in the burn-up which will probably be obtainable with much improved types of fuel element.

The Fast Reactor

The fast reactor operating on the plutonium/uranium 238 cycle has the greatest potential conversion ratio of any type; thus it should be capable of producing considerably more fissile material than it consumes. Because it has no moderator, the fuel must contain a very high proportion of fissile material, at least 30—40%; the fuel is thus very expensive and, to avoid an enormous capital investment in the initial charge of fuel, a very high heat rating is necessary. This can only be achieved by the use of a liquid metal coolant, probably sodium.

This type of reactor is shown diagrammatically in Figure 9. The core, consisting of fuel elements canned in stainless steel or niobium, is surrounded by a "blanket" of uranium 238 or natural uranium. This is necessary because, due to the very small size of the core, large numbers of neutrons escape from it. These are absorbed in the blanket where plutonium is formed. Both core and blanket are cooled by liquid sodium. The sodium becomes intensely radio active and the whole of the primary coolant system has to be shielded. Sodium also reacts violently with water and to obviate the possible risk of liberating quantities of highly radio-active sodium due to a leakage in the steam generator, a secondary sodium circuit is interposed between the primary sodium and the steam circuit. This secondary sodium does not become radioactive.

In order to get the very high heat ratings required, the fuel elements must be very thin in section to avoid impossibly high temperature being produced in them; at the same time they must be mechanically stable under the conditions of intense radiation and high temperatures which obtain in the core. Since only partial burn-up of each charge of fuel will be possible, the rate of fuel turn-over will be very high, and if the costs of processing the spent fuel and blanket cannot be made sufficiently low, the fuel cost will be too high to make the reactor an economic proposition, even though a surplus of fissile material is being produced. New and much cheaper methods of processing will have to be evolved before such a system becomes a profitable undertaking. A fast reactor is now being built at Dounreay and has a core about 2 ft. in diameter by 2 ft. high producing 60 MW of heat.

The Aqueous Homogeneous Reactor

In this type of reactor, shown in Figure 10, the fuel is uranium 233 in the form of a salt in solution in heavy water; the latter acting as a moderator and chosen because of its negligbly small absorption of neutrons. As in the fast reactor, the core is surrounded by a blanket of fertile material, in this case a suspension of thoria in heavy water.

The core and blanket are separated by a spherical vessel of zirconium alloy, chosen because of its low absorptive property; the core and blanket being both contained in a spherical pressure vessel. The core solution and the blanket suspension are pumped through separate heat exchangers where dry saturated steam is produced. A conversion ratio of at least unity should be possible, so that after initially charging with fissile material, only a feed of thoria will be required. This reactor should show very low fuel costs. It requires only a very small investment of fissile material and thus the fuel rating is high and the capital cost should be low.

In order to obtain reasonable temperatures in the steam cycle, high pressures are necessary; thus to obtain dry saturated steam at 600 p.s.i.g. the core and blanket circuits must be pressurised to 2,000 p.s.i.g. Hence the thermal efficiency of the steam cycle cannot be high, not more than 25%.

The chief problems in this type of reactor are those of corrosion of the containing circuits and fuel processing. If these can be solved then in spite of low thermal efficiency the running cost should prove to be low.

The Liquid Metal Fuelled Reactor

The operation of this type of reactor, shown diagrammatically in Figure 11, is very similar to the previous type. It uses, however, the unique property of bismuth for dissolving small quantities of uranium and it is possible to dissolve enough pure uranium 233 in liquid bismuth to produce a chain reaction. The core of the reactor is a block of graphite with holes through which the uranium-bismuth is pumped, and the core is separated from the blanket which is

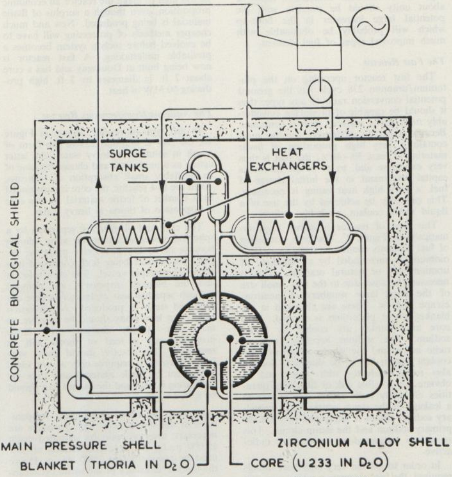


Figure 10 Aqueous Homogeneous reactor. (Blackburn: A.E.R.)

a slurry of thorium in bismuth, by a graphite vessel.

Like the Aqueous Homogeneous reactor, this reactor should be capable of a conversion ratio greater than unity. It has one considerable advantage over the Aqueous Homogeneous type, in that high temperatures can be obtained without the need of pressurising the circuit thus making high cycle efficiencies possible. For this reactor to become a practicable working proposition, much development work, chiefly on metals, will have to be done.

Nuclear Power in South Africa

In South Africa the costs of generation vary considerably depending upon the costs of fuel delivered at the power station, the total installed capacity of the station and the load factor. The Figures 12 and 13 show the comparison between the costs of operating existing South African power stations and the estimated costs of nuclear power stations. It must be emphasised, however, that the comparison shown is qualitative rather than quantitative in that a precise estimate of the cost of power genera-

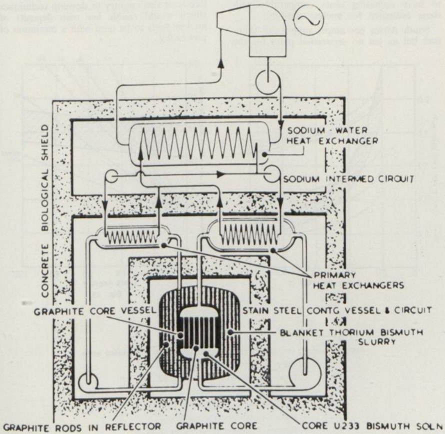


Figure 11 Liquid metal fuelled reactor. (Blackburn: A.E.R.)

tion in nuclear stations can only be given when the size of station, local conditions and the cost of fuel are specified. It will be noted from these curves that it would be uneconomic to establish nuclear power stations in South Africa except in the Cape Western, Cape Northern and the Border regions. The stations of the Rand and O.F.S. and the Eastern Transvaal Undertakings which are sited close to the coal-fields have such low operating costs that, from an economic point of view, they would be immune from competition from nuclear power stations. The stations of the Natal Undertakings appear to have operating costs comparable with those estimated for nuclear stations.

South Africa has ample supplies of uranium but as yet no separation plant for the production of uranium 235 has been established. The use of natural uranium as a nuclear fuel is of particular interest to this country. The South African uranium deposits are largely uraninite, which is mainly crystalline uranium oxide containing variable amounts of thorium and rare earths. For various reasons uranium and thorium used in existing reactors are required mainly in the metallic form, although the possible use of oxides, carbides and other suitable compounds is feasible. The Canadian reactor NPD now being built will use urania as fuel. It would appear that it is in the interests of this country to develop techniques which would enable her own deposits of nuclear fuels to be used with a minimum of processing.

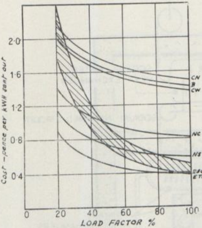


Fig. 12

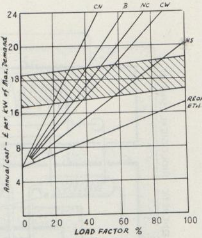


Fig. 13.

Figure 12 and 13

Approximate nuclear power station costs lie within the shaded areas.

CW – Cape Western Undertaking E.S.C.
CN – Cape Northern Undertaking E.S.C.
B – Border Undertaking E.S.C.
NS – Natal Southern Undertaking E.S.C.
NC – Natal Central Undertaking E.S.C.
ETvl – Eastern Transvaal Undertaking E.S.C.
R&OFS – Rand and Orange Free State Undertaking E.S.C.

Electrical Protection of Distribution Systems

With Special Reference to the Durban Corporation Electrical System

By J. MICHEL-SMITH

Introduction:

Protection of electrical apparatus is largely a matter of economics, the more complex and costly forms being used to protect feeders and apparatus handling large blocks of power. However, generally, the more complex a protection scheme is, the less reliable it is over a period of time and in order to justify its installation, regular maintenance and testing must be carried out.

Generally, protection has two main objects; one is to protect current carrying conductors of feeders and apparatus against thermal damage resulting from overcurrent conditions and the other is to protect insulation against rupture or puncture by overvoltage.

There are two principal causes of overcurrent. They are overload (load impedance too low) and short circuit. Short circuits may exist either to earth (in the case of systems having an earthed neutral or star point) or to an adjacent current carrying conductor.

On the Durban Corporation System, all overcurrent protection of the H.T. and L.T. systems is used with the express object of avoiding thermal damage due to short circuits as previously defined and not overload. The most reliable means of preventing overload is to obtain current readings throughout the system at least once annually, preferably at time of peak load on all H.T. and L.T. feeders and transformers. Maximum reading ammeters are not as yet used to any extent by the Durban Corporation.

Overvoltage protection on the Durban Corporation System is effected by the usual means, i.e. lightning arrestors or more correctly surge diverters and/or spark gaps situated at appropriate points on the system.

The main items of electrical plant on a distribution system requiring protection are overhead lines, underground cables, transformers and substation busbars.

The four main types of protection at present used by the Durban Corporation comprise overcurrent, earth leakage current, current balance and Buchholz and winding temperature protection for transformers.

Other forms of extra high voltage feeder protection (not at present used by the Durban Corporation) are distance protection with impedance and mho relays (with or without carrier relaying between feeder ends), directional earth leakage and phase comparison protection combined with negative phase sequence detection, both forms being combined with feeder end to end relaying by means of H.F. carrier.

Computation of fault currents on the Durban Corporation System:

In computing the short circuit currents for faults at any point on the System, only two types of fault are considered. These are balanced three phase faults for overcurrent protection and single phase to earth faults for earth leakage protection. Faults of the latter type result in maximum earth currents and consequently maximum currents in C.T. secondary residual circuits. These fault currents are also easier to calculate by means of symmetrical component analysis than those resulting from double phase to ground faults. Average earth resistivities are also assumed.

Figure 1 is a sketch showing only the interconnected portions of the Electricity Supply Commission and the Durban Corporation systems which would affect the fault levels at the three major points of supply to the Durban Corporation, i.e. Congella Power Station, Umgeni Power

Station and Springfield substation. All other portions of the Durban Corporation network are radial or dead end feeders radiating from all three of these major points of supply.

Recently, however, since the commissioning of 132 K.V. at Coedmore by Escom, the Durban Corporation interconnectors via Berea Park and Alice Street substations have been opened at the points shown in Figure 1 with a corresponding reduction in fault level at the points of supply to the Durban Corporation.

There are only two earthing points or sources of earth or zero sequence currents on the System. The first consists of a solidly earthed neutral of the 33/6.6 K.V. coupling transformer at Congella Power Station (referring to Figure 1). The second consist of a neutral of one of the 33 K.V. earthing compensators at Springfield substation, earthed via a 12 ohm. liquid resistor. This gives a substantial reduction in earth fault current, resulting in better co-ordination of the earth leakage protection on feeders radiating from this substation.

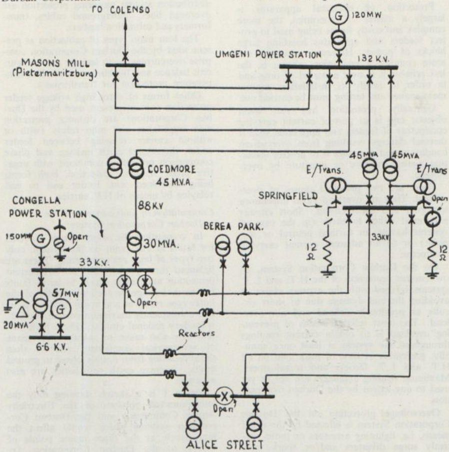


Fig. 1. Interconnected portion of the Escom and Durban Corporation Systems.

At Congella Power Station, on occasions in the past, 33 K.V. generator earthed neutrals have been used but have recently resulted in third harmonics resonating with certain critical values of cable star capacitance and inductance, causing maloperation of earth leakage protection on the Durban Corporation feeders from this power station. This difficulty was the cause of an investigation, the findings of which formed the basis of a short paper presented at an S.A.I.E.E. meeting held recently here in Durban.

However, since this difficulty arose, generator neutrals have not been earthed at Congella.

Protection of Underground Cables:

On the Durban Corporation System the incidence of underground cable faults (including mechanical damage caused by picks, bulldozers, etc.) is given for the three principal classes of voltage viz. 33 K.V., E.H.T. (11 K.V. and 6.6 K.V.) and L.T. (500 volt, 3 phase and 380 volt, 3 phase).

Table 1	33 K.V.	E.H.T.	L.T.
Electrical failure	8	72	19
Failure due to mechanical damage	2	50	12
Average route miles over period specified	102	571	275
Failure rate (electrical only)	3.36	5.42	2.97

Failures per 100 route miles per year. (Referring to Table 1.)

The faults as tabulated, occurred from 1st April 1957 to 31st July, 1959, i.e. over a period of 28 months.

The above table indicates that out of a total of 163 faults, 64 or 39% were due to mechanical damage, which in my estimation represents a rather poor record of carelessness on the part of local authorities and earth moving contractors.

It is interesting to note that the electrical failure rate of 5.42 faults per 100 route miles per year compares very favourably with the accepted average failure of 6 faults per 100 route miles per year for 11 K.V. underground cables in Great Britain.

These electrical failures on the Durban Corporation System include a small percentage due to earth movement and subsidence and include failure in the cable run, at points and failures of terminal boxes.

The protection of underground cables is in actual fact the protection of a network, the component parts of which will be dealt with in logical order starting from the source.

One of the problems confronting the protection of the 33 K.V. and E.H.T. underground cable system is the limited I.D.M.T. relay time settings for overcurrent and earth leakage provided by Escom on the main 33 K.V. feeders at the three present major points of supply.

This problem is much greater on the North and South Coast overhead line feeders due to the lack of unit protection and the number of 33 K.V. substation en route.

The majority of the main 33 K.V. feeders, however, are terminated in 33/11 or 6.6 K.V. transformer as shown in Fig. 2.

Figure 2 shows a typical portion of the Durban Corporation 6.6 K.V. and 33 K.V. underground cable network, the switching substations actually having several distributor cables of 0.1 square inch cross section radiating out to other similar substations with kiosk substations en route as shown. Most of the 6.6 K.V. network is run as radial feeds with the interconnecting 0.25 square inch cable (as shown) serving only as a standby feeder in the case of failure of one of the main 0.25 square inch feeders.

However, loading on the E.H.T. network generally is such that should this sort of failure occur, a certain amount of distributor cable load would have to be shifted before supply could be restored. When the total loading on the two 0.25 square inch main feeder cables (referring again to Figure 2) is within the capacity of one such cable, all three substations can be run with the ring closed at O.C.B. "G". Also, this can only be done when unit protection is provided on all three 0.25 square inch cables, thus ensuring complete and instantaneous clearance of a fault without interruption of supply.

The starting point for protection co-ordination, of course, is the overcurrent setting of the I.D.M.T. relay on O.C.B. "A" in Fig. 2 which, to quote a typical case is 100% current plug and 0.4 time multiplier for a C.T. ratio of 300/5.

As far as earth leakage protection is concerned, the current and time settings at O.C.B. "A" are set by Escom but in fact can be as light as possible since these are not affected by earth faults beyond the 15 M.V.A. transformers.

Unit protection is also installed in some cases to protect the 33 K.V. cable and transformer jointly. This consist of Overall Translay in the case of the older 33/6.6 K.V. substations.

O.C.B. "B" in Fig. 2 is fitted with reverse power protection only, about which more will be said later.

In all cases on the Durban Corporation system, the overcurrent relay current plug settings are such as to start relay operation on a primary current some 30% above the

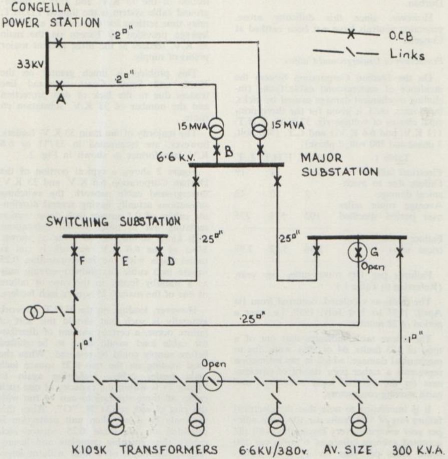


Fig. 2.

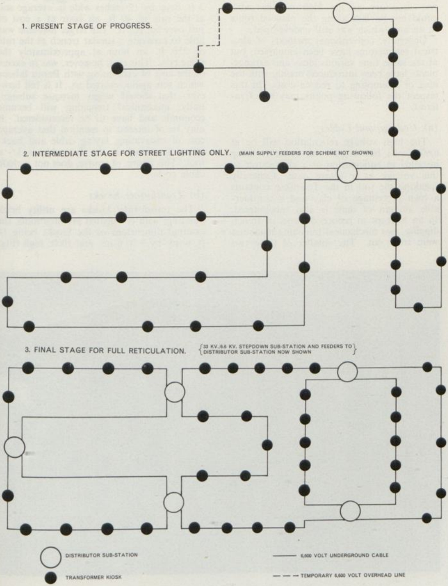


FIG. 2. SCHEMATIC LAYOUTS OF 6600 VOLT SYSTEM.

Fig. 2.

provide certain kiosks with a supply. This was necessary as the high voltage cable could not be laid along the planned route in an area which was still undeveloped.

Generally, conventional methods of electrical reticulation have been employed, but at the same time various ideas and arrangements have been introduced mainly with the idea of attempting to reduce costs. In this respect the following points may be of interest.

(a) *Underground Cables*

The high voltage reticulation will be at 6,600 volts but 11,000 volt cable is being installed in anticipation of a changeover to this voltage at a future date. Generally speaking the soil in the Township contains a high percentage of clay and a considerable amount of shale is also encountered. In an attempt to reduce the cost of trench digging, two mechanical trenching machines were tried out. The smaller of these two machines was capable of digging a trench 3 ft. deep by 12 inches wide in average soil at the rate of 40 ft. an hour at a cost of just over 6d. per ft. The larger machine was able to excavate a similar trench at the rate of 250 ft. an hour at approximately the same cost. This cost, however, was in excess of the cost of excavating with Bantu labour which was again resorted to. It is felt however, that should wages increase substantially, mechanical trenching will become economic and have to be reconsidered. It may be of interest to mention that average cost of excavating, laying cable and backfilling the trench in the Township is 3/- a foot. This figure, of course, does not include cable costs.

(b) *Transformer Kiosks*

The transformer kiosks are utility brick buildings with corrugated asbestos roofs, the external dimensions of the kiosks being 14 ft. 6 ins. by 9 ft. 6 ins. and 10 ft. high (Fig.

Fig. 3.

3 Transformer Kiosk). The buildings are being constructed with Bantu labour under European supervision at a cost of £200 each. They provide adequate accommodation for a 300 K.V.A. transformer, a 3 way ring main panel and low voltage distribution boards for L.V. and street lighting supplies, the ring main panels being manufactured in the Department's workshops. The panels are fitted with three airbreak switches and the overall cost is considerably less than that of the more usual type of panel fitted with oil immersed links.

(c) *Low Voltage Reticulation*
Overhead Mains:

As already mentioned, street lighting throughout the Township is being supplied from single phase overhead mains. Up to the present, supplies of electricity have only been given to public and administrative buildings but as the intention is to ultimately fully reticulate the Township with a three phase, four wire overhead mains system, the layout of the street light mains has been planned with this object in view.

The usual difficulties experienced in laying out the overhead mains are familiar to all engaged in this type of work. The tendency to design townships with curved streets, splayed corners and irregular stand boundaries prevails with the usual resultant difficulties.

In the interests of economy, connection between two lines crossing at road intersections with splayed corners is being made by vertical mid-span jumpers and in isolated cases where this is not possible, an underground loop cable is used to connect the two lines together.

Creosoted wood poles with copper conductors are being used throughout. 30 ft. poles are generally used but where ground has been filled for road construction it has been necessary in certain cases, to plant poles at the foot of the bank and in order to maintain adequate ground clearance, 35 ft. poles have been employed.

(Fig. 4 is a photograph of a typical road in kwaMashu showing the type of overhead mains construction.

Service Connections

Domestic suplies of electricity have not yet been provided in the family housing areas. The type of service connection to be used is still under consideration although underground cable services are generally favoured, and are at present being provided to shops and various other public buildings.

In the Hostel Area, all hostel buildings are being supplied by a completely underground low voltage reticulation system. In desgning this reticulation, it was necessary to make certain assumptions regarding electrical load and diversity. The Hostel Area consists of 32 and 16 bed bungalow type buildings. 300 K.V.A. transformers in brick kiosks have been strategically placed to supply buildings containing approximately 3,000 beds. Five main .1 sq. in. L.V. feeder cables radiate from each kiosk. The feeders are graded, depending upon voltage conditions, along their length down to .06 sq. in., .04 sq. in. and .0225 sq. in. with single phase .0225 sq. in. service cable T-offs to the individual buildings. A system of

Fig. 4.

looping from one building to the next is being adopted where this will mean a saving in both labour and cable.

In order to facilitate looping, a special type cast iron distribution box has been designed (Fig. 5). The box, which is mounted outside the building, has two compartments. The upper compartment contains the normal distribution board for the building and is fitted with miniature circuit breakers. The lower compartment can be fitted with one or two cable entry glands as required, and the loop cable joint is made in this compartment. The box is completely weatherproof, being fitted with a sliding door which cannot be inadvertently left in the open position. Other adventages of the box are its rugged construction and non-rusting properties. The cable connections to the box shown in Fig. 5 had not been made at the time of taking the photograph.

Up to the present, paper insulated lead covered armoured cables have been used

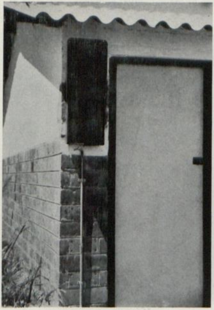


Fig. 5.

for the L.V. reticulation in the hostel area, but it is the intention to make use of plastic insulated cables to a greater or lesser extent depending on the economic aspect of their use. The new continuous current rating of plastic insulated cables has eliminated one disadvantage over the paper insulated cables. It is doubtful however, whether the use of plastic insulated cables in this particular type of reticulation will effect much in the way of a saving owing to the high cost of the gland fittings. This matter is being investigated and in any event, the saving in actual labour with plastic cables may be a deciding factor in their favour.

A further saving in cable costs could possibly be effected by adopting a multiple earthing system using the outer sheath and armouring as the fourth core in a concentric cable.

(d) *Street Lighting*

A simple type of cast iron street light bracket fitted with a plastic or fibre glass reflector and complete with all other fittings at a total cost of £2 5s. each is being installed throughout the Township (Fig. 6). The brackets are fitted with a 75 watt incandescent lamp and mounted at a height of 20 ft. above road level. It has not been found necessary to provide wire guards over lamps to protect them from stone throwing and from experience it has been found that this type of damage only occurs in non-built up areas.

Other types of street lighting such as fluorescent, sodium or mercury vapour are not considered suitable, mainly from a cost point of view but it is possible that one of these more effective types of lighting will be employed in the main roads, at a later date.

Street lighting in the Township is controlled by Solar Dial type electric spring guided time switches installed in the main substations. A contractor is energised by the time switch which in turn energises the street light circuits. Several circuits, each protected with a miniature circuit breaker, radiate out from each supply point. A cascade system is used to energise the contactors at each transformer kiosk, all control equipment being installed in the substations or kiosks.

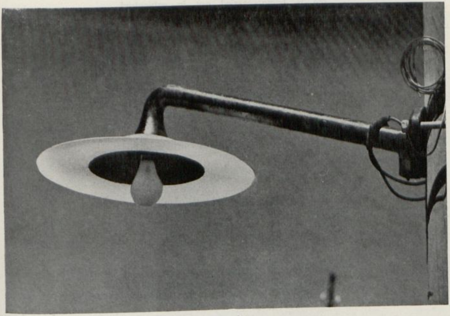


Fig. 6.

(e) *Internal Wiring of Residential Building*

The type of wiring suitable for residences in Bantu Townships is generally dictated by the conditions encountered and the necessity to keep costs as low as possible. For example, with open ceilings, cleat wiring is not considered advisable owing to possible interference by the occupants. Black conduit is also considered to be unsuitable due to corrosion caused by limewashed walls. Pre-fabricated wiring harnesses have been tried out but subsequent maintenance difficulties have tended to preclude the use of this method. As a result of past experience, therefore, the policy of wiring in galvanised conduit has been adopted. It is also felt that wood mounting blocks should not be used as these are likely to harbour vermin, and deteriorate rapidly with rough treatment.

The layout of the wiring installation and the number of points provided, will of course, affect the cost. In this respect, it is considered essential to provide suitable socket outlets, otherwise the use of multiway adaptors and makeshift connections to lampholders increases subsequent maintenance costs, and in any event, if the Bantu is to be encouraged to use electrical appliances, the proper facilities must be provided. The practice of fitting miniature circuit breakers on distribution boards has been generally adopted as these have the advantage of limiting circuit loading and preventing the insertion of fencing wire and hairpins as "fuses."

At Chesterville in 1955, 1,265 houses were wired using galvanised screwed conduit at a cost of £23 per house, this being a contract price. Each house consisted of 2 bedrooms, a kitchen and diningroom with one light per room and two socket outlets. At kwaMashu, a bungalow type hostel building with 16 living rooms providing accommodation for 32 single persons and complete with ablution and laundry facilities, is at present being wire under contract at an average cost of £110 per building. The wiring is being carried out in galvanised screwed conduit and 21 lighting points and 8 socket outlets are being provided per building.

Conclusion

The problems, both financial and technical, that are being encountered in providing electricity supplies at kwaMashu are common to all Electricity Supply Authorities and although there are several approaches to these matters, it is hoped that this paper will serve a useful purpose in making available a general picture of the position at kwaMashu.

The actual methods of reticulation are generally speaking, conventional, but again it is hoped that the descriptions of this aspect of the electrification have proved of interest to those persons connected with this type of work.

In conclusion I would like to express my thanks to the City Electrical Engineer, Durban, for having been given the opportunity of presenting this paper to the Association, and also my thanks to my colleagues in the Durban Electricity Department for their assistance in its preparation.

Annual Report of the Secretaries and Accounts

To the President and Members of the Association.

Mr. President, Gentlemen,

It gives me great pleasure to submit to to you the Annual Report of your Association together with the Revenue and Expenditure Account and Balance Sheet for the financial year ended 29th February, 1960.

Obituary:

I deeply regret having to formally record the passing of the following Members not previously mentioned in the Annual Report. They were referred to by the President at the 33rd Convention:

Mr. E. Poole originally of Durban was a foundation member of the Association and first acted as Secretary Treasurer in 1917. His association with the A.M.E.U. lasted for 15 years.

Mr. Coulthard, a former Member of the Association, also passed away prior to the 33rd Convention.

Thirty-third Convention:

The 33rd Convention of the Association was held in Johannesburg from Tuesday, 12th May, to Friday, 15th May, 1959. Delegates were welcomed to the Convention by His Worship the Acting Mayor of Johannesburg, Councilor A. Gorshel.

The Convention was formally opened by Mr. R. Gettliffe, President of the South African Institute of Electrical Engineers, and a record total of 570 members, delegates, representatives, officials, visitors and ladies attended.

On behalf of the President, Members of the Association and all others who attended the 33rd Convention held at the Cranbrooke Hotel, Johannesburg, it is my pleasure to place on record appreciation to His Worship the Mayor and City Councillors of Johannesburg for the hospitality extended to those attending the Convention as well as for the assistance rendered in connection therewith.

It is indeed a pleasure to have the opportunity of recording appreciation for the work of the President. In recording the proposal of Mr. Kane as President, Councillor Ross-Spencer referred to his outstanding ability to keep calm and unruffled irrespective of problems and irritations. It is this quality coupled with an inimitable sense of humour and an ever willingness to do a job of work that contributed so largely to the success of the Johannesburg Convention in 1959. To Mr. and Mrs. Kane I extend the sincere thanks of all.

The first paper presented at the Convention was "Nuclear Power" by Mr. A. E. Powell. This paper introducing as it did for the first time discussion at a Convention on a subject which will in the more or less distant future be one for ever increasing consideration and study by those responsible for the provision of electricity supplies was unanimously accepted as an outstanding contribution to the Proceedings of the Association. The remaining papers were "The Supply of Electricity to Native Townships" by Mr. G. Masson and "The Development of a Method of Reticulation for the Johannesburg Township of Montgomery Park" by Mr. W. Barnard, B.Sc.(Eng.), A.M.I.E.E., A.M.(S.A.)I.E.E. Mr. Masson's paper, dealing as it did with an aspect of the development of Undertakings which is receiving particular attention at the present time, aroused a great deal of interest and as a result it was decided that the programme of the 34th Convention should include a symposium devoted to the further discussion of various aspects of Electricity Supply to Native Townships. Mr. Barnard's paper evoked much informative discussion on reticulation problems.

Members' Forum maintained its usual high standard and provided many members with an opportunity for discussion on a wide variety of problems.

The Convention unanimously accepted the invitation to hold the 34th Convention in Durban.

Membership:

The following new members were elected during the year ended 29th February, 1960:

Councillor Members:

- Peri-Urban Areas Health Board.
- Lydenburg Municipality.
- Stilfontein Health Committee.
- Orkney Health Committee.
- Tarkastad Municipality.
- Hermanus Municipality.
- Stutterheim Municipality.
- Kenhardt Municipality.

Engineer Members:

- A Billington Eales (Stutterheim).
- H. A. Durr (Peri-Urban Areas Health Board).
- H. A. McIntyre (Assistant Electrical Engineer, Vereeniging).
- R. K. Jooste (Oudtshoorn).
- B. G. van Heerden (Heidelberg).
- P. J. Botes (Assistant Electrical Engineer, Roodepoort).
- G. R. Beard (Grahamstown).
- E. de C. Pretorius (Assistant Electrical Engineer, Klerksdorp).
- H. J. Koeslag (Riversdale).
- H. Zausmer (Hermanus).

Associates:

- M. J. Ross (Brandfort).
- B. F. Carpenter (Middelburg, Tvl.).
- J. H. Bester (Ventersdorp).
- J. H. Jordaan (Vryburg).
- G. T. van Wyk Schoombee (Lydenburg).
- J. S. Lochner (Ladybrand).
- C. P. Laas (Kenhardt).

Associate Members:

- A. B. Cowen, Chairman and Chief Engineer, Southern Rhodesia Electricity Commission.
- G. R. Peterson, Deputy Chief Executive, Federal Power Board of Rhodesia and Nyasaland.

Affiliate Members:

- The Morgen Crucible Co. (S.A.) (Pty.) Ltd.
- The English Electric Co. (C.A.) (Pvt.) Ltd.
- N.V. Nederlandsche Kabelfabrieken, Ltd.
- African Lamps (Pty.) Ltd.

	1958/59	1959/60
Councillor Members	112	120
Engineer Members	109	119
Honorary Members	13	12
Associate Members	31	30
Associates	1	9
Technical Associates	1	–
Affliates	87	90

Finance:

The Income and Expenditure Account for the year under review and the Balance Sheet as at the 29th February, 1960, which are submitted to you herewith do not, I feel, call for any particular comment. The excess of Income over Expenditure of £152 19s. 1d. is not unsatisfactory when it is considered that the Presidential chain has been written off, heavier than normal printing and stationery charges were incurred due in part to the printing of the Constitution, and a reduced profit was made on the Proceedings due principally to a reduction in advertising, resultant upon various amalgamations. It will be noted that the accumulated funds of the Association now total £4,744 17s. 2d.

Messrs. Kane and Downey continued to be members of the Finance Committee during the year under review and I again thank them sincerely for their assistance to the Association in this capacity. The continued support of the advertisers in the Proceedings is acknowledged with appreciation.

General:

The Regional Branches of the Association in the Eastern Cape and Natal are developing and will clearly play an increasingly important part in the work of the Association.

Johannesburg acted this year as host for the Mid-year Executive Meeting and on behalf of all we convey thanks for the hospitality extended on the occasion of the meeting.

between successive reclosures is about one second to allow for de-ionization of the air at the site of flashover, burning away of bark or twigs etc., from the line before re-energising.

These auto-reclosers also have the advantage of automatically resetting for a full cycle of operations provided lock-out does not occur the actual reclosing energy being obtained from the large current solenoids in each phase. In the smaller current ratings, the thermal limitations of this solenoid dictates the maximum short circuit current that can be handled and does, in many cases, preclude the use of an auto-recloser of a particular rating in situations where the fault current is high.

The Durban Corporation have noticed quite a decrease in outages apparently mainly due to the rapid clearing of transient faults before insulation becomes thermally damaged or conductors parted.

In Britain, the tests of these same auto-reclosers at 11 K.V. by the B.E.A. over a long period under all the conditions met with in that country and using carbon tetra chloride filled fuses for sectionalising, apparently gave very gratifying results.

Results of these tests appeared in an extract from the Electrical Review of 28th September, 1956, by R. Mallett and N. C. Heathcock, and would indicate that about 80% of all the 11 K.V. overhead line faults experienced were of a transient nature and were cleared successfully by the auto-reclosers.

The tests also showed that the greatest single cause of 11 K.V. transient and persistent faults on overhead lines was lightning, which is surprising considering the lower isokeraunic level in Britain compared with that in Durban and districts. Locally, the most troublesome factor affecting E.H.T. overhead lines is bark, branches and trees being blown onto the line by wind, which is very prevalent here.

Lightning is known to account for a small percentage of the failures on the Durban Corporation system although it is often difficult to ascertain during a storm whether lightning surges or vegetation being blown onto the line actually cause the transient faults.

In order to install an auto-recloser of the type already described, the first step is to ascertain the maximum line load and the

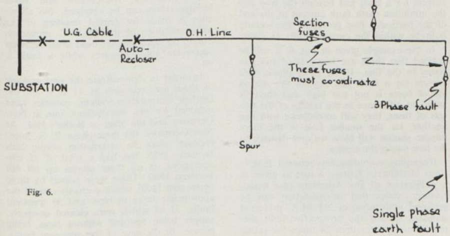


Fig. 6.

three-phase fault level at the start of the line which position would be the logical site for the recloser.

In computing the fault current at this point, the impedance of the recloser trip coil must be included and if the fault level exceeds the rating of the auto-recloser, the latter can be repositioned further along the line if the fall off of fault level is sufficient.

The line being fed from the auto-recloser is then divided up into sections as shown in Fig. 6.

A set of fuses can be inserted half way along a long line and all spurs of any length should always be fused at the tee-off points as shown.

All these "line fuses" should be of the slow burning type, the ratings being determined from tables supplied by the makers of the auto-recloser. It will be found from these tables that a fuse of a particular rating will co-ordinate with an auto-recloser of a particular rating, between two current limits. Beyond the upper current limit, the fuse melts before the first delayed trip portion of the auto-recloser cycle is reached and below the lower current limit, the auto-recloser will complete the full cycle to lock-out without belowing the fuse. Thus, correct co-ordination of fuses with an auto-recloser of a particular rating will be assured providing the maximum three phase fault current for a fault just beyond the fuse and the minimum earth fault current at the end of the particular fuse protected line section, both be within the current limits as given.

In the example given in Fig. 6, it will be noticed that there are two sets of fuses in series in the line. If the three phase fault current for a fault just beyond the second set of fuses is not too high and there is sufficient difference in the ratings of the two sets of fuses, they will co-ordinate with one another, i.e. the smaller fuse in the more remote section will blow without damage to the fuse nearer the source.

Regarding co-ordination between E.H.T. fuses of different ratings, a rule as given in a publication of any American fuse manufacturer, states that co-ordination can be achieved with adjacent N.E.M.A. preferred standard sizes if the prospective fault current is not greater than 24 times the rating of the smaller fuse for slow burning fuses and not greater than 13 times the rating of the smaller fuse for fast burning fuses.

The schedule of sizes used by the Durban Corporation is the N.E.M.A. preferred standard (except for the 5A and 8A sizes) as stated before, which standards appear to have been adopted by certain British manufacturers (i.e. those whose tenders would be acceptable to the Durban Corporation.)

The next problem which faced the Durban Corporation with auto-reclosers was to make them co-ordinate with the substation protection.

We found that, when using I.D.M.T. overcurrent and/or earth leakage at the substation, for a certain primary current setting of the I.D.M.T. overcurrent relay, the time multiplier setting had to be sufficient to cover the cumulative tripping time for a complete cycle of the auto-recloser taken for several fault currents up to the maximum possible, i.e. for a fault just beyond the auto-recloser. This is necessary as the time/current characteristic curve for the standard I.D.M.T. 3/10 relay and auto-recloser are not the same. The two curves for any particular case are superimposed on graph paper so that at all points the characteristic of the substation protection lies above that of the auto-recloser. In this way, satisfactory time multiplier settings for the substation I.D.M.T. overcurrent and earth leakage relays can be obtained. No allowance is made for partial resetting of the induction discs of the I.D.M.T. protection during the auto-recloser dead times between successive auto-reclosures while a fault is on.

In order to demonstrate the performance of these auto-reclosers at 11 K.V. on the Durban Corporation system, statistics were obtained for two installations, one at New Germany and the other at Botha's Hill. At New Germany, the three-phase 50 A. auto-recloser, since its installation about 26th January, 1959, has had a total of 75 trip operations on all three phases up till 4th January, 1960. These were caused by three permanent faults which correctly caused the appropriate fuses to blow and 36 transient faults, 31 of which were cleared correctly, supply being restored without fuses being blown. In the case of five transient faults, fuses were blown before the first quick trip operation of the recloser. One of these incorrect operations was due to a wrong sized fuse, another was due to excessive fault current during abnormal switching conditions at the substation and the causes of three were unknown.

Therefore, if this auto-recloser had not been installed, there would have been 39 interruptions to the entire overhead line instead of only three interruptions to about half this circuit at any one time; a remarkable improvement in continuity of an essential service for a capital outlay of about £500.

In the case of the 3 phase auto-recloser installed at Botha's Hill, the record is also quite impressive.

From 21st March, 1958 to 31st December, 1959, i.e. a period of 22 months, there were 3 permanent faults which caused fuses to blow correctly, and approximately 113 transient faults, where fuses were quite correctly not blown. The cause of one incorrect operation is unknown.

Unfortunately the number of transient faults as recorded is only approximate since the number of recorded auto-recloser operations includes manual operations for switching purposes. Prior to the installation of this auto-recloser, this overhead line was protected with an auto-reclosing O.C.B. situated in Hillcrest substation. Thus it is difficult to assess the improvement in this particular case.

Apart from pole mounted auto-reclosers for overhead lines, the Durban Corporation uses reclosing O.C.B.'s in substations at E.H.T. and 33 K.V. The protection in these cases consists of the usual I.D.M.T. overcurrent and earth leakage relays and autoreclosing is accomplished by a heavy spring, charged by a motor. In one or two cases, reclosing is effected with a d.c. solenoid supplied from a selenium rectifier. However, tripping is relatively slow and many transient faults develop into permanent faults by shattering insulation or burning away conductors.

The matter of earth fault currents that are too light to operate either I.D.M.T. earth leakage protection at the substation or the auto-recloser feeding an E.H.T. overhead line, have given us of the Durban Corporation a problem for which there seems no solution at present.

This condition sometimes arises when earth wires (which are nearly always used with E.H.T. overhead lines) are stolen and has also occurred at E.H.T. voltages and 33 K.V. when one phase of the overhead line has parted at an insulator, the load side of the parted line falling to ground only.

However, I have no doubt that in the fullness of time, this problem will be solved by the use of transistor or magnetic amplifiers to magnify and detect primary earth fault currents of only a few amps.

One of the difficulties in accurately determining the incidence and possible cause of time faults on the Durban Corporation system is the lack of suitable instrumentation of the recording type connected to the line.

A very successful fault recorder of reasonable cost, known as a "Perturbograph" is on the market but so far has not been used by the Durban Corporation.

This instrument which avoids the use of cumbersome photographic processes, consists of a current operated pen for each of the three phases, recording traces continuously on an inked drum. This record is continuously erased after each revolution of the drum so that under no fault conditions, no recording chart is used. However, when a fault occurs, a current solenoid removes the eraser and engages the recording drum with the paper chart for several seconds after the inception of fault. Thus, traces for three phases are obtained starting a second or two before the occurrence of the fault, indicating how it spreads to other phases and the magnitude of fault current in each phase all up to and beyond the time of clearance of the fault.

Busbar Zone Protection:

At present, the Durban Corporation has only one installation of this sort in operation and that is on the 33 K.V. busbars in Alice Street substation.

There, a single set of busbars is split into two sections by a bus-section breaker.

Currents are summated for all breakers on each of the two sections of the busbars, the current in the bus-section breaker only being common to both summation circuits.

If a busbar fault occurs in one section, an out of balance current is set up in the summation circuit on that section, tripping all breakers associated with that side including the bus-section breaker.

Tripping is instantaneous and in addition, the condenser sections in the busbar insulation are connected to sensitive leakage indicators which give an alarm only, in the event of low current leakage.

Overvoltage Protection:

On the Durban Corporation System and most other electrical systems in South Africa, the majority of overhead line insulation breakdowns due to overvoltage are caused by lightning charging the overhead conductors either by direct striking or in the majority of cases, the steep magnetic flux wavepoint originating from the heavy stroke current of a near flash cutting the overhead conductors over a distance of many hundreds of yards.

This causes steep voltage and current surges to travel along the line until a discontinuity or sharp change in surge impedance is experienced, such as a transformer. The surge impedance of a transformer winding, particularly the H.V. winding, is high, resulting in nearly all the surge voltage appearing across the first few turns of the winding.

Rod type spark gaps are often used to protect transformers (and other electrical apparatus), mounted externally across the H.V. bushings but are not entirely satisfactory because apart from the inevitable power follow-through arc, the breakdown characteristics are different from those of other forms of insulation such as oil, paper or porcelain.

Generally, rod gaps have a high initial value of breakdown voltage which falls relatively slowly with time. This means that in order to protect equipment against very steep wavefronts (say 1 micro-sec. to wavecrest) the rod gap would have to be set so small to protect the piece of apparatus concerned, that long duration voltage surges of relatively small magnitude would operate the gap unnecessarily.

Thus in order to protect transformers, etc., which reach a constant value of breakdown voltage after about 3 micro-sec., the valve type arrester or surge diverter consisting of totally enclosed multistyle spark gaps and non linear resistor has proved to be most satisfactory, reaching a steady breakdown valve in about 1 micro-sec.

This enables a much higher gap setting to be used without danger of unnecessary spark over, the non-linear resistor having a sufficiently high resistance to extinguish the power follow through arc at the gap.

As far as the overhead lines themselves are concerned, the only protection against direct strikes and then only partial protection is to construct the line with a high earth wire connected to an earth mat or counterpoise at each pole or tower. The earth wire, if high enough above the conductors acts as an "umbrella" intercepting the stroke. Insufficiently low tower or pole footing resistance defeats the object of the whole scheme since the stroke current would set up sufficient voltage between earth and the metalwork of the top of the pole to flash over to the line.

However, this scheme alone, when correctly executed, is no protection against induced surges from nearby lightning strokes. This problem can be partially solved for voltages up to about 22 K.V. by constructing the so called "high impulse" line, the poles and cross arms of which consist of treated wood with no electrical bonding between insulator clamps and pins. The earth wire is omitted completely and all stays insulated, with or without a horn gap across this insulator. Therefore, only near strokes of high intensity would cause flashover either between conductors or from conductors to earth down the length of the pole.

This latter form of construction has not been generally adopted by the Durban Corporation because of the danger of fallen lines remaining alive in relatively densely populated areas with the inherently low earth fault currents obtained in the absence of earth wires. Also the widespread use made of the same poles to carry E.H.T. and L.T. circuits as required in suburban areas, would preclude the omission of an earth wire.

However, from all accounts, the high impulse line has been successfully used by other supply authorities in rural areas on account of cheapness and relative rarity of direct lightning strokes to the conductors.

On a 33 K.V. line, horn gaps across each insulator string would discharge surges safely and an auto-reclosing O.C.B. when used to feed the line, would restore the supply after de-ionization of the power follow through arc at the gap. On 11 K.V., and lower, with the use of pin insulators on which spark gaps cannot conveniently be fitted, it is a matter of chance whether the insulator fails from puncture or cracking by heat in the event of flashover.

Valve type arresters are essential at all points of connection between underground cables and overhead lines, the breakdown characteristic of an underground cable being similar to that of a transformer for steep voltage wave-fronts.

Miscellaneous forms of Overhead Line Protection:

To conclude this paper, I would like to deal very briefly with some more advanced forms of high voltage transmission line protection of which I have had experience.

One fairly popular form is impedance protection using beam relays.

Beam mounted on jewel bearings is operated by a current solenoid energised from the line C.T.'s and is restrained by a voltage solenoid energised from voltage transformers. When the ratio of the line voltage to line current drops below a certain value as predetermined by the current settings of the relay, the beam tips and completes the breaker trip circuit. Thus it can be seen that the relay senses the impedance of the line from the breaker position to the point of fault. One of these elements is situated in each phase and is adjusted to trip instantaneously for phase faults occurring over a distance of up to 80% of the line length to the next substation. This is termed the "reach" of the relay.

As a back up, a similar but time delayed relay element is situated in each phase to reach about 120% of the line length, that is beyond the next substation in the line. Usually, a second set of back up elements with longer time delay is fitted to reach to about 150% of the line length.

Thus the whole relay has a 3 step characteristic as shown in Fig. 7.

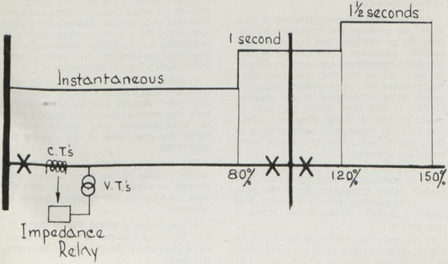


Fig. 7.

One development which will have very far reaching social consequences is the establishment of communal bath houses in native townships, similar to those which have existed for many years in the cities of Europe. Here natives will be able to obtain hot baths with soap and towels, at moderate charges. This may be considered by some as far fetched and fanciful but I prefer to believe that it is inevitable progress.

Opportunities for influencing the pattern of development of native people for good exist in this work and it is perhaps particularly gratifying to those concerned with electricity supply that the possibility of very considerable load building is also present.

The Electrical Reticulation of kwa Mashu Bantu Township, Durban

By D. R. Hill

Introduction

The problem of devising an economic reticulation for Bantu Townships is one that is confronting most Municipal Supply Authorities in the country today. It is generally recognised that electricity in the home plays a considerable part in improving the social life of a community, and from experience already gained, it is evident that this is particularly true in respect of Bantu Townships. This aspect, however, is not primarily the concern of the engineer but at the same time, co-operation between all persons involved in directing activities relating to native communities is essential in order that the best results can be obtained from all available resources.

Several papers have now been written on the subject of reticulating Bantu Townships and these together with subsequent discussions appear to have covered the subject fairly thoroughly. I feel that these papers have all made a very valuable contribution to the sources of information now available for the guidance of both present and future engineers engaged in this particular type of work and, although this paper probably contains little that is not already familiar to most of us, I hope that it will serve the purpose of again focussing attention on the problems involved and at the same time available to those interested, the methods employed and experiences gained at kwaMashu.

At this stage, I would like to give a few statistical details in order to present a general picture of kwaMashu Bantu Township and the electrical work involved in reticulating the Township.

The Township which is situated 8 miles north of the centre of Durban, covers an area of 3,000 acres and will be divided into 10 neighbourhood units. Of these 10 neighbourhood units, 9 will be in the form of Bantu village units, for family housing and will contain approximately 11,000 dwellings whilst the remaining area will be developed on the cottage hostel system and provide for approximately 17,000 beds. The total ultimate population of the Township is estimated at approximately 100,000 persons.

Finance

In common with other similar schemes, the capital cost of the electrical reticulation at kwaMashu is being financed from Native Services Levy and Government Housing Funds subject to the approval of the Minister for Bantu Administration and Development.

The financial arrangements are as follows:—

1. Cost of access from existing City Mains to the Scheme to be financed as a grant from Native Services Levy Funds.
2. Cost of major distribution system to provide for eventual full reticulation of the scheme including domestic supplies, to be financed as a grant from Native Services Levy Funds.
3. Cost of street lighting in village units. A rudimentary form of street lighting with lights spaced 300 ft. apart in every second road to be financed as a grant from Native Services Levy Funds and the additional cost of supplementing the street lighting system to provide lights 150 ft. apart in all roads, to be financed from Government Housing Funds.
4. Cost of reticulation in Hostel Area. The low tension reticulation including street lighting and the internal wiring of the hostel buildings to be financed from Government Housing Funds.

This impedance relay is also made directional so that tripping will not occur for a fault on the busbar side of the line breaker when such line is either part of a ring feed or a tie line between power stations.

A more refined version of this protection is that which uses admittance or "mho" relays, consisting of induction cups operated by a certain predetermined ratio of line current to line voltage. These elements are inherently directional, and operate most readily, or reach furthest, for faults of a predetermined power factor. The power factor setting of this relay would naturally be the same as the line power factor. This relay also has a 3 step characteristic similar to that of the impedance relays.

When this form of protection is installed at both ends of the line used as a ring feed or tie, and the relays adjusted to operate for faults within the line length, instantaneous tripping over 100% of the line or unit protection of the line can be obtained, provided a pilot or carrier link is set up between the two relay positions at the ends of the line. This causes tripping to occur simultaneously at both ends, only if both relays have operated and blocks tripping at both ends in the event of only one relay operating, which latter circumstances would indicate a fault external to the protected line.

Another form of protection which provides unit coverage and instantaneous tripping for an overhead line is "phase comparison" protection. This consists of high frequency transmitters and receivers situated at each end of the line, the transmitters being started by a relay which operates for certain values of negative or zero sequence current in the line. From the end, 50 pulses per second of high frequency (about 200 KC) are transmitted, corresponding to the positive half cycles of specially summated line current.

These pulses are then compared at both ends in identical terminal equipment with similar pulses transmitted from the other end, corresponding to the negative half cycles of similarly summated line current at that end.

If the pulse summation is as shown in Fig. 8(a), no tripping takes places at either end of the line indicating a fault external to the protected line but if the pulses overlap by more than about 30° as in Fig. 8(b), tripping occurs instantly at both ends indicating a fault in the protected line section.

I have seen 132 K.V. installations of this type combined with high speed auto-reclosing at both ends, using breakers capable of clearing a fault in about 4 cycles. The dead time of these single shot auto-reclosers is about 20 cycles, this apparently being quite sufficient for arc de-ionization at this voltage. The result is a faintly discernable dip in supply for a transient line fault.

"Out of Step" Protection:

This is used on the lines between two systems or power stations.

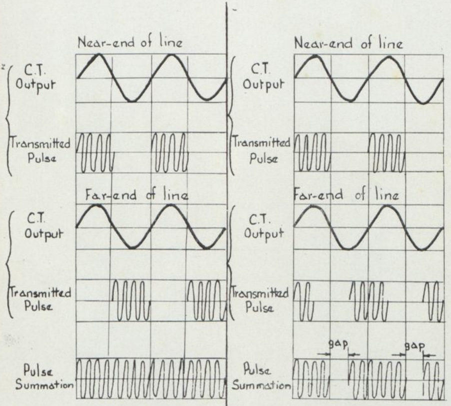
The object is to allow swing between the two stations to reach a certain predetermined angular displacement before tripping the breaker in the tie line. Thus connection is maintained between the two stations up to the point of no recovery or "out of step," after which it is pointless to retain connection.

This is achieved by two similar non-directional "mho" relay elements similar to those already described, one set very lightly, i.e. pick-up for small current/voltage ratio and the other set to trip the breaker after a small time delay for a current/voltage ratio corresponding to the critical phase angle displacement between the two stations, after which there is loss of synchronism.

However, if a line fault occurs of sufficient admittance to pick up the less sensitive "mho" element used for initiating tripping, the more sensitive mho element picks up simultaneously and blocks tripping before the delay time of the tripping element is up.

The swinging condition starts relatively slowly, picking up the more sensitive mho element in advance of the other mho element, making the trip blocking feature inoperative.

In conclusion, I would like to thank the City Electrical Engineer and the City Council of Durban for the privilege of presenting this paper.



Power stable, indicating an external fault

Protection operates, fault within protected section of line.

Printed by
JOHN O. RODD (PTY.) LTD.
P.O. Box 7462 Phone 23-7020
JOHANNESBURG